TRANSACTIONS

OF THE

ROYAL SCOTTISH SOCIETY

OF

ARTS.

VOL. IV.

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1856.

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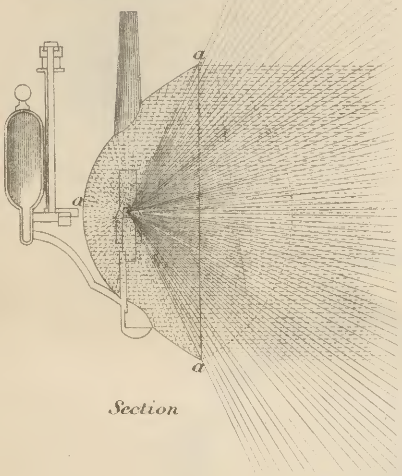

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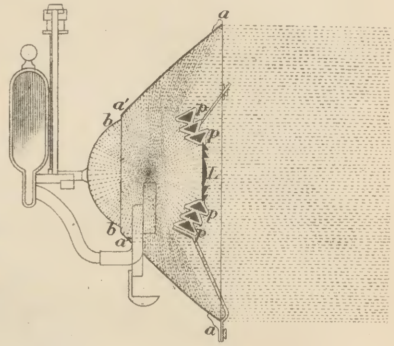

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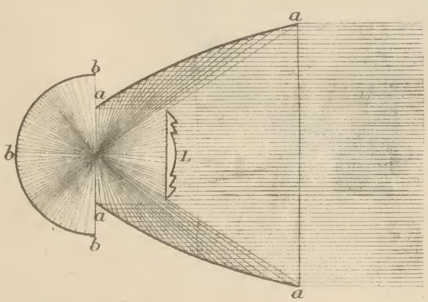

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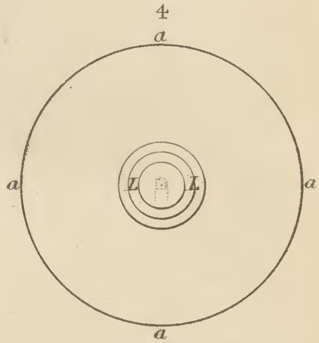

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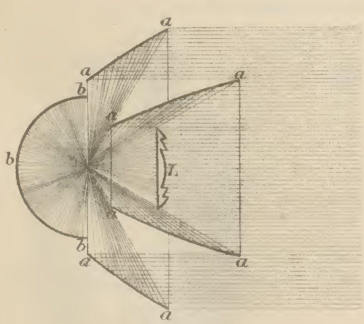

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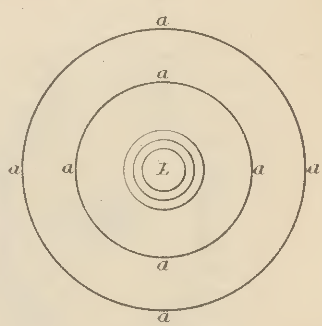

Front Elevation

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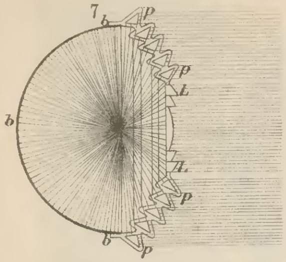

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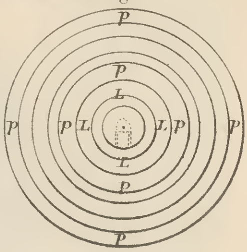

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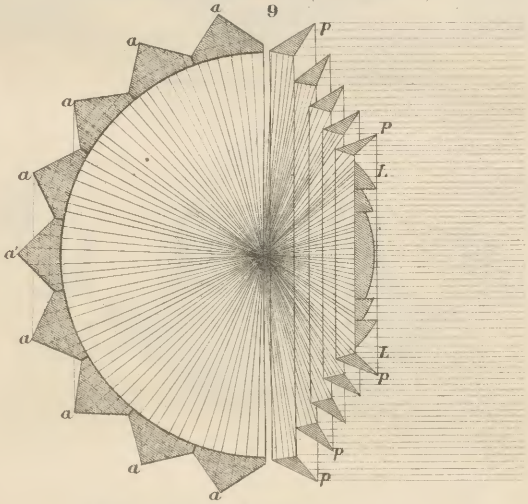

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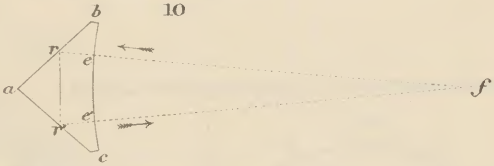

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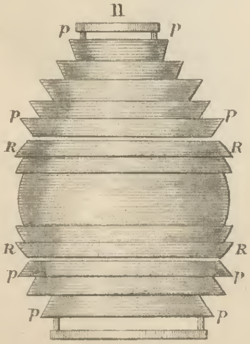

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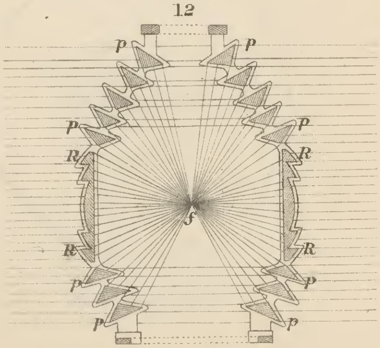

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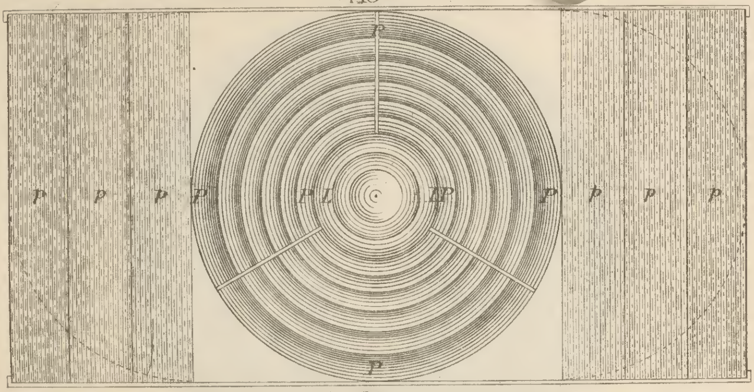

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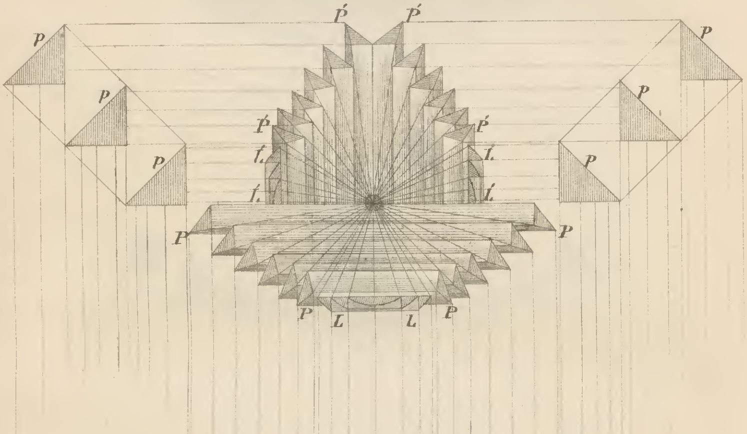

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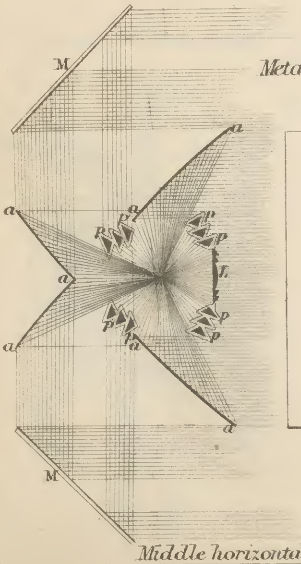

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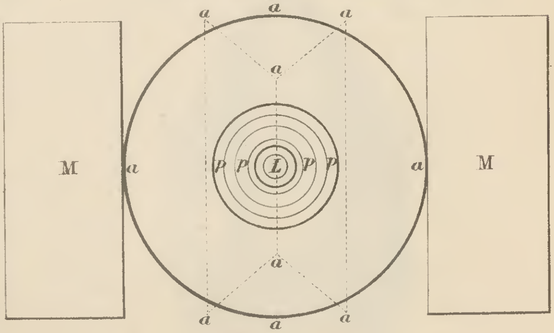

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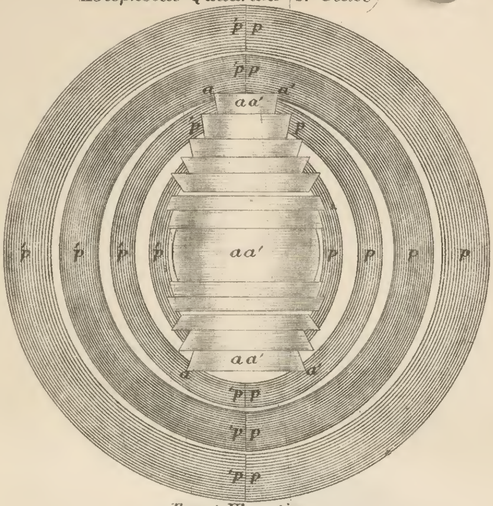

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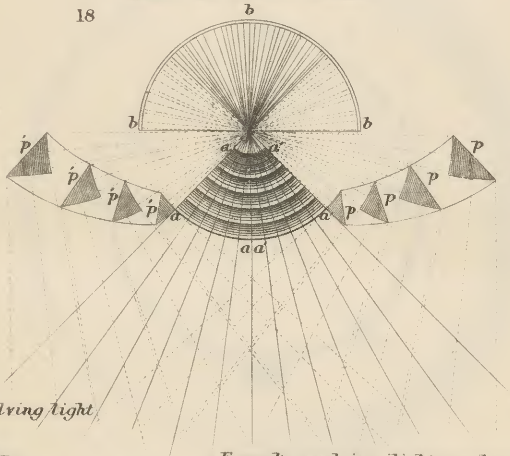

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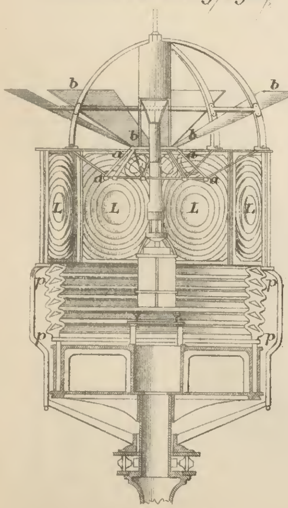

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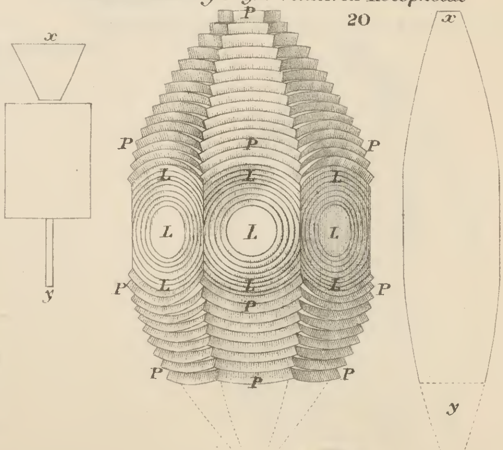

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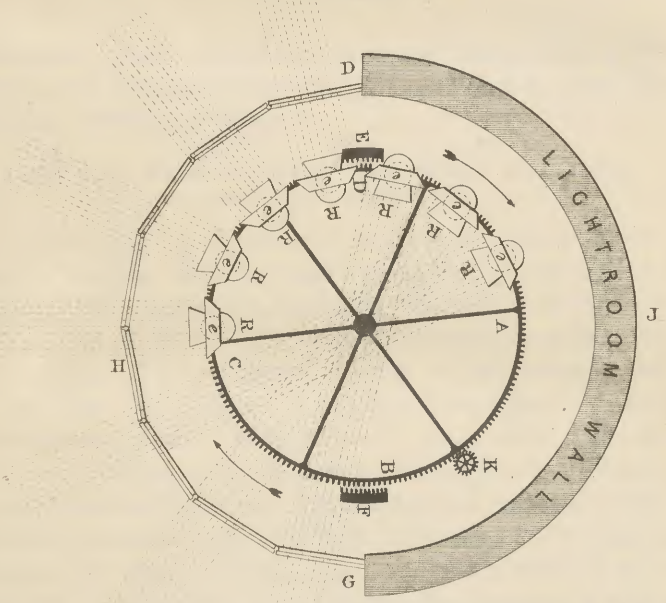

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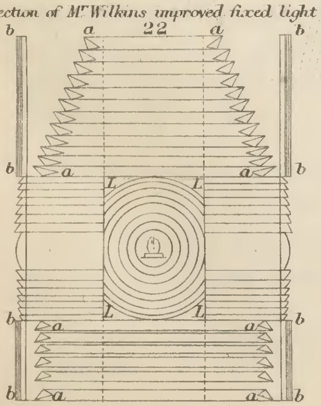

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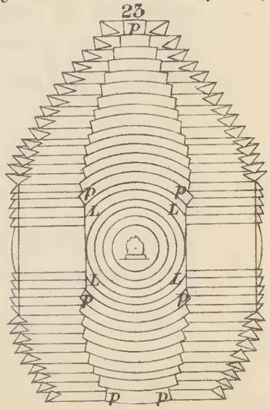

TRANSACTIONS

OF THE

ROYAL SCOTTISH SOCIETY OF ARTS.

Description of the Holophotal System of Illuminating Lighthouses, by THOMAS STEVENSON, Esq., F.R.S.E., *Civil Engineer.* With five Plates.*

KEITH GOLD MEDAL, OR PLATE VALUE THIRTY SOVEREIGNS, AWARDED NOVEMBER 1, 1850.

The principle of virtual velocities in dynamical science teaches us, that whatever power is applied at one end of a machine, will be given out, diminished by friction, at the other end, so that the theory of a perpetual motion, or, what is the same thing, of an apparatus capable of generating power, will not bear the scrutiny of a sober investigation. As in dynamics we cannot create power by any system of mechanism, so in optics, we cannot by any arrangement of instruments, however ingenious, ultimately give out more light than what proceeds originally from the flame. All we can do, therefore, to obtain the maximum effect of a flame of given intensity is to transmit all its rays in the required direction with the least possible loss from absorption or irregular scattering. It is important to recollect these views when considering the application of optical principles to the illumination of lighthouses.

Optical Apparatus used for Fixed Lights, which are constantly visible all round the Horizon.

Let us suppose that it were required to illuminate every part of the sky, the horizon and the sea at the same instant

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* Read before the Society, 11th March 1850.

of time, or, what is a better illustration, suppose it were required to illuminate simultaneously the whole interior surface of a hollow sphere, it is obvious that a simple taper or rather a luminous point unassisted by any optical instruments, but casting its divergent rays in every plane, is the proper and indeed the only means by which the conditions postulated can be fulfilled, and it is also evident that such an arrangement fulfils those conditions *perfectly*. Such a case as that supposed cannot, however, occur in the practice of lighthouse engineering; for, although it may be desirable to light the whole horizon, it never can be required to illuminate either the sky or the waters of the ocean. The kind of light on which the largest demands are made, is what is termed the *fixed light*, which, if erected on a rock or in an insular position, may, and generally does, require to exhibit a light of constant brilliancy simultaneously all round the horizon. In such a case, to revert to the illustration of the hollow sphere, no light is required near the poles, which are dark, but it is necessary that an equatorial belt of a certain breadth should be lighted up. The light, therefore, which was formerly expended in illuminating the poles, may now be bent downwards from the superior, and upwards from the inferior pole, in order to contribute to the intensity of the luminous equatorial belt.

Fresnel's fixed dioptric light may be considered as *perfectly* fulfilling the conditions we have just described for a fixed light. This apparatus is shewn at figs. 11 and 12, Plate II., where *f* is the flame, R is what has been termed the cylindric refractor, and *p* are the totally reflecting prisms. The cylindric refractor is the solid which is generated by the revolution of the middle vertical section of an annular lens round its vertical axis. Such a hoop of glass, while it possesses no refractive action horizontally, will have such an action in the vertical plane, so as to give out in every azimuth a vertical strip of light whose breadth and height depend upon the size of the flame, and the height of the refracting hoop itself. The totally reflecting prismatic rings *p*, are intended to act upon the light which would otherwise escape *above* and *below* the cylindric refractor, so as to make such light available like that portion which falls upon the refractor itself. These prisms are the solids which are generated by the revolution of triangles of certain forms round the vertical axis, which passes through the focus of the cylindric refractor. The positions and forms of these zones are determined on the principles of refraction and *total reflection.* The diverging rays falling upon the first or inner side of the zone are refracted, and pass on to the second or upper side, where they suffer total reflection and then emerge after a second refraction at the third or outer side of the zone. The effect of the zones is to lengthen, both upwards and downwards, the vertical strip of light produced by the action of the cylindric refractor, and thus there is given out in every azimuth a vertical strip of light, whose size depends on the breadth of the flame and the height of the apparatus.

Optical Apparatus hitherto used for Revolving and Leading Lights.

Where numerous lighthouses are required on any line of coast, it becomes necessary to resort to some expedients for distinguishing one from another. Such are the different modifications of revolving and coloured lights. In some situations, also, there is no occasion for lighting up the whole horizon. In leading lights, for example, two towers, whose lights are visible in only one azimuth, are all that are required for producing the desired effect.

For both revolving and leading lights the parabolic reflector has long been in use, and for revolving lights the lens system of Fresnel has been recently much employed. The characteristic requirement of a revolving light is the alternation of light and darkness in every azimuth. In the catoptric system this is generally effected by means of a revolving frame on which the reflectors are placed, each having its own lamp attached to it. Whenever, by the revolution of the frame, the axis of the reflector is pointed to the eye of a distant observer, he receives the full effect of the light. From this description, it is obvious that, if the revolving frame has four, six, or eight faces, there will be constantly illuminated four, six, or eight corresponding portions of the horizon. The action of the optical agents in this instance must obviously differ from that required in the fixed lights. For the fixed light the bending of the diverging rays so as to become parallel to each other was confined to the vertical plane; whereas in the revolving light, the lenticular action, or that by which the diverging rays are rendered parallel, extends to every possible plane, including the horizontal and the vertical, so that while the fixed apparatus gives only a *sheet* of light, the revolving gives a *beam* of parallel rays.

If a radiant point be placed in the focus of a paraboloidal reflector, *a*, fig. 1, Plate I., each diverging ray which falls upon its surface will, as is well known, be thrown forward parallel to the axis, for a tangent to the parabola makes equal angles with the diameter which passes through the point of contact and a straight line drawn from that point to the focus. It must be obvious, however, that this instrument is a very imperfect one. The diverging rays which are intercepted by it are little more than what emanate from the back part of the flame, and not very much short of one-half of the whole sphere of rays escapes by natural divergence past the lips of the reflector. It is a fact which is perhaps little thought of, but the greater part of the light which reaches the eye of the mariner from our catoptric lights emanates from the back of the flame, or that side which is turned *from* him; while those proceeding from the side which is turned *towards* him, escape by natural divergence, and never reach his eye.

In the revolving dioptric apparatus of Fresnel, shewn at fig. 19, Plate IV., the same object is attained by means of one large flame, surrounded by a revolving frame carrying a given number of annular lenses, L. Those lenses are nothing more than burning glasses on a large scale, built in separate concentric rings, in such a way as to avoid as much as possible loss of light from absorption. As the rings have different curvatures, the effects of spherical aberration are also to a great extent corrected. Fresnel introduced a compound arrangement of lenses and silvered plane mirrors, *a* and *b*, to intercept the diverging rays which pass above the lenses; while below the lenses there is added a series of totally reflecting prisms, *p*, exactly similar to those already described for the fixed light. Such an instrument cannot, then, be described as strictly a revolving light, for, while the lenses and upper portion will produce a revolving light, the zones below will shew as a fixed light. On this account, the revolving dioptric apparatus hitherto employed cannot, like the apparatus for the dioptric fixed light already described, be regarded as *perfect.* The loss of light produced by the compound arrangement of lenses and silvered mirrors above the lenses must also be very considerable, the loss by absorption from metallic specula being generally believed to be not less than *one-half* of the whole incident light.

Metallic Holophotal Reflectors.

The great loss of light by natural divergence in the parabolic reflector, and the separation of the rays into as many portions as there are lenses in the frame, in Fresnel's revolving dioptric apparatus, together with the objectionable plan for intercepting the rays which pass above and below the lenses, led me some years ago to inquire into the possibility of increasing the intensity of our lights by changes in the optical arrangements. The problem which I assigned to myself was the following:—Suppose a box containing a lamp, and having only one hole of given dimensions cut in one of its sides, let it be required so to enclose the lamp, with apparatus capable of modifying the directions of the rays, as *avoiding all unnecessary refractions or reflections, to cause the whole diverging sphere of light which proceeds from the flame to pass ultimately in one parallel beam through the aperture in the side.** Such a light I have called the "*Holophotal,*" or *light of maximum intensity.*

This effect is produced by the combination of an annular

* *Vide* Sir D. Brewster's article, "Burning Instruments," in the Edinburgh Encyclopædia, for the best method formerly proposed of sending forward divergent rays by means of a combination of numerous small lenses and plane reflectors.

lens, L, figs. 3 and 4, Plate I.; a parabolic conoid, *a*, truncated at its parameter; and a hemispherical mirror, *b*. The lens, when at its proper focal distance from the flame, subtends the same angle from it as the outer lips of the paraboloid. The hemispherical reflector occupies the place of the parabolic conoid which has been cut off behind the parameter. The flame is at once in the centre of the hemispherical mirror and in the common focus of the lens and paraboloid. Suppose the whole sphere of rays emanating from the flame to be divided into two portions, viz., the hemisphere of front rays and the hemisphere of back rays. Part of the anterior hemisphere of rays is intercepted by the lens and made parallel by its action, while the remainder is intercepted by the paraboloidal surface and made parallel by its action. The rays forming the posterior hemisphere, and which fall upon the hemispherical reflector, are sent back through the focus in the same lines, but in directions opposite to those in which they came, whence passing onwards they are in part refracted by the lens, and the rest are made parallel by the paraboloid. The back rays thus finally emerge horizontally in union with the light from the anterior hemisphere. This instrument, therefore, fulfils the conditions prescribed by collecting the *entire sphere of diverging rays into one parallel beam of light.*

The first instrument which I had constructed upon this principle, was for the North Harbour of Peterhead, and has been in use since August 1849. Mr A. Stevenson has also introduced an instrument of this kind, on a large scale, into HOY SOUND LIGHTHOUSE, one of the Northern Lights stations.*

Experiments were lately made at Gullane Hill on the comparative power of a brass reflector on this principle, and a highly finished silver reflector of the usual construction, both instruments being 25 inches in diameter at the lips. The lights were viewed at distances of from 7 to 12 miles every night during a week, and *in every instance the brass reflector on the holophotal principle had the advantage of the silver*

* At Hoy Sound there are two leading lights, the highest, which is of a red colour, requiring to be visible a great distance seaward. The Hoy reflector is of very great size. It measures 45 inches across the mouth, the lens is 11½ inches in diameter, and the light is produced by a double wick-burner.

reflector, although it cost only about half as much as the other; and on one occasion, when the atmosphere was thick, the light from the holophotal brass reflector was alone visible. As the great objection to red, green, and other coloured lights, is the enormous loss by absorption, the holophotal arrangement seems specially adapted to all lights which pass through coloured media.

Another modification of the holophotal metallic reflector still remains to be described. The execution of such an instrument as that shewn in figs. 3 and 4, if of a large size, is necessarily attended with considerable difficulty. To remedy this evil, as well as to render the instrument smaller and more compact, I have recently had reflectors made of the form shewn in figs. 5 and 6. This plan consists of the union of two or more paraboloids, each having a different focal distance, with a spherical mirror and a lens. By this arrangement, the whole light is rendered parallel, in the same manner as in the instrument first described.*

Totally Reflecting Holophotal Apparatus, substituted for the Metallic Paraboloid.

In so far as concerns the arrangement of the different parts, irrespective of the nature of the materials of which they are composed, the light emitted from any given flame by the instruments just described, should be the light of *maximum intensity*. But, as already stated, the most accurate experiments which have been undertaken by scientific observers, have shewn that reflection from the best silvered mirrors, and even from metallic specula made with the utmost care for experimental purposes, involves a loss of light by absorption of not less than about one-half of the whole incident rays.†

The advantage of employing as largely as possible the principle of *total reflection* from glass, in place of ordinary reflection from metallic specula, induced me to attempt further improvements in the Holophotal system of illumination. M. L. Fresnel found that the totally reflecting prisms *p*, figs. 11 and

* A small temporary light for Morecambe Harbour, Lancashire, is now being made of this form.

† *Vide* Brewster's Optics.

12, Plate II., of fixed lights were superior to the silvered mirrors which were formerly in use, in the proportion of 140 to 87.* It occurred to me that it might be possible to construct totally reflecting prisms so as to obtain a lenticular action in *every* plane. In the holophotal apparatus, figs. 3 and 4, Plate I., if we retain the lens and the spherical mirror, and in place of the paraboloid, we conceive the arc between the lens and the spherical mirror to be filled up with glass rings, which are the solids of revolution generated by the rotation of the cross section of the totally reflecting prisms used in fixed lights, round a horizontal axis passing through the flame, we shall then have succeeded *in extending the action of the lens, so as to parallelize one-half of the whole sphere of incident rays.*† Such an arrangement is shewn in figs. 7 and 8, Plate II., where L is the lens, *p* the totally reflecting prisms, and *b* is the spherical mirror. The distinguishing peculiarity of this arrangement is, that the prisms, instead of transmitting the light in parallel vertical plates, diverging all round as in the fixed light apparatus of Fresnel (figs. 11 and 12), produce an extension of the lenticular or *quaquaversal* action of the common annular lens, by assembling the light around its axis in the form of concentric hollow cylinders. In order to distinguish this system of prisms from those introduced by M. Fresnel, which have no lenticular action, they may therefore be termed "holophotal" or "catadioptric lenses."

Holophotal Apparatus, consisting entirely of Glass, and acting by refraction and total reflection only.

I shall now describe a method of replacing the hemispherical reflector of metal or silvered glass, by means of a polyzonal totally reflecting hemisphere of glass, *vide* fig. 9, Plate II. By this arrangement reflection from metallic specula is abolished from every part of the system, and the principles of total reflection and simple refraction are substituted.

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* *Vide* Treatise on Illumination of Lighthouses, by Alan Stevenson, LL.B., F.R.S.E., Civil Engineer.

† These prisms might perhaps be extended in number so as to take in even more than the half sphere of rays.

The action of these glass zones will be best understood by referring to fig. 10, which gives the cross section of one of them ; *f* shews the flame or centre of the system, and the diverging rays are represented by dotted lines, the arrows indicating the direction of one diverging ray before and after being altered by the prism. The side *b c* is concave, the centre of curvature being in *f* the centre of the flame. The surfaces of the other sides, *a b*, and *a c*, are portions of parabolas whose common focus is *f*, or of circles osculating the parabolic curves. Those parabolic surfaces face each other, and their tangents form an angle of 90° with each other at the vertex of the prism. Any ray proceeding from the centre *f* will be received as a normal to the surface *b c*, and will consequently pass on without suffering any deviation from *e*, where it meets the prism, to its incidence on the surface *a b*, where it will be totally reflected in the direction *r r′*, tangential to the sphere at the axis of each zone. At *r′* it again suffers total reflection, and finally emerges in a radial direction without deviation at the point *e′*. An exactly similar action will take place simultaneously with another ray in the same path from the flame, though passing in an opposite direction. The concentric zones, *a*, which compose the dome, *vide* fig. 9, are solids of revolution, generated by the rotation round the horizontal axis of the instrument of triangles similar to *a b c*, fig. 10, with a radius equal to *a f*. The angle formed by the radius with the horizontal axis of the instrument varies from nearly 90° down to zero, as shewn in fig. 9. Where those angles vanish at *a′*, a conoid will result, having the radius of its base equal to the semichord of its inner surface. The formulæ for calculating such zones, by Mr William Swan, who has kindly rendered me much assistance in prosecuting this part of the subject, are printed in the Society's Transactions.* The prisms *b a c*, resemble in their action that of the drops of rain which give rise to the natural phenomenon of the rainbow. From this peculiarity, these zones may be distinguished by the name of "*Rainbow Prisms.*" In fig. 9, which shews the whole

* Page 20. (Vol. iv.)

instrument complete, L represents the common lens acting on the rays by refraction only; *p*, the catadioptric portion of the lens acting by refraction and total reflection; and *a a′ a*, the "rainbow prisms" acting by total reflection only. Should the execution of the hemispherical dome be attended with success, the effect will be striking, as no direct light from the flame should be visible behind the apparatus, although the screen interposed is but of transparent crystal. When in Paris, in March 1850, I had an opportunity of shewing a model and drawings of this apparatus to M. Fresnel, and also to M. Letourneau, the manufacturer of the French lenses. M. Fresnel was of opinion that *theoretically*, it was wholly without defect, although the execution might be found troublesome.* Mr John Adie, optician, is at present engaged in the construction of a complete apparatus on this principle, the diacatoptric lenses having been already finished.

Alteration of the Common Parabolic Lighthouse Reflector to the Holophotal System.

To render holophotal the ordinary reflectors which are still much used in lighthouses, let there be cut off, *vide* fig. 2, Plate I., a small portion, *a′*, *a′*, behind the parameter, substituting a portion of a spherical mirror behind, and adding a lens, L, with three diacatoptric lenticular rings. The Horsburgh lighthouse, now being constructed on the Pedro Branca rock, near Singapore, according to plans by Mr J. T. Thomson, Government Surveyor, was lately fitted up with apparatus on this principle, under the direction of Mr A. Stevenson. It consists of a frame having nine holophotal reflectors of this kind. A similar apparatus is now being made for the new harbour light of Pulteneytown.†

* It is worthy of remark that in this instrument there is no loss of light by superficial reflection.

† The reflector for Pulteneytown is constructed of zinc, which forms a cheap substitute for silver. I have also had made for me a porcelain reflector, 6½ inches diameter, of what is called "lustre ware," which gives a good light, and requires no polishing. Were plane circular discs or portions of hollow spheres (which are the best forms) constructed of this material, and fixed in the top or cover of our street lamps, the light which now escapes upwards might, at a very trifling cost, be usefully directed downwards to the street.

Alteration of Fresnel's Revolving Light to the Holophotal System.

Fig. 20, Plate IV., shews the adaptation of the holophotal system to Fresnel's revolving light of the first order which is now in such general use ; L are the lenses, and P the catadioptric lenticular rings. The advantage of this system will clearly appear by comparing it with Fresnel's apparatus, fig. 19. I have projected, at each of figs. 19 and 20, proportionate sections, marked *x y*, of the beams of light which are given out by the two kinds of apparatus. The objectionable arrangement of the lenses and mirrors *a* and *b*, fig. 19, by which one-half of the light is lost, is also done away with.

REPORT OF COMMITTEE, *appointed by the Royal Scottish Society of Arts, on Mr Thomas Stevenson's description of the Holophotal System of Illuminating Lighthouses.*

EDINBURGH, *5th October* 1850.

Your Committee having met and carefully considered the paper remitted to them, and having also communicated with Mr Stevenson, and examined the models which he has caused to be constructed, are of opinion that he has very satisfactorily established the four following improvements in the system of lighting :—

1. By an arrangement of a lens with two reflectors, the one a truncated paraboloid, the other a hemisphere, whereby all the rays diverging from the flame are rendered parallel (figs. 3 and 4).

2. By substituting for the truncated paraboloid, several annular paraboloidal strips, having different focal distances, and so arranged round the flame as in combination with the hemispherical mirror and the lens, to render all the rays parallel. This arrangement appears to be a great improvement, from its compactness (figs. 5 and 6).

3. By the application of total reflection to the parallelizing of divergent rays in every plane (figs. 7 and 8).

4. By the application of two total reflections so as to produce by means of prisms, the effect of the hemispherical mirror, thus render-

ing the whole divergent beam parallel by a lens and prisms, without the intervention of any metallic reflection at all (figs. 9 and 10).

Your Committee are of opinion that these improvements are of the greatest value. Some of them are already in practical operation, and are stated to be highly successful. The fourth mentioned improvement, which consists of the application of two total internal reflections, instead of a spherical metallic reflection, appears to your Committee to be so simple and elegant in theory, and so promising as a practical improvement in lighthouses, that they hope it will speedily be constructed.

Your Committee feel warranted in recommending the Society to testify their approbation of these improvements in the strongest form.

(Signed) PHILIP KELLAND, *Convener.*
WILLIAM SWAN.
ALEXANDER BRYSON.

SUPPLEMENT TO PRECEDING PAPER.

Since the foregoing account was written, and reported on, the following plans have occurred to me as being useful in some situations:—

Method of lighting without the Spherical Mirror.

In figs. 13 and 14, Plate III., which shew an elevation and middle horizontal section of the apparatus, L is the lens and P the reflecting diacatoptric rings similar to those already described. The posterior hemisphere of rays is received upon two complete sets of half lenses, and half rings, marked L′ and P′ respectively. This apparatus renders parallel the back rays, and sends them in two beams on either side of the lamp, where they fall upon a series of straight right-angled prisms, *p p*, by which the directions of the immergent rays are altered, so as to be at right angles to the emergent rays. Figs. 15, 16, shew an adaptation of this plan to an ordinary-sized reflector, which does not require separate explanation. M M are silvered plane mirrors.

Holophotal Quadrant.

No want probably presents itself more frequently in the course of lighthouse engineering, than an apparatus possessing a greater divergence than the ordinary parabolic reflector which illuminates about 15°. Where half the azimuth is to be illuminated, nothing can be better than half of Fresnel's apparatus (figs. 11, 12, Plate II.) In situations, however, where smaller arcs are required, much light must be lost, unless recourse is had to several parabolic reflectors, which are expensive both for first cost and annual maintenance. What is most wanted is a Holophotal arrangement, capable of illuminating a quadrant of a circle. Such an arrangement is shewn on Plan and middle horizontal section (by figs. 17, 18, Plate IV.), in which *f* represents the flame; and *a a a′ a′*, a quadrant of one of Fresnel's fixed light apparatus (of which a complete one is shewn at figs. 11, 12, Plate II.); *p* and *p′* are prismatic half rings, of a peculiar form, arranged vertically round the flame as a centre, and *b* is a hemispherical mirror placed behind.

The action of Fresnel's quadrant, as already described, is to scatter equally in the horizontal plane throughout the quadrant, all the light which falls upon it. The prismatic semi-rings, *p* and *p′*, possess the property of diverging all the rays that fall on them, so as to cause them to emerge parallel to their corresponding or complemental rays which emerge from Fresnel's apparatus. Those marked *p′*, send out rays parallel to the different rays which pass out of the half of the quadrant *a′ a′*, which is on the side opposite to them; while those marked *p*, send out rays corresponding to those from the side *a a*. This will be best seen by comparing the paths of the different rays individually. The prismatic rings are straight on the totally reflecting side, concave on the immerging side, and convex on the emerging side. The centre of curvature for the immerging side is the centre of the flame, so that the diverging rays will enter as normals to that surface without undergoing any deviation, and will continue to diverge. On reaching the straight side, each diverging ray will be totally reflected at right angles to its former direction, and will pass on, each diverging from the other, as before, to the emerging side. The radius of curvature for this last side must be such, that each diverging ray will be a normal to the surface generated, and therefore that surface must be equidistant from the focus, as measured at any point along the track of the diverging rays. Each diverging ray must, in short, traverse the same distance between the radiant point and the surface of emergence. The point of junction of the emergent and reflecting sides of each prism (which is the exterior corner of the prism) will therefore be equidistant from the centre of curvature of the emergent or convex side and the centre of the flame ; and the lines joining those centres with the exterior corner of the prism will be at right angles to each other.

As a very large proportion of existing lights, more especially harbour lights, do not require more than a quadrant, but have half of Fresnel's apparatus, it may be mentioned that such lights can, although at a disadvantage compared with the plan just described, be rendered Holophotal by simply placing in front of them *straight* right-angled prisms, having similar cross-sections to those above described, for the circular prismatic rings marked *p p′*, in fig. 18, Plate IV.*

This kind of apparatus will, I am persuaded, be found to be of very general utility, and to be especially convenient in situations where it is desirable to *mask* or cut off the light in some one definite azimuth,—to cut off, on a sharp bearing, the light proceeding from an ordinary parabolic reflector or lens, being, in practice, a most difficult and unsatisfactory problem.

The Reversing Light, being a substitute for Reciprocating Lights.

Where only one half or less of the horizon requires to be illuminated by a revolving light of the common construction,

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* If metallic reflection be used instead of total reflection, where there is only a quadrant of Fresnel's apparatus used, the position and form of the strips will be the same as that of the straight sides of the prisms marked *p p′*, in fig. 18.

it is obvious that, while one half of the reflectors on the revolving frame are pointed usefully towards the sea, the other half must be uselessly illuminating the landward side. In order to save this unnecessary expenditure, Captain Smith, of the Royal Engineers, proposed what he termed a reciprocating light. This plan was to place reflectors on only one part of the frame, and to give the frame a reciprocating, instead of a uniform, circular motion. In this way, one half of the number of reflectors answers the purpose of illuminating the seaward arc, while there is no light whatever shewn towards the land. This plan, however, is open to very grave objections, inasmuch as the distinctive character of a revolving light is no longer preserved ; the alternations between light and darkness being equal only in the middle of the arc, and varying towards the two extremities. Such an arrangement is therefore fraught with the greatest risk of confusion, seeing that it presents ever varying characteristics according as the observer passes from one azimuth to another, and hence the risk of confusion, and of mistaking the light for another cannot be avoided.

To effect the same economy which the reciprocating light secures, and, at the same time, to obviate the disadvantages referred to, the following plan will, I think, be found in every way suitable. Fig. 21, Plate V., shews a ground plan of the apparatus, in which A B C D represent the frame, having toothed segments on its periphery. R are the reflectors and lamps, which have a vertical spindle passing through their common centre of gravity. On the lower end of this spindle, a small pinion wheel *e*, shewn in dotted lines, is attached, and on separate standards there are two concave toothed segments E F, placed at the same level as the pinion wheels, and at opposite points of the circle. Let it be supposed that the side which is to be illuminated is the half of the horizon marked G H D which is next the sea, while the landward side D J G is to be kept dark. As the frame A B C D is made to revolve by the ordinary machinery of the light room, working on the large toothed wheel at the point K, the reflectors will have their directions reversed whenever the pinions at the end of their spindles come into gear with the fixed concave segments, E, F. The reversing segments E, F, have just as many *leaves* as are sufficient to turn the reflectors backward through an arc of 180°; and to prevent any casual obstruction from causing the reflector to alter its position before it reaches the other reversing segment, a small spring acting as a pall, secures it in the exact position which has been given to it by the last tooth of the segment. It is hardly necessary to observe that one large reflector may be made on the same principle to illuminate half of the horizon.

From the description which has just been given, it will be very easily seen that the reflectors will be arranged as if on the *outside* of a cylinder while they are on the seaward arc, and on the *inside* of a hollow cylinder while they are on the landward arc. Each reflector and lamp is turned with its face toward the centre of the apparatus on coming into gear with the fixed segment E, and with its back to the centre on coming into gear with the fixed segment F. I think it proper to mention that I have been favoured with the sight of an elegant and ingenious plan for effecting the same objects, by Mr J. T. Thomson, Government Surveyor, Singapore. As I do not consider myself at liberty to give any description of this instrument, I shall merely mention that it appears to me to be well suited for fulfilling the required conditions, although not perhaps so rigorously as the plan above described, and certainly not so simply.

Apparent Lights.

I take the present opportunity of throwing out some hints on the possibility of causing a light, for the use of the mariner, to appear as coming from a position different from its real one. The reader is no doubt familiar with the many sunk rocks which have proved of great danger to shipping, and which have hitherto, from their limited size, defied all attempts to erect lighthouses upon them. A large number of our tidal harbours have their lighthouses erected not on the seaward extremity of their covering breakwaters, where they would be undoubtedly of most value to vessels taking the harbour, but on the inner piers or even in landward situations. The cause of such localities being preferred is from the greater amount of shelter which they possess. It has always been regarded as an axiom in lighthouse engineering, that it is better to have no light at all than to exhibit one whose appearance is doubtful, and on the certainty of whose exhibition the mariner cannot at all times rely. To establish a light at the extremity of the outer covering pier of a large number of our harbours, would be to place it beyond the control of the lightkeeper during the prevalence of stormy weather, when its exhibition is of most value.

Several plans have been adopted or proposed for warning the seaman of his approach to hidden dangers, such as the tolling of bells by the waves, or by machinery acted on by the hydrostatic pressure of the tidal column, as proposed by the late Mr R. Stevenson in 1808 for the Carr Rock, and several preparations of phosphoric oils, and agents of a similar nature, have been attempted to be used.

Although unprepared to offer any decided opinion as to what extent the method may be available of employing light which is derived from distant sources, I may nevertheless observe, that it appears to be worthy of trial, whether light projected from a distant lighthouse could not be concentrated on some inaccessible rock, so as to be there acted on by optical apparatus placed in a hermetically sealed lantern. The great difficulty attending such a plan is the small divergence which the light would have after reflection; and where dioptric action was employed there would also be a risk of the light being disfigured by prismatic colours. These difficulties I have found to exist to a greater or less extent in repeated experiments which were begun in the month of January last. One of these experiments was an attempt to cast parallel rays, proceeding from a distant lamp, upon glass prisms placed in the same line with the observer's eye. The prisms were of the same cross section as the rings in Fresnel's lens, but were the solids generated by those cross sections moving parallel to the vertical axis of the lens, instead of round its centre, which generates the solids in the concentric arrangement of the common lens. Where it is required that the apparent light should illuminate 180°, parallel rays from the emerging lens must be received upon a glass screen which is the solid that would be generated by a cross section of the holophotal prisms and lens (figs. 7 and 8) moving parallel to the vertical axis of that apparatus. Straight rectangular glass prisms, plane and spherical mirrors, were also tried for reflecting the rays in such a manner as to make them appear to proceed in a direction at right angles to the original direction.* The effect produced by plane mirrors or straight rectangular prisms seemed in every instrument to be nearly as good as the original light for very considerable distances, but the great evil, as might have been expected, was the limited arc in which the light could be seen. Without experiments upon a large scale, and attended with considerable expense, it would be difficult to decide to what extent such a system could be carried out; but for limited distances, such as could be easily had at many of our harbour mouths, or at beacons near the shore, I am inclined to think that apparent lights capable of indicating the position of the seaward pier-heads or sunken rocks could be constructed without much difficulty. A most satisfactory trial was made in the Meadows, Edinburgh, when the emergent and immergent apparatus were 500 feet apart, and the light was seen in different azimuths at the distance of about 600 feet, although the night was so foggy that Inchkeith light could not be seen from Edinburgh. But for the intervention of trees the light might have been seen very much farther. The immerging apparatus consisted of straight prisms, whose cross section was similar to those shewn in figs. 7 and 8. Where it is desirable to make the apparent rays at right angles to the original rays, the original light might be concentrated as near as possible to a cylindric reflector placed in the mock-lantern. Where it is necessary to have the mock-lantern in line with the observer's eye and the original light, the mock-lantern might contain a pane of glass of a different colour from the original light. This pane would probably be more useful if of a cylindric shape, and the rays might be made to converge, by placing a lens immediately in front of it.

* The rays were also made to converge to a point near to the focus of the apparatus in the lantern, instead of being transmitted in a parallel beam.

The position of rocks or dangerous ground may also be shewn without erecting any beacon by having the under half of the reflector or lens, with a shade of coloured glass before it, placed with a given inclination to the upper half, so as to cast the coloured rays downwards upon the shoal ground. By this arrangement, a vessel would be warned of its approach to danger, whenever she passed the boundary between the white and coloured rays. Lights subtending distant shoals might surely, in many situations, be found valuable to the mariner.

Application of the Holophotal Principle to Fresnel's "Fixed Light varied by Flashes."

The fixed light varied with flashes was invented by A. Fresnel, and is produced by the revolution of straight prisms similar to those described, p. 17, in front of a fixed light apparatus, so as to give occasional flashes of greater brilliancy. Mr Wilkins of London has exhibited an instrument of this kind, but possessing some improvements, at the Great Exhibition. Fig. 22, Plate V., represents a section of his apparatus as taken from a recent publication called the "Illustrated Exhibitor," and fig. 23 represents the same effect produced by using the holophotal prisms (described, pp. 7, 8, Plate II.) In fig. 22, the upper and lower prisms *a* are fixed, and a frame containing alternately a cylindric refractor and a lens with straight prisms *b*, revolves round the interior apparatus. In fig. 23, the whole apparatus revolves. It consists of alternate portions of Fresnel's fixed light, fig. 11, 12, Plate II., and of Fresnel's revolving light rendered holophotal, fig. 20, Plate IV. The catadioptric prisms may be arranged in a position slightly excentric from the lens so as to prolong the flash.

By comparing these two kinds of apparatus it will be seen that I can accomplish, with one set of holophotal prisms, *p*, fig. 22, Plate V., what requires in fig. 23, two sets of prisms *a* and *b*. By making the prisms *a*, fig. 23, of the same form as those marked *p*, fig. 22, the second set of prisms *b*, fig. 23, are rendered unnecessary. The adoption of the holophotal system, in this kind of light, makes the apparatus much simpler, and a great saving of expense and a very considerable saving of light are effected.

Price of Holophotal Apparatus.

I have had instruments of almost all the different forms constructed for me; and since the substitution of either cast or hammered zinc for silver, where metallic reflection is employed, the price has been exceedingly low. A metallic apparatus for a harbour or railway light costs from about £1 upwards, according to the size and construction.

Formulæ for constructing Mr Thomas Stevenson's Totally Reflecting Hemispherical Mirror. By WILLIAM SWAN, Esq., F.R.S.E.*

Among the various arrangements of optical apparatus hitherto used in lighthouses, there is none that possesses the property of collecting all the light which emanates from a flame, and transmitting it in a single beam of parallel rays. The most perfect of these arrangements, which were invented by Fresnel, were not intended to produce this effect; and the ordinary parabolic reflector, which at first sight might seem fitted to transmit all the rays in one direction, in reality fulfils this condition most imperfectly, as it leaves a large proportion of them to radiate in their natural directions.

The importance of the problem of transmitting all the light in a single direction will at once be seen, when it is considered that there are only two ways in which it is possible to increase the apparent brightness, and, therefore, the efficiency of a sea-light. One is by increasing the intensity of the source of light, the other, by using to most advantage the light actually produced. Now Carcel's mechanical lamp, as adapted by Fresnel to lighthouse use, is an instrument so perfect, and produces so brilliant a flame, that we shall not probably soon have a better source of light than that which we already possess. The only available method for increasing the efficiency of our sea-lights, is, therefore, to obtain the maximum effect of the mechanical lamp, by transmitting all its rays in a single direction.

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* Read before the Society, 25th November 1850.

As there is positively no limit to the extent to which the brightness of sea-lights might be usefully increased, it is evident that, although we were in possession of a practically available source of illumination many times more intense than that which we actually employ, it would still be an object of the greatest importance to use it in the most advantageous manner.

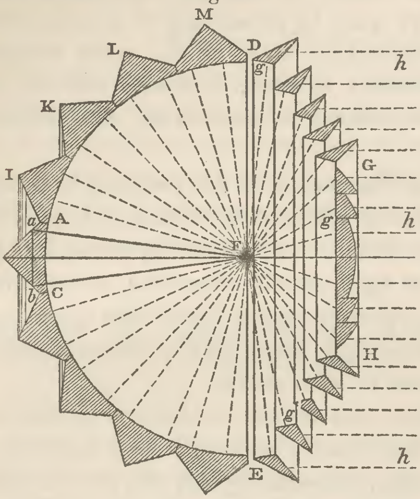
My friend, Mr Thomas Stevenson, in his recently invented holophotal arrangements, has afforded the means of transmitting in a single direction all the rays emanating from a flame; and the resulting beam of light should, therefore, be brighter than that emitted by any other species of lighthouse apparatus not fulfilling the same condition, provided the intensity of the source of light is the same in both cases.

This paper has relation, not to the holophotal system of illumination generally, but simply to a new and somewhat singular species of reflector, invented by Mr Stevenson, and which forms part of his apparatus.

The use of this reflector will be understood from fig. 1, which represents a vertical section of one of Mr Stevenson's holophotal arrangements. The holophotal apparatus in every variety of form consists essentially of two parts. One, D G H E, placed before the flame, which, in the apparatus shewn in the figure, is a series of totally reflecting prisms, with a central polyzonal lens, possesses the property of transmitting all the rays, F *g*, falling upon it in parallel directions, *g h*. The other, D B E, is a hemispherical mirror placed behind, with the flame in its centre; and its use is to collect all the remaining rays, which otherwise would be lost, and to reflect them back through the flame, so that they may fall on the apparatus in front in such directions as to admit of their being finally transmitted in the same parallel beam with the other rays.

Now, if this reflector were composed of polished metal, a large portion of the incident light would be lost by absorption; and Mr Stevenson conceived the ingenious idea of substituting for a metallic mirror, a series of prisms of glass, by which the light, after suffering two reflexions, might be returned back to the radiant point. The object of this paper is to investigate formulæ for the construction of these prisms.

Fig. 1.



The *totally reflecting* mirror is represented in fig. 1, where D B E is a semicircle, divided into an *odd* number of equal arcs. *a* B, B *b*, are portions of parabolas having the common focus F, and the axis of each coinciding with the line D E; while I, K, L, M, are figures equal and similar to A B C. If, now, the figure D K B revolve round the axis B F, it will generate a solid of revolution, and this, when constructed of glass, forms the totally reflecting mirror.

It is evident that the portion of the light reflected from the surface generated by the revolution of the semicircle D A E, since it is everywhere incident at an angle of 90°, will be returned to the point F; and the rest of the light entering the glass at an angle of 90° will suffer no deviation by refraction. Let F *a* represent one of the rays. Then, since A B D is a parabola whose focus is F, and whose axis is D E, the ray F *a*, will be reflected in the direction *a b*, parallel to D E. Again, because B C is a parabola whose focus is F, and whose axis is D E, the ray *a b*, incident upon it in a direction parallel to its axis, will be reflected to the focus, which it will reach; for it is incident at an angle of 90° upon the surface of the glass, and therefore, will suffer no deviation by refraction.

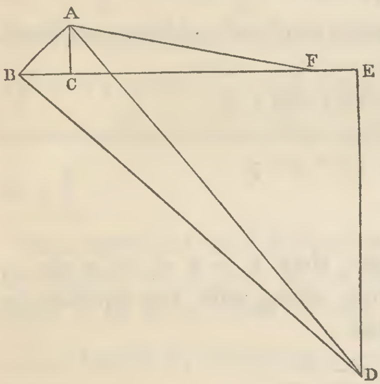
As the figures I, K, L, are all identical with A B C, their action will be precisely the same; and if the angle of incidence of the rays upon the parabolic surface of the prism A B C, be everywhere sufficiently great to ensure total reflexion, all the light will be returned to the point F, except what is unavoidably lost by absorption, or irregularly scattered at the surfaces.

As it is impossible in practice to grind and polish parabolic surfaces in glass, it becomes necessary to make the arcs A B, B C, portions of circles instead of parabolas; and this may be done either by finding a circle having a common tangent with the parabola at the points A and B, or by finding the osculating circle to the parabola at a given point in the arc A B. In order, then, to construct the apparatus, it becomes necessary to find the radius and centre of curvature of one of the arcs A B, which may be taken to represent all the others; and to avoid the loss of any of the light incident on the surface A B, it is necessary to find the greatest arc of the circle D A E, which a single zone may subtend, consistently with the total reflexion of all the rays.

I. *The Radius and Centre of Curvature.*

We shall first find the radius and centre of the arc A B, fig. 2, on the supposition that the rays incident at its extremities, A, B, are reflected in the proper direction, which is at right angles to B F; and next, on the supposition that A B is the osculating circle to the parabola at the point B. By the latter assumption it will be found that the formulæ become extremely simple, and will probably be sufficiently accurate in practice.

Fig. 2.



1. *To find the Radius of Curvature on the supposition that the rays incident at the points A and B are accurately reflected.*

If A B be assumed, so that the rays at A and B will be reflected in a direction perpendicular to B F; the problem to be solved is *to determine a circular arc, so that rays incident upon its extremities in given directions may be reflected in given directions.* This problem may easily be extended to the case of a refracting instead of a reflecting surface; and as it may be useful in constructing other sorts of lighthouse apparatus, it may be proper to give a general solution.

Since the directions of the rays at the extremities of the arc are supposed to be known both before and after reflexion, it is evident that tangents to the arc may be drawn at these points.

Let the co-ordinates of the two extremities of the arc be $x'y'$, $x''y''$, then the equations to the tangents at these points will be

$$y-y'=\tan\theta(x-x')\ ;\ y-y''=\tan\gamma\,(x-x'')$$

where θ and γ are known.

Also the equation to the circular arc will be

$$(x-a)^2+(y-b)^2=r^2\ ;$$

where r the radius of the circle, and a, b, the co-ordinates of its centre, are to be found.

The equation to the tangent to the circle at the point $x'y'$ is

$$(x-a)\,(x'-a)+(y-b)\,(y'-b)=r^2$$

and since this line is the same as $y-y'=\tan\theta\,(x-x')$ we have evidently

$$-\frac{x'-a}{y'-b}=\tan\theta$$

But since $x'y'$ is a point in the circle $(x'-a)^2+(y'-b)^2=r^2$, Therefore substituting for $x'-a$

$$y'-b=\pm r\cos\theta$$

In like manner we obtain

$$y''-b=\pm r\cos\gamma$$

Therefore $r=\dfrac{y'-y''}{\cos\theta-\cos\gamma}$

Similarly it may be shewn that $x'-a=\mp r\sin\theta$; $x''-a=\mp r\sin\gamma$; from which, along with the equation to the circle, it will be found that

$$r=\frac{x'-x''}{\sin\gamma-\sin\theta}$$

From this and the value of r already obtained, we have

$$y'-y''=\tan\frac{\theta+\gamma}{2}\,(x'-x'')$$

an equation of condition between the co-ordinates $x'y'$, $x''y''$, from which, if three of them be assumed, the fourth may be found.

Next, to obtain a and b, we have

$$x'-a=-r\sin\theta\quad y'-b=r\cos\theta$$

from which, by substituting the values of r,

$$a=\frac{x'\sin\gamma-x''\sin\theta}{\sin\gamma-\sin\theta}\ ;\quad b=\frac{y''\cos\theta-y'\cos\gamma}{\cos\theta-\cos\gamma}$$

To apply these results to the case before us, making F the origin, and B F the axis of x, fig. 2 :

The co-ordinates of A are $-x', y'$; and of B $-x''$ 0.

Therefore, in the preceding formulæ, putting $x' = -x'$, and $y'' = 0$

$$r = \frac{y'}{\cos\theta - \cos\gamma} = \frac{y'}{2\sin\frac{\gamma+\theta}{2}\sin\frac{\gamma-\theta}{2}}$$

$$a = -x' + r\sin\theta$$

$$b = -\frac{y'\cos\gamma}{\cos\theta - \cos\gamma} = -r\cos\gamma$$

Also, putting ψ for the whole angle which the breadth of one of the zones subtends at the point F, and d for the radius of the mirror measured from F to the point A, the angle A F $= \frac{\psi}{2}$, $x' = d\cos\frac{\psi}{2}$, and $y' = d\sin\frac{\psi}{2}$. Next, because the ray A F is reflected in the direction A C perpendicular to B F, C A F $= 90 - \frac{\psi}{2}$; and since the normal A D to the reflecting surface bisects the angle C A F, therefore C A D $= 45° - \frac{\psi}{4}$.

Now, since A C and A D are respectively perpendicular to the tangent at A, and to the line B F, it follows that the angle C A D is equal to the inclination of the tangent to the line B F; therefore $\theta = 45° - \frac{\psi}{4}$.

Again, because the ray A B is reflected at B in a direction at right angles to B F, the tangent at B is inclined at an angle of 45° to B F. Hence $\gamma = 45°$. Therefore, substituting these values of θ, γ, x', and y', we obtain finally

$$r = \frac{d\sin\frac{\psi}{2}}{2\sin\left(45° - \frac{\psi}{8}\right)\sin\frac{\psi}{8}} \quad . \quad . \quad . \quad . \quad (1)$$

$$a = -d\cos\frac{\psi}{2} + r\sin\left(45° - \frac{\psi}{4}\right)$$

$$b = -r\sin 45°$$

2. *To find the Radius of Curvature on the supposition that* A B *is the osculating circle to a parabola at the point* B.

It has already been shewn that the true form of the arc A B is a parabola whose focus is F, and whose axis is a line at right angles to F B. Then F B is an ordinate through the focus, and the equation to the parabola will be

$$y^2 = 4\,m\,z, \text{ where } F\,B = 2\,m\,;$$

so that m is determined by assigning the diameter of the mirror from the flame to the outer edges of the zones.

From the equation to the parabola

$$\frac{d\,y}{d\,x} = \frac{2\,m}{y}\,; \text{ and } \frac{d^2\,y}{d\,x^2} = -\frac{4\,m^2}{y^3}$$

Then, if r is the radius of curvature,

$$r = \pm \frac{\left(1 + \frac{d\,y^2}{d\,x^2}\right)^{\frac{3}{2}}}{\frac{d^2\,y}{d\,x^2}} = \frac{\left(1 + \frac{4\,m^2}{y^2}\right)^{\frac{3}{2}}}{\frac{4\,m^2}{y^3}}$$

$$= \frac{2\,(x+m)^{\frac{3}{2}}}{m^{\frac{1}{2}}}$$

and if a and b are the co-ordinates of the centre of curvature,

$$y - a = -\frac{1 + \frac{d\,y^2}{d\,x^2}}{\frac{d^2\,y}{d\,x^2}} = \frac{x\,y}{m} + y$$

$$\text{From which } a = -\frac{2\,x^{\frac{3}{2}}}{m^{\frac{1}{2}}}$$

$$\text{also } \quad b\,x - = -\frac{d\,y}{d\,x}\,(y - a)$$

$$\text{Hence } b = 3\,x + 2\,m$$

But at the point B, $x = m$ therefore substituting, we obtain

$$b = 5\,m\,;\ a = -\,2\,m\,;\ r = 4\,m\,\surd\,2\,;$$

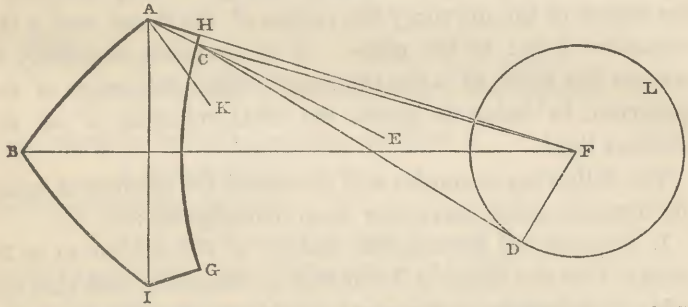
and if the origin be now transferred to F, so as to have the same axes as formerly,

$$b = -4\,m\,;\ a = 2\,m\,;\ r = 4\,m\,\surd\,2 \quad . \quad . \quad (2)$$

II. *Determination of the greatest breadth of the Zones consistent with the Total Reflexion of all the Incident Light.*

We have still to ascertain the greatest value of ψ consistent with the total reflexion of all the incident light; and in determining this, it is necessary to take into consideration the diameter of the flame, an element which has not entered into the previous calculations.

Fig. 3.



Let A B G H, fig. 3, be a section of one of the zones, D L a section of the flame, and D C A the course of a ray proceeding from the edge of the flame to the point A. Produce A C to E, join C F. Draw D F at right angles to C D, and A K a normal to the circle A B.

Then putting C F $= d$ as before, F D $= f$, and $\mu =$ the index of refraction of the glass for the extreme red rays of the spectrum.

Sin F C D $= \frac{f}{d}$, but sin F C E $= \frac{1}{\mu}$ sin F C D $= \frac{f}{\mu\, d}$; and C A F = F C E − A F C = F C E nearly, neglecting A F C on account of its smallness.* Therefore C A F $= \sin^{-1} \frac{f}{\mu\, d}$.

But since the ray F A is reflected in the direction A I perpendicular to F B, if A K be a normal at A,

$$\text{K A H} = \tfrac{1}{2}\ \text{I A F} = 45° - \frac{\psi}{4}$$

$$\text{and C A K} = \text{K A H} - \text{C A H}$$

$$= 45° - \frac{\psi}{4} - \sin^{-1} \frac{f}{\mu\, d}$$

* This assumption is perfectly safe; for its effect is evidently to make the angle of incidence C A K less than it really is, and consequently the resulting value of ψ will be rather too small.

But if the ray C A H totally reflected

$$\sin \mathrm{C\,K\,A} \succ \frac{1}{\mu}, \text{ or } \sin\left\{45° - \frac{\psi}{4} - \sin^{-1}\frac{f}{\mu\, d}\right\} \succ \frac{1}{\mu}.$$

Therefore the equation of condition to insure the total reflexion of all the rays is

$$45° - \frac{\psi}{4} > \sin^{-1}\frac{1}{\mu} + \sin^{-1}\frac{f}{\mu\, d},$$

from which it is easy to find ψ, having previously assumed d the radius of the mirror, f the radius of the flame, and μ the refractive index of the glass. It is obviously necessary to assume the value of μ for the least refrangible rays of the spectrum, in order to insure the total reflexion of all the incident light.

The following examples will illustrate the manner of using the formulæ which have now been investigated:—

1. Suppose we assume the radius of the mirror to be 20 inches, that the flame is 1·4 inches in diameter, and that the index of refraction of the glass is 1·57, we have first to determine ψ from the formula,

$$45° - \frac{\psi}{4} > \sin^{-1}\frac{1}{\mu} + \sin^{-1}\frac{f}{\mu\, d}.$$

In this, putting $f = \cdot 7$, $d = 20$, and $\mu = 1{\cdot}57$, we obtain $\psi = 16° \; 38'$ nearly. Now, since $\frac{180}{11} = 16° \; 21' \; 49''$, it follows there must be at least five zones and a central conoid.

Having thus obtained ψ, we have next to find r, a, and b, from the formulæ at (1).

$$r = \frac{d \sin\frac{\psi}{2}}{2 \sin\left(45 - \frac{\psi}{8}\right) \sin\frac{\psi}{8}}$$

$$a = -d \cos\frac{\psi}{2} + r \sin\left(45 - \frac{\psi}{4}\right)$$

$$b = -r \sin 45$$

From these it will be found that

$$r = 58{\cdot}512 \qquad a = 18{\cdot}523 \qquad b = -41{\cdot}375.$$

To compare this result with that given by the formulæ (2), it must be borne in mind that $2\,m$ in the second set of formulæ is the same as x'' in the first. Now, we have already found, p. 24, that

$$y'-y''=\tan\frac{\theta+\gamma}{2}(x'-x'')$$

from which, since $y''=o$, and x', x'', are both negative,

$$x''=x'+y'\cot\frac{\theta+\gamma}{2}$$

and since $x'=d\cos\frac{\psi}{2}$, $y'=d\sin\frac{\psi}{2}$, and

$$\frac{\theta+\gamma}{2}=45-\frac{\psi}{8}$$

we obtain

$$2\,m=d\left\{\cos\frac{\psi}{2}+\sin\frac{\psi}{2}\cot\left(45-\frac{\psi}{8}\right)\right\}$$

from which by substituting the value of ψ

$$2\,m=22\cdot85362,*$$

and then from the formulæ

$$r=4\,m\sqrt{2},\ a=2\,m,\text{ and }b=-4\,m,$$

we find $r=64\cdot640$; $a=22\cdot854$; $b=-45\cdot707$

It will now be observed that the values of r found by the two formulæ differ by nearly 4·77 inches; but this will not produce a very great aberration of the rays, seeing the arcs of the circles are so small that they will not deviate greatly from each other. To ascertain the amount of the error introduced by using the approximate value for r, we must bear in mind that the circles calculated by the two formulæ have a common tangent at B. For in the osculating circle to the parabola at B,

$$\frac{d\,y}{d\,x}=\frac{2\,m}{y}=\frac{2\,m}{2\,m}=\tan 45°,$$

and the tangent to the other circle at the same point by the construction, makes an angle of 45° with the axis; and therefore, since one lies wholly within the other, they will separate from each other most widely at A. We shall, in order to estimate the error introduced by using the formulæ (2), calculate the difference of their ordinates at A, and also the difference of their inclinations to the axis at that

* It may be proper to remind the reader that this preliminary calculation is only required here in order to compare the formulæ by calculating the value of r for a mirror of exactly the same dimensions in both cases. In applying the second set of formulæ, originally, we might at once assume a value for m, and then the calculation would be much shorter than by the other method.

point. For this purpose we have the equation to the circle found by formula (2)

$$(x-2m)^2+(y+4m)^2=r^2,$$

in which substituting for x its value, $d\cos\frac{\psi}{2}$, we obtain

$$y=2{\cdot}86515.$$

But the correct value of y at that point is

$$d\sin\frac{\psi}{2}=2{\cdot}84634.$$

Therefore the distance of the two arcs, reckoned along y is ·019; but since the ordinates are evidently inclined to the normals to the circles at the point A at an angle

$$45-\frac{\psi}{4}=40°\,54',$$

The true distance of the circles will be ·019 sin 40° 54′ = ·012 —a difference perhaps within the limit of the errors of workmanship in such apparatus.

Again, to calculate the aberration of the rays reflected at A, we have from the equation to the circle

$$\frac{dy}{dx}=-\frac{x-2m}{y+4m}$$

which should evidently be equal to $\tan\theta$; and substituting the values of x and y, we find $\theta=41°\,17'\,7''$. Now, the true value of θ at the point A in the circle depends upon that of $\frac{\psi}{2}$, and we have seen that

$$\theta=45-\frac{\psi}{4},\text{ also }\frac{\psi}{2}=\tan^{-1}\frac{y}{x}.$$

Therefore, substituting the values of x and y, we find $\theta=40°\,52'\,56''$, which shews an error in the inclination of the reflecting surface at A amounting to 0° 24′. But since the error in the direction of the reflected rays is double of this, and the same error affects the opposite reflecting side of the prism, the final error in the direction of the rays will be 1° 36′, and this will give a *lateral* aberration of ·56 inches when the rays are finally returned to the flame.

In this example we have taken a value of μ perhaps rather higher than that of the ordinary flint-glasses for the least refracted rays. We shall, therefore, in the next example assume $\mu=1{\cdot}55$.

Suppose the mirror intended for a light of the first order, illuminated by Fresnel's great lamp, with a wick 3·6 inches in diameter, then, if the internal radius of the mirror be assumed at 24 inches, and if $\mu = 1{\cdot}55$ for the extreme red rays, we shall find, as formerly, the limiting value of ψ to be $8^\circ\,11'\,40'' = 8^\circ{\cdot}2$ nearly; from which it follows, since $\frac{180^\circ}{8^\circ{\cdot}2} = 22$, that there must be 11 zones and a central conoid. Hence $\psi = 7^\circ\,49'\,34''$. From this value of ψ, putting $d = 24$, and $f = 1{\cdot}8$, it will be found from the formulæ (1)

$$r = 70{\cdot}624\,;\; a = 24{\cdot}260\,;\; b = -49{\cdot}940.$$

If r, a, and b, be calculated by means of the osculating circle to the parabola in the manner already explained, it will be found that

$$r = 72{\cdot}517\,;\; a = 25{\cdot}639\,;\; b = -51{\cdot}278.$$

From this it appears that the values of r, calculated by the two formulæ, differ by nearly 1·89 inch, or by about $\frac{1}{35}$th of the whole length of the radius. The difference of the ordinates of the circles at the point A will be found in the same manner as before, to be ·0027 inch, from which the perpendicular distance of the arcs is found to be ·0018 inch, a quantity quite within the limits of error in constructing such apparatus.

Finally, the error in inclination of the osculating circle to the parabola at the point A is $5'\,46''$, from which the lateral aberration of the rays from the point F will be about ·16 inches, a quantity which may be safely neglected with a flame 3·6 inches in diameter. It seems, therefore, from these examples that the approximate formulæ will give sufficiently accurate results in the cases most likely to occur in practice.

It may have already occurred to the reader as a remarkable peculiarity of the totally reflecting mirror, that since the rays at their first incidence and final emergence are perpendicular to the surface of the glass, they suffer no deviation by refraction; and consequently the curvature of the different surfaces is totally independent of the refractive power of the glass. It is otherwise, however, with the determination of the greatest admissible breadth of the zones. Here the index of refraction of the glass enters as an element into the calculation; and the higher the refraction the greater may be the breadth of a zone capable of reflecting all the incident light. Flint glass, from its high refractive power, is therefore more suitable than plate glass for the construction of the totally reflecting mirror; for, owing to their greater breadth, a smaller number of zones of the former material will be required to complete a hemisphere, and the expense of construction will accordingly be lessened.

Since this paper was read, it has occurred to me that the totally reflecting mirror will probably have certain properties rendering it preferable to a metallic reflector, which it may be proper to mention here. In a recent application of the holophotal principle to an instrument of very great size, so much heat was reflected from the metallic hemisphere as to cause the ebullition of the oil; an inconvenience which, however, has been obviated mechanically. Now, it has been found that, at moderate angles of incidence, glass reflects much less heat than metal. If this be true also at an incidence of 90°, the totally reflecting mirror, by its superficial reflexion, will return much less heat than a metallic hemisphere. Then, of the heat-rays which enter the glass, besides those which are absorbed, it is probable that a considerable portion, owing to their low refrangibility, will escape total reflexion, and emerge harmlessly at the back of the mirror.

The investigation of the different formulæ already given, is that by which they were originally obtained. The following are the principal steps of geometrical demonstrations, which are added for those who may prefer them.

1. In fig. 2 join AB, and let AD, FB intersect each other in G. Since the ray FA is reflected at A in the direction AC perpendicular to FB, the normal AD bisects the angle FAC.

Therefore putting

$$AF=d,\ AD=r,\ FE=a,\ DE=-b,\ \text{and}\ AFC=\frac{\psi}{2}$$

$$CAD = DAF = \tfrac{1}{2}(90^\circ - AFC), \text{ or } DAF = 45^\circ - \frac{\psi}{4}.$$

Then $GBD + GDB = GAF + AFG$;

from which $ADB = \frac{\psi}{4}$, and $ABF = ABD - FBD = 45^\circ - \frac{\psi}{8}$.

$$\text{Now} \quad AB = \frac{AF \sin AFB}{\sin ABF} = \frac{d \sin \frac{\psi}{2}}{\sin\left(45^\circ - \frac{\psi}{8}\right)};$$

$$\text{and} \quad AD = \tfrac{1}{2} AB \operatorname{cosec} \tfrac{1}{2} ADB = \frac{AB}{2 \sin \frac{1}{2} ADB};$$

$$\text{Hence} \quad r = \frac{d \sin \frac{\psi}{2}}{2 \sin\left(45 - \frac{\psi}{8}\right) \sin \frac{\psi}{8}}.$$

Also $FE = EC - FC = AD \sin ADE - AF \cos AFC$,

and $DE = BD \sin EBD$. From which

$$a = r \sin\left(45^\circ - \frac{\psi}{4}\right) - d \cos \frac{\psi}{2} \text{ and } b = -r \sin 45^\circ.$$

2. To find the osculating circle at the point B, on the supposition that AB is a parabolic arc, whose focus is F, and BF its principal semi-parameter. Produce BF towards F, until the whole line produced is equal to four times BF; and on it describe a square. About the square describe a circle, which will then be the osculating circle at the point B (see Wallace's Conic Sections, Prop. 1. on *Curvature*); and putting $FB = 2m$, we shall evidently have the radius of the circle $= 4m\sqrt{2}$.

$BE = ED = 4m$; therefore $FE = 2m$. Hence, as before,

$$r = 4m\sqrt{2}; \qquad a = 2m; \qquad b = -4m.$$

On the Improvements on the River Clyde during the past Hundred Years. (Part I.) By WILLIAM CAMPBELL, Esq., C.E.* With a Plate.

The progress of improvement on the River Clyde, during the past hundred years, has been from a state of nature, spreading over a wide bed full of shoals, to a highly improved condition ; forming a valuable inland navigation and one of the greatest works of the kind.

What makes this the more remarkable is, that the extensive forest of masts at the Broomielaw Harbour of Glasgow has accumulated before our own eyes ; so rapid has been the progress of improvement since the commencement of the present century.

Just one hundred years ago the magistrates of Glasgow had their first report on the levels and depths of the river, down to Dunglas Quay. Since then, about fifty reports have from time to time been had from the principal engineers and others. These reports point out proposed works and embrace the navigation down to Port-Glasgow ; in some the remarks extending to the banks at the deep sea. I have to observe that it is chiefly from these, as also from historical and statistical information, joined to my own knowledge of the works, that I have been enabled to attempt to lay before you a general description of what has been *done* on this important national undertaking ; and I have endeavoured to indicate the whole on the maps and plans now before you.

On Dumbuck Ford, twelve miles down from Glasgow, there was but 2 feet depth at low water summer level, and the same at Newshot Isle and other points up to a sand at the lower end of the harbour, on which there was but 15 to 18 inches of water.

The spring-tides, which in the estuary rose 10 feet, di-

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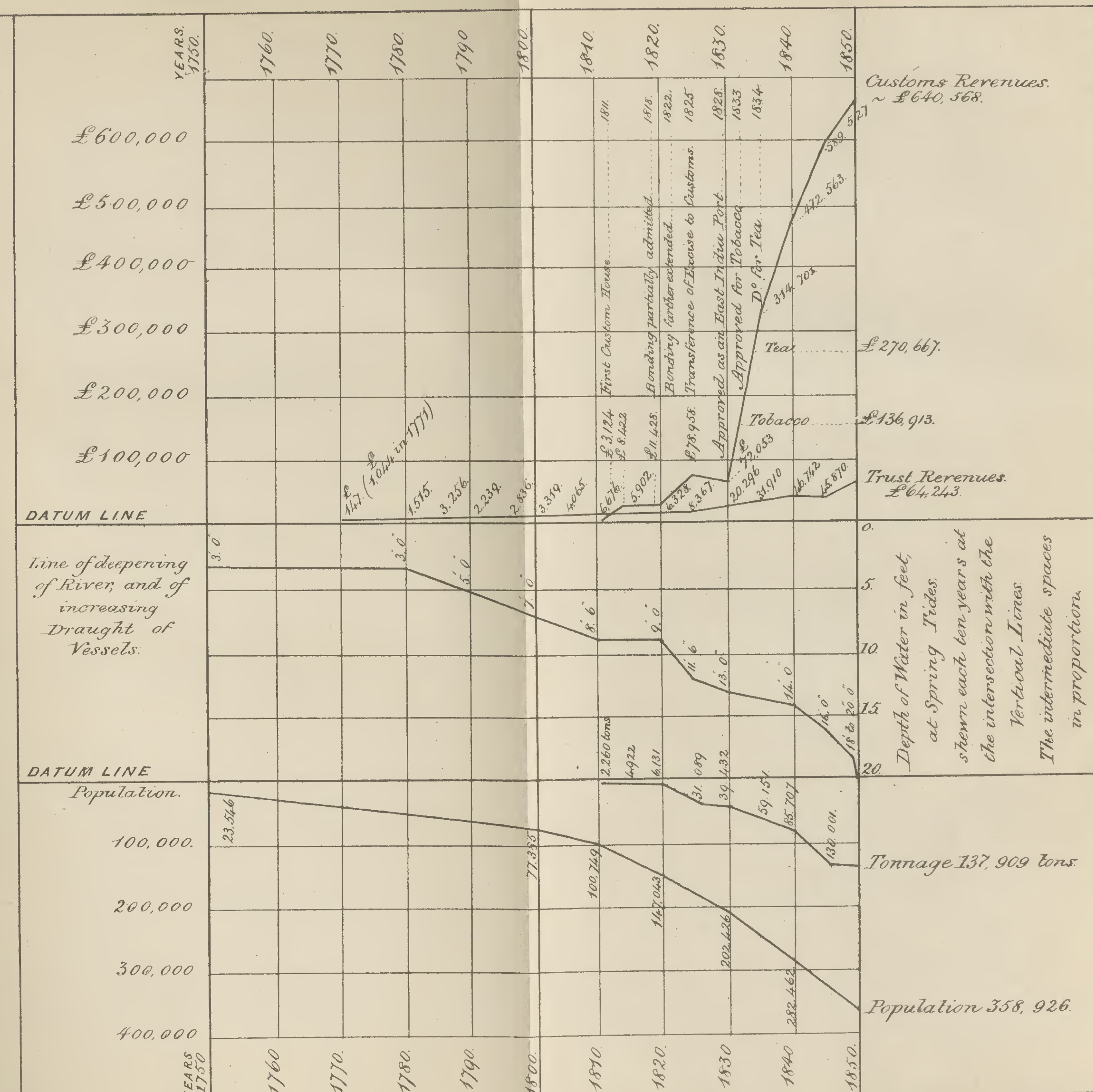
* Read before the Society, 10th February 1851.

THE RIVER CLYDE & ITS IMPROVEMENTS.

DIAGRAM

Shewing the Proportionate Rate of Increase in the Depths of the Channel and Draught of Vessels; The Revenues of the Clyde Trust and of the Customs, also the Registered Tonnage and the Population, all at Glasgow.

Wm. Campbell, C.E.
Edinburgh, 11, Scotland Street,
March, 1851.



minished to 6 feet at Newshot Isle, and to 1 foot 9 inches at the harbour, and here the rise of neap tides died away, so as to be only perceptible at the Broomielaw Quay.

Before entering on the details, allow me, Sir, to draw your attention to a general view of the river.

The Clyde rises in the south of Lanarkshire, in the same hills above Moffat as the Annan and the Tweed, each taking a different direction. The catchment basin of the Clyde defines the county of Lanark, to which the tributary streams give the appearance of a leaf of which the Clyde is the stem, draining 972 square miles. From the water-shed on Queensberry-hill, the Clyde follows a north-easterly course of seventy miles to Dumbarton Rock, where it receives the Leven and joins the Frith of Clyde, which extends about thirty miles to the little Cumbrae Island, on which is the first lighthouse maintained by the Clyde Ports.*

The sources of Clyde are about 2500 feet above the sea; and near Bothwell, about eight miles above Glasgow, it has fallen to about the level of the sea. About half way between these points where it winds round the base of Tinto, it has fallen to about 700 feet above the sea, and the Falls of Clyde at Lanark descend 180 feet in three miles. At Bothwell the river spreads over a wide rocky bed, and the banks are often flooded up to Dalserf, which is sixteen miles above Glasgow. And finally, there is now only a fall of 1 foot on the surface of the tide below Glasgow, the bottom of the channel being quite level to Port-Glasgow, a distance of eighteen and a quarter miles. The level of the tide in the Frith of Clyde is higher than in the Atlantic Ocean, and up at Bowling Bay it is higher than on the Frith of Forth. The neap tides rise to the level of the weir at Glasgow harbour, and ordinary tides reach Dalmarnock bridge, three miles above.

If the weir were removed, and Dalmarnock ford deepened, &c., it seems possible to get the tide to ebb and flow ten or

* This lighthouse, erected in 1757, was one of the earliest in Scotland. The light is fixed, and 106 feet above the sea.

perhaps fifteen miles above Glasgow. That would be the rise of H.W. from the river being dammed up by the flowing tide of the lower Clyde, for the brackishness of sea water has not been detected above Renfrew wharf, six miles below the harbour.

This is, however, one of the most important points connected with the *future improvement* of the navigation.

An increased body of water from this reservoir, in the upper reaches, would be discharged each ebb tide, which would scour the harbour, but there are various interests opposed to this deepening above the bridges as the tide would then ebb 4 or 5 feet lower than the present summer level; and it might also inconvenience small vessels in the upper harbour.

The tide would then continue to flow longer at the Broomielaw, and perhaps rise higher than now, or at least have a longer dead H.W. It is, however, uniformity of sectional area in the channel that has the greatest effect on the tides.

The surface of H.W. in the upper reaches would be considerably above that of the estuary, and its height at the Broomielaw would probably be increased.

The Clyde (to Port-Glasgow) drains 1200 square miles, and though third in size, is the most important river in Scotland, and the great artery of commerce in the west.

About two hundred years ago the liming of the land greatly reduced the salmon fisheries; and one hundred years ago the agricultural improvements and reclaiming of waste land in Strath-Clyde, by facilitating the passage of rains from the surface of the ground, rendered the river subject to sudden risings.

On 12th March 1782 the river rose 20 feet at Glasgow, and flooded the town to a fearful depth never before known. This being but a few years after the erection of Jamaica Street bridge, and the commencement of the improvements which form the subject of this paper; and as the flood stood 19 inches higher above the bridge than in the harbour, there was a great dread among the inhabitants that the discharge of the water had been impeded by the operations of the trustees.

There have been several *spates* since, rising 17 and 18 feet. In 1831 the river above Glasgow rose 20 feet, but the improved form of the navigable channel allowed the waters to pass the town without producing any calamitous result. Since then the cutting away of a point in the harbour, in 1843, has increased the velocity of the discharge of floods from the upper reaches of the river from four and a half miles an hour to six miles an hour.

At summer level, the current at Glasgow Green is scarcely perceptible, and then the volume of water passing is only about 625 gallons per second; during *freshes* it increases rapidly, and, in one of those *spates* already noticed, the discharge is upwards of 218,750 gallons per second.

The valley of the Clyde, from below Glasgow to its rocky bed several miles above, is a soft diversified strata 40 to 100 feet deep, mostly of mud, covered with running sand and a crust of gravel, under which lie the coal-measures.

The waters of the Clyde carry down annually, from the upper reaches (above Glasgow) about 22,000 cubic yards of fine sand and loose soil.

Tradition tells us that the Clyde has changed its course at several places. It now winds round a haugh in Glasgow Green, through which it once ran when its velocity had been greater than it was latterly. The low grounds at White Inch indicate something similar.

It has left the ancient town of Renfrew, six miles below Glasgow, close to which it once ran, forming a bay in which vessels of considerable burden were built; but the old harbour had to be joined to the present channel by a canal, in 1785; and the river, still holding to the north, has, in confluence with the Cart, formed Newshot Isle. Its southern course at this island is fast disappearing, though lately it was the navigable channel.

These changes on the course of the river have affected the ancient town of *Rutherglen* most. It stands two and a half miles above Glasgow, and was a shipping place when the latter had only a *landing shore*. On its ancient seal was a *Ship*, while on that of Glasgow is a *Fish*. The exact site of that ancient burgh, with the freest constitution in the kingdom, was unknown till the lines of old streets were ploughed up near the present village.*

Before leaving the old state of the Clyde, it may be introductory to the late improvements, to glance at what had before been done to the navigation above Dumbarton, for the trade of Glasgow.

In the year 560, St Mungo founded his church at Glasgow on an eminence 104 feet above the level of the Clyde, and for five hundred years it was chiefly of timber, till in 1100, the present cathedral was commenced. Then in 1172, the town was made a burgh. Shortly after this (in 1221), Dumbarton was also made a burgh. Charters were granted to Dumbarton exempting it from river dues at Glasgow. These were confirmed in 1609, with powers to levy dues at its own harbour on the Leven.

In 1636 was confirmed the right of Glasgow to elect a bailie of the river, with maritime and civil jurisdiction, and the alveus of the river were granted in trust to the magistrates

There was no *Quay* at the Broomielaw then, but Glasgow had some shipping a hundred years previous; that is, at least three hundred years ago.†

In 1556, the river having (chiefly in consequence of the many cart-loads of rubbish, &c., thrown into it at Glasgow) become impassable even for small boats, Dumbarton, Renfrew, and Glasgow, agreed to excavate the fords for six weeks each alternately.

In 1668, the magistrates of Glasgow purchased 22 acres of land and commenced to build *Port-Glasgow*, eighteen and a quarter miles down the river.‡ A few years after this a quay

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* We know that its castle, which stood sieges in the time of Robert Bruce, was rased to the ground by Regent Murray, and that it was the present village through which Queen Mary passed from Langside.

† The "Lion of Glasgow" privateer was of 60 tons burden.

‡ In 1653, Glasgow had its shipping port on the Ayrshire coast, the magistrates then treated for leave to build docks at Dumbarton, but the negotiation was broken up lest the influx of traders should raise the price of provisions on

was built at the Broomielaw, which cost £1666 sterling, and in 1710 Port-Glasgow was made the chief custom-house on the Clyde. Trade rapidly increased, and the first graving or dry-dock for repairing vessels in Scotland was built here, in 1762, under the direction of the afterwards celebrated James Watt.

We are now fairly introduced to the improvements of the past hundred years, but we may proceed with the rise of Port-Glasgow, and I may also add its decline, before we return to the channel of the river.

In 1801 the port was enlarged to a double harbour of 3½ acres in each, with an entrance of 130 feet wide. The anchorage in the river, off the quays, is good, with 18 feet low water; but it being found that sharp-bottomed fast-sailing vessels did not like the port, from having to lay aground when in harbour, a wet dock was proposed in 1828, and in 1833 one was accordingly commenced, inclosing 10 acres, the lock-gates 53 feet wide, with 14 feet low water on the cill.

This dock got out of repair in 1837, and as by that time large vessels could get up the river, nothing has since been done to repair it.*

There are three building-slips at Port-Glasgow, and there are 1500 yards of available wharfage, but the trade has fallen off very much.

It is worthy of remark that GREENOCK, which occupies one of the best positions in the west of Scotland, had no harbour till the year 1710, when the first was completed by subscription at an expense of £5600. It enclosed 13 acres, and was the greatest work of its kind then in Scotland. The first act

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the inhabitants of the burgh. They next tried Troon at the mouth of the Clyde but were refused from similar fears; as the supplies of a town were slowly brought forward over the tracks by the pack-horses of those days, regular roads, save the old Roman, there were none, but such as they were, were kept up by the parishes; the drove-loans, which still stretch across the country, are the only remains of the old system. Hence the magistrates had to build a new town at the old castle and village of Newark, and called it New Port-Glasgow.

* Since this paper was read, repairs to the extent of several hundred pounds had been proposed.

for improving Greenock harbour was got just one hundred years ago, and eight commissioners were to represent the interests of Glasgow in the Trust at Greenock.

Now, to return to the river channel.

Dumbuck Ford, already mentioned, was deepened in the autumn of 1773, from 2 feet at low-water, to a depth of 6 feet, at an expense of £2300 sterling.

The grand object of this deep cut was the admission of a larger body of tidal water up the river. The next step was to secure the ebbing of this increased volume of water through the new channel, which was effected by throwing a jetty of loose stones across the bed of the river where it formerly divided into two low-water courses; and so successful was this operation, that in the autumn of 1781, when the magistrates again sounded at the ford, the channel-cut had been scoured to no less a depth than 14 feet at low-water.

Next, the channel at Newshot Isle was cleared of boulder stones and gravel, and so deepened from 2 feet at low-water, to having a depth of 7 feet.

It may be observed that the volume of tidal water then passing above that part of the river was not great enough to scour so hard a bottom, and more stones had afterwards to be taken out, when the general depth of the channel was increased; and this holds good of all the hard parts of the bottom to the present day, for, as the scouring increases, stones in the bottom are laid bare, which can only be operated upon by means of the diving-bells.

By the year 1775 there had been 117 jetties run out on the alveus of the river (that is, on the space between high and low water lines) to guide the water into the channel. Five years after (in 1781), the silt had accumulated between them, and was forming land yielding grass; the jetties were then raised and extended to the land, with the view of forming shore banks for the river.

Pools were naturally formed by the eddy-water at the points of these jetties, and the additional deepening increased the evil. The time was now come to join the points of these jetties with DIKES running across them and parallel with the current.

They enabled a more uniform depth of channel to be maintained; and now, in this age of steam-power, they protect the banks against the waves from the steam-boat paddles.

These dikes were commenced in 1768, and new jetties were carried out from the shore,—they did much good; but at Glasgow and at Dumbarton the dike was laid too close on the channel. *Cairns* were erected to shew the position of these dikes when the tide was up, and *beacon perches* have been erected, as also lights and mile-posts, for the guidance of vessels.

The river was then surveyed, and a plan made in 1800, shewing the dikes and all the jetties, 219 in number.

In 1807, lines were laid down on this plan for the continuation of the parallel dikes; commencing at the harbour with a width of 136 feet, gradually expanding to 150 feet at the mouth of the river Kelvin, and 700 feet at Dumbarton. These lines guided the work, but it has been executed a little wider.

Since 1840, the trustees have a Parliamentary plan with much wider lines, commencing with the present width at the harbour 420 feet, then 360 feet at the Kelvin, and gradually expanding to a width for the channel at Dumbarton of 1053 feet. And to these lines the cutting away points, &c., is proceeding.

In comparing the width of these parallel lines bounding the channel, we must keep in view what had been already accomplished. The effect of these dikes, in concentrating the scour of the waters, was to gain a depth of 11 feet, although before the introduction of the *Steam Dredging-Machine* in 1824, their effect in deepening had only been assisted by the porcupine plough on the hard parts of the bottom, and by spooning at the sandy fords, it not being till then that large quantities of stuff were raised from the channel, and the punts discharged behind the dikes. Since then the channel has been dredged to 10 feet low water, and the stone pitching on the face of the dikes repaired to suit the additional depth. The new wide lines, while they will, of course, improve the currents, are not for the mere purpose of deepening, but to give waterway to the increasing traffic which the improvements in depth have already created.

The tides and currents being contracted by the jetties, were forced to cut a deep channel, and this was maintained by the dikes. It would have been a hopeless task to commence upon the original shallows with the wide lines which are now required, and even with its present depth, the widening of the lines will render the navigation still more dependant on the dredging power than it now is; but the revenues authorise it, and the facilities to commerce, and advantage in passing off the land floods, will be great indeed, and the river will then match the present spacious harbour.

The Clyde was the *cradle* of the steam-engine, the *nursery* of steam navigation in Europe, and nowhere has the application of steam power worked greater changes.

When vessels trusted to the winds to bring them through this inland navigation, how few were the traders that reached the Broomielaw.

The *packet for goods* could, with a fair wind, reach the Isle of Bute in three days, though it sometimes took as many weeks; and when the river had been so far restored as to allow of fly-boats starting from Glasgow to Greenock, they reached their destination in ten hours!

So late as 1807, when the river dikes were advanced enough to allow a *tracking path* to be formed from Renfrew up to the harbour, a great point was gained, for the wind generally failing vessels at that place, *horses* were attached, and so the good ship at last arrived. But now the tug steamboat starting with the well-freighted ship, leaves her to set sail at the "tail o' the bank," then looking about the deep sea, takes in *tow* some "homeward bound," and brings her up to port in a few hours.

Our President, in his Address, read you the advertisement of *Henry Bell's Passenger Steam-Boat* in 1812; I need only add that, in this, the first successful attempt at steam navigation in Europe, the trip of twenty-two miles was accomplished in three hours.

This was the dawning of the new era. It was the steam tug-boat annihilating the old difficulties of distance and time, which made Glasgow indeed a SEAPORT, and it is the same power that still renders the navigation available to her wealthy merchants.

That these results are far beyond what were ever anticipated, even at a late date, will be apparent when we look at the progressing powers which the trustees have sought under their various ACTS of PARLIAMENT.

In 1758, the first Act was got for improving the river, "which had become so full of shoals that even boats and lighters drawing more than 3 feet water could not reach the Broomielaw except in time of floods or at spring tides."

A lock was to be built in the channel four miles below Glasgow, by means of which 4½ feet depth of water was to be secured upwards to the harbour.*

This Act authorised the building of the first bridge opposite Jamaica Street; but we shall take the bridges with the harbour, &c., in an after part of this paper.

In 1770, an Act was got to deepen the whole stretch of the river from Dumbarton up to Glasgow, to a depth of 7 feet neap tides. Powers were got to levy dues upon shipping, to be applied towards improving the river, and same year £147 sterling were drawn.†

Under this Act the principal fords were cut through, and, with spring tides, vessels drawing 8 feet 6 inches of water could come up. It was then half a century from the com-

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* It is to be observed, that this would only let up vessels of 70 tons, and in time of floods, vessels of about 100 tons were the largest that could have passed, as the lock was only to be 18 feet wide.

† This was an important feature in the commencement of the undertaking, as under the first Act, the dues were to be levied after the expensive lock and dam were made, thereby requiring a heavy outlay of capital, before any return could have been got; in which case it is not likely that we would ever have seen such a maritime trade at Glasgow; for, had the improvements been delayed, the capabilities of Greenock and Port-Glasgow would have been developed, and railway communication would have settled the question. Even as it was, ten years ago, a line of railway was run down its banks, inducing a new harbour to be commenced at Greenock, and which is just finished, having 14 feet depth at low water. Of these it may be said that they are now rather late to do more than *compete* for the sea-borne traffic.

mencement of the work, and the draught of vessels was just half of those now daily arriving.

The revenues having reached £5400 sterling, additional depth of water and increased powers became desirable.

In 1809, an Act was got to deepen to 9 feet neap tides, and to borrow £30,000 sterling on the credit of the trust.*

Under this Act, the *harbour* was joined to the *river trust*, and since then both harbour and river dues are levied by the "Parliamentary trustees for improving the navigation of the river Clyde, and enlarging the harbour of Glasgow."

Works of construction were prosecuted, and, by thus assisting nature to form a channel, increased depths were achieved, till vessels drawing 11½ feet of water could ascend the river. One hundred and eleven vessels belonged to the port (amounting to 14,000 tons); the size of the ships was also increasing; the revenues reaching £8500 sterling, supplied the sinews of the warfare; and, in July 1824, the first application of the Steam Dredging-Machine to a river in Scotland, was made on the Clyde.

The success of this operation warranted the trustees in applying to Parliament for powers to increase the depth of water 4 feet.

In 1825, a fourth Act was got, being sixteen years after the former Act, the deepening to extend to 13 feet neap tides.

This Act authorised the erection of weighing-machines, cranes, and sheds on the quays.†

These powers were vigorously followed up, and in fifteen years vessels of 300 and 400 tons, drawing 12 and 13 feet water, were numerous in the harbour, though they could not pass the river in neap tides. The number of vessels had increased threefold, their tonnage fivefold; the revenues had also increased fivefold. The trade had outstripped the accommodation, and 4 feet more of water, with other enlargements, were required.

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* Previously to this, the money necessary to carry on the works had been advanced by the town, but at this time had all been repaid out of the trust revenues.

† This Act of 1825 also defined the exemptions enjoyed by Dumbarton, under the charters already named, and their mutual contract of 1700.

In 1840, was obtained the Act defining those bold lines of river and harbour improvement which we have already considered; the deepening to extend to no less than 17 feet neap-tides.*

In 1846, an Act was obtained for increased harbour accommodation.

The number of vessels belonging to the port amounted to 512, and their tonnage to 134,603 tons. The number of arrivals that year was 14,319, and their tonnage 1,117,968 tons: the customs duties on which were no less than £631,305 sterling. The trust revenues had risen to £51,198 sterling, the total amount drawn since the first (1758) being £906,554 sterling, and the total expenditure £1,253,951 sterling. †

The annexed diagram (Plate VI.), which is divided by vertical lines into periods of ten years, shews the progress of the deepening of the navigable channel, with the financial and commercial results throughout, from 1750 till 1850 inclusive, viz., along the centre between two datum lines, the depths of the channel, from 3 feet in 1752, and 7 feet in 1800, to 17½ feet in 1850. Above the datums, the trust revenues rising from £147 in 1770, and £3319 in 1800, to £64,243 in 1850. Also the customs receipts at Glasgow, from £3124 in 1811 (when a custom-house was established there) to £640,568 in 1850.

Then under the datum lines is shewn the tonnage of vessels registered at Glasgow (rapidly increasing as the depth of the river is increased), from 35 vessels, amounting to 2620 tons, in 1811, to 512 vessels, amounting to 140,741 tons, in 1850. Also the population of Glasgow, increasing from 23,546 in 1755, and 77,385 in 1801, to 358,926, in 1850.‡

Thus in the diagram is seen at a glance the proportionate rate of increase, under these different heads, in relation to the depths of the river.

Majestic operations must continue to go on upon the "River Clyde and Harbour of Glasgow" these fifty years to

* A new chart of the river down to Greenock, was also to be made. The survey was completed on an accurate *triangulation* in 1841.

† The total receipts now amount to above one million, and the expenditure to about two millions sterling.

‡ At the date of the Reformation 1560, the population of Glasgow was 4500, and at the Union 1707, it reached but 12,766.

come, for the wants of the third city in the empire are yet far from being supplied.* The entrance to the river channel, indeed, from the deep water below Greenock-bank up to Dumbarton, still requires the greatest engineering skill, that a deep channel may be preserved among the many banks.

To operate on the mouth of a river is the most difficult of all engineering, the lower parts being always in danger from any alterations farther up, and the great art and difficulty is to secure the detritus from the bed of the river being carried out to deep water, lest the currents being affected, shoals should be produced.

The old charts gave 12 feet depth at low-water, from Dumbarton downwards, before the improvements began, but by the year 1840, the depth over Port-Glasgow bank, and others above it, had decreased to 5 feet, consequently channels had to be cut through them by means of the dredging machines, in 1842 to 1845, and about 420,000 cubic yards of stuff were lifted out and deposited on shore.

These heavy operations were considered the most important that have of late been effected on the navigation. The cuts were 300 feet wide; that through Port-Glasgow bank, being 700 yards long, has been so successfully laid out as to guide the currents, and as I understand, also to maintain 10 or 11 feet low water; but I am sorry that I cannot state positively from personal observation the results of these difficult works. However, on looking at copies of the Admiralty charts, I find that, at Dumbarton in 1839, there were but 6 feet low water on the bank, while in 1846 there is again but 6 feet depth.

This brings us to the important consideration of MAINTENANCE.

That the depths we have been speaking of have been obtained, there is no doubt, but they cannot then be considered as won, for they require constant attention, and this alone costs £8000 a-year for dredging, the total annual expenditure on works, exclusive of new works, being about £14,000.

* Previous to the population return of 1851, Glasgow stood second in importance.

In reviewing what has been effected, therefore, we must keep in view the outlay and the arduous perseverance which not only secured, but *maintained* the whole.

While speaking of banks and the maintenance of the depth of the channel, I may mention the *bank* which regularly accumulates near *Bowling.* In the sand of this bank particles of coal are found and but little shell, shewing that it is formed not from the sea but chiefly of the scouring of the harbour. To keep this single bank down costs the trustees about £1200 a year, but it is expected, that when the river dikes are joined, the deposit will thereafter be mostly carried out to sea.

There have been removed from the channel of the navigation, since the commencement of these operations, about five millions cubic yards of earthy stuff, besides hundreds of tons of stones annually lifted from the bed by means of the diving-bells. Of this quantity, two millions were removed previously to 1824, chiefly by means of the scour produced between the dikes, only a trifling portion having been lifted out of the river at the fords.

There are now four steam-dredgers on the rivers. No. 5 is a powerful and efficient boat. I have laid before you copies of drawings which I prepared for its construction. I understand there is an additional machine in preparation, having a double row of buckets in the well. These machines have raised about three million cubic yards of stuff into punts, which have been discharged in-shore. (White Inch, three miles below Glasgow, being the principal low ground which has been raised by the stuff.) These large quantities are calculated from the sections, and are irrespective of the annual depositions. The silt in the harbour alone amounts annually to about 80,000 cubic yards.

The average cost of the dredging is 8d. per cubic yard for lifting, and 4d. depositing on shore, making 1s. The dikes have cost from 25s. to 30s. per lineal yard. The timber-wharfs of Bowling Basin (made in 1840), about £12 sterling per lineal yard.

It will be observed from the lines on the large map, that the dikes are not continuous along both sides of the channel.

There have been about twenty-four and a half miles built, besides jetties, as also BEACON PERCHES, floating lights, &c.

As to the theory of the erection of the dikes, their heights should be, at the mouth of the navigation, that of quarter tide; about half way up, half tide; then three-quarters tide high, soon rising to the height of flood-tide, with the face pitched, so as to protect the banks of the river where it is narrow.

The object of beginning with low dikes is to allow the tide to pass over them quickly, and at full breadth, so as to diminish as little as possible the volume of tidal water ascending to the upper reaches, and also to allow the tide and land floods to get freely away; and for this latter object it is necessary, where the dikes have in the narrow part of the river to be carried to the height of the tide, that the top banks should slope well back, and remain clear of all obstructions, so that the waters may rise on them, to the breadth of the ancient margins, and so pass down the river.

In the year 1824, when the operations were in an advanced state and the dikes had formed a good channel, the river was compared to a CANAL; and so late as 1836, the subject of making a ship canal from Bowling to Glasgow was seriously considered; but the Clyde had much more important functions to perform than merely those of a canal, and perseverance in the original system of improvement has been crowned with success.

Standing on the towing-path—the setting sun glittering in the water,—you see gliding past you the tall heavy-laden ship from America or India, tugged against wind or tide by some broad "Hercules" of a steam-boat: Then up comes another "tug-steamer" with a train of some dozen Highland boats in its wake, all sure to arrive in good time for their respective markets; and ever and anon, the long sharp "river steamer" shoots through the busy scene of commerce and prosperity, its decks covered with the gay happy faces of those who enjoy a run to some of the delightful bathing places and residences on the shores of the Firth of Clyde; and, as the expense is small, these passengers form no small proportion of the population of Strath Clyde.

To complete this glance at the noble river, we must note the English and Irish steamers with their great paddle-wheels, going perhaps with half steam, and the Highland boat ploughing its way along. Here and there you see the old luggage steam-boat lazily carrying freights between the different ports, and as night is setting in the poor *Rafters* pulling up some huge float of timber. This traffic, Sir, is something beyond what we have seen on canals, unless looked for on those *subaqueous shores*, where are found such works as those which you so elaborately described to us on a late occasion.

On the Improvements on the River Clyde during the past Hundred Years. (Part II.) By WILLIAM CAMPBELL, Esq., C.E.*

In the former part of this paper which I had the honour to read before you, I described "The Progress of Improvement on the River Clyde during the past hundred years," in so far as it referred to the Navigation of the river. I beg now to proceed with the harbour and the works more immediately connected with it, giving first a general view of the navigation works.

I have given a general account of the ancient navigation of the Clyde, as introductory to the state in which the magistrates of Glasgow found it one hundred years ago, before they applied to Parliament to improve it, so that the coasting trade which was then carried on in vessels of from 30 to 50 tons burden, might be admitted to the Broomielaw Quay at ordinary tides.

By means of dikes, a channel was formed from Dumbarton up to Glasgow, so that by the year 1806, vessels drawing $8\frac{1}{2}$ feet could reach the harbour, and by 1824 there was water for vessels drawing 11 feet. Since the latter year, by lifting stuff out of the river with the dredging machines and diving-bells, the depth of the channel has been gradually increased; whereby in fifteen years, vessels of 300 and 400 tons, draw-

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* Read before the Society, 10th March 1851.

ing 12 to 13 feet of water, became numerous in the harbour,—though they could not sail at neap-tides. The number of vessels had trebled, the tonnage quintupled, and the revenues also had increased fivefold during that period, viz., 1824 to 1839. In 1846, a ship drawing 19 feet of water arrived, and now the largest class of merchantmen and steamers are to be seen in the harbour of Glasgow.* The berths of large vessels are "spooned" out of the soft bottom in front of the quays, to about 12 feet low water, and a depth of 10 feet at low water is maintained throughout the river. The lowest ford of the river was at Dumbuck, where the largest ships can now sail. The Romans commanded the Pass from Dunglass,

> "When Rome no more could in her camps confide,
> She reared her forts between the Forth and Clyde."

The great object of these improvements having been the accommodation of Glasgow, which was the metropolis of the west, and the result being to render her the commercial metropolis of Scotland, I shall bring under your notice some facts in comparison with her present greatness.

For two hundred years after the founding of the cathedral, Glasgow was but a hamlet, and in the middle of the fourteenth century, though then a burgh, was not important enough to be one of the towns held by Edward in caution for David II. The city then measured 1118 ells east to west; that was between the port-gates, but it had no walls. It was, however, then extending towards the beach. And the wooden bridge having decayed in 1340, the stone one from Stockwell to the Gorbals was completed in 1350. The fire of 1652, having destroyed many thatched houses, caused slates to be more generally used two hundred years ago.

In 1650, Cromwell and his army passed two days in Glasgow, and thought it would make gallant head-quarters. At that time boats came up with provisions from Patricks Town where vessels of good burden lay. The flower gardens of

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* The "Taymouth Castle," 1000 tons burden, has just been launched, and will be the largest ship from Glasgow to Calcutta direct.

that period were much admired. Of these accounts, Sir Walter Scott says, they give a higher idea of Scotland's western capital than would be anticipated, as commerce had brought wealth to Glasgow, causing an attention to the decencies and conveniences of life then unknown in other parts of Scotland. Glasgow had a printer in 1638, but no newspaper till 1715.

So early as 1420, pickled salmon were exported from Glasgow to France. When the chief maritime trade was in salmon, the beautiful beach and "Landing Shore," with the creeks of the different burns into which the boats were drawn in time of floods, gave the necessary accommodation. But after the merchants, in 1662, got a harbour of their own in the Clyde at Port-Glasgow, matters became much changed. In 1669 the first sugar-house was built, and also about the same time the first Broomielaw Quay.

The union of these kingdoms in 1707 gave an opening for Scotch merchants in the English colonies, of which Glasgow, though much opposed to the measure, soon availed herself. Her merchants engaged so largely in the Virginia trade, as to excite the jealousy of the English merchants. It was carried on in vessels chartered from English ports, till, in 1718, the first Clyde-built ship owned at Glasgow crossed the Atlantic. The first arrival from India to Scotland was just one hundred years later, being January 1817, and was on account of Glasgow merchants.

The manufacture of linen fabrics was introduced about 1725, of bottles in 1730, and of inkle-wares in 1732. There are many circumstances which indicate the change which Glasgow was undergoing about the middle of last century, when the river improvements were projected; for instance, a timber-merchant started the first private four-wheeled carriage in 1752; it was made by his own men. The surgeons were separated from the barbers, with whom they were previously incorporated. The first front shops opened, viz., a shoe-shop, in 1749; same year the ship bank was opened, being the first that succeeded; two hatters' shops in 1756 and sign-boards introduced. In 1790 a mail-coach by the Carlisle road, reached the town, and the first four-horse coach from Edinburgh in 1799; but Parliament had been applied to in 1709 for a riding post to Edinburgh.

Trade with America continued the grand object, and a harbour at the city was a great desideratum, but the American war turned Glasgow capital in 1775 to manufactures. There were Arkwright's inventions in spinning; the introduction of chemical processes, as the manufacture of cudbear dye-stuffs in 1777, and Turkey-red dying from Rouen in 1785. Necessarily upon all this, cotton was largely in use, and, since the peace of 1783, Glasgow merchants had resumed their intercourse with America. The cultivation of cotton-wool in the southern states led to a large importation of that article for Glasgow consumption, at the end of last century.

In searching out information as to the trade of Glasgow in regard to the necessity for a harbour, it has occurred to me that there is an intimate connection between these fluctuations of trade and the progress of the river improvements; as it was not till the present century that the harbour was rendered capable of receiving vessels larger than boats and lighters of 30 to 40 tons, and the increase of foreign traders is still encouraging the extension of the harbour.

A good deal had been done to the river before it became necessary to increase the berthage much, but in 1806, the subject of forming a harbour was seriously considered. The old quay, with an addition of 150 yards, was 383 yards long; and 300 yards were added about 1810, making it extend about one-third of a mile below the bridge. About sixteen years afterwards it was extended in timber; and a timber quay, with cast-iron edge-plates, was erected opposite it on the south side of the river.

I need not describe the various plans which were proposed for having both wet and dry Docks close to the harbour. Some were to project beyond the line of the north quay into the waterway, which, it was then said, might cause the town again to be flooded. Also various tidal Basins, some of them to have been in what is now the southern half of the harbour and one for steam-boats in the street of the present spacious quays at which the Liverpool steamers lie. Suffice it to say, that the soft bottom always presented an insuperable difficulty, while the increasing traffic of each year shewed that the plans of the former year would have been insufficient, even if carried out, and that the lengthening of the quays, even with the increase of distance of cartage to the east end of the town, where most of the warehouses were, was the efficient mode of relief.

The width of the harbour then became the important consideration. The waterway of the bridge, when cleared of obstructions, was 396 feet; but it was not till 1834, when the idea of erecting works on the accumulated banks of the south side seems to have been abandoned, that the cheaper and more spacious plan of widening out the river was finally determined on, and the bold line of the present south quays adopted. By 1838 they extended down to Springfield, where the widening stopped, and the old width of 200 feet at high water remained. The new plan of 1840 follows out the wide line, and in 1842–4 Tod's mill was removed, and a point cut away. The harbour was anciently understood to reach down to the river Kelvin, and the widening at present going on, already exceeds half that distance.

The width of the harbour is therefore about 400 feet, and as it requires a width of 300 feet clear in which to cant large vessels with safety, the remaining space would only allow of two tiers of merchantmen on each side, as these vessels average 26 feet in breadth. The river steamers are about the same breadth, but the Liverpool steamers are from 47 to 50 feet wide over the paddle-boxes. At certain seasons several tiers of vessels have to lie at the quays, but the centre space has to be kept clear for the river steamers, which have sailed from the timber wharfs erected for them at the upper end of the harbour these ten years past. The discharge of floods is thereby facilitated, and ships are the less likely to be torn from their moorings on the breaking up of ice. The space is marked by two lines of buoys, with screw moorings, in the channel, to which the vessels of the outer tiers are fastened in addition to their hausers from the cast-iron pauls on the quays.

By these improvements both the town and the harbour will be benefited, the former being less liable to inundation, while the removal of the narrow neck of the latter will tend to reduce the deposition of mud, not to speak of the general benefit from the increased facilities for trade and commerce.

The bridge at the foot of Jamaica Street was built under the first Acts, between 1763 and 1768. A weir was afterwards placed immediately below, to preserve the founds from the scour produced by the deepening down the river. In 1781, it was proposed to "reduce the fall through bridge by cutting down the piles," &c., however, on Sunday, 8th Sept. 1808, when the flood had carried away the bridge at Hamilton, a great quantity of stones were thrown in to save this bridge.*

The Glasgow waterworks were commenced in 1807, with one small steam-engine, and now there are eleven engines drawing water from the river, about three miles up, at the level to which the weir retains it. Some factories also draw their water from the river both above and below the bridges. It is now proposed to place the weir opposite Glasgow Green, 140 yards above the Hutchesons or Saltmarket Bridge.

The Act of 1840 renewed the powers of the trustees to improve the space between the bridges. By 1843, the weir was lowered four feet, one at the old Stockwell bridge being substituted; 500 feet of timber wharf piled on the north side from Glasgow bridge to the wooden accommodation bridge, and deepening to 2 feet at low water, or 9 feet high water, commenced, but this caused the latter bridge to subside and it was removed in 1846. It is now being replaced by a chain bridge, in one span of 400 feet. The large water space between the Glasgow and Stockwell bridges is 13½ acres. In 1846, the lower harbour was about 31 acres with 2200 yards of quayage.

The springing of Glasgow bridge is 7 feet above high

* This was the second bridge to Glasgow; and it is remarkable that even London had only one river-bridge until 1749, when Westminster bridge was completed: and also that on a Sunday, in 1761, a quantity of stones had to be thrown into the Thames to save the north pier of old London Bridge from falling.

water, and the centre arch 15¼ feet. Vessels under 100 tons strike their masts and pass up, which gives great relief to the lower harbour, and when in the upper harbour small vessels are not inconvenienced by so great a fall of the tide, so that their discharge or loading is not interrupted.

The first Jamaica Street bridge was called "the bonnie brig;" it had circular openings through the haunches over each pier. It was rebuilt from designs by Telford in 1832–5, and called "Glasgow Bridge." It is the widest in the kingdom, being 60 feet, or 4 feet wider than London bridge.

The old bridge at Stockwell was built in 1345–50, after the decay of the ancient bridge in 1340, and was 12 feet wide. In 1671 an arch fell, but was immediately rebuilt. Ten feet was built to its eastern side in 1777, and, in 1821, it was farther widened by the footpaths being carried on cast-iron ribs thrown between the cut-waters of the piers. The whole has been removed the end of last year, when the piles, 500 years old, were found quite fresh. This bridge is being rebuilt, from a magnificent design by James Walker, Esq., who is consulting engineer for the Clyde works. It is founded no less than 19 feet deeper than the old bridge, with 14 feet piles under that, so as to provide against any future deepening of the navigation. It is to be called the "Victoria Bridge." There is pontage, but no charge for foot-passengers on these two bridges.

It has been proposed to have a great common sewer down the north quays discharging below Stobcross. This would be a great improvement to the harbour, and a principal sanitary measure for the city of Glasgow. It would relieve the harbour of 40,000 or 50,000 cubic yards of the filthy silt that accumulates annually in it, causing increased expense of dredging, besides polluting the waters, so that they exhale a pestilential miasm injurious to the public health. But in this respect Glasgow does not stand alone; the air of London is poisoned from its harbour, only there they take an additional benefit by drinking some of the water, whereas the water to Glasgow is drawn pure from the upper reaches and filtered. Glasgow is chiefly drained by several burns which discharge into the harbour.

Common sewers were introduced into Glasgow in the year 1790, there being then about thirty miles of street; now there are about one hundred miles, half of which has sewers, and some plan must ultimately be adopted for carrying the increased discharge further down the river. The first effects of a flood is to stop the drainage, and as the river rises the water comes up through the grates of the low streets. Now as floods get lower below the harbour, having an inclination of 18 inches to the mile, that evil might be reduced by the great conduit. The flowing tide would dam back the sewerage water, and the ebb would carry the contents down the river, leaving very little to ascend into the harbour. We have a parallel case in this city (Edinburgh), which, while its streets have been extending in magnificence, continues to throw its increasing sewerage water partly to the east through broad marshes, and to the north into the river whose waters are dammed up under rights acquired when it did not drain a "New Town." Witness the pool at Warriston Crescent. It might be well to have a great conduit independent of the Water of Leith, and it would relieve Leith harbour of much of the silt exposed there at low water. In Glasgow harbour the mud is only seen when dredged up to the punts, and it is so soft that one half of it runs back into the water ; and the dredging of the harbour has hitherto cost as much as that for maintaining the depth throughout the rest of the channel.

The original quays were only about 3 feet and 4 feet above high water, but they are now 9¼ feet above ordinary high water and 16¼ feet above low water, which suits large vessels at all states of the tide. The moderate rise of tide and gentle current has hitherto induced the enlargement of the harbour in the river in preference to docks, to which ships would not have had such ready access, and which would not have suited the prosperous trade of the steamers.

About 400 yards of the lower end of the south quays is a railway wharf, with the rails and coal-shipping cranes upon it. When the harbour works in progress are completed, the quays below Glasgow bridge will extend more than a mile along each side of the river, giving about 43 acres of water space in the lower harbour ; and, as it will soon be all occupied, then will be commenced the docks at Stobcross, for which the trustees got an Act in 1846. This wet dock will have $12\frac{1}{4}$ acres surface of water, with 1166 lineal yards of quayage, besides the tidal basin outside the lock-gates, of $4\frac{3}{4}$ acres with 584 yards of quayage. A place will surely then be found for a dry or Graving Dock. It is unfortunate that the Glasgow merchants have still to send most of their vessels down the river to be repaired, and the large ones to Liverpool, incurring the additional expense of towing, &c. I have laid before you plans of a dry-dock which I was employed to prepare for a company in 1844, which did not go on, as the trustees then contemplated going to Parliament themselves. The main feature of this design is the plan for overcoming the difficulties of the running sand in the vicinity of the harbour at a moderate expense, with an iron bottom. It was a great object to have the dock close to the harbour, as taking vessels down to where hard ground is found involves the expense of towing, but from the rapid extension of the harbour these last few years, even Stobcross can hardly now be considered beyond it. What I think is required is a dry-dock for sailing vessels, with a gate only about 35 feet wide, but having a good depth of water on the cill, so that it would not be necessary to remove the stores from large ships when the bottom had to be examined, and that small vessels might enter for the repair of any slight damage. A second dock should next be built, and it should be about 700 feet long if possible, so as readily to receive a second large steamer, should one be already in under repair.

There are still two slip-docks at Glasgow, but the proposed Stobcross docks will probably annihilate one of them. Glasgow should take serious warning from Liverpool, where the extension of the docks along the Mersey has swept away the building yards, and is only now about to retrieve the mistake when it is found that parties do not now go there to arrange about a vessel. I hear that the shipbuilding trade is greatly gone; and as companies can get the machinery where the boat is built, the engine shops are nearly all idle. Now, slips and building yards have been gradually disappearing from Glasgow harbour. New ones are started at Govan, but it will be well to keep the iron shipbuilding trade where the great engineer shops now are. There can be no doubt that building-slips and dry-docks are the necessary adjuncts of such an important harbour as that of Glasgow now is.

The increase in the trade of the port has now been described, and, as will be seen from the diagram, has chiefly taken place since the beginning of this century. The steam marine of the Clyde is intimately connected with the progress of the river works described in the former part of this paper, and with the realization of a great harbour at Glasgow.

The first steam-boat, the "Comet," in 1812, was three horse power, of 30 tons burden, 40 feet long by $10\frac{1}{2}$ feet broad, and went five and a half miles an hour against the tide; other boats rapidly followed. In 1814 there were four in Scotland; next year the first appeared on the English rivers;* same year (1815) the "Caledonia" on the Clyde could go eight and a half miles an hour: It was 102 tons, had two engines twenty-eight horse power, was 196 feet long by 15 feet broad over all, and drew $4\frac{1}{2}$ feet water.

In 1816 the "Majestic" could go ten miles an hour. It was 350 tons burden besides engine room, and had two engines 100 horse power.

The first steamer between Scotland and England sailed from Greenock, 29th July 1819. Next year (1820) England had 17, Scotland 14, and Ireland 3 steamers.

In 1826, the "United Kingdom" left the Clyde for the Leith and London station, and was then the finest sea-going steamer in the world. It was 1000 tons besides engine room, had two engines 200 horse power, was 175 feet long by $45\frac{1}{2}$ feet broad over all. It burned no more coals than the Ma-

* When the news of Fulton's success with his steam-boat on the Hudson in 1807 reached England, it was treated as falsehood and impossible. And when a Clyde boat was brought to the Thames, only a few would venture her first voyage to Margate, though before the end of the season the same packet sailed down with 350 passengers! In 1840 there were about 600 steamers in America with 150,000 tons. Some of their river steamers are as large as the Great Western, with powers from 800 to 1500 horses, but many of them are high pressure at 130 to 150 lb. per square inch. Their fires are placed on each side, so that the ashes of the timber falls into the river.

jestic, though double the power, viz., 11 lb. per horse power per hour: 8 lb. is now obtained in our best vessels.

In 1821 there were 21 steamers sailing from Clyde, some being to England and Ireland. In 1837 the. were 63 steamers sailing from Glasgow, whose united tonnage was 6644 tons; and these 63 steamers effected 9000 arrivals, making 718,400 tons at the quays in the year. In 1838 there were in the United Kingdom 760 steamers, whose united tonnage registered 78,664 tons, but, including engine room, amounted to 140,718 tons, and the horse power to 560,490.

In 1840 there were 76 steamers on the Clyde, in all 8000 tons; they effected 11,149 arrivals, making 894,378 tons. This total has fallen slightly since, being 873,159 tons in 1850.

The river steamers draw 4½ feet, the coasters and sea-going steamers 8 feet and 12 feet of water. Of the arrivals last year eighteen of the vessels drew 18 feet, and one 19 feet of water.

The largest steamers have been built on the Clyde; and since the Great Western, from Bristol in 1838, steamed successfully to New York, there has been built on the Clyde the whole "Cunard line" of steamers—from 500 to 800 horse power, and 1832 to 2266 tons each; also fourteen of the twenty-five "Oriental liners," and it is ready for a lion's share of the Australian liners which are all that is now wanting for the circumnavigation of the globe by means of steam-power.

It is now proposed to have transatlantic steamers direct from Glasgow, the first being expected to be ready by August next; and the City of Glasgow screw-steamer made several successful trial trips last year direct to New York and back. There is now direct steam-boat communication from Glasgow to London, a distance of about 1000 miles in seventy hours.

From the Clyde sprung the steam-engine, as also the steam-boat, twin-sister to our railways; and, as already shewn, it is steam power which makes Glasgow harbour as accessible as any sea-port, and developes the advantages of her inland position.

I have now laid before the Society as complete an account of the river Clyde and its improvement as my time and resources have allowed me to prepare. In doing so I have found it necessary to trace its state from the earliest periods, that we may see how very much has of late been done; and though the modern improvements began in the middle of last century we find that for many years all that was done was only preparatory to what has been required in this century; the ancient system of narrowing, under which even two arches of the old bridge were once built up, having been continued till a depth was produced which demanded widening to give room for ships from all parts of the world. No doubt hydraulic and marine engineering, and the introduction of good roads, was the feature of last century, and the wonder of this is our railways and steamers; but I trust I have been able to arrange my subject so as to shew that the navigation of the Upper Clyde and its concomitant, the rapid advancement of Glasgow, is a work of this century, and one not the least important in the march of improvement.

In conclusion, may I remark that the past half of this century has altogether been the most remarkable the world ever saw, not only for its war and its peace, but because in it man has improved his time and talents to wonderful effect. Europe and America, vieing in the encouragement and perfecting of every new improvement at all calculated to preserve peace and encourage universal prosperity, witness our means of conveyance, penetrating every barrier, disregarding frontiers, and connecting shore to shore; which already, by letting not only the courier of a government but the whole world know what was going on, has rapidly brought to a head a simultaneous convulsion of all the nations of Europe, which, under the old regime, might have smouldered to disturb the world for the rest of the century; bringing the world's heroes together, indeed, but for the exhibition of more warlike manufactures than those of 1851.

Account of Observations on the Solar Eclipse of July 28, 1851, *made at Sebastople.* By EDWARD SANG, Esq., Professor of Civil and Mechanical Engineering, Constantinople.*

While engaged in preparing to observe the eclipse of the sun from Constantinople, I received a copy of a letter, of date June 5th, addressed by the Astronomer Royal to Mr Waddington, proposing a trip across the Black Sea, and accompanied by copies of the Suggestions to Astronomers, prepared by the Committee of the British Association, which was forwarded to me by His Excellency Sir Stratford Canning. Subsequently, I have learned that this was at the instance of the Secretary of the Royal Scottish Society of Arts, and, accordingly, to that Society I make my report.

The idea of a journey into Russia had previously crossed my thoughts, and, for various reasons, had been dropped; but on learning that my observation of the phenomena of the total eclipse might be of the least service, and that no one had been deputed from England to this quarter of the world, I laid aside all my preparations here, and resolved on a journey to the region of total shadow.

Unfortunately, His Excellency's note of date July 12th only reached me on the 15th, and the very next was the sailing day of the Odessa steamer; it was utterly impossible to complete my arrangements in time; there would be no other opportunity by steam until the 26th, and thus our only chance of reaching the Crimea previously to the eclipse, was by a sailing vessel; this chance, too, with the prevailing north winds, and the high state of the barometer, was a very small one. So long, however, as a possibility of success remained, I was determined not to abandon the enterprise. With a change of wind we might still reach Kertche or Theodosia, and make the observations from the quarantine grounds. I

* Read before the Society, 24th November 1851.

therefore proceeded at once to make the necessary preparations, and obtained a readily granted leave of absence from His Highness Ahmet Fethi Pasha.

On learning the state of matters, His Excellency the Baron Titoff shewed all the anxiety to assist us which could have been hoped from the most enthusiastic astronomer. After weighing in his own mind the almost impossibility of our reaching in time by help of a merchant vessel, M. Titoff made me the unexpected and most welcome offer of a passage on board the brig of war Perseus, which was about to return to Sebastople, and whose departure he proposed to accelerate. Since, even with this aid, our only hope lay in a change of weather, it is needless to say how gratefully I accepted so liberal an offer.

His Excellency M. Titoff having furnished me with letters which every where procured for me the most courteous assistance, we left the Bay of Buyukderé, under the command of Prince Chickmakoff, early on the morning of the 21st. Notwithstanding the most strenuous exertions, and the help of the steamer Molnia, it was not until noon of the next day that we succeeded in stemming the current and fairly launching into the Black Sea.

The anxiety attending such hasty preparations being now over, we had leisure to concoct our plans and to discuss the nature of the instruments which we had collected. The tedium of our voyage may be well relieved by an account of both.

The ingress of Mercury on the 8th November 1848 was beautifully seen here. I had the good fortune to study it with an excellent $4\frac{1}{2}$ inch aperture refractor, by Plössel, belonging to Ohanes Dadian, Esq. Having had every reason to be satisfied with the performance of this instrument, and being desirous of leaving my own telescope for the use of my family, I applied to Mr Dadian, who at once most kindly conceded to me the use of the Plösselsche. We constructed a light octahedral frame of slender fir rods to fit upon the eye-piece of the instrument, and to carry a card on which a graduated circle was traced. The intention was to receive the sun's image on this card, under a tent, and to watch there the progress of the phenomenon, so as to avoid fatiguing the eyes; the graduated circle would enable us to refer any appearance to the proper place on the sun's disc. With the lowest power, the sun's image on this screen is about 7½ inches in diameter; the spots with their surrounding umbrae, the variegation of the sun's surface, and its gradual diminution in apparent brilliancy towards the edge are beautifully distinct. In this way we had examined the ingress of Mercury; the progress of the planet was distinctly followed without any appearance of that distortion which is mentioned in the Committee's suggestions. Hence I expected that this instrument would afford conclusive evidence concerning the nature of the beads.

The owner of this refractor procured from the same maker a splendid equatorial of 14½ inches aperture, completely mounted, for the Ottoman Government; this magnificent instrument has not yet been set up.

For the purpose of determining our geographical position, we had an 8 inch portable astronomical circle, by Adie of Edinburgh, the performance of which has long given me the greatest satisfaction. It is read to 10″ with three verniers, both in altitude and in azimuth, and is fitted with all the adjustments which an instrument of that size can require. This was accompanied by a chronometer, whose rate had, for several years, been found sufficiently steady, with a slight over-compensation, that is, a tendency to go faster in summer. Its winter rate had been 0s. 9 losing, and its summer rate was 0s. 24 losing. For comparison we had also a pocket-watch, whose rate was as close as that of the chronometer. A mountain-barometer for correcting the refraction, a pair of Nicol's eye-pieces, darkening glasses, boxes of tincture of litmus of various thicknesses, stearine candles for comparing shadows, and other odds and ends completed the apparatus.

Encountering only light winds and calms, we saw our prospects of reaching Kertche gradually wane; computations for Theodosia were made, and instructions were drawn up for a nearly tangential phase. Latterly we had been hoping against conviction, when, on sighting the south point of the Crimea, our hopes were revived by a fresh breeze.

With the sunset of the 27th, however, the wind again fell, and the morning of the 28th dawned upon us with the impossibility of reaching even Theodosia. There was still a small probability of making Sebastople, the only other place at which we could set foot on shore: so after a short consultation the vessel was put about.

Computations were now made for our new haven of hope, and corresponding instructions were drawn up. The rate of the log and our distance from the lighthouse of Kherson were anxiously compared; the light breeze gradually stiffened; the chronometer was coming up to the computed time of commencement, and our race against the moon promised to be a very close affair. We rounded the point of Kherson, and just as the quarantine bay was opened up, the index pointed to the time of look-out. Meantime, in anticipation of our anxiety, our commander had caused the boat to be lowered and the instruments to be handed down; and almost simultaneously with the first appearance of the moon's edge came the intimation "boat ready."

A very smart pull brought us to the quarantine while the vessel continued on her way. To choose our stations, open the boxes, set up the instruments, and compose ourselves for observation, occupied some time and gave occasion for anxiety; but within forty minutes from the beginning of the eclipse we were all settled to our duties.

The party consisted of the first lieutenant, Mr Gregory Jelesnoff, who had engaged to measure the distance between the cusps, accompanied by Lieutenant Andreowsky, with a chronometer; of Mr Zazebin the first sailing master, who had undertaken to measure the breadth of the illuminated part, accompanied by Mr Daïn, the second master, with another chronometer; and of myself and son who were occupied with observations on the appearance of the beads.

As our computation had given 38″ for the least breadth of the illuminated part, there was no other physical phenomenon likely to come under our notice; so, excepting a glance at the aspect of the surrounding scenery, and an attentive examination of the cusps in search of any appearance of the moon's limb beyond the sun's disc, of which there was no trace, we gave our whole attention to the appearance of the beads.

My previous opinion on this subject was very decided. I had carefully studied the annular eclipse at Edinburgh, with an excellent reflector carrying a power of about 100; had seen the well-defined angular projections of the moon cut the sun's edge, and followed their disappearance to the last without perceiving the slightest distortion of the solar limb, or of any of the spots which were successively eclipsed. At another time, with the same instrument, I observed an occultation of Saturn. The end of the ring, which then shewed almost as a line, was seen gradually to shorten, and, when the moon's edge came up to the disc of the planet, the sharp angular contour of a mountain was plainly seen and observed by several of our party, while the planet retained its form unchanged. For these reasons, while preparing the notice of the eclipse of 1847, which was almost central here, I drew the attention of our observers to the ruggedness of the lunar contour as sure to produce the appearance of a string of brilliants, about the time of each of the internal contacts. In all matters of difficult observation, one's pre-formed ideas go for a great deal; for this reason I have stated mine.

On examining the edge of the sun's image made on the screen, there was found a very extensive trembling, subject to sudden fluctuations, as thin hazes and fleecy clouds passed before us: the depth of the undulations varied from 5″ to 8″ or 10″. This undulation prevented any accurate measurement of the altitude of the lunar ridges, although it left their existence sufficiently apparent; the cusps also were rendered indistinct. Had we not been acquainted with the excellent performance of the instrument, we might have complained of great spherical aberration, as the large and palpable undulations were accompanied by a minute undertremor which gave to the outline a permanent indistinctness analogous to that arising from a bad adjustment of the focus.

Towards $3^h\ 15^m$ Greenwich time, the cusps shot out and retracted considerably with a leech-like motion, and at $3^h\ 33^m$ separate roundish beads began to appear; these became more frequent as the angle of intersection grew less.

On attending closely to that part of the moon's edge, which was about to pass off the sun's disc, whenever we found an indentation and followed it up to the cusp, the hollow was seen to separate from the rest of the illuminated surface, and to assume a roundish form, which fluctuated with the undulations. Carefully observed, it seemed that the indistinct roundness of the form was due to the retention, by the retina, of the rapidly succeeding impressions.

At the incoming cusp again, whenever a bead made its appearance and was followed until it united with the rest of the illuminated surface, that portion of the moon's limb which had come on with it was found to be deeply indented. The last of this class of phenomena which we noticed was so distinct, as of itself to be decisive. A large and well separated bead was seen coming on, and its distance from some irregularities on the moon's edge was estimated. After the bead had amalgamated, that part of the moon's edge which had the same distance from these irregularities was found to be marked by two prominences whose height above the general surface might be 3″ or 4″, and whose summits were at the distance of 8″, with a deep hollow of about 6″ between them.

On the whole, the impression on my mind was confirmatory of my previous opinion, that these detached portions of light result simply from the ruggedness of the moon's edge. I had not previously had an opportunity of witnessing the appearance under such favourable circumstances. What I have now seen has convinced me that the distortions arising from the unequally heated state of the atmosphere, or from the imperfections of the telescope, have been taken for something else.

The decision of this question is not without important results in practical astronomy, for the instant of occultation of a star must be subject to an uncertainty depending on the configuration of that part of the moon's limb on which it falls; and this uncertainty must pervade all determinations of the longitude by this means. During the eclipse there was seen a range of elevation measuring in length about 150″, and of which the altitude was some 6″ above the general outline. Now the moon's mean motion is roughly one second of arc in two seconds of time, and the occultation of a star by this ridge would therefore have preceded by no less than 12″, the computed occultation; and even by a longer time if the appulse were oblique. A very small change of latitude also will bring the observer opposite to a different part of one of these irregularities.

This unevenness of outline also opens up a discussion as to what is to be considered as the moon's diameter. With a power of only 50 the bright edge is seen as an irregular line not merely indented and studded with prominences, but irregular in the large way, that is, deviating greatly from the circular form. Photographic portraits of the moon in various states of her libration would be of immense value in enabling astronomers to compute exactly an occultation. On our globe the ocean spreads over the greater part of the surface, and, by its unity, determines the general form; but on the moon there is nothing analogous. Even those spots which appear with a low power as extensive plains, are found, when more narrowly examined, to be undulated and even studded with small volcanic mountains. What then is to be regarded as the moon's diameter, and from what starting point are we to reckon the heights of the lunar hills?

To return to our eclipse; the rapid formation of heavy clouds warned us of the propriety of determining our local time, for which purpose the altitude of the sun's lower limb was taken with Adie's circle, face east and face west, and then the end of the eclipse was waited for; a few seconds before it happened the sun's disc was completely concealed by a cloud, and thus we had neither the beginning nor the end from which to compute our longitude.

On the evening of the 29th we determined the latitude from the observed altitudes of α Polaris and of Vega to be north 44° 36′ 17″. The chronometer was also compared at the same time with the local sidereal time, and thence, by help of observations made here before our departure and after our return, the longitude was found to be 18^{m} 04^{s} east of my present residence.

As I had hitherto made no very careful observations to determine my longitude here, not anticipating any protracted stay, I resolved to postpone sending my report until an opportunity should have occurred of verifying it. For this purpose the occultation of 74 Aquarii was observed on the

9th September, and at the same time the right ascension of the meridian was taken by help of the altitudes of α Polaris, Arcturus, and Vega. This plan I was forced to by the want of a distant night-signal for my meridian. On making the computations *strictly* without any approximate operations there came out lat. 41° 03′ 06″, long. $1^h\ 55^m\ 51^s$, which thus gives for the longitude of the quarantine station at Sebastople $2^h\ 13^m\ 55^s$.

As we had not been fortunate enough to observe either of the contacts so as thence to deduce directly the longitude of Sebastople, we were thrown upon our other resources, viz., the angular distances of the cusps, and the breadth of the illuminated part. Seeing, however, that with the sextant we can hardly come within 15″, especially when we use darkening glasses, and that this would give an uncertainty of 30^s in longitude; and seeing also that towards the end of the eclipse the cusps approach each other very rapidly, it followed that our most favourable observation was the last made by Mr Jelesnoff. From it, and from the observations on the altitude of the sun's lower limb, the longitude was found to be $2^h\ 14^m\ 08^s$, only 13^s more than that found by the chronometer.

All of these results indicate a greater longitude for Constantinople than that usually given in the books, for which reason I have deferred the transmission of this report, awaiting the opportunity of another occultation. Having prepared the preliminary calculations for that of B.A.C. 6607, I have just been disappointed by the otherwise welcome appearance of rain-clouds. The next occultation visible here is that of ξ Ceti on the 11th, for which, considering the chance of broken weather, it is scarcely worth while to wait.

In conclusion, I have to regret that an unaccountable delay in the transmission of the "Suggestions" should have prevented me from making arrangements in time for the packet, and that, notwithstanding the energetic assistance which was accorded me by His Excellency Baron Titoff, and by the officers of the Perseus, we were unable to attain the principal object of our mission. There is, however, this consolation, that, as the Russian astronomers had made complete arrangements, no loss to science has accrued from our misadventure.

CONSTANTINOPLE, October 2, 1851.

Trans. Roy. Scott. Soc. of Arts

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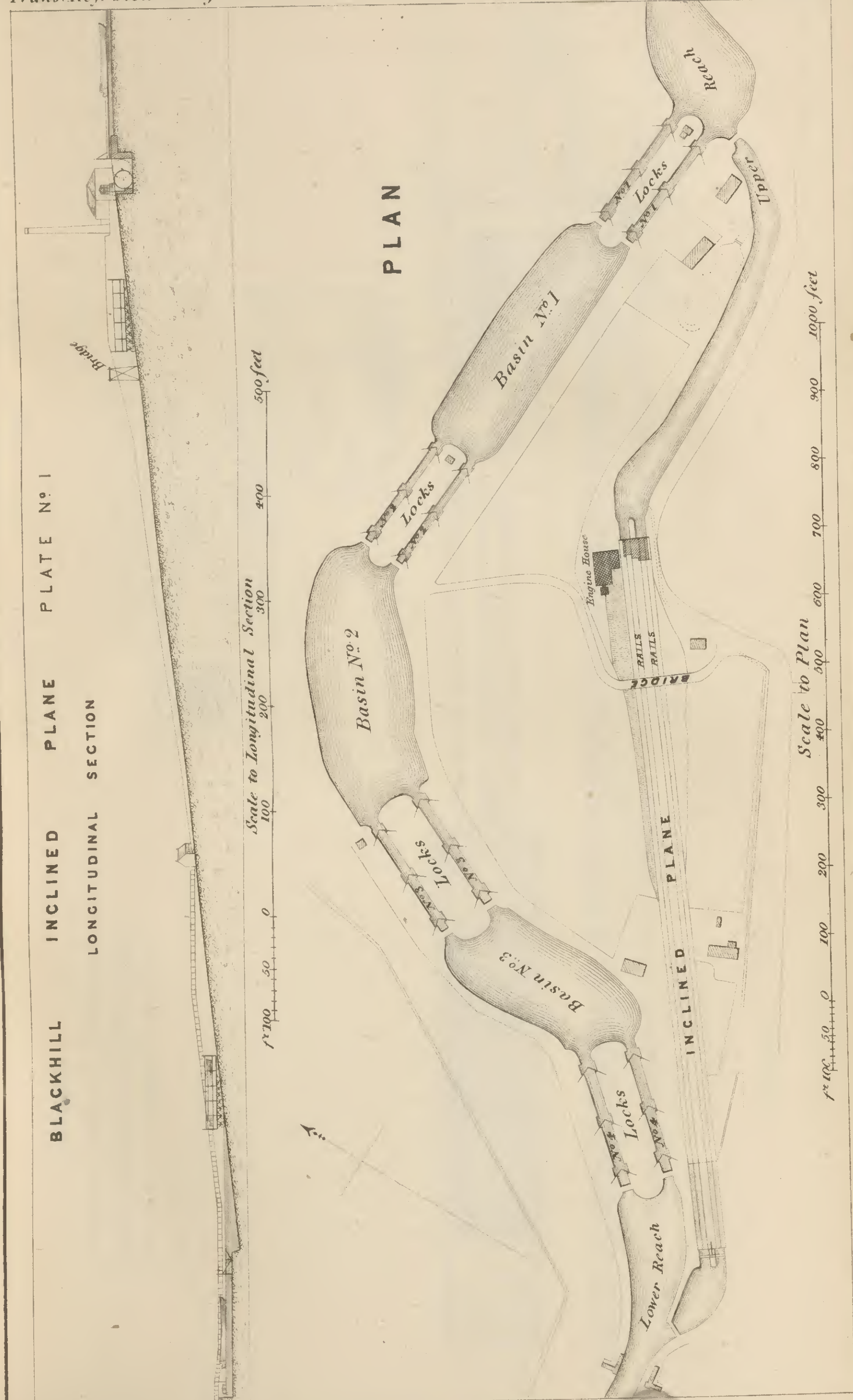

S. Leith. Edin

Trans. Roy. Scot. Soc. of Arts

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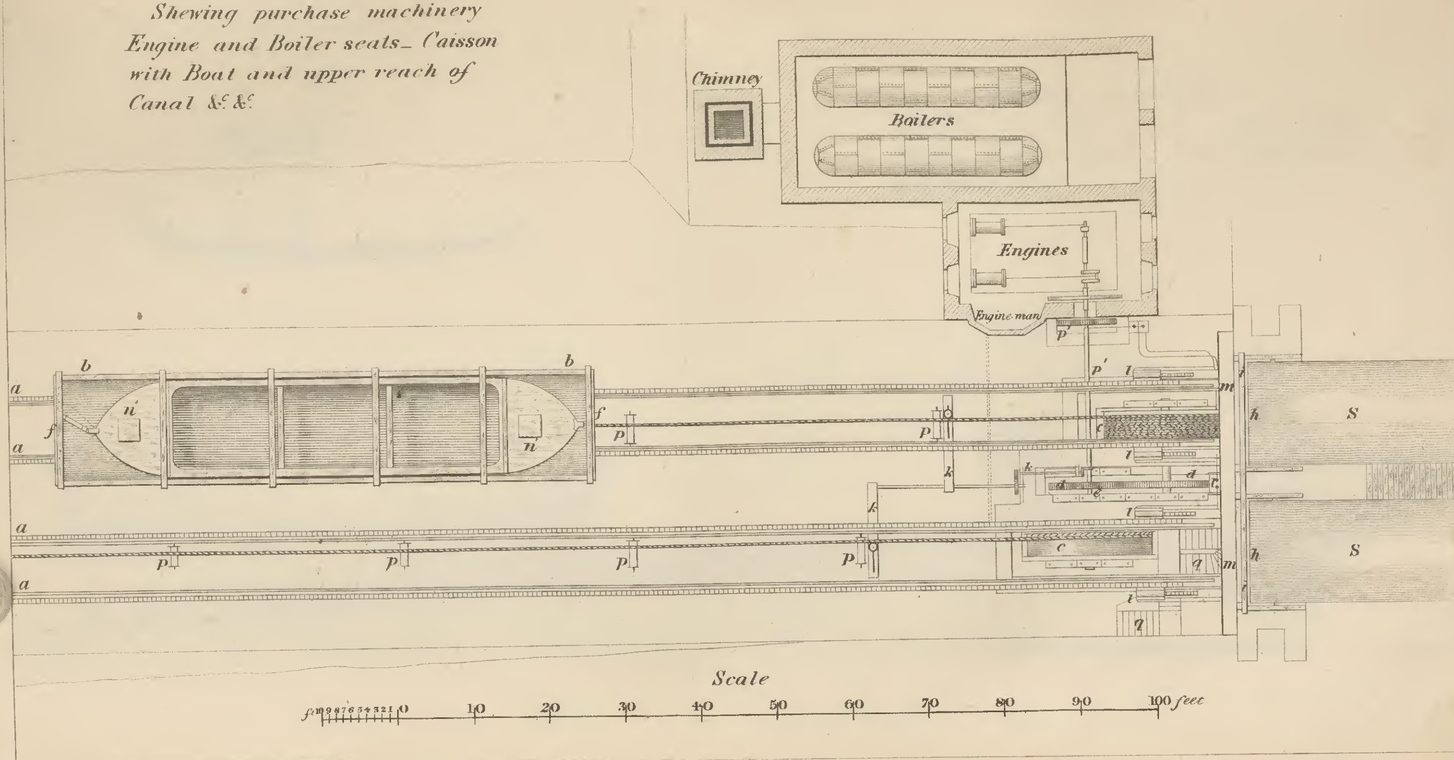
PLATE Nº 2

BLACKHILL INCLINED PLANE

PLAN

Shewing purchase machinery Engine and Boiler seats_ Caisson with Boat and upper reach of Canal &c. &c.



S. Leith, Edin.

BLACKHILL INCLINED PLANE PLATE No. 3

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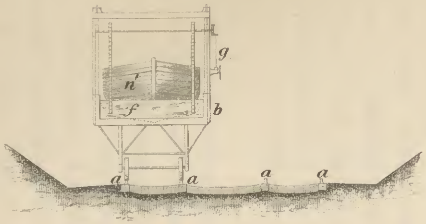
BLACKHILL INCLINED PLANE

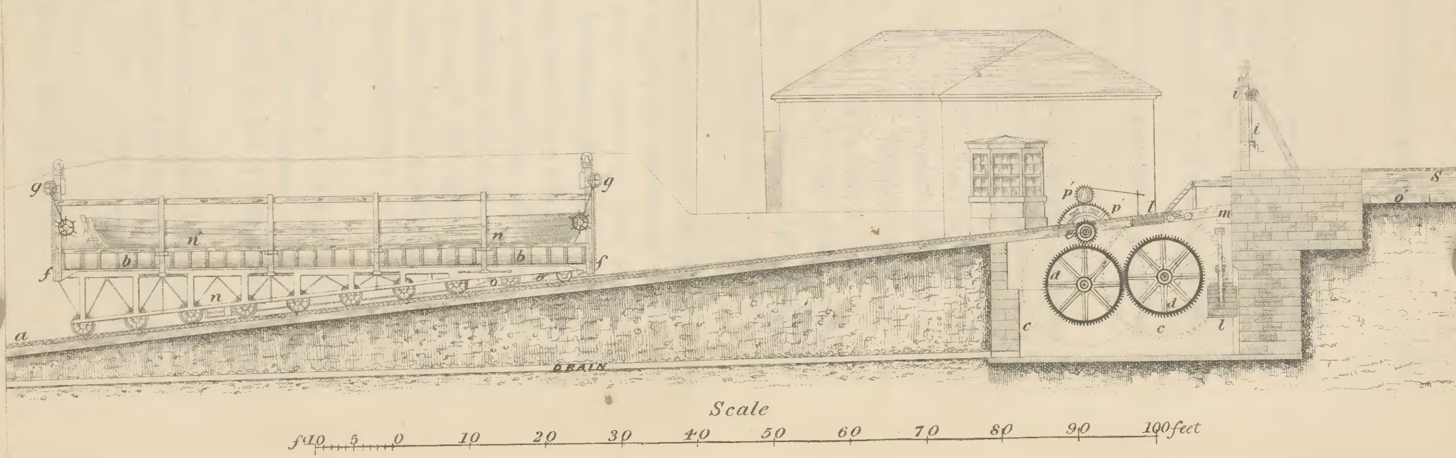
PLATE No. 3

END ELEVATION OF CARRIAGE & CAISSON



SIDE ELEVATION

Shewing carriage and caisson with boat — Engine house and purchase machinery &c. &c.



S. Leith, Edinr.

Description of an Inclined Plane, for conveying Boats from one level to another, on the Monkland Canal, at Blackhill, near Glasgow, constructed in 1850; *from Designs* by JAMES LESLIE, Civil Engineer, Edinburgh.* With Three Plates.

THE SILVER MEDAL AND PLATE, VALUE FIFTEEN SOVEREIGNS, AWARDED 1851.

The application of the inclined plane to the purpose of conveying vessels from one line of a canal to another, is by no means new. It was, I believe, first made use of practically by Mr William Reynolds, on the Ketley Canal in Shropshire, about the year 1789; it was afterwards adopted on the Shropshire Canal, and on the Duke of Bridgewater's Canal, on which last, however, it has since been laid aside. On the Shropshire canal incline, the weight of the boat, carriage, and load, is about 11 tons. More recently, it has been successfully employed, and on a larger scale, on the Morris Canal, United States.

A description of the Morris Canal inclines, of which there are a great number, is given in Mr D. Stevenson's book on the Engineering Works of North America, and in the 5th volume of the Engineer and Architect's Journal; but various modifications and improvements have been effected since these descriptions were given,—on at least one of these planes, particularly in running the carriage and vessel over a summit, and then down into the water of the upper reach, or in hauling them up out of the water of the upper reach over the summit, so as to be able to dispense with a lock at the top of the incline.

On the Great Western Canal, boats are raised and lowered by means of a perpendicular lift; as described by the late Mr Green, civil engineer, in 1838, in the Transactions of the Institution of Civil Engineers.

The inclined plane was first recommended for adoption on the Monkland Canal, for the purpose of taking up empty boats, in a report, dated January 1839, by the late Mr Andrew

* Read before the Society, 28th April 1851.

Thomson, civil engineer, of Glasgow, who was then engaged in superintending the construction of new locks at Blackhill.

The Monkland Canal has a depth of 5 feet, and is adapted for the passage of boats 70 feet in extreme length, including the rudder, 13½ feet in width, drawing, when light, from 18 to 21 inches, when loaded 4½ feet, and carrying a load of 60 tons. It is about 12 miles in length, and connects the rich mineral district of Monklands, abounding in valuable seams of coal and ironstone, with the Forth and Clyde Canal at Glasgow.

As originally constructed in 1772, it extended from the Townhead Basin at St Rollox, near Glasgow, a mile and a half to the foot of a steep ascent at Blackhill, where the first reach terminated ; and from the top of that ascent it extended eastward to Sheepford, a distance of eight miles, where it was stopped by another ascent.

An inclined plane for railway waggons at Blackhill, connected the two reaches of the canal. The coals were unloaded from the boats in the upper reach into the waggons, run down the inclined plane, and again loaded into boats in the lower reach, which was a tedious operation, and was hurtful to the coals.

At one time, the canal was in such an unprosperous state, that it was seriously contemplated to fill it up ; and it is understood that the chief, if not the only reason why that intention was not carried out, was the want of pecuniary means. As matters have turned out, it is very fortunate that the company could not spare funds to fill up the canal ; for the original £100 shares, which were at one time down to £5 or £7, afterwards rose to be worth about £3200. This remarkable rise in the value of the canal stock, may afford some encouragement to the shareholders in some of the many unremunerative undertakings of the present time.

This prosperity was brought about mainly by the gradual development of the mineral riches of the district, aided materially, however, by the farther extension of the canal, and by other new works and improvements.

About the year 1788, a set of locks was constructed at Blackhill, enabling boats to pass from the one reach to the other. Two locks were constructed at Sheepford, and the canal was extended thence eastward two miles, to Woodhall, near Airdrie; and in 1790, the Forth and Clyde Canal Company formed the connection called the Cut of Junction, about one mile long, between the Monkland Basin at St Rollox, and the Forth and Clyde Canal Basin at Port-Dundas, so that cargoes can now be conveyed from the further extremity of the Monkland Canal to Glasgow, or to the Forth and Clyde Ship Canal, without breaking bulk.

The set of locks at Blackhill, consists of four double locks 75 by 14 feet, having each two lifts of 12 feet, the whole height from reach to reach being generally 96 feet, but varying a few inches, according to the supply of water, and to the state of the winds.

In the year 1837 the two uppermost locks were so very much out of repair, that it became necessary either to rebuild them or to construct two new ones. On being consulted then by the Monkland Canal Company as to what was best to be done, I recommended, in order to save stopping the trade during the time that the work was in progress, to build two new locks by the side of the old ones; and I advised, in order to save water, that, if sufficient space could be found for three chambers, each lock should be divided into three lifts of 8 feet each, instead of into two of 12 feet, assuming that the two lowermost locks should be rebuilt on that plan at some future time, or that two new ones should be constructed, and keeping in view that, ultimately, it might be necessary to have two sets of locks, which might allow the ascending trade to pass by the one, and the descending by the other.

From the want of room, and from the additional expense that would have been incurred, the last recommendation was not adopted, but it was resolved to proceed immediately with the construction of two new double locks by the side of the old ones, which was done from plans furnished by me in 1838.

By the time that the two new locks were finished, it had become evident, from the great increase in the trade, that either an entire second set of locks must be constructed, or some other means must be devised for passing a greater number of boats, than could be accommodated by one set of locks.

The trade in the canal, to the extent of about seven-eighths of the whole, is downward towards Glasgow, consisting almost entirely of coals and iron; the other eighth passing upward consists chiefly of ironstone, limestone, and manure; consequently nearly all the boats descend the locks loaded, and three-fourths of them return empty.

The plan proposed by Mr Thomson for taking up the empty boats by means of an inclined plane seemed suitable for such a trade, and it was remitted to me by the Committee of Management to report on it.

In that plan there was only one line of rails proposed for the boats, which were to be taken up afloat in a caisson placed on a carriage. The other line was to be occupied entirely by water-vessels, which were to form the counter-balance and the moving power, water being filled into them from the upper reach of the canal, and emptied out into the lower reach.

A chain, having the one end attached to the carriage and caisson, and the other to the water-vessels, was to pass over the upper rim of a large horizontal drum or pulley, at the top of the inclined plane, placed between the two lines of rails.

According to this plan one pulley was quite sufficient, as no bite or friction was necessary, the load being at one end of the chain, and the moving power being attached to the other. Mr Thomson, however, suggested, in a postscript to his report, that it might be expedient to employ a steam-engine instead of the water-vessels as a moving power.

In a report, dated October 1839, I recommended that the plan of the inclined plane should be adopted with modifications; the first of which was, that there should be two lines of rails for the boats instead of one, so that the descending carriage should act as a counterbalance, but nothing more, to the ascending one, and that the motive power should be a steam-engine acting on two vertical drums, each having a chain of its own, instead of there being only one chain passing over the upper rim of a horizontal pulley.

I proposed two plans: first, one by which the vessels were to be brought up dry on a cradle, and launched over the summit of the incline into the upper reach of the canal, thereby not only losing no water at all in the upper reach, but actually gaining a quantity for every boat that was brought up, equivalent to the displacement by the boat when immersed; and, second, one having the boats taken up afloat in a water-tight caisson like that suggested by Mr Thomson, having a gate or sluice at each end, and set level on a moving carriage.

One caisson was to be run down full of water into the lower reach, its lower gate opened, the boat floated into it, the gate again shut, and the caisson and boat hauled up to the top of the incline, while the other caisson was descending on the opposite line of rails. When the caisson reached the top it was to be pressed hard, by means of a couple of screws, against the frame of the gate of the upper reach, so as to make a water-tight joint, by which means the caisson might be made to serve the purpose of a shallow lock, and no water would be wasted except the very small quantity contained between the gates of the canal and the upper gate of the caisson, which does not amount to 50 cubic feet. This plan admits of empty boats being sent down as well as taken up; but the cases of empty boats passing down, although they do occur occasionally, are but rare.

The owners of boats objected to their being grounded on and launched from the cradle, from fear of injuring them; and so that plan was laid aside, but the other was considered feasible.

In 1840, Sir John Macneill was called on to report on the inclined plane. He also recommended its adoption, and proposed taking up the vessel lying dry on a carriage or cradle provided with small wheels running on level rails fixed on the principal carriage. The carriage was to be first run down into the lower reach, and the vessel floated on to it. When the carriage was hauled up to the top of the incline, the smaller carriage or cradle was to be moved forward off the main carriage into a shallow lock of masonry with rails in the bottom, the outer gates shut on it, and the water admitted from the canal, by which means the boat would be floated off the cradle and into the canal, after which the water in the lock was to be run down, and the upper carriage moved back to its place on the principal carriage.

Sir John proposed that there should, in the first place, be only one boat-carriage and one lock, leaving the second ones until the increase in the trade required them. On another line of rails there was to be a counterbalance equal to one-half of the weight of the boat and carriage. The motive power was recommended to be a high-pressure steam-engine, though one of the drawings which accompany the report shews a water-wheel. The engine, when not taking up boats, was to be employed in pumping back into the upper reach the water that had been run down out of the shallow lock, and which otherwise would have been wasted.

However, it was ultimately resolved, instead of carrying out any of the plans of the inclined planes, to rebuild the two old upper locks, and to build two new lower ones, so as to give an entire double set, which was done in 1841.

The intermediate basins were enlarged; a graving-dock, entering from the lower reach, was removed, to make room for the new locks; a new graving-dock was built in the upper reach, and other improvements were effected.

After this the trade was amply accommodated until the summer 1849, when the supply of water ran short, notwithstanding that storage is provided exceeding 300 millions of cubic feet, and the canal was shut in consequence for six weeks. It then became evident that some effectual means must be adopted for preventing any such interruption in future.

The Monkland Canal had by this time become the property of the Forth and Clyde Canal Company, and in September 1849 I was called on to report, along with Mr Bateman, that company's consulting engineer, as to the best means to be devised for securing the uninterrupted use of the canal, by providing an additional supply of water for lockage or otherwise.

We considered the plan of providing an additional supply of water, by enlarging the store-reservoirs, or forming new ones, and by pumping water from the lower to the upper reach; and, finally, we turned our attention to the old scheme of the inclined plane, the designs for which had lain aside for ten or eleven years.

After due consideration, we found that there was great difficulty in increasing the supply of water by additional storage, seeing that the existing reservoirs were already sufficiently capacious for the extent of gathering-ground, as sometimes they were not filled once in a year; and also, that there would be very great expense and loss of power, in pumping up water from the lower to the upper reach, as there would be required, with the best of management, at least 12,600 cubic feet, or 350 tons, to be pumped up 96 feet for every boat passing the locks.

After having considered and weighed all the difficulties and objections on both sides, we finally agreed in recommending the application of the inclined plane, having the boats taken up water-borne in a caisson, as being the most expeditious, the most economical, and, under all circumstances, the most eligible mode of passing the empty boats.

The committee of management adopted this recommendation, and resolved to proceed immediately with the construction of the inclined plane. About the end of October 1849, they instructed me to prepare the working-plans and specifications, authorising me, at the same time, to communicate with Mr Bateman, which I did occasionally, and had the benefit of his advice and suggestions.

The earth-work was contracted for by the middle of November, and the buildings and machinery were contracted for in the middle of January 1850. The whole work was to have been completed by the middle of May 1850, but owing to various delays it was not ready for action until the end of July.

The general arrangement is much the same as that proposed in 1839; but the caissons and carriages, instead of being formed of timber, as then proposed, are made of malleable iron; wire ropes have been substituted for the chains formerly intended, and various other improvements and modifications have been adopted.

In arranging the details and working-drawings, and also in superintending the execution of the work, I have had the benefit of the valuable assistance and co-operation of my friend Mr Stirling, civil engineer, and I beg to acknowledge my great obligation to him.

I shall now proceed to describe the plan, as it has been actually carried into execution, and which is illustrated by the drawings and model now exhibited.

The two caissons are constructed of boiler-plates $\frac{3}{8}$ths and $\frac{5}{16}$ths inch thick, rivetted together. They are each strengthened by thirty ribs of T iron, and are set on a malleable iron carriage strongly framed and braced, and raised up at the lower end, so as to keep the caisson level.

The caissons are 70 feet long, or just the extreme length of the boats, including the rudder; 13 feet 4 inches wide, and 2 feet 9 inches deep, exclusive of wash-boards, to keep the water from splashing over.

The water, is only meant, however, to be 2 feet deep, that being sufficient to float the deepest empty boat. The cross section of the caisson is, as nearly as may be, taken from the mould of the boats, with a hollow space for the keel, so as to contain as little superfluous water as possible. Each caisson has ten pairs of wrought iron flanged wheels, similar to those of an ordinary railway-carriage, whereof eight pair are 3 feet diameter, one pair 2 feet 3 inches diameter; and, in order to keep the caisson as low as possible above the rails, the uppermost pair is only 18 inches diameter.

There are upright timber fenders at the sides of the caissons, for guiding the boats, and for fixing the sluice gearing, framed and bound across the top, so as to give greater strength. The sluices are counterbalanced, and are worked each by two racks and pinions. The weight of the carriage, caisson, and water, or water and boat, varies from 70 to 80 tons.

The gauge of the railway is 7 feet, and the distance between the centres of the two lines of rails is 18 feet 3 inches. The gradient is 1 in 10; and the height from surface to surface of water being, as before stated, 96 feet, and the length of the carriage 70 feet, the whole length of the incline requires to be 1030 feet; but an additional length of 10 feet has been allowed as a provision for the case of the water being very low in the lower reach, and consequently the whole length of the incline is 1040 feet.

The rails are 65 lb. to the yard, with flat soles, and are screwed down to longitudinal sleepers. These are of half logs where the ground is solid, laid on continuous stone blocks with cross ties 15 feet apart; but are of whole timbers, with cross bearers, resting on piles 12 feet apart, where the ground is made up and soft. There is a cast iron ratchet-plate along the outside of each rail, also screwed down to the longitudinal sleeper; and as a means of safety, in the event of any accident befalling the ropes or machinery, there are palls attached to the carriages, working constantly into the teeth of the ratchets while the caisson is ascending, and ready to drop into them when descending, the instant the tension is taken off the rope.

The motion is given by two coupled high pressure steam-engines, of 25-horse power each, with horizontal cylinders. This is a much greater power than is needed during the greater part of the transit; but it is nearly all required at the time when the descending caisson is entering the water, and, so losing its gravity, ceases to act as a counterpoise; in consequence of which the engines have for a short distance to pull up nearly the whole weight of the ascending caisson, water, and boat.

There is a double-friction drag on the fly-wheel, acted on by the piston-rod of a small steam-cylinder, by means of which the machinery may be speedily stopped and held on.

A pinion on the crank-shaft outside of the engine-house, 2 feet 4½ inches in diameter, drives a spur-wheel on the lying shaft, of 7 feet 9 inches diameter, having a friction-wheel in its interior, which, for the sake of safety and of preventing shocks, is made to slip when any unusual resistance is met with. The introduction of this friction-wheel, which is similar to that commonly used in dredging machines, was suggested by Messrs Yule and Wilkie, the contractors for the machinery, and is a decided improvement.

A pinion, 2 feet 10½ inches, on the lying shaft, drives a spur-wheel of 10 feet 7 inches on the drum-shaft which is farthest down the incline, being on the left hand line of rails in looking down, or the further side from the engine-house. This spur-wheel drives another similar wheel on the drum-shaft which is uppermost, and on the right hand line of rails looking down, or the side nearest the engine-house. These shafts are all of malleable iron.

It is necessary to have the two drums on separate shafts, so as to move in opposite directions, in order that the one may coil and the other uncoil the rope at the same time, both by the upper side; otherwise another drum or pulley would have been required to bring up the rope from the lower side of one of the drums. The drums or rope-rolls are 16 feet in diameter, 4 feet broad, and make one turn nearly for every twelve strokes of the engines, so that while the engines are going at their usual speed of forty strokes (though they often go considerably faster), the caissons are travelling at the rate of about two miles an hour, and the time occupied in ascending or descending is between five and six minutes.

The rope-rolls are formed of wrought iron arms, rings, and bracing, with a cleading of boiler-plate half-an-inch thick. The ropes, which were manufactured at the Patent Wire-Rope Works, Gateshead, are 2 inches in diameter. They are guided on to the drums by a screw and moving pulley apparatus, and are attached to the carriages by strong draught-springs placed in the frame under the caisson. The springs serve the purpose of saving jerks, and also are made the means of letting down the palls in the descending carriage, in the event of any accident befalling the rope or machinery, and thereby taking the tension off the spring.

As originally constructed, when the caisson got to the top of the incline, two palls fell into clams formed on a lying shaft extending across the top of both rails, and acted on by means of a lever and screw worked by hand, which turned round the shaft, and so pressed the caisson hard to the gates. This acted well enough, except that it gave too short a range for stopping the carriage in, viz., only about 4 inches, and consequently the caissons were sometimes brought with too much impetus against the gates, which tended to shake the building, and to strain unnecessarily the ropes, springs, and machinery.

Mr Crichton, the manager of the Canal Company, devised an India-rubber buffer-joint, which is useful both for more perfect tightness and for lessening the jerk; but as a still more effectual precaution, a hydraulic apparatus has now been provided in addition, which, while the engines are working, slowly raises a heavy weight, and when the caisson is at the top of the incline, this weight is made, by turning a cock, to act by means of rams or pistons on two sliding ratchets, into which the palls drop as before, but which have a range of 3 feet; and as the engines can be stopped with ease quite within that range, the risk of striking the building is now altogether avoided. This apparatus, which was made by Messrs A. More and Son, of Glasgow, is placed in the spur-wheel pit, between the two lines of rails, and is directed by a man stationed in the pier between the two gates, where he also opens and shuts the gates. The original screw apparatus is still, however, retained, and can be used in the event of anything being wrong with the hydraulic apparatus.

A self-acting trigger has also been applied, by means of which the steam is first partially and then wholly shut off, when the carriage gets to the proper place.

After the canal gate has been shut, the caisson is slackened off from the framing, and the joint opened, so as to allow the water contained between the two gates, amounting, as before stated, to about 50 cubic feet, to escape by means of a transverse wrought iron trough and a line of pipes into the uppermost basin of the canal locks. Any water in the caisson which is above the ordinary or proper level, in consequence of the upper reach being over full, is also run off in this way, so as not to overload the carriage; or if required the caisson may be entirely emptied.

It will probably be found advisable, except in special cases, to bring up the boats not quite afloat, but slightly bearing on the bottom of the caisson, in which case the descending caisson would also require to be partly emptied, so as to give less strain on the ropes and machinery.

The original spur-wheels on the drum-shafts had either been made too slight, or there must have been a flaw in one of them, for shortly after the machinery had been set to work last August, one of the wheels broke in pieces. Luckily it was the second wheel that gave way, or that on the upper drum-shaft, which is driven by the one on the lower drum-shaft. Had it been the driving-wheel or that on the lower drum-shaft which gave way, both must have been stopped. As it was, instead of stopping the incline entirely, and so losing the benefit of it during the dry season, one of the carriages was worked all the rest of the autumn, until there was enough of water stored to ensure the locks being kept going for the rest of the year.

Of course the work was carried on at a very great disadvantage in this way, as the engines had a very great deal more work to do than they otherwise ought to have had, owing to the want of counterbalance, and at the same time were doing only half the effective work; but even with these drawbacks, there were taken up generally about 30 boats a day, and in all 1124, including a few empty boats descending, were passed over the incline, up to the beginning of November, when it was stopped for the winter. This is equal to a saving of nine entire days' water in the ordinary working of the canal, which is reckoned at fully 60 boats down and as many up in one day.

The time taken by a boat to pass all the locks is from half-an-hour to 40 minutes; but as there may be one boat in each of the four locks, that would admit of four passing during that time by each set of locks, or from 12 to 16 by both sets of locks in one hour, supposing no interruption to occur from boats going in opposite directions stopping each other, which however, very frequently takes place, and on an average not more than nine boats can be reckoned on as passing up or down in an hour.

The whole time taken to ascend the inclined plane, allowing two minutes to enter the caisson, and two minutes to leave it, does not exceed ten minutes, but as one boat is entering while another is leaving, there is a boat passed upwards every eight minutes. Were there always empty boats both ascending and descending, one would be passed up and one down, both in ten minutes, but, as it has been before stated, cases of empty boats descending, although they do occur sometimes, are very rare.

Putting out of consideration the aggregate amount of traffic that can be passed, the time saved by the incline to each boat, considered by itself, is from two-thirds to three-fourths, as each takes only nine or ten minutes, instead of thirty or forty, to ascend; and there is also a very great economy in the wear and tear of the boats and gates, and in labour of men and horses, by using the incline instead of the locks. This seems now to be so well understood, that there is a great feeling in favour of having the inclined plane worked constantly, instead of only during summer, as was originally intended; and there is little doubt that soon it will be found necessary to keep it going all the year round.

The working of the inclined plane after it had been suspended for above four months during the winter, was resumed on 21st March, and it has been acting successfully and satisfactorily since then up to the present time, taking up generally about thirteen boats in two hours.

In conclusion, I have to express my sense of very great obligation to Mr Crichton, the superintendent of the Forth and Clyde Canal Co.; Mr M'Call, the overseer of masons; Mr Wilson, the overseer of mechanics; and Mr Thomson, the overseer of the Monkland Canal, for their zealous and efficient co-operation in their respective departments, in carrying into execution the plan of the works, and in devising means for giving increased facility and efficiency to the working of the inclined plane.

EDINBURGH, 28*th March* 1851.

P.S.—Edinburgh, 28*th Feb.* 1852.—The total cost of the incline, including land, was about £13,500.

From 20th March till 23d August 1851, there were passed over the incline 5227 boats up and 225 down, making a total of 5452. The longest day's work was 10 hours, and the greatest number of boats passed in a day was 55. Rather a singular effect, and one which it may be worth noticing, is produced, in the frequently-occurring cases of the boats being taken up, for the sake of lightening the load, with rather less than the full depth of water in the caisson, which is due to the level of the canal, or when the upper reach of the canal is over-full. On the opening of the two gates or sluices, after the caisson has been pressed close to the mouth of the canal, a rush of water takes place from the canal into the caisson to level the surface, and this water being stopped by the after-end of the caisson, recoils, and forms a wave in the opposite direction, which, striking the stern of the boat, drives it with a considerable impetus out of the caisson into the canal, without any help being required from the horse. This result which was quite unlooked-for, considerably expedites the working of the incline.

Reference to the Plates (VII., VIII., and IX.), and Abstract of Description.

a a Lines of rails and ratchets laid on longitudinal timbers: gauge of rails 7 feet.

b b Caisson and carriage of wrought iron. Caisson 70 feet long, 13 feet 4 inches wide, and 2 feet 9 inches deep, with wooden framing to serve as fenders for guiding boat, which is shewn in the caisson.

c c Drums or rope-rolls, 16 feet diameter, and making about one turn for twelve strokes of the engine.

d d Spur-wheels for driving rope-rolls.

e e Pinion for driving spur-wheels.

f f Vertical sluices at ends of caisson.

g g Bevel gear for lifting sluices, with balance weight.

h h Vertical sluices at entrance to upper reach of canal.

i i Gearing and portcullis for lifting sluices.

k k Gearing for laying ropes on the rolls.

l l Hydraulic apparatus and weight of eight tons, lifted 4½ feet, for pressing caisson with a power of twelve tons, and a range of 3 feet, close up the masonry of the canal, so as to tighten the joint.

m m Trough for carrying the spilled water into the uppermost basin of the canal.

n n Springs for taking jerks off the rope and for working the safety palls.

o o Palls always working in the ratchets when the caisson is ascending, and also arranged so as to work when the caisson is descending, should anything go wrong with the rope.

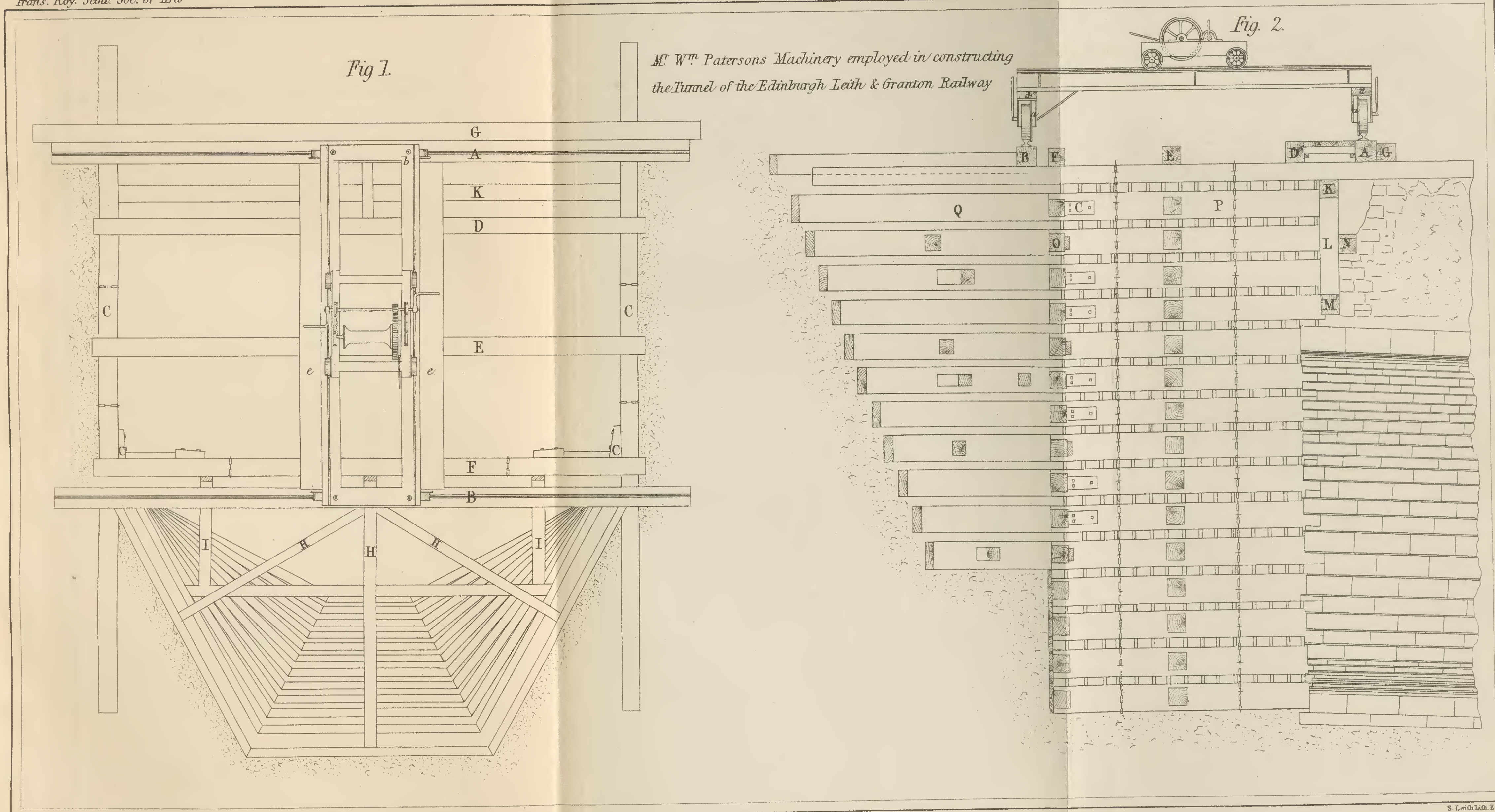
p p Rope sheave.

q q Stair down to rope-roll chamber.

s s The upper reach. *n′ n′* The canal boat. *o′* Bottom of canal. *p′p′* Pinion on end of crank-shaft, driving wheel with friction-centre, and lying shaft carrying pinion. *e* Motive power, two coupled engines of 25-horse power each. Average height from surface to surface of water, 96 feet, length of rails 1040 feet, gradient 1 in 10.

Weight of carriage, caisson, water, and boat, from 70 to 80 tons; weight of empty boat about 22 tons.

Mr. Wm. Patersons Machinery employed in constructing the Tunnel of the Edinburgh Leith & Granton Railway



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Mr. Wm. Patersons Machinery employed in constructing the Tunnel of the Edinburgh Leith & Granton Railway

Fig. 3

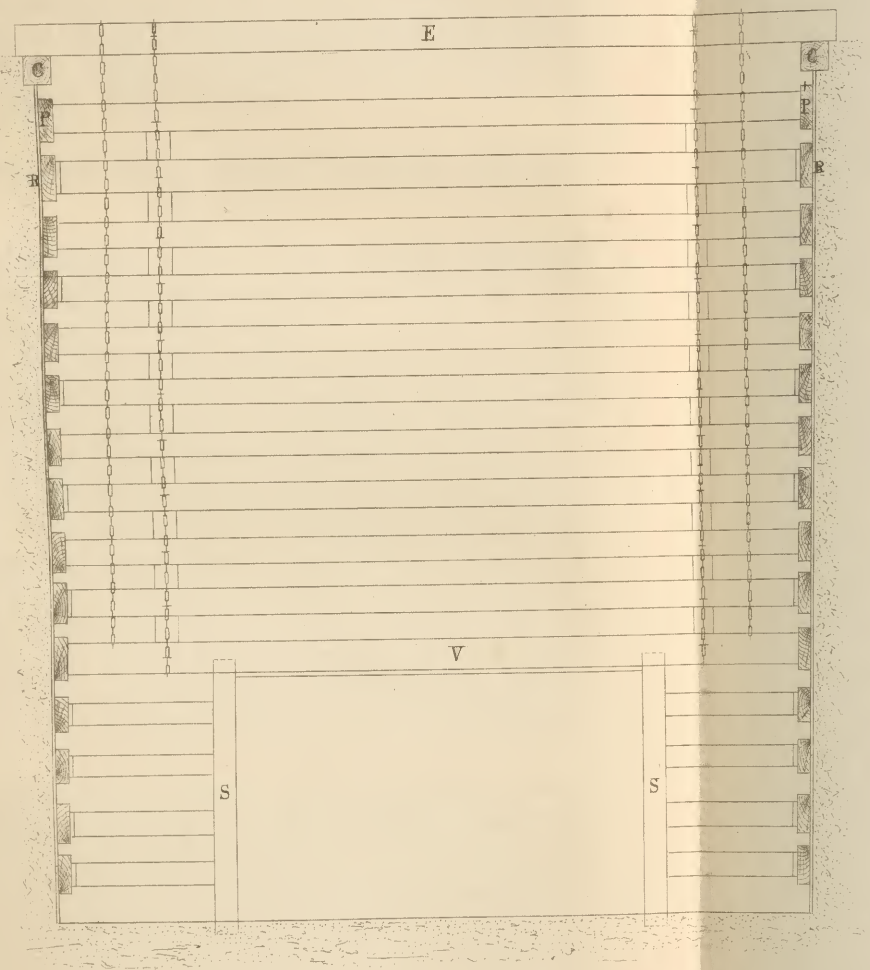
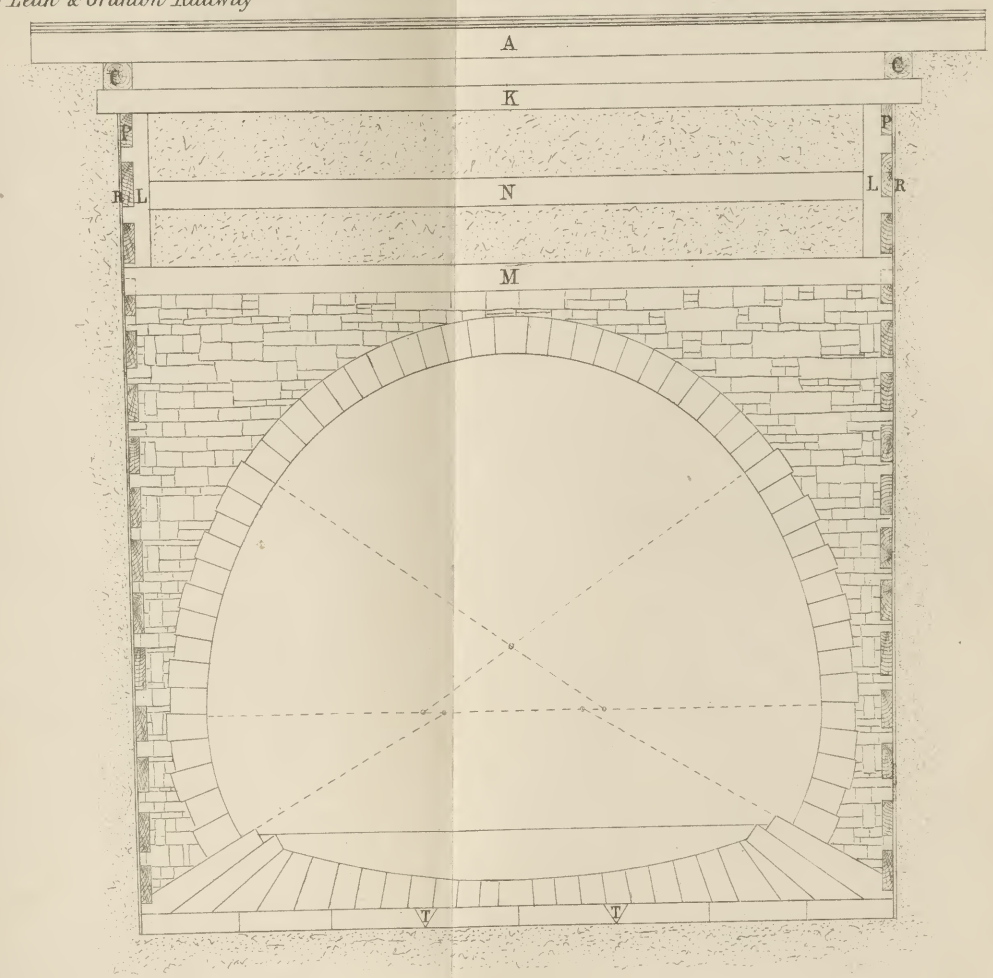


Fig. 4.



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A Description of the Machinery used, and the manner in which the sand in the sides and ends of the Open Cutting was supported, during the excavating and building the works of the Edinburgh, Leith, and Granton Railway Tunnel, in Scotland Street. By Mr William Paterson, Resident Engineer of the Tunnel.* With two Plates.

THE SOCIETY'S SILVER MEDAL AND PLATE, VALUE TEN SOVEREIGNS, AWARDED 1846.

It will be unnecessary for me to give a minute description of the state in which I found the works when I commenced operations on the 1st of March 1845.

It may be sufficient to state that about 30 feet of the tunnel, with the north entrance and wing walls, were executed by the contractors, Messrs Ross and Mitchell, in the preceding year, who also carried the drift-mine from the north to the south entrance for the purpose of ventilating and draining the works of the tunnel during its formation; and it was in consequence of the unavoidable fatal occurrence that took place when the last junction was made in the mine, that the whole of the works at the north entrance were flooded with water, standing at the entrance wall at least 3 feet 6 inches above the forming line of the railway, and which was supplied both by the water from the drift-mine and the water from the sand.

My first endeavours, therefore, were to get rid of the water, which was done by bringing up a drain sufficiently deep to clear the under side of the inverted arch of water, from the north end of the tunnel on the north side of Scotland Street Station. In that drain I left cesspools about 18 inches below the sill of the drain, for intercepting the sand which was brought by the water from the works; and by removing the sand as it accumulated in these cesspools the drain was kept in working order.

* Read before the Society, 8th June 1846.

To prevent also the water which flowed through the drift-mine from percolating through the sand, and thereby annoying us with more water in the foundations (the drift-mine being at the commencement about 6 feet above the forming line, and consequently about 9 feet 6 inches above the inverted arch), wooden troughs in 15-feet lengths, 9 inches wide by 7 inches deep, were laid in the drift-mine for about 100 yards. These troughs were slip-scarfed in the sides, the bottoms overlapping and jointed into each other with tar. 15-feet lengths were adopted to save cutting, that being the length fixed on for each stretch of building.

It had been agreed and settled between Thomas Grainger, Esq., engineer for the Company, and George Buchanan, Esq., the engineer appointed by the Sheriff to superintend the works, that it was requisite to opencast this section, and not to mine it as in the other portions of the tunnel. I believe this resolution was formed on account of the peculiar nature of the sand, the high houses on each side of the street, and the sill of the main sewer and cross drains in the street being at the least 1 foot 6 inches below the soffit or extrados of the arch.

I was therefore ordered by these engineers to prepare a plan for executing the work, which was shewn to them for approval. The following is a description of the plan shewn, and by which the works have been executed, with a very few alterations as the work proceeded.

The drawings give a correct representation of the top-framing, planking of the sides and heading, poling-timber, strutting-logs, section of tunnel building, and one large and one small carriage. There are two used on the works. The drawings are made to a scale of $\frac{1}{8}$ of an inch to a foot.

Fig. 1 (Plate X.) is the plan of the logs for bearing the carriages, and hanging the logs, with the angular heading and struts, and one set of carriages.

Fig. 2 (Plate X.) is the elevation of the side planking and carriages, the sections of strutting-logs, with a part of the tunnel.

Fig. 3 (Plate XI.) represents the centre strutting-logs with the planking and poling timber section.

Fig. 4 (Plate XI.) represents the section of the tunnel with the framing and filling above. The same letters refer to the same parts on all the figures.

As it was necessary to have machinery as low as possible in the street, but at the same time sufficiently strong and portable, I adopted a modification of the diving-bell staging carriages, the difference being principally in the running wheels of the carriages, the diving-bell apparatus having pinion-wheels and racked rails, while these carriages have plain waggon wheels and common rails, the wheels of the large carriage being fixed into a cast-iron frame, *a*, which frame is fixed to the carriage by one strong $1\frac{1}{4}$-inch bolt, *b*, the head of which is countersunk into the iron frame, and screwed on the upper side of the carriage with a nut and large washer. The tops of these frames are let up into the wooden frame of the carriage $\frac{3}{4}$ of an inch, to keep them from turning; there are also two stays of $1\frac{1}{2}$-inch iron put on the wheels above log B, to keep the bolt from bending at the neck. These wheels, being so arranged, are for the purpose of allowing them to be turned quarter round, or in a line with the carriages when they require to be shifted for a new length.

The length of the large carriages is 22 feet, by 6 feet 1 inch broad, outside measure, formed of 12-inch square Memel logs, having two strong bolts $1\frac{1}{4}$-inch diameter, put through the sides immediately on the inside of the ends; the sides are made flush with the ends, which are half-tenoned into the sides, and kept in their position by these bolts. On the under side of the ends and across the sides are placed a half-log *d*, 12 by 6 inches, which is spiked to the ends and sides, and into which the iron frame of the wheels is let up. There are also two foot-boards, *e*, 14 inches broad and 3 inches thick, of the whole length of the carriage, and hung to it by three brackets of iron for each foot-board.

The size of the small carriage is 4 feet 11 inches long, by 4 feet 1 inch wide, inside measure, formed of Memel half-logs, 12 by 6 inches, having four wheels 15 inches in diameter, on axles all the width of the carriage; the ends are tenoned into the sides about 9 inches from the end of the sides. The other parts of the machinery are what are usually put on single powered cranes.

The large carriages run on two large logs, A and B, 46 feet long and 1 foot 4 inches square, which lie across the tunnel, having rails fixed on them; these carriages have also rails fixed on them for the small carriages running on. Underneath logs A and B are two logs, C C, lying one on each side of the tunnel, and 32 feet apart; one end passes log A 6 feet, the other end passes log B 12 feet. These logs, C C, support other three logs, D, E, and F. D is placed about three feet 6 inches from A, and having three planks 1 foot 2 inches broad, 3 inches thick, the whole width of the opening, being supported in the centre by a piece of wood fixed to A and D, forming a scaffold for lifting the materials off; E is placed on the centre of the excavation for attaching the chains, to which hang the centre strutting-logs; F is placed within 9 inches of log B, and is for the purpose of hanging the end strutting logs with chains same as the centre logs.

Log M is laid on the top of the spandril wall of the end of the arch; on the upper side of this log, and right under C C, two uprights, L L, are set; log K is then laid on the top of these uprights, and hard wedged up to C C. And as the filling above the last built arch is faced up on the outside by a wall of dry stones, for greater security a scarcement is formed about 4 feet up on that wall; log N is laid along that scarcement, and being behind the uprights L L, support the dry wall, and prevent it from falling down or being forced in by the pressure of the filling behind it.

On the logs C C two chains are fixed on each for hanging the side planks. All these hanging chains are $\frac{7}{16}$ths of an inch, and of the best cable iron, and they are fixed to the logs and planks with staples of $\frac{1}{2}$-inch iron 4 inches long.

There is also another log G, laid outside of A, nearly the same length as A, for the purpose of bringing back the carriages when they are to be shifted.

These logs being all arranged, and the carriages set, the excavations are then ready for being commenced; and when the sand is excavated about 3 feet all over the centre of the space, the sides being left with a slope of 1 to 1, till it is fairly cleared; the sides are then prepared for the poling timber R, by being made perpendicular; and as one foot in length is so prepared, the poling timber is put in, and so on till the whole length of the space is timbered with poling timber; and at no time are the sides left in a perpendicular state without being supported by the poling timber.

The first poling timbers that are put in are made to butt up against C C, the lower ends being sunk in the sand so that they may be from 6 to 8 inches below the plank P, that is placed in front of them when it is on. The lower ends of the poling timber are scarfed on the back or side next the sand for 4 inches up, for the purpose of receiving in behind them the upper ends of the next tier of poling timber (which is put underneath), the upper ends of which are scarfed on the face for that purpose. The poling timbers were put in generally from 2 to 3 inches separate, unless where the sand was so loose that it even ran through that space; they were then put close in the joints.

The poling timber is of home wood from 2 feet 9 inches to 3 feet long (according to the breadths of the face planks), from 6 to 9 inches broad, and $1\frac{1}{4}$ inch thick.

The planks P, that are placed in front of the poling timber, are of yellow pine, 17 feet long, from 20 to 24 inches broad, by 6 inches thick, and are placed from 6 to 8 inches separate from the logs C C, and from each other. As they are put on downwards, the ends of the planks next the last built arch are held by the uprights of the frame K, L, and M; and when down opposite the building of the spandril walls and arch, by a toothing end of stone left there for that purpose; the planks are then fixed by a log put across the centre of the space and right under log E; it is then hung by the chains from E, and being cut about 4 or 5 inches shorter than the exact width, allows two hardwood wedges, 1 foot 6 inches long, 7 or 8 inches broad, and tapering from $2\frac{1}{2}$ inches to half-an-inch, to be driven in at each end, thereby jambing the planks and the poling timber tight into the sand; the other ends of the planks are held by logs same as the centre, and wedged in the same way, with the exception of the four permanent logs O, which will be described after. The planks which are held by the logs that are not permanent have cleats *c*, of hard-wood, 1 foot 9 inches long, 10 inches broad, and tapering from 6 to 2½ inches, bolted on their face with three bolts of ¾-inch iron. These cleats are sunk about ¾ths of an inch into the face of the plank, and placed close to the inner side of the end logs, and are for the purpose of preventing the lateral pressure of the sand in the heading from forcing in these logs. But the greatest part of the lateral pressure from the end or heading is supported by the permanent logs O; these logs run past the side planks, and a cleat, same size, &c., as those on the planks, are bolted to this log. About 3 feet 6 inches from the face of the planks, a jambing piece is then put in between the plank and the cleat. The reason this cleat on the log O is kept so far from the plank is to allow the plank to turn inwards, when it is taken out for the building. These logs O were termed permanent on account of their remaining always in their places when the planks were taken away; while the other logs were dropped down on each other as far as allowed the planks to be taken out for the building operations.

On the outside of the railed log B, there is formed an angular heading of the same kind of planks, Q, that support the sides of the open cut. The side planks of the heading being about 17 feet, and the end ones 15 feet long each, for the upper tier, in each tier of planks downwards the end planks are shortened about 1 foot 8 inches, and are also given a scarcement of 9 or 10 inches, which shorten the side planks. The ends of the planks next to the end logs F, are butted against them nearly opposite the cleats; the end plank is metred to the side planks, and by having a scarcement allows them to be hard jambed behind with sand, which is essential for keeping up the end when the sand was very loose; for about 6 feet of the sides next the end logs were supported by poling timber. As it was necessary to throw the most of the lateral pressure of the end upon the permanent logs, and also to support the sides and end planks from bending, diagonal struts, H H, are put in; but to prevent too much of the pressure from being thrown against the centre of the end logs, strutting in the form of I I are placed alternately with the strutting H H; 3 planks are placed up the back of the logs F F, for the struts bearing against, and these planks are made to bear principally on the permanent logs.

This heading answers a triple purpose beside keeping back the sand in the end, viz., it allows the chains which hang the end logs to be got on and off; it allowed the common sewer waters which came from the main sewer and side drains to be conveyed into the two new sewers which were formed in the haunches of the arch; and it also allowed the excavations for a new length to be thrown into the tunnel underneath, to be taken away by waggons or carts.

When the planking of the sides of the open cut and heading are brought down to within 6 or 8 feet of the forming line of the tunnel, and strutted and fixed as above described, the two lower logs of the centre E, and the end one, F O, have each mortise holes in the underside of them, the centre one V, having two, each mortise hole being about 6 feet from the face of the planks, and between these holes a batten is spiked to the underside of the log, and the end log has four mortise holes, equidistant from the sides and each other. Pits were then dug into the sand immediately underneath the mortise holes in the centre log, to the depth of 6 or 8 inches below the foundation of the inverted arch, then uprights of log S S are put into these pits, having tenons for the mortise holes, they are then drawn by the upper carriages into the mortises, the bottom being firmed with sand, iron dogs of $\frac{5}{8}$ iron are driven into the log and these uprights.

The heading is brought no farther down than these logs; the end sand is supported by 3-inch planking being placed behind these uprights; the sides are poled and planked same as above, only the struts are short, being only from the uprights S S. By doing it in this way allowed the masons to get wrought with ease, it also afforded an opportunity of getting one of the sides made secure with planking, and afterwards by building, while the other side was being made ready; something, such as boulders, extra water, or a different kind of sand which did not work so well, having frequently retarded the progress of one side.

When the whole of the excavations were taken out, and the planking put in, as above described, a safety chain was fixed to E, and passed round the log above the lower centre log, and brought up to E again, and fixed there; jambing pieces of wood are also put in between each log. This safety chain was for the purpose of hanging the centre logs during the building operations going on, for after the lower centre log and uprights were taken away, as the building was brought up, the centre logs were hanging only by the chains with staples and the pressure from the sides. This safety chain was regularly shortened as the logs were taken out. Every part is now prepared for the commencement of the building, which was begun by laying a course of flat stones, having a superficial area of from 12 to 16 feet, and from 8 to 10 inches thick, closely jointed, underneath the whole of the inverted arch, and the foundations of the abutments of the arch. In that course of stones there were two small drains T T, which allowed the water to run on stone and not on the sand. The inverted arch was built of stones from 2 feet long and upwards, from 6 to 10 inches thick, and from 1 foot 2 inches in the centre, increasing in depth as it neared the foundations of the arch. The foundation stones were in two courses, each stone having a superficial area of at least 10 feet, being generally about 3 feet 6 inches broad, and 10 inches thick, each having a scarcement of 4 inches, and laid to the proper radiating bed of the first course of ashlar.

The inverted arch being formed, and the foundations laid, the lower ends of the last put in poling timber being made secure by the building of the foundations, the lower planks were removed, and rubble building placed in front of the poling timber, and built close up to the under side of the plank above; thus building in the 6 or 8 inches which the next poling timber above is below the plank. After the ashlar is brought up to the height of the rubble work another plank is taken out, the poling timber again keeping its place by the building below, and the scarfed ends of the tier above; rubble work is again built in the face of the poling timber, and in this manner the whole of the building is brought to its height.

After the planks that are held by the short struts from the uprights S S are taken away, S S are then drawn from below the centre log but left under the end logs, and to allow the next planks to be taken out the centre log is taken away and drawn to the surface; the end log being a permanent log and resting on the uprights below, the jambing piece between the planks and the cleats that are on the log are taken out, and the plank drawn from behind the toothing end of the mason work. The same process is gone on with the taking out of each two planks as the building progresses upwards, only the end logs that are not permanent ones are dropped down as much as to allow the plank to be drawn from the toothing end; these logs when dropped are firmly jambed to the end of the building.

It being sometimes necessary to take out the centre log from between the planks before the planks could be taken out, which circumstance generally took place when the arch was near the closing, screws in the form of a T were used for keeping the centre of the planks from bending inwards, and thereby allowing the sand to move out of its place. The screw was fitted into a piece of Norway timber, 6 feet long and 9 inches square, the cross end of the screw was placed in between the two planks above the one the log was to be taken away from; it is then turned round, and the cross end takes hold of the back of the planks. The piece of Norway timber is brought to bear on that plank from which the log is to be taken, and being tightly screwed up the tension of the timber keeps the planks in their places.

As it is also necessary to keep the permanent logs from being pressed inwards, when the planks are withdrawn from before them, two screws are used having square claws, one being put on each end of the log; they are also fixed into a piece of Norway timber, but rather stronger than the T screws. These screws are put on in the heading side of the end logs, and by grasping log O, the piece of timber is bearing on the log beneath, which is firmly wedged off the building, and on the log above, which has the cleat on the face of the plank to keep it in its place. These screws are kept on the permanent logs till the building is brought up opposite to it; it is then wedged off the building, when the screws are at liberty to be used for the next permanent logs.

But the lowest end log is kept in its place by placing the screws on the building side, and, by grasping the next log above, the timbers of the screw holds the log in its possession.

The ashlar of which the tunnel is built ranges from 3 to 7 feet long, about 18 inches on the beds, and from 18 to 8 inches thick on the soffit of the arch.

The rubble work is from 18 to 22 inches broad at the belly-line or widest part of the tunnel, and is carried from the foundations to the top of the spandril walls plumb on the back, or rather filling all the space between the poling timber and the back of the ashlar.

The spandril walls above the arch were built to the average height of 4 feet above the extrados of the arch, running from 1 foot 6 inches at the north end, to 6 feet 6 inches at the south end as the street gained in height above the arch. A rough arch was thrown on each of the spandril walls having a rise of 9 inches in the centre, and by having good end walls, pressed the sand underneath the area cellars when the weight of the filling came on them. Every 15 feet of arching had 3 spandril walls. The sewers of the street were placed in the haunches of the arch on the top of the spandril wall, and when they were filled with dry stones between them, clay puddle 12 inches thick was laid all over from side to side, to prevent surface water from getting through the arch. One length of building being then finished, the carriages and upper framing are ready to be shifted; the process of doing so is as follows, viz:—

The carriages are brought each above C C; a block of wood, having a part cut out for the rail, is laid right under the screws that are in the ends of the carriages; log D is laid within 2 feet of F, then four planks are laid opposite the centre of the wheels, two being placed on D and F, and two on G and on the filling behind, care being taken not to allow these planks to lie on A or B; the small carriage is chained to the end of the large carriage above B and the setting chain attached to A, the screw is then used, and one end of the large carriage is lifted up as high as the top of the planks.

The large bolt of the iron frame of the wheels is unscrewed, allowing the frame to get below the check in the wood, the frame and wheels are then turned quarter round or in a line with the lengthway of the carriage, they are then screwed tight up again and wedged up level with the planks; when both ends are prepared in that manner, the crane work is set in motion, and the chain being kept fixed to A, the carriages are drawn backwards above F, D, and G; A is then lifted by the carriages 15 feet farther forward, B is rolled the same distance, and when both are levelled and set to their exact parallel width, two struts are put in between them; four planks are then laid (the side planks are the exact length) two on G and A, and two on F and B, and being set opposite the wheels, and as these planks rise all their thickness before the wheels, the screws are again used, and the wheels raised to the height of the planks; the small carriage is then fixed to the other end of the large carriage, and the setting chain fixed to B, the crane is then set in motion, and the whole is brought forward till the centre of the wheels are right over the rails; the screws are again used, the wheels in frame returned to their proper position, and when they are firmly screwed they are again ready for duty. The logs C C are then drawn forward by the carriages, the one end resting on the surface of the ground beyond B, or in a track cut for it, the other end is hung to A till the frames K, L, M, are put underneath them, the other logs D, E, and F, are again placed in their position, when the whole process as before described is gone over again. The safety chain and the setting one of the small carriages are of $\frac{5}{8}$ of an inch, and of the best iron; all the logs not otherwise mentioned are of Memel or Riga timber.

On account of the very loose nature of the sand, it was found necessary, in order to prevent the drift-mine from collapsing, to put in three strong tressles, having two strong logs run along the top of them and wedged slightly up to the roof timbers of the mine; the feet of these tressles were placed on 6 feet planks, having an inclination inwards, to prevent them from drawing outwards, the mine having a natural tendency to come that way, from the uprights in the mine for supporting the roof timbers having been originally set with their tops lying outwards.

I beg leave, however, most respectfully to state, that, should any part of the machinery or timbering used be thought, in the matured judgment of the Society to have been either too slight or ineffective, the blame of such rests wholly with myself; for my Directors put ample means in my power, with strict injunctions to take every precaution necessary for the safety of the public and for the security of the properties adjoining.

EDINBURGH, 12*th May* 1846.

Report of Committee of Royal Scottish Society of Arts on Machinery employed by Mr Wm. Paterson, F.R.S.S.A., in executing the Tunnel of the Edinburgh, Leith, and Granton Railway.

We have carefully inspected the model and drawings, and perused the paper by Mr Paterson, descriptive of the machinery used, and of the manner in which the sand at the sides and end of the open cutting was supported, during the excavating and building of the works of the Edinburgh, Leith, and Granton Railway Tunnel, in Scotland Street; and we have much pleasure in recommending the communication to the favourable notice of the Society. Mr Paterson deserves great credit for his ingenious mechanical arrangements, which we have reason to know were most successfully applied in the execution of the difficult and important work in which he was employed as Resident Engineer under Messrs Grainger and Buchanan.

DAVID STEVENSON, *Con*r.
JAMES SLIGHT.
ALEXANDER BLACK.

EDINBURGH, 30*th September* 1846.

Description of a Large Iron Roof recently erected at the Liverpool Terminus of the Lancashire and Yorkshire Railway. With Four Plates.

This roof has been erected under the superintendence of John Hawkshaw, Esq., civil engineer to the Lancashire and Yorkshire Railway, by Messrs Fox, Henderson, and Company, engineers and iron-founders, of Birmingham.

Lancashire & Yorkshire Railway

Roof for Tythe Barn Street Station Liverpool

Nº 1.

General Plan

Scale 30 feet to an Inch

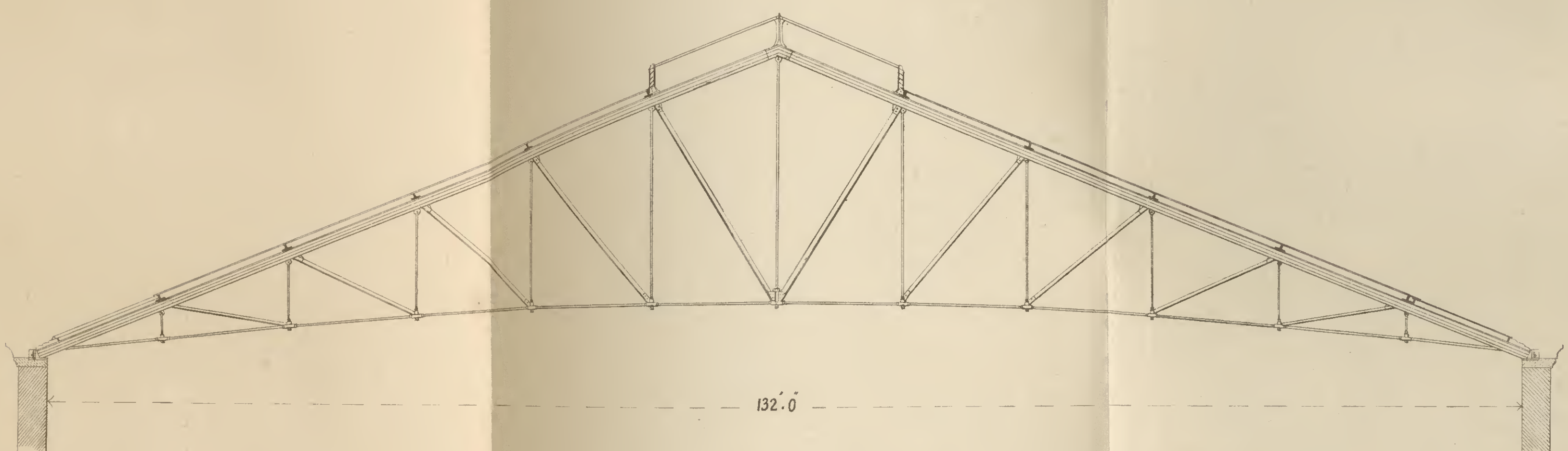
S. Leith Lithogʳ. Edinʳ.

Fox Henderson & Cº.

No. 2.

Roof for Tythe Barn Street Station Liverpool.

OF THE LANCASHIRE & YORKSHIRE RAILWAY.



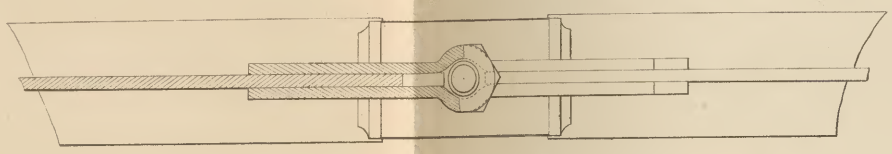
Scale 1/16 in = 1 ft

Fox Henderson & Co.

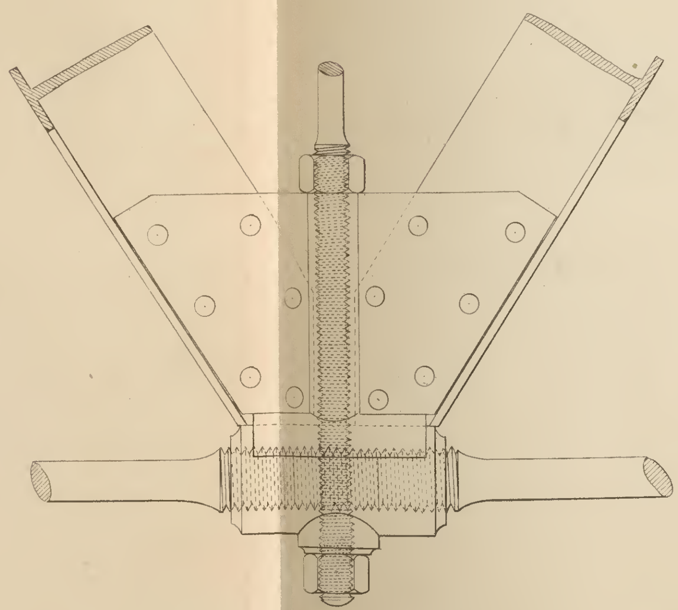
Lancashire & Yorkshire Railway

Roof for Tythe Barn Street Station Liverpool

No. 3



Joint at bottom of King Rod



Scale 1½ in to a Foot

S. Leith Lithogr. Edinr.

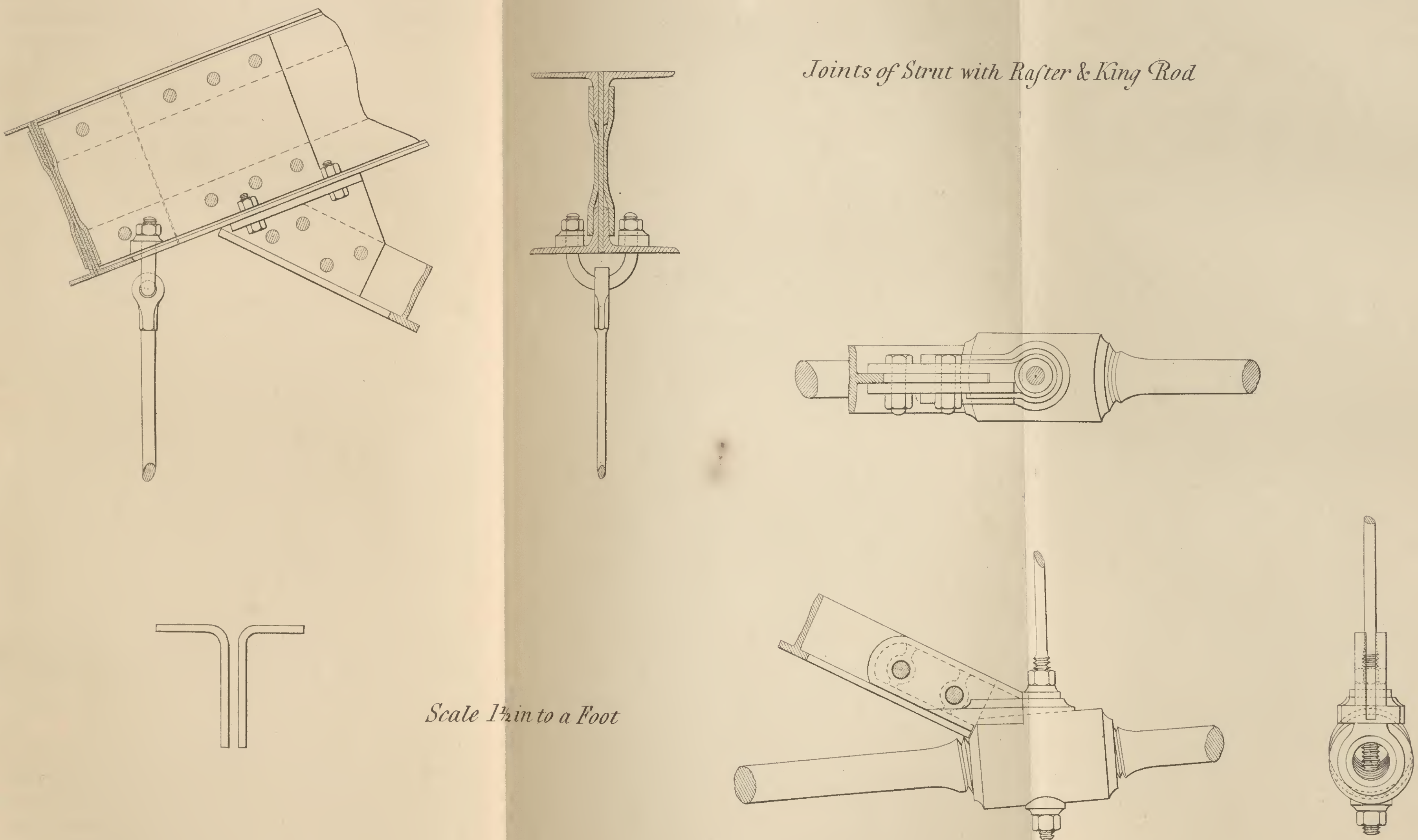
Fox Henderson & Co.

Lancashire & Yorkshire Railway

Roof for Tythe Barn Street Station Liverpool

No. 4

Joints of Strut with Rafter & King Rod



Scale 1½ in to a Foot

S. Leith Lithogr. Edinr.

Fox, Henderson & Co.

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The roof covers five lines of rails and three platforms, and a carriage-road twelve yards wide, in one span, having no columns or supports besides the outside walls ; the span varies from 136 to 128 feet over the walls, and the total length is 638 feet; the total area thus covered is 83,457 square feet, or 834 squares.

Drawing No. 1 (Plate XII.) shews the plan of the roof with the sky-lights, corrugated iron covering, ridge, purlins, eave-gutters, and walls complete ; part of the covering is removed, in order to shew the general structure of the roof.

Drawing No. 2 (Plate XIII.) shews an elevation of one of the principals of the roof.

Drawing No. 3 (Plate XIV.) shews a detail of the joint at the bottom of the king-rod.

Drawing No. 4 (Plate XV.) shews a detail of the joints of strut with rafter and tie-rod.

In the construction of large wooden roofs it is usual to form strong framed principals of timber of large scantlings, and to place them at distances of 10 to 16 feet apart, to act as the main supports for the roof. On these principals strong wood beams or purlins are placed, reaching from principal to principal, and on these purlins are placed the ordinary rafters of much lighter scantling, and these rafters receive laths or battens, on which the slates are ultimately fixed. It will thus be seen that there are five distinct members in an ordinary large wooden roof, viz., the principals, purlins, rafters, laths, and slates.

In the roof which is the subject of the present paper there are three distinct members only, viz., the principals, purlins, and corrugated iron covering, and the arrangement is as follows :—

Firstly, The principals are placed at 11 feet from centre to centre, and span across from wall to wall ; each principal being provided with two cast-iron shoes, which are bedded into the top course of masonry of the wall, the distance from centre to centre of these shoes being 132 feet 8 inches at the widest part, and 125 feet at the narrowest part.

Secondly, The purlins, which are framed of wrought-iron of a T section, are placed on the back of the principals, directly over the upper end of each strut, and reach from principal to principal; their own weight and the weight of the roof-covering upon them, is therefore immediately supported by the struts in the principals, so that there is no tendency to bend the back of the principal between the struts; the purlins thus form substantial longitudinal ties between the principals.

Thirdly, The covering of the roof, which is made of corrugated galvanised iron plate, is supported by the purlins without the aid of any other support, as it is strong enough to bear its own weight and the weight of snow, &c., on it without injury; its stiffness in a direction at right angles to the purlins being derived from its corrugated form, the corrugations running down the roof parallel with the principals. The sheets of corrugated iron are secured together by rivets with washers, and to the purlins by bolts and nuts; every plate being lapped over the one below it as in slating.

The backs of the principals, or "principal rafters," as they are termed, are formed of a wrought-iron plate, with two large pieces of angle-iron rivetted along the top, one on each side, and two along the bottom, one on each side, thus forming a section like the letter I, or, in fact, a regular girder section; this form gives ample width to receive the purlins on the top, and the struts on the bottom, and, at the same time, there is sufficient space on the bottom flange to receive the staples by which the queen-rods hang.

The struts in the principals are all of T iron of large sizes, and are secured at the upper ends to the "principal rafter" by means of stiff wrought-iron knees firmly rivetted to them, and bolted to the "principal rafters;" at their lower end the struts are fixed into cast-iron shoes, which fit on the tie-rod and are fixed by the queen-rod.

The main tie-rods are of round iron, and are screwed into wrought-iron sockets or connecting pieces under each queen-rod, the queen-rod passing through it and being provided with a nut below; by which means the sockets and tie-rods are supported, together with the struts, which start from them as above described.

The upper ends of the "principal rafters" are secured in a strong cast iron kinghead, formed of two castings firmly bolted together through the ends of the "principal rafters;" from this kinghead hangs the king-rod, and above it is fixed the centre louvre standard, which carries the cast iron ridge piece into which the upper ends of the sash bars of the skylights are fixed.

Light is admitted through the roof by four continuous lines of skylights, two of which are placed at the ridge over the louvres, the other two being fixed near the eaves upon opposite sides; the ridge skylights are about 22 feet wide, and those at the eaves 10 feet each, making up a total width of 42 feet across the roof by 616 feet long, and giving a surface of glass equal to upwards of one-third the entire area of the roof.

The roof is ventilated by means of fixed louvres, placed under the ridge skylights; these louvres consist of cast iron standards with galvanised blades of sheet iron fixed between them, at a sufficient angle to prevent the ingress of the rain, and at the same time to allow the steam from engines passing beneath freely to escape.

The lower ends of the "principal rafters" are formed double or forked, so as to admit the cast iron shoe before alluded to, and through the centre of which the tie-rod passes, having a nut at the back of the shoe; one of these shoes is fixed in the wall, and the other is hung by two short links from lugs on a strong bed-plate which is fixed in the wall; the object of this arrangement being to allow for the expansion and contraction due to variations of temperature, which would otherwise throw very unfair strains on the roof and on the walls. Considering also the great length of this roof, it has been deemed advisable, in order to counteract the injurious effects arising from great variations in temperature, to break the continuous line of iron covering by making four expansion joints in the corrugated plates. This principle is also applied to the cast iron ridge and skylight rails, which otherwise might be subject to disruption from the violent strains produced in iron work by very high or very low temperatures.

There is a complete system of wind-ties in the roof staying the principals together diagonally.

Previous to the roof being fixed, one of the principals was put together, erected and proved under the inspection of Mr Hawkshaw, and to his satisfaction. The dead weight with which this principal was tested was 14 tons in addition to its own weight, and with that weight is equal to 30 lbs. per foot superficial upon the roof measured on plan. The principal sustained this proof without any permanent deflection. The whole of the main ties in the entire roof were proved in a proving machine, with a strain of 10 tons per sectional inch.

This roof was ordered at the latter end of September last; the erection of it, together with six others, was commenced in the beginning of December last, and the whole are now completed, with the exception of the glazing, which is not quite finished.

The superiority which an iron roof possesses over one of timber is now universally admitted by engineers, and in railway roofs, especially, are the advantages of iron experienced. Amongst its many recommendations may be mentioned the symmetry of form of which it is susceptible; the great strength that can be obtained in combination with a light and elegant appearance; its durability and freedom from all ordinary sources of decay; and the fact of its being fire-proof. In this last particular, indeed, iron roofs are altogether unequalled by roofs of timber; and this characteristic has doubtless been one of the main causes of their being generally adopted by the profession.

March 1850.

Report of the Committee of the Royal Scottish Society of Arts, on the Description and Drawings of the Roof of the Terminus of the Lancashire and Yorkshire Railway at Liverpool, by Messrs Fox, Henderson, and Company.

This roof appears to be a very remarkable work, being constructed entirely of iron, no less than 130 feet in one span and 638 feet in length, covering nearly 2 acres of ground, and a very striking example of the extent and perfection to which the construction of iron roofing has been

Trans Roy Scott Soc of Arts

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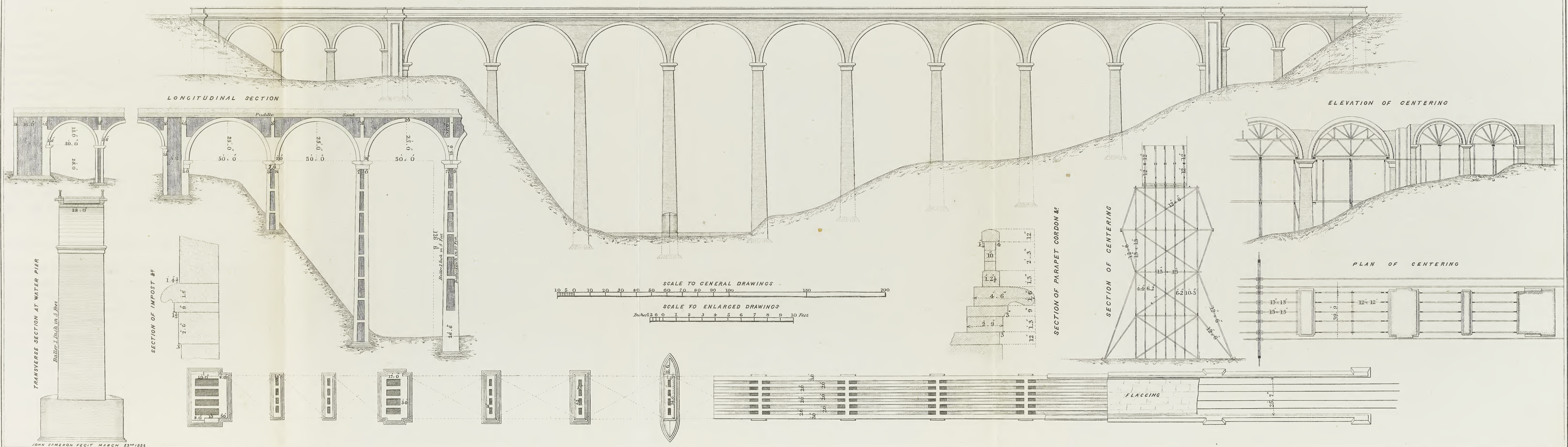
LUGAR VIADUCT

JOHN MILLER ESQ[R] ENGINEER

1851



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carried in this country since the introduction of railways and their vast termini.

The Committee have carefully read over the description and examined the drawings, and have much pleasure in reporting the great satisfaction they have had in going over these documents, which they consider a highly-interesting contribution to the Society's Transactions. The drawings are very complete, and exhibit both an imposing general view of the structure and enlarged views of all the details. They much approve of the design of the work, and all the parts seem to have been contrived with judgment and skill, and with due consideration of the strains, both tensile and compressive, falling on the different parts of the structure, and of the proportional strength in the materials calculated to bear them. They think the best thanks of the Society are due to Messrs Fox, Henderson, and Company.

GEO. BUCHANAN, *Convener.*

EDINBURGH, 24*th July* 1850.

Description of the Lugar Valley Viaduct on the line of the Glasgow and South-Western Railway, erected from the design of John Miller, Esq., C.E. By JOHN CAMERON, Esq., C.E., 132 George Street, Edinburgh.* (With a Plate.)

SPECIAL THANKS OF THE SOCIETY AWARDED OCTOBER 21, 1851.

As probably most of those whom I have the honour of addressing this evening are unacquainted with the sources from which I have derived the information relative to the Lugar Viaduct, I think it proper to mention that Mr Miller, the engineer for the work, under whom I have the honour of serving, having informed me of the desire of your President, that a description of this viaduct should be presented to your Society, and having added a request that I should prepare such a description, I was induced to undertake the task, although I could have wished that it had been intrusted to other hands better fitted for doing justice to so grand a subject.

* Read before the Society on 24th February 1851.

Before commencing to describe the manner of executing the Lugar Viaduct, it will not be irrelevant to give a short account of the railway of which it forms a part. The Glasgow and Ayr Railway was amongst the first of those constructed for locomotives in Scotland, and at first consisted merely of a line from Glasgow to Ayr, in length about 40 miles. About three years after the opening of the main line, the branch to the town of Kilmarnock was opened; since that time, various additions of branches have been made, and a line from Kilmarnock to Gretna was opened throughout in October 1850.

There are few lines on which more extensive works have been executed, than on the last division of the Ayrshire Railway. And the magnificient scenery through which the line passes, viz., the Braes of Ballochmyle, rendered celebrated by the poetry of Burns, and the valley of the Nith, adds considerably to the interest to be attached to these works. The most extensive of the works on the line are, the viaduct through the town of Kilmarnock; the Mossgiel tunnel, passing through a ridge near Burns' farm at Mossgiel; the Ballochmyle viaduct, by which the line crosses the water of Ayr, on which a paper was read before the Society last year, besides other works of a most extensive nature, too numerous to mention.

Position.—The Lugar Valley viaduct, of which it is now proposed to give a description, carries the line of the Glasgow and South-Western Railway across the valley of the Lugar, near the village of Old Cumnock, and is situated about 50 miles from the terminus at Glasgow.

General Dimensions.—The viaduct consists of 14 semicircular arches, 9 of which are 50 feet span, and 5 are 30 feet span; 3 of the 30 feet spans terminate the viaduct at the north end, and 2 at the south end. These small arches are separated from the large ones by strong abutments about 16 feet thick. The total length of the viaduct is 752 feet; the greatest height, from level of foundation to top of parapet, is 161 feet 6 inches; the average height is 94 feet 6 inches. The viaduct is built level throughout, being approached at the north end by a gradient of 1 in 200, and at the south end by a gradient of 1 in 150.

Material.—The stone of which the viaduct is built is a white sandstone, which was quarried near the spot, from quarries on the estates of Sir James Boswell and the Marquis of Bute.

Strata.—The ground on which the viaduct is built consists of beds of limestone and coal, the limestone in many places being visible on the surface. The coal had been worked out, and the roof was supported by stoops or pillars of coal.

Coal-Workings.—These coal-workings gave rise to some difficulty in founding the piers. The waste, though not very thick, was so considerable, that it would have incurred a great expense to have sunk the piers through to the solid ground. And as there existed two or three beds of stone between the upper surface and the coal-workings, and the workings were supported by the stoops, the following plan was adopted for giving a firm base to the piers.

Foundation.—When the foundations were to be laid, shafts were sunk to the coal-workings, to find their exact position in relation to the piers, and the condition in which they were; and it was found that the waste was about 2 feet thick, the roof being supported, as before mentioned, with stoops or pillars of coal, in the usual manner. The coal-workings were cleared of all refuse and soft material, and built up with dry stones, carefully selected and firmly packed together; and the success of this operation was proved by the absence of all appearance of settling in any of those piers which were founded in this manner. On the north bank the small abutment was sunk 20 feet below the surface, owing to the ground at that place consisting of forced earth, which, though tolerably firm and consolidated from the time which must have elapsed since it was placed there, yet not sufficiently solid to support a building of such massive proportions as the viaduct. The ground being excavated to such a depth as to secure a firm foundation, properly levelled, and cleared of all soft and yielding material, the foundation courses were laid, which consist of large flat stones 12 inches thick, laid so as to have the scarcements shewn in the drawing. No stone contains less than 9 superficial feet, all dressed parallel on the beds, with square dressed vertical joints, and laid so as to break bond and fit together without packing. The foundations of the abutments and piers of the large arches consist of three courses, except the large water pier, which, with the piers of the small arches, are in two courses.

Large Piers.—The piers are all what are termed hollow piers; those of the large arches are 7 feet thick at the top, viz., two outer walls, each 2 feet 6 inches thick, and a void between them 2 feet wide. The outer walls are bound together by walls placed 3 feet apart. The piers being bonded across horizontally by stones running right across the voids with a view of counteracting any tendency which such tall and slender piers might have to twist, at the same time acting as intermediate covers to the void during their execution. These floorings are placed every 15 feet in height of the piers. There is a batter on the faces under the arches and on the ends, *on the exterior*, of 1 inch in 5 feet, and *in the interior* of 1 inch in 10 feet. The water pier is built in precisely the same manner, but it is solid for 11 feet above the foundation, by this means lowering the centre of gravity of the pier, and at the same time offering a better resistance to the action of floods, &c., than a hollow pier would. All the piers are built of ashlar without rubble; it is left rough on the face, and built in courses of from 10 to 14 inches in thickness. The thickest course being laid at the base, and laid header and stretcher alternately, no stone being less than 2 feet 6 inches broad on the bed, and 2 feet 9 inches long. The caps on the sterlings of the water pier consist of two ashlar stones droved on the top, and moulded to the form shewn on the drawing.

Small Piers.—The small piers are 5 feet thick at the top, viz., two walls each 2 feet thick, and a void 1 foot wide between them, with cross walls, and battens in exactly the same manner as the large piers, but the voids are not covered at intermediate distances in the height. They consist of hammer-dressed stones laid in regular courses, of from 6 to 8 inches in thickness, properly bonded together, and left rough in the face, having quoins of droved ashlar, 2 feet long and 1 foot broad, and from 10 to 12 inches in thickness, laid header and stretcher alternately, full chamfered in the bed-joints, and half chamfered on the ends.

Abutments of Large Arches.—The abutments of the large arches are 16 feet 6 inches thick, viz., a wall 5 feet thick, from which the large arches spring, and a wall 3 feet thick, from which the small arches spring, having a void between them 8 feet 6 inches long, the two walls being bound together by walls 2 feet thick, every three feet in width, built of the same kind of masonry as the piers of the small arches, except that the wall from which the large arches spring, is built of ashlar, of the same character as that in the piers of the large arches, but only 2 feet 6 inches thick or broad on the bed; the rest of the wall is hammer-dressed stones. These abutments are battered on the faces in the same manner as the faces of the piers.

Abutments of Small Arches.—The abutments of the small arches, which have to receive the pressure of the embankments at either end of the viaduct, are 23 feet thick, consisting of a 5 feet wall, from which the arches spring, and a wall 3 feet thick which receives the pressure of the embankments. These two walls are bound together by walls running longitudinally in precisely the same manner as the piers of the small arches.

Imposts.—The imposts or springing stones from which large arches spring, are of droved ashlar, 2 feet 6 inches broad on the bed, and 2 feet 3 inches long on the face, they are 18 inches thick, and project 1 foot beyond the fillet beneath, and moulded in the same form as the cordon course hereinafter described. The fillet underneath the springing stone is 9 inches thick, and projects 3 inches beyond the face of the walls of the pier. The impost of the small arches are of the same form, but smaller dimensions.

Pilasters.—The face of the pilasters consist of brotched ashlar in courses of from 10 to 12 inches in thickness, laid header and stretcher alternately. No stone is less than 20 inches broad on the bed and 2 feet 6 inches long. A groove 6 inches wide and 9 inches deep is cut on the face, which very materially relieves the flat and bare appearance of such a mass of masonry.

Large Arches.—The arch stones of the large arches, are of droved ashlar, 2 feet deep, laid in regular courses of not less than 10 inches in thickness, nor more than 13 inches on the face ; the thickest course being laid next the springing gradually diminishing towards the crown. The reason of this is explained hereafter. No stone is more than 3 feet 6 inches long, nor more than 2 feet 3 inches, laid so as to break joint with the adjoining courses, at least 1 foot. The stones have a chamfer 1 inch deep and 2 inches wide, and the chamfer is carried up the face of the ring pens ; the arch stones are made to project 3 inches beyond the spandril walls.

Small Arches.—The small arches are also of ashlar, of the same description as that in the large arches, the arch stones are 1 foot 6 inches deep, laid in the same manner as those of the large arches, no stone being less than 2 feet 3 inches long, and 9 inches thick on the face, chamfered on soffit and face of the ring pens.

Outer Spandrils.—The outer spandrils are 3 feet thick, carried up to the level of 1 foot above the extrados of the large arches at the crown. They consist of hammer-dressed masonry, of the same dimension as that used in the piers and abutments of the small arches ; it is left rough on the face.

Solid Spandrils.—The solid spandrils are carried up 15 feet above the springing in the large arches, and 10 feet above it in the small arches, and a cross wall, 2 feet thick, is built exactly over the centre of the pier, running across the viaduct transversely and carried up to the level of the top of the outer spandril.

Inner Spandrils.—The inner spandrils are five in number, each 2 feet thick, having voids between them 2 feet 6 inches wide. These walls are built to the same level as the outer spandrils ; four of the walls carry the roadway, the fifth one, which is the middle, merely distributes weight to the arch.

Flagging.—The voids in the arches and abutments are covered with flagging 9 inches thick, having a rest of from 6 to 9 inches on each wall.

Puddle.—Above the flagging a layer of puddle is placed 9 inches thick.

Sand.—And over the puddle a layer of sand 9 inches thick.

Belt.—On the top of the outer spandril a belt is laid, consisting of droved ashlar, 2 feet 6 inches broad on the bed, and 1 foot 3 inches thick, projecting 3 inches from the face of the outer spandril, and exactly in line with the face of the ring-pens; this consists of droved ashlar.

Fillet.—Above the belt a fillet is laid, 9 inches thick, 2 feet 9 inches broad on the bed, laid so as to project 6 inches beyond the belt, and having a cavetto moulding 3 inches radius on the corner; this is also droved ashlar.

Cordon.—Above the fillet the cordon is laid, which consists of droved ashlar 18 inches thick and 2 feet 4 inches on the bed, no stone being less than 3 feet 6 inches long, projecting 2 feet beyond the fillet beneath, and moulded so that the under part of the moulding forms a throat which prevents the water from running down the walls.

Parapet.—The parapet consists of a base, dado, and cope, the base is 1 foot 2½ inches thick, and 1 foot 3 inches deep, consisting of droved ashlar, placed so that the face of it corresponds to the line of the face of the outer spandril. The dado is 10 inches thick and 2 feet 3 inches high; consisting of three courses of brotched ashlar. It is placed so that the base projects 3 inches beyond it on the outside, and 1½ inch on the inside. The cope is of droved ashlar, 1 foot 3 inches thick, 12 inches deep, projecting 1½ inch over the dado on the inside, and 4 inches on the outside, the outside having a throat 2½ inches diameter cut in it.

Ashlar.—The whole of the ashlar used in the bridge is pick-dressed on the beds and joints, having a chisel draft round the edges and square-dressed vertical joints; except in the archstone when the beds are radiated to the centre of the arch, the ends of the stones having square-dressed vertical joints.

Iron work.—The only iron work used was in the dowalls by which the cope and cordons were fastened together and to the adjoining masonry.

Centering.—The centering of the large arches was supported in various manners, sometimes by uprights of rough timber from the ground to the centre of each rib of the centering, the uprights to the other ribs being braced to it by diagonals and walings every 27 feet in height, and a series of uprights against the piers were used to support the ends of the ribs. In some places instead of carrying up uprights from the ground to support the ends, stones were left projecting from the faces of the piers, and rough logs rested on these, and supported the ends of the ribs, being tied to one another by diagonals and walings in the same manner as the other uprights, and they were bolted to the wall with iron bolts. These uprights were capped at the top with beams running horizontally across the span of the arch. This completed the supports for the centre. Above the horizontal beam the wedges were laid, by which the centres were relieved of the arch when the wedges were slacked. Above the wedges the ribs were placed; each rib consisted of a horizontal beam at the level of the springing, and another about 12 feet 6 inches above it. On the centre of the lower horizontal beam a log was placed exactly over the vertical supports beneath. This log connected the two horizontal beams in the middle, and therefore supported the upper one in the centre. From the point at which this vertical meets the lower horizontal beam two struts rose, one on each side, which met corresponding struts from the ends of the lower horizontal beam in the centre of the two halves of the upper horizontal beam, and thus supported the upper beam in three different places, besides the support at each end, and divided the upper horizontal beam into four equal parts. Above the centres of the two divisions of the upper horizontal beam vertical logs were placed, carried to such a height that their upper ends met the cleading on which the arches were laid. On the side of these uprights next the piers a strut was placed, so as to give an intermediate support to the arch between the ends of the upper horizontal beam and the ends of the verticals above it. From the centre of the upper horizontal beam five struts rose in the form of a fan, giving a good support to the crown of the arch. This framing formed the whole support of the arch, and timbers cut to the exact form of the arch were fitted to it in the usual manner. On this the cleading was fixed, which consisted of planks 3 inches thick. The centres of the small arches were of a more simple construction, consisting of a horizontal beam at the level of the springing, from the centre of which six struts spread in the form of a fan, to which the timber, cut to the form of the arch, was bolted, and above this, which constituted the whole framing of the rib, the cleading was laid in the same manner as was explained for the larger arches. It may be mentioned that the principle kept in view in framing the centering of the necessary strength, was to cut up the timber as little as possible.

Manner of Execution of the Work.—The pier and abutments were built to the height of 25 feet above the ground with derrick cranes; above that level a service road was used, which was laid on the first tier of walings which tied the uprights together; on this service road a tramway for the carriage of stone was placed, and a rail on each side of the bridge, by which the travelling crane was worked. At first the tramway was placed 27 feet above the level of the bed of the river; the pier and abutments being finished to that height it was lifted 30 feet, and the piers were completed to their full height; the road was then raised to that level and the whole work was completed except the parapet. Six horses performed all the carriage of the stones, and two masons set all the ashlar of the piers and arches. The large arches were all completed in nine weeks after commencing to throw them. The whole work was completed without any accident except one, viz., a man who was employed on the work, lost his balance and fell about 80 or 90 feet, and died soon after the accident.

This noble specimen of railway architecture contains the immense quantity of 500,000 cubic feet of masonry; the weight of which is about 33,500 tons. The total cost has been about £30,000, the expense of the centering being about £4500.

General Principles of Construction.—Having now completed the description of this viaduct, it may not be uninteresting to those unconnected with the engineering profession, to give an outline of the general principles which guide the engineer in the execution of such works as the Lugar viaduct. It is not intended, however, in this place to enter into any discussion on the mathematical formulæ which treat of these subjects, but merely to state what is generally considered before designing such a work, so that it may be suitable in design for the situation and uses for which it is intended. The general object in building a viaduct is to obtain a convenient, and if possible permanent, communication across some river, valley, or other obstacle.

Position.—The first point to be considered is the position in which it should be built, so as to interfere as little as possible with any existing roads, &c. The position, however, in a railway is to a certain extent fixed, as it is not always possible to deviate much either in line or level.

Material.—The next point to be taken into consideration is the material. If the building is to be permanent it is best to procure such material as is not easily affected by either weather or heavy traffic. Stone has the superiority over either wood or iron ; the former being only durable for a fixed number of years ; the latter having the same quality, with the additional objection that the time when it is unsafe is not easily determined. The stone should, if possible, be of a good hard texture, and procurable in large quantities of the same colour.

General Dimensions.—The site and material being fixed, the next subject to be considered is the form best adapted to the situation and the nature of the foundations. This is a point of material consequence in the execution of such a work as the Lugar viaduct.

Foundations.—The foundation should either be laid on firm ground, or such artificial foundations formed as are most easily executed and most conducive to the stability of the work and prevent settlement. The great difficulty is not so much to prevent settlement as an unequal sinking. This is done in many ways : usually by clearing away all soft and compressible matter, and filling the space with masonry or concrete.

Piers.—The piers, having for their object the support of the weight of the arches and the thrust which they exert, must be of such dimension and weight that the thrust of the arches shall not be able to overturn them, and of such a sectional area that the pressure of the arch shall not be able to crush the stone. In the case of the Lugar viaduct, the pressure occasioned by the weight of the arch on the top of the piers is 1000 tons, equal to 2,240,000 lb. The area of the top of the wall is 160 feet, therefore the pressure is 14,000 lb. per square foot.

Quoins.—Piers are sometimes strengthened at the corners by quoins of ashlar, the rest of the pier being made out of an inferior kind of masonry. These beds receive a direct vertical pressure, having horizontal beds, and bind the rest of the masonry together.

Abutments.—The abutments having to receive the weight of the bank on the back, as well as the thrust of the arch on the face, ought to be of such a strength that the abutment would support the arch of itself, without the aid of the pressure of the earth, so that, if any space should exist between the bank and the wall, the abutment may be perfectly secure. There are many ways of strengthening abutments, viz., by continuing the arch through the abutments down to the earth, and thus making the arch abut from the earth, but supported also by masonry in the form of an abutment, as is often done. The most generally adopted plan is to have an abutment wall for the arch, and a wall to receive the bank, tied together by longitudinal walls, which are again sometimes tied by cross walls. By this plan equal strength and greater facility for construction is obtained than by any other method. The cause of the increased strength obtained by this method is, that the centre of gravity of the abutment is moved to a greater distance from the point on which the abutment would turn if it were falling, than if it were built in one solid wall of the same cubic contents as an abutment on this plan. The abutment would turn on the edge next the embankment, therefore the weight ought to be increased near the arch ; at the same time the longer the abutment is, the more leverage is obtained to resist the thrust of the arch. The greatest allowance, however, must be made, as the masonry is not of the same firmness or density as a uniform mass of stone.

Imposts.—The imposts or springing stones are used to communicate the pressure of the arch to the piers or abutments, and ought to be of such dimensions as to communicate the pressure to such an area as may sustain the weight and pressure of the arch.

Pilasters.—Pilasters are adopted, not only for the effect which they produce on the appearance of the viaduct, but that their weight and strength may act like buttresses, and strengthen the abutments to which they are added.

Arches.—The best form of arch for general purposes is a semicircle, from having the advantage of great solidity and easy construction. In a semicircular arch, it is well known that the pressure is not transmitted through the voussoirs at right angles to the joint, but by a certain curve called by most engineers the line of pressure. This curve must fall within the voussoirs at every joint, and if the thickness of the arch is so small that it will not contain the curve of itself, that arch must be so weighted to make it contain the curve. A semicircular arch would, if not supported by anything but its abutment, require the archstone to be $\frac{1}{9}$th of the diameter of the arch in depth. This, it will be easily seen, would not do in practice; the viaduct which we have described would require to be 5 feet 6 inches deep in the voussoirs, whereas they are only 2 feet deep. To effect this, the arch is loaded in such a manner that the curve of equilibra falls always within the arch. In the Lugar viaduct, it does not deviate above an inch or two from the centre line of the voussoirs. An arch to stand must conform to three rules: 1*st*, That the curve of equilibrium must always fall within the voussoirs; 2*d*, That it must not cut any of the joints at a greater angle than the limiting angle of resistance of the material to slide; 3*d*, That the pressure of the load with which the arch is weighted must not exceed the pressure which the sectional area of that joint is capable of bearing. In the case of the Lugar viaduct, the horizontal pressure on the keystone, for the whole breadth of the arch, is about 560,000 lb. The area to which this pressure is applied amounts to 8064 square inches, or about 70 lb. per square inch. If we examine the mathematical formulæ connected with the curve of equilibrium, we shall find that in a semicircular arch, the pressure at the springing, or the load on the arch, would require to be infinite; but it must be borne in mind that that part of the arch which lies within the line of the face of the abutment is not an effectual part of the arch, but merely acts as a curved impost from which the segmental arch springs. It is therefore only necessary that the curve of equilibrium should fall within the joint at that place to insure stability. In general cases arches have a tendency to sink at the crown and rise at the haunches. From this it is clear that the extrados at the crown have a greater pressure exerted against them than the intrados, and *vice versa* at the haunches the intrados have more pressure against them than the extrados. Thus it is only a certain part on each side of the line of pressure that can be considered the effectual part of the arch. The archstone ought to be chamfered on the soffit. By this means the arch is not so apt to splinter on the edge. The ringpens ought to project beyond the spandril walls for the same reason. The archstones are generally made to get thinner as they approach the crown. This is done so that the curve of equilibrium, which runs more horizontally at the crown, may be able to change its direction frequently, so as to make the pressure as nearly as possible in the true curve of equilibrium.

Superstructure.—These, then, are the general principles on which an arch is constructed; it is only necessary to distribute the material over the arch in fixed proportion, and to carry up walls to carry the roadway and confine the road, and form a level platform at the top. This is done by the erection of the outer and inner spandrils, cross walls, flagging, &c., on which the road is laid; parapets are then built to protect the road.

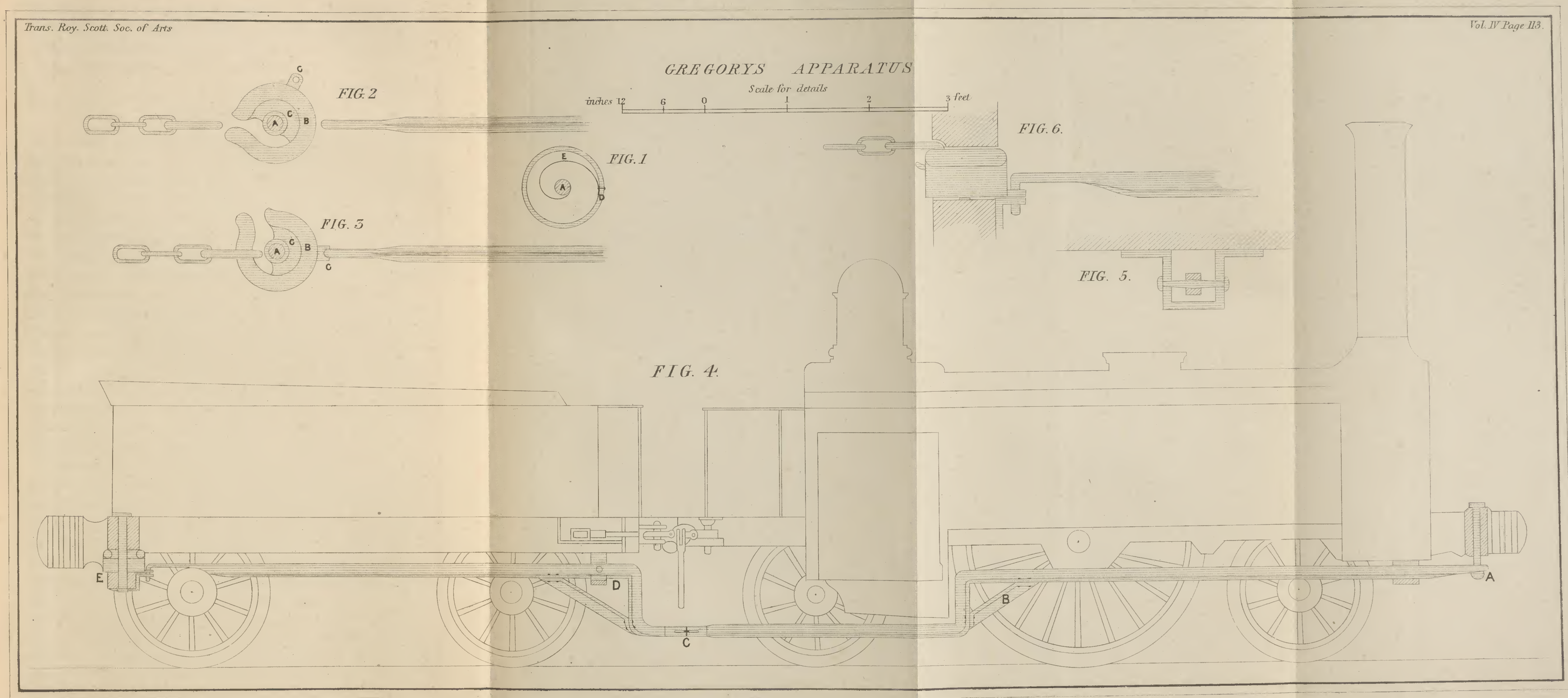
Decorations.—The decorations of a bridge are of course left to the taste of the designer, but even in these he ought to be guided by the nature of the building, the most suitable for one building being decidedly inappropriate for another. The decorations of the Lugar viaduct are simple and plain, the most suitable for such a work, where general appearance, good proportion, utility, boldness of design, and massiveness, rather than minuteness, being the chief feature.

Centering.—In the framing of a centering, it is necessary that the lower part should be able to sustain without any appreciable movement the lateral pressure of the arch, and the upper part the vertical weight of the arch stones. The centering of the Lugar viaduct, though very simple in the framing, answered the purpose very well. The centres of the small arches were still more simple, but they also succeeded very well.

Having now given an account of the Lugar viaduct, of the manner in which it was executed, and the general principles which guide the engineer in the design of such works, it is only necessary to mention, that, in the designing of a building of this description more practical than theoretical knowledge requires to be brought into play, and every point fully considered in a practical manner; for though mathematicians have laid down rules, deduced from theories in which the most delicate formulæ are used, yet it is found that works often succeed, though they may differ very much from the deduction of theory. In fact, in many cases, a much greater latitude is allowed by the most eminent engineers of the day than what theoretical deduction seems to justify. For, according to Gauthey, the key-stone of an arch ought to be $\frac{1}{28}$ of the span, added to 1′ 3″ in the case of a 50 feet arch; Perronet says $\frac{1}{24}$ of the span; Palladio and others $\frac{1}{15}$ and $\frac{1}{12}$; whereas the Lugar viaduct is only $\frac{1}{25}$; (see Cresy, Encyclopædia of Engineering, page 1495.)

March 17, 1851.

PLATE XVII



Trans. Roy. Scott. Soc. of Arts
Vol. IV Page 113.
GREGORYS APPARATUS
Scale for details
inches 12 6 0 1 2 3 feet
FIG. 1.
FIG. 2
FIG. 3
FIG. 4.
FIG. 5.
FIG. 6.
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Description of a Self-Acting Apparatus for Disconnecting the Carriages of a Railway Train from the Tender, upon the Engine leaving the Rails. By Thomas C. Gregory, Esq., C.E., Edinburgh.* (With a Plate.)

THE SOCIETY'S SILVER MEDAL AND PLATE, VALUE TEN SOVEREIGNS, AWARDED 1851.

The object of this invention is to produce an instrument, that may be the means of preventing many of those serious accidents that happen in railway travelling. The contrivance is simple and, it is hoped, efficient. The engine, on leaving the rails, proceeds at an angle to its previous course, and, unless the impetus previously acquired be sufficiently checked, it eventually either dashes over an embankment or buries itself in a bog. The chains that couple the tender to the train sometimes break; but the force exerted in so doing is so violent as to dash the carriages to the one side or the other, causing their destruction. If the chains remain unbroken the carriages follow the engine, and in their downward course fall and crush one another to pieces, frequently causing an enormous loss of life. By the contrivance to be described, the carriages are insensibly detached, and they proceed on their direct course, until stopped by the roughness of the bent rails or by the break applied by the guard.

Drawing No. 4 (Plate XVII.) represents the longitudinal section of an outside cylinder engine, having the apparatus attached and shewn in elevation. The lever A B C D E runs along the centre of the engine and tender, and is hung to the engine by a bar through the buffer-board at A, and to the tender at D by a strong tray, which also bears the fulcrum. At A there is a round nut, on which the lever may rest and turn easily. The lever is made of wrought iron with a ⊥ section, $3\frac{1}{2}$ inches deep, and $2\frac{1}{2}$ inches broad in the flange. At B and D are cross ties, which tend materially to stiffen the lever, and are necessary from the length from A to D unsupported. Near A there is a strong tray to relieve the stress

* Read before the Society, January 27, 1851.

on the bar from which the lever hangs. That the engine and tender may be separated the lever is cut at C, and iron welded to the cut ends. The one end is solid and the other hollow. The two parts fit nicely, and to allow for the play between the engine and tender, there is an opening left, in which a pin is placed, and kept from falling out by a cross pin. Near the junction a chain or tray will require to be hung on the engine, to support the lever when it is disjoined. At the extreme end of the lever, iron is welded into the form of a hook, which passes through a stud on the box at the back board of the tender, and keeps the box in position.

Drawing No. 5 is a representation of the fulcrum. It consists of an iron bar, 6 inches long, passed through the sides of a strong iron tray which is attached to the bottom of the tender. The bar is conical, tapering from the middle both ways, for a reason to be hereafter explained.

Drawings Nos. 2 and 3 represent the plan of the box. No. 1 is a section, shewing the spring. A is a strong iron bar, $2\frac{1}{2}$ inches square, run through the back board of the tender, which, owing to the level of the lever in this case, is increased in depth, and also in thickness. There is a space cut out of the board to admit the box, and, on account of the disparity between the thickness above and below, the bottom is strengthened by an iron plate. The bar is immoveable, and is secured at the top and bottom by nuts. The part round which the box revolves is turned $2\frac{1}{2}$ inches in diameter. B is a round bar, $2\frac{1}{2}$ inches thick, forming the top rim of the box, and to which the carriage hook is attached. There is an opening in it of sufficient dimensions to allow of the hook falling out when required without tension. The inside of the rim exposed to the cutting of the hook is well steeled. C is a plate fixed to the middle of the rim, and having the $\frac{1}{2}$ inch next the centre-rod considerably thicker than the rest. It is this rim on the bottom plate that carries the weight of the box, and on which it turns. The disc is not complete on the top of the box, as space must be left for the hook to slip out. E is the spring; one end is attached firmly to the centre rod, which is immoveable, and the other end to the side of the box, so that when the box is turned in opposition to the spring, and let go, it will revolve. The strength of the spring must be determined by experiment. The box is of cast iron, and one foot in diameter. Drawing No. 6 is a side view of the box, with carriage-hook and lever attached.

In order to charge the instrument the box must be turned, before the engine and tender are joined, from the position shewn in Drawing No. 2, where the spring is inactive, until the stud G is brought under the end of the lever. The hook of the lever is run through this stud, and also through a bar of iron attached to the buffer-board. The intention of this bar is to keep the lever steady, and prevent any action on it by the spring. The junction at C is then effected. The carriage-hook is attached, and the engine starts with its train. As long as the front wheels of the engine are on the rails, the level of the lever at A is unchanged; but whenever they leave the rails, the end at A falls with them, and, the lever turning on the fulcrum, the back end consequently rises out of the stud, and releases the box. The spring recoils, and the box returns to its original position, as in Drawing No. 2, when the carriage-hook falls out, and the train is detached. The hook may be prevented accidentally falling out by a heavy weight hung to the middle of the chain, which would descend when the chain slackened, and thus retain the hook in its place.

By the intervention of the box the whole weight of the train is thrown upon the bar passing through the buffer-board, and round which it turns. Without some such intervention no lever could stand the great stress which would be constantly upon it; and, besides, having the weight of the train upon it, at the moment of action, it would be bent, or the fulcrum torn off ere action could take place. In this mode of construction the lever has never any stress upon it. On account of the sudden check that the motion of the engine gets by going off the rails, the carriage chain is sure to slacken a little, so that the spring will have, for the moment, little or no resistance to overcome.

As to the fulcrum.—When the engine and tender come on to a curve, there is a lateral motion of their junction line to the outside of the curve. On an eight chain radius curve, which is sometimes adopted at the entrances to engine-sheds, &c., the motion will not exceed 2 inches. The lever is a rigid body, and consequently allowance must be made for this motion. The fulcrum is attached firmly to the bottom of the tender, and the lever hung on a cross pin, allowing a play of 2 inches ; so that as the fulcrum moves to the one side with the tender, the lever may be unbent. As the face line of the tender will alter its perpendicularity to the straight, there will be a slight variation of the line of the fulcrum to the lever, and to prevent any twist the pin is tapered from the middle to the ends. It is presumed, that the expense of fitting a new fulcrum to the tender, in case of its being torn off by the engine after it has left the rails, would be quite a trifle, compared to the other damages sustained, so no provision is made for its preservation, or of that of the lever. This could be attained by hanging the fulcrum by a swivel pivot sliding between two guides. The back end of the lever, when released, would then be enabled to move to the one side or the other to a considerable extent.

There is one more point to be taken into consideration, viz., The liability of the instrument to be discharged by the variations in gradients ; and in order to put the instrument to a severe investigation, let us take an extreme case.

It may be premised, that the delicacy of the instrument may be reduced to any amount by lengthening the hook at the end of the lever. The proportion of the lever is 2 to 1. That part below the engine being 22 feet, and that part below the tender 11 feet. When the front wheels of the engine leave the rails, they are likely to sink in the ballast to the bottom of the sleeper, a depth, in most cases, of about 11 inches ; but to err on the safe side, say only 9 inches. Then the fore end of the lever will fall to that amount, and the back end will rise $4\frac{1}{2}$ inches. A hook of this length from the top face of the stud would, in this case, just disengage the carriage-hook.

Let us now see if there are any chances of the hook rising this amount without the engine being off the rails. Suppose the engine on a falling gradient of 1 in 75, and the tender on a rising gradient of 1 in 75, the change of gradient being at the point of junction. By the depression of the front of the engine of about $3\frac{1}{2}$ inches, the back end will be raised $1\frac{3}{4}$ inches. Add to this the depression of the back end of the tender of $1\frac{3}{4}$ inches, and we have a total rise of the hook of $3\frac{1}{2}$ only. Take this from $4\frac{1}{2}$ before determined, and we err an inch on the safe side. We have assumed a case that never occurs. Though two rising and falling gradients of 1 in 75 were in existence, still the change would not be so abrupt as has been assumed above, for it is found expedient to take off the angle and sweeten the gradients into one another.

When the engine goes off the rails the flange has to pass over the rail, and consequently the hook will be depressed about $\frac{3}{4}$ of an inch, to allow for which the bend is above the level of the box-stud to that amount.

From the above considerations, we determine that a depth of hook of $3\frac{1}{2}$ inches from the top of the stud would be sufficient, with every regard to safety. The instrument would then act when the engine had fallen to the depth of 7 inches, or little below the top of the sleeper.

Report of Committee of Royal Scottish Society of Arts, on Mr Gregory's Apparatus for Disconnecting the Carriages from the Tender, on the Engine leaving the Rails.

The present Committee, in reporting on Mr Gregory's improved "method of disengaging the carriage from the tender, on the engine leaving the rails," have to refer to their report on the original paper. In that report they expressed doubts of the efficiency of the lateral disengagement there proposed, as arising from the too delicate adjustment of the parts that kept up the connection between the carriage and the tender. On this point, the most important in the arrangement, the Committee are happy to observe that Mr Gregory has effected the design of a most decided improvement. This he produces by changing the lateral to a vertical disengagement, and in doing so he obtains equally, if not more, certain means of self-action to effect the disengagement, and at the same time removes the objection expressed by the Committee to the original mode, by which it appeared to them that the carriage might be disengaged, at any moment, by even a casual jolt. By the new arrangement such a disengagement cannot take place, so long as the engine and tender keep the rails; while the instant the engine departs from it, and the leading wheels fall below the level of the rails, disengagement will follow.

Mr Gregory seems now to have viewed the subject in all its bearings, and his demonstrations leave little room to doubt the efficient action of this apparatus for the intended purpose. Some modifications may be found necessary on applying it to actual practice, but the Committee now view the proposed mode as likely to afford satisfactory results, and therefore beg to recommend it to the special notice of the Society.

JAMES SLIGHT, *Conv*[r].

EDINBURGH, 25*th June* 1851.

SANG'S PLATOMETER,

OR SELF ACTING CALCULATOR OF SURFACE.

Fig. 5

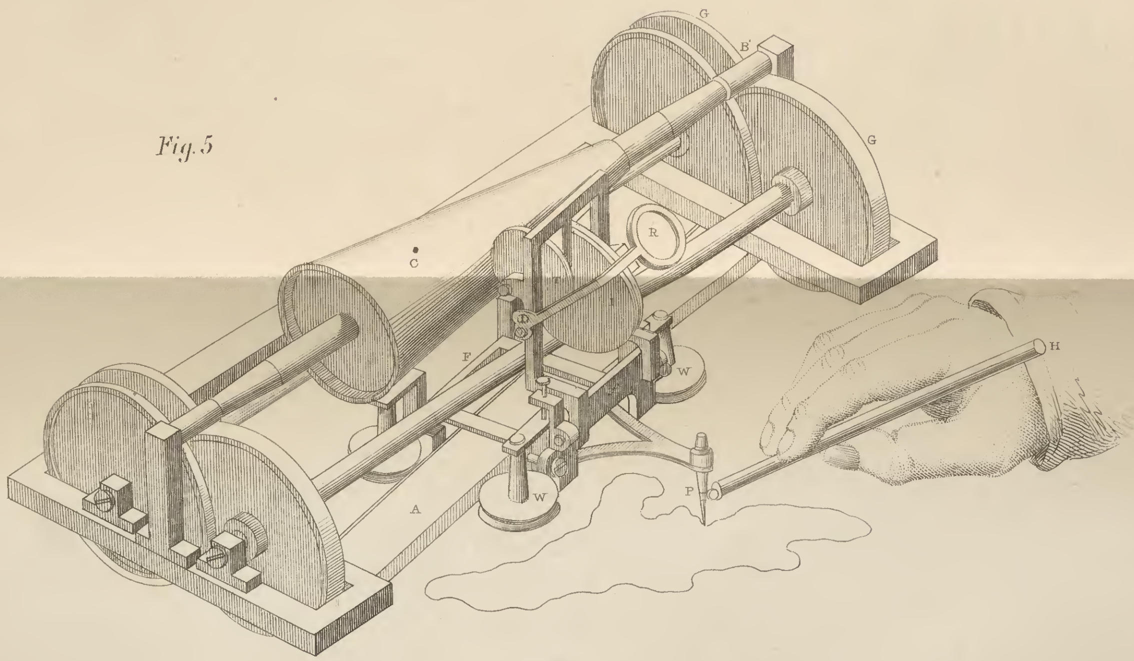
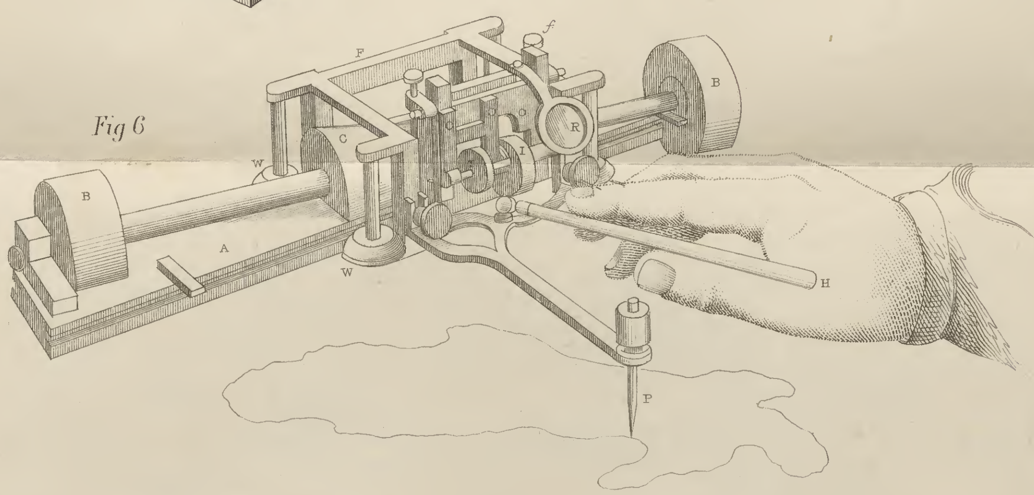


Fig 6

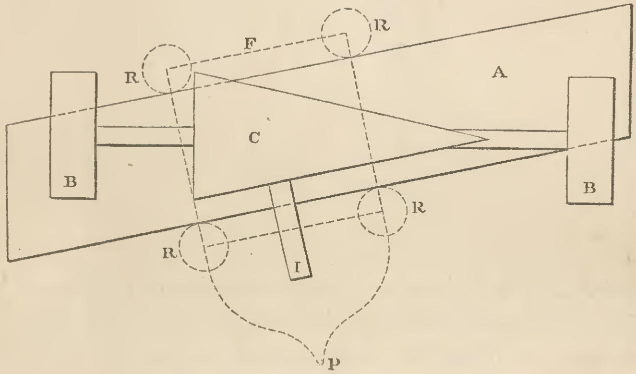


S. Leith, Edin.r

Description of a Platometer, an Instrument for Measuring the Areas of Figures drawn on Paper. Invented by JOHN SANG, Kirkcaldy.* (With a Plate.)

The instrument consists of a cone C (fig. 1), on the axis of which are fixed two wheels B B, which roll over the paper. The wheels are of equal diameter, so that the cone is carried forward or backward in a straight line, as is also the frame A, in which the axis of the cone is geared. The frame A

Fig. 1.

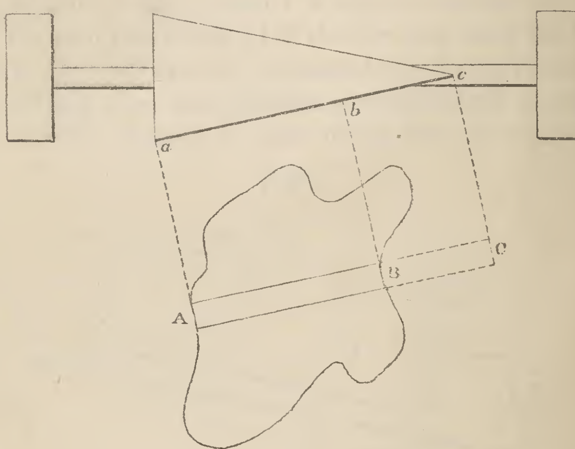


has its edges fitted to receive the friction rollers R R R R, which carry another frame F in a right or left direction parallel to a side of the cone. The light frame F carries with it an index-wheel I, the circumference of which is kept in contact with the cone by means of springs or weights, and it also carries the tracing point P. When the tracing point is moved to the right or left, the index-wheel slides along the surface of the cone without revolving. When the tracer is moved forwards or backwards, the wheels roll over the paper, and the rotatory motion which they give to the cone is imparted to the index-wheel. When the tracer is moved in any intermediate direction, the index-wheel receives both a rotatory and lateral motion.

* Read before the Society, and Instrument exhibited, 12th January 1852.

It will be seen that, from this construction, if the point P be conducted completely round the boundary of any figure, the motion which the index-wheel receives will be proportional to the area of that figure.

Fig. 2.



Let A B (Fig. 2) be a very narrow section of the figure, having its sides parallel to the sides of the cone, and let *a b* be the points at which the index-wheel touches the cone when the tracer is at A and B; also, let C be the point at which the tracer would be found if the index-wheel were brought to the apex of the cone *c*. The distance A B = *a b* and B C = *b c*. But while the tracer moves over the short line A, the cone makes an angular motion proportional to the length of that line, and, at the same time, the circumference of the cone at *a* moves through a distance proportional to that angular motion multiplied by its diameter at that place, which again is proportional to A C, the distance of *a* from the apex of the cone. If S were the breadth of the section A B, the motion of the circumference of the cone at *a*, and hence of the index-wheel, would be proportional to A C × S. In like manner, when the tracer, in making its circuit round the figure, moves over the short line B, the motion of the index-wheel would be proportional to B C × S. That motion, however, would be in a contrary direction, so that the sum of the two would be

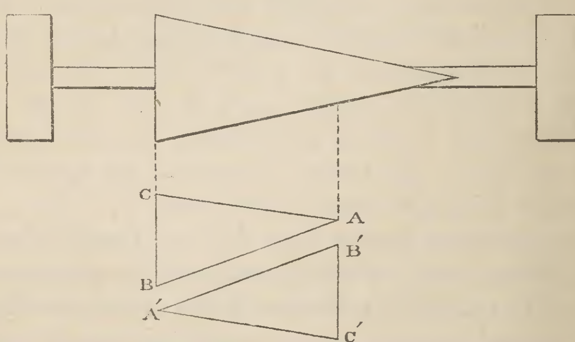
$\overline{\mathrm{A\ C}} \times \mathrm{S} - \overline{\mathrm{B\ C}} \times \mathrm{S}$, which is equal to $\mathrm{A\ B} \times \mathrm{S}$. But $\mathrm{A\ B} \times \mathrm{S}$ is also the area of the section A B. The same thing would hold, however narrow the sections were conceived to be, for every other section of the figure ; and, consequently, the motion of the index-wheel gives a quantity proportional to the whole area when the tracer is carried completely round the boundary of the figure. The divisions of the index-wheel are so arranged, that when the section A B is one square inch, the wheel indicates one.

From this, the details of the machine will be easily understood. The index-wheel must move along the line in which a plane, parallel to the paper, and passing through the axis, intersects the surface of the cone. Hence, the wheel is placed on a third light frame *f*, provided with adjusting screws (Figs. 4, 5, 6), by means of which it can be brought into that position ; and the diameter of the wheel is such, that a whole revolution indicates an aliquot part of 100. In the case of instruments Nos. 1 and 3, a revolution values 20 inches, in No. 2, 10 inches. In order to carry on the indications to 100 square inches, a second index-wheel T, of the requisite diameter, receives motion from I. The reading-glass R is placed, always ready, over the vernier of the divisions of the wheel. The handle H is attached to the instrument by means of a universal joint, in order to assimilate the effort necessary to move the tracing point, as much as possible, to that required to guide a drawing-pen. The weights of the parts are also so arranged that the tracer just slightly presses on the paper without scratching it.

As the sides of the figures which the instrument is intended to measure do not always lie in the direction A *a*, or A B, but in any direction taken at hazard, the index-wheel, while it is receiving its motion from the cone, may, at the same time, be continually altering its distance from the apex. It might be expected that the sliding along the cone would prevent the wheel receiving the whole rotatory motion due to it. But, on a little consideration, it will appear that the fineness of the divisions of the index-wheel does not in the least depend on the diameter of that wheel, nor on the obliquity of the cone, but solely on the distance between the apex of the cone and that part of it which has a diameter equal to the rollers. Hence the obliquity of the cone may be selected as that on which the retardation might be expected to be least. From considerations of this nature, which it would be too tedious to go into here, the obliquity of the cones in these machines was fixed. On constructing them, the retardation was found not to be great, and indeed to be smaller than was expected, but it is still so considerable that it must be taken into account.

If the triangle A B C (Fig. 3) were of such a form, and were placed under the instrument in such a manner, that A B was parallel to the edge, and B C perpendicular to the axis of the

Fig. 3.



cone, the motion which the index-wheel would receive while the tracer was carried along the sides A B and B C, would be the whole due, and it would be forward or positive ; but while the tracer was carried along C A, the motion of the index-wheel, on account of the retardation, would be less than that due, and it would be backward or negative. Thus, the positive motion would be enough, and the negative motion too small, or the instrument would indicate too much. On the other hand, if the triangle were turned round exactly 180°, so as to have the position A′ B′ C′, the revolving motion of the index in passing over C′ A′ would still be too little, but it would be on the positive quantity, while that on A′ B′ and B′ C′ would be enough, but on the negative quantity. Hence the instrument would now indicate too little ; the true area of the figure would be half the sum of the two indications. And it will be found that this would be the case in whatever other two positions, differing from one another 180°, the triangle were placed. In using the instrument, therefore, two circuits round the figure are necessary, and the mean of the indications is to be considered as the area. In general, the fewer sides the figure has, the greater will be the difference between the two parts of this mean; and the more wavy and irregular the outline, the nearer the truth will the indication from a single circuit be. The severest test of the instrument is in a triangle placed as in figure 3.

In order to test the practical value of the instrument as to accuracy, the following method was taken:—A figure in an estate plan was divided into triangles and trapeziums, and measured by a scale and calculations. The calculations were carefully revised, and the area was found to be 19·51 inches. The dividing lines were then obliterated, and by means of a new set of lines, measurements, and revised calculations, the area was found to be 19·56 inches. The difference ·05 is an indication of the degree of accuracy obtained. The platometer was then applied to the figure; the first result was 19·52, and on turning 180°, 19·54—mean 19·53; on being applied in another direction, 19·57, and turning 180°, 19·59—mean 19·58. The difference between these is ·05, the same as in the scale measurement. The result of the measurement of fourteen other figures in the same manner was—

	By Scale.	By Instrument.
Sum of the means of each pair, .	112·425	112·730
Sum of the differences of each pair, .	·51	·38
Greatest difference, . . .	·09	·07
Least difference, ...	·00	·00

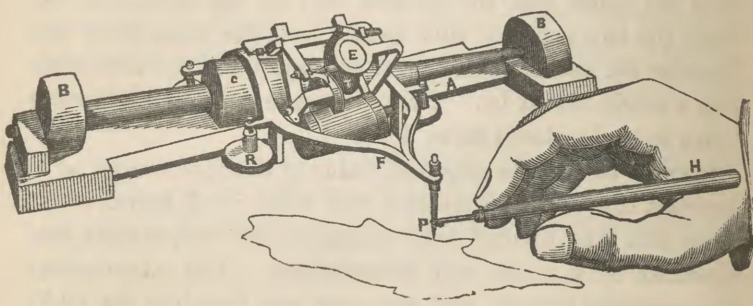
This experiment indicates the accuracy of the instrument to be considerably more than the scale. The difference between 112·425 and 112·730 does not point to the relative accuracy of the two methods; it only shews that the scale used was a little longer than the standard inch to which the platometer was adjusted.

I hope to be able to exhibit a more complete set of tests along with the instruments, and also by the favour of Captain

James, R.E., to lay before the Society a table shewing the performance of the instrument used in the Ordnance Survey Office.*

The platometer, No. 1. (Fig. 4.), is the first model, and was

Fig. 4.



in the Great Exhibition. No. 2. (Fig. 5.) has the cone raised up on additional wheels G G, in order to allow the rollers B′ B′ which correspond to the wheels B B in the other instruments, to be made of smaller diameter. In consequence of this the divisions are larger, one square inch being represented by about ·8 lineal inch. The figures on its toothed wheel give tens of inches; on the silvered wheel tenth parts of inches; the divisions give hundredth parts, and the vernier thousandth parts of a square inch. Nos. 3, 4, and 5 (Fig. 6) are the last-made instruments. They differ from No. 1. in the details. The second index-wheel is toothed, and the handle is placed near the body of the instrument, to allow of

* On this point the Editor has been favoured with the following note from Captain James, R.E., who, as superintending officer of the Ordnance Survey in Scotland, has had unusual opportunities of forming an opinion as to the relative advantages of different methods of measuring areas :—

"GRANTON, 8*th June* 1853.

"From the experience I have had of Sang's platometer, I have no hesitation in pronouncing it a very valuable instrument for obtaining the areas from plans; and it has the peculiar advantage, that it gives the areas of the most irregular figures with the same accuracy that it gives the areas of the most regular, and with the same facility.

"The precautions to be taken in using it are, to see that the table on which it is placed is perfectly steady, and perfectly level."

the tracing point being brought farther out without flexure in the parts of the frame to which it is attached. These instruments, although not so minute in their divisions as No. 2, are, I believe, of the preferable form, on account of being more portable; and also, because they do not require a great degree of exactness in the plane on which the paper is laid. The numbers on the toothed wheels in these give tens of inches; on the silvered wheel inches; the divisions give tenth parts, and the vernier hundredth parts.

In order to use the platometer, let it be placed over the figure, so that it may command every part of it. If the figure be too large, divide it into two parts by a pencil line. Bring the tracer as near as convenient to the left-hand side of the figure, and make a mark. Read the index. Then carry the tracer round the boundary, proceeding in the *sun* direction, until the mark be again reached. Read the index again, and subtract the first reading from the last. Turn the instrument round 180°, and repeat the operation. The average of the two results is the area of the figure. In going over straight lines, a ruler may be used as in drawing.

KIRKCALDY, *24th December* 1851.

Description of Plate XVIII., *Fig.* 6.

A, a heavy brass frame carried over the paper in a straight line by means of the rollers B B.

B B, two rollers of equal diameter attached to an arbor which works in the frame A.

C, a cone fixed on the arbor of the rollers B B.

W W, four friction-wheels which roll in grooves cut on the edge of the frame A, and are centred in the frame F.

F, a light frame moving to the right and left along the frame A, and carrying the index-wheel.

I, the index-wheel attached to the frame F, the edge of the wheel being kept in contact with the cone by means of two springs not seen in the drawing. It is divided on silver by lines into spaces representing square inches and tenth parts; and further, by a vernier, into hundredth parts.

f, screws for adjusting the height of the index-wheel.

R, a glass for reading the divisions of the index-wheel.

T, another index-wheel toothed, driven by a pinion on the arbor of I. The edge of this wheel is divided into spaces, each representing 10 square inches.
P, the tracing point, firmly fixed to the frame F.
H, handle attached to the frame F by a universal joint.

The same description applies to Fig. 5, except that

G G, are a pair of rollers centred in the heavy frame A, and acting as wheels, on which the whole instrument may be moved backwards and forwards over the paper in a straight line.
B, two cylindrical surfaces on the arbor of the cone C, receiving motion from the rollers G G.
I, the index-wheel divided by lines into inches, tenths, and hundredth parts, and by a vernier into thousandth parts.
P, the tracing point attached to the light frame F by centre points not seen in the drawing, so that it may be lifted up a little from the paper.

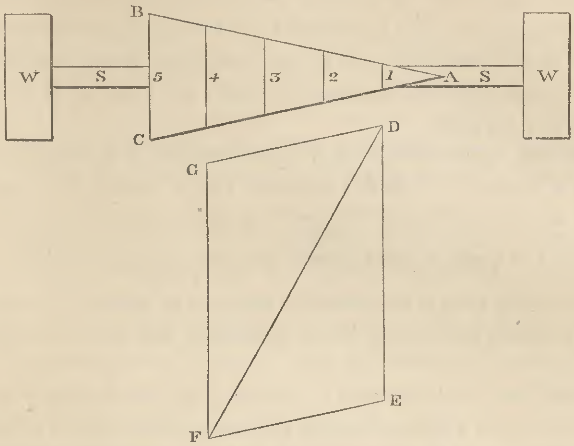
Report by Committee of the Royal Scottish Society of Arts, appointed to examine and report upon the Platometer, an instrument for measuring Areas of Figures drawn on Paper. Invented by Mr John Sang, Kirkcaldy.

Your Committee have much pleasure in bringing up their Report on this most ingenious and beautiful instrument, so creditable to the inventive genius of Mr Sang, and so useful in its application to the purposes for which it has been constructed.

The instrument having been so recently exhibited to the Society, it is not necessary to enter into any detailed description. It will be sufficient to mention that the leading feature of it is the employment of a cone acting on an index-wheel, from which is read off the area of any figure whose outline has been followed by the tracer of the instrument.

The employment of a cone as a multiplier, is no less simple than ingenious; and when the idea was conceived, it was easy to fix upon the proper proportions, so that the number of revolutions of the index-wheel in relation to those of the moving wheels and of the cone, being always directly in proportion to its distance from the apex of the cone, the area of the figure would be indicated.

A simple diagram will at once illustrate the action of the instrument, and the principle upon which it is constructed—



Suppose a cone A B C mounted on a spindle S S, having two wheels W W, the circumference of the cone at its base B C being 5 inches, and the length to the apex A also 5 inches; the circumference at any intermediate point being of course equal to the distance of that point from the apex; the wheels W W are also 5 inches in circumference. Suppose also that the index-wheel when in contact with the cone at the point 1, which is 1 inch from apex, and consequently 1 inch in circumference, was so constructed that it would indicate 5 inches by one complete revolution of the one.

We are now in a position to ascertain by the instrument the area of the parallelogram D E F G, which we will suppose to be 5 inches on the longer sides, and the perpendicular 3 inches, having therefore an area of 15 inches.

The tracer being placed at D, with the index-wheel in contact with the cone at 1, it is passed over the line D to E, the distance being 5 inches, the travelling wheels, and consequently the cone, would make one complete revolution, and the index-wheel would read 5 inches also. The tracer is then passed along the line E F, which being parallel to the side of the cone, no revolving motion is produced, and the index-wheel also remains stationary. The line F G is next traced, which, being also 5 inches, the wheels and the cone make one complete revolution; but during this operation the index-wheel is in contact with the cone at 4, where the circumference is four times what it is at 1; the cone will therefore move the index-wheel through four times the space, or 20 inches. But it is to be noticed that the motion of the index-wheel in passing over the line F G, is in the opposite direction to what it was in passing over D E, so that the previous reading of 5 inches is deducted from the 20,—the reading at G will therefore be 15 inches. The tracer is then passed from G to D, but as this line is also parallel to the cone, the reading on the instrument remains at 15 inches, which is also the area of the figure.

If the area of the triangle, D E F, was required, it is evident that the reading at F would be 5 inches as before, and in passing the tracer from F to D the index-wheel would receive a motion, which is the mean between what it would be from D to E and from F to G, or $\frac{5+20}{2}=12\frac{1}{2}$; but the reading D to E would also in this case be deducted, which would leave $7\frac{1}{2}$ inches, the reading on the instrument, and also the area of the figure.

Mr Sang has explained how he obviates any errors arising in using the instrument on a figure—such as this last—where there is retardation of the index-wheel by the compound sliding and revolving motion in passing over the line F D. This is done by simply turning the figure to be traced right round, and again going over the operation, the mean of the two readings being the correct result.

Since the subject was last before the Society, a wish has been expressed that your Committee should endeavour to ascertain the nature of the Tuscan and French instruments, exhibited in the Great Exhibition, for a similar purpose as the instrument now under consideration; more particularly as there appeared to be an impression on the minds of some of the members that there was an identity of principle between it and instruments in use in France.

Your Committee thought it due to Mr Sang that these surmises should be communicated to him, and the following was the answer received:—

"I am sorry that I am unable to inform you whether or not the statement referred to in your letter be correct. I was informed when in London, by one of the jury, that he had been told there was an instrument in the Exhibition on somewhat the same principle as mine, but that he had not seen it. The juryman who was appointed to try the working of these machines told me that besides those of Professor Gonella's construction there was no other, and that there were none on the same principle as mine.

"As I felt interested in the matter, I went afterwards to the convener of the jury, who said that he did not think there was any instrument on the same principle as mine, but he promised to write me if, on looking over his notes, he found that there was. He never wrote. A very intelligent gentleman, who had the charge of one of Gonella's, assured me that there was nothing of the sort, but that there was a dynamometer acting on somewhat the same principle, which I saw.

"As this took place after the juries had made up their reports, I left London fully in the belief that there was no instrument in the Exhibition like mine; and as, through the favour of Colonel Reid, I had obtained the means of trying the others, and found (*as I thought*) my own to be the best, I had on returning home a number of them made for sale."

None of the members of your Committee having seen the foreign instruments, and not knowing any one who had, they thought it right to communicate with Mr Digby Wyatt, secretary to the Exhibition, but he was unable to furnish any information to guide your Committee in determining the question of originality. As a last resource, they applied to Sir David Brewster, chairman of the jury on the class to which these instruments belong; but as yet they have not been favoured with any communication from him.

Your Committee see no reason to alter the opinion they previously expressed of the merits of the instrument; and even should it turn out that the French instrument was similar in principle (of which your Committee have no evidence), yet they have a thorough conviction that, as far as Mr Sang is concerned, the merit of originality would no less belong to him.

Your Committee beg, therefore, again to recommend that the thanks of the Society be accorded to Mr Sang, and that he should receive one of the highest rewards it has in its power to bestow.

Thos. Grainger, *Convener.*

Edinburgh, *7th June* 1852.

Account of the Bursting of Bilberry Reservoir. By James Leslie, Esq., C.E.* With a Plate.

Having had an opportunity lately of examining the embankment of Bilberry reservoir, which burst on 5th February last, I have been induced, by the advice of the President, to offer some account to the Society of what I saw and heard of the causes and effects of the catastrophe.

I have little to add to what transpired before the coroner's inquest, including what is stated in the report of Captain Moodie, R.E., who was sent by Government to inquire into the circumstances connected with the accident; and I do not profess, by any means, to give such minute details as are to be found therein, by those to whom they are accessible; but, as I have prepared a few rough sketches shewing the appearance of the embankment, and of the breach through it, these, with a very brief explanation of them, will probably make the matter more intelligible than the most elaborate verbal description would of itself do.

It appears from Captain Moodie's report, as quoted in the newspapers, that the embankment,—measuring, I presume, along the top,—is 340 feet long; that it has an outer slope of two horizontal to one perpendicular, and an inner slope of three horizontal to one perpendicular; and that it has a puddle-wall in the centre, of 16 feet thick at the bottom, and 8 feet at the top.

The height of the embankment in the centre of the valley was originally 98 feet, and the outlet sluice was 67 feet below the top of the bank, being placed at the level which was necessary for the supply of Bilberry mill; so that, after allowing for a moderate rise in the valley, between the centre line and the foot of the inner slope of the embankment, there must have been a considerable depth of dead water in the reservoir below the outlet, probably not less than 25 feet in the deepest place.

The breadth of the top of the embankment is stated, in the

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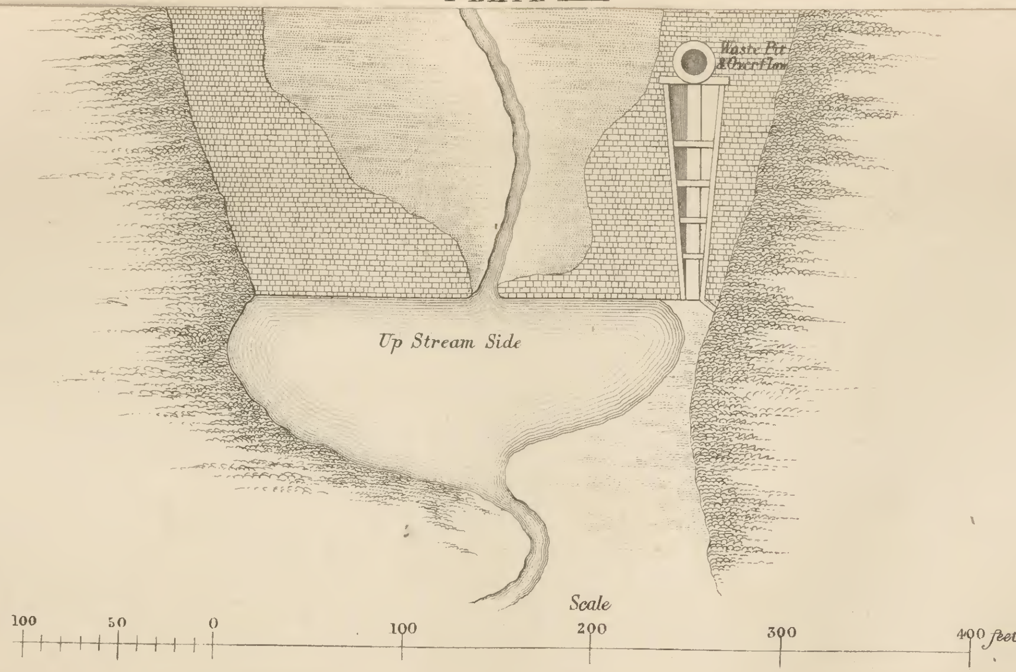
* Read 26th April 1852.

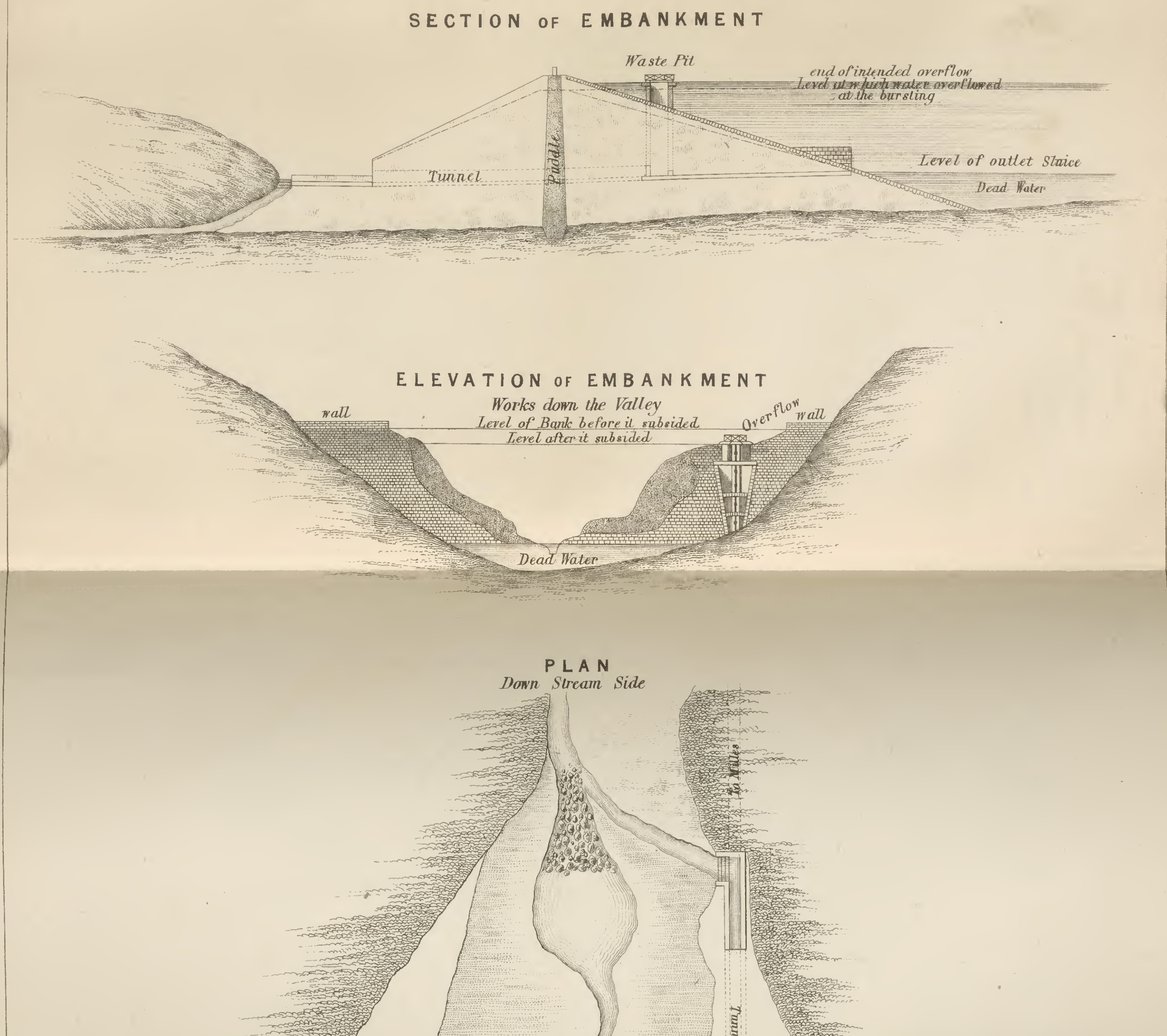
PLATE XIX



S. Leith, Edinr.

PLATE XIX

Trans. Roy. Scott. Soc. of Arts. Vol. IV Page 130



stated, in the evidence of Mr Leather, the engineer, to be 16 feet. With such slopes and dimensions, the bank ought, if well constructed, and if it met with no unfair play, to have been perfectly and beyond doubt secure.

The rock of the sides and bottom of the valley consists of beds of millstone grit, alternating with shale, and seems to be of a very open and pervious nature.

It appears that there was a very considerable spring in the rock or shale under the puddle-trench, and that it had never been stopped or carried past, so that the bottom of the puddle could not be got well put in, and it is described by one of the witnesses as being rather slush than puddle.

There were several leaks in the embankment besides the springs in the bottom; and when the water rose above 44 feet, there was a very heavy leak above the outlet culvert, described by the sluice-keeper to be as thick as his arm. A former sluice-keeper states that it was never necessary to draw the sluice when the water was above 30 feet in height, as more water passed then through the leaks than was required for the use of the mills.

Shortly after its completion, the embankment sunk in the centre of the valley, it is said, 10 feet, so that instead of remaining at the level of 8 feet, or thereabouts, above the waste weir, as was originally intended, the top of the bank came to be about 2 feet below the weir.

Therefore the overflowing and consequent bursting of the embankment were inevitable some time or other, sooner or later, if no effectual means were adopted to prevent it; and most probably it would have happened long ago, but for the precaution which it was thought necessary to take, in consequence of the leaks before mentioned, of never, usually allowing the water to rise to above half its intended height, so that there was always a considerable vacant space in the reservoir to contain any flood water beyond what the outlet-pipe would allow to escape, before it could overtop the bank.

It appears that, six years ago, there was a flood which touched the coping of the waste weir, and flowed over the inner slope of the embankment and the puddle, but did not overtop the outer slope of the embankment. That seems to

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It appears that, six years ago, there was a flood which touched the coping of the waste weir, and flowed over the inner slope of the embankment and the puddle, but did not overtop the outer slope of the embankment. That seems to have been a narrow enough escape, and might have shewn the danger to which the state of the embankment made it constantly liable.

Captain Moodie estimates the drainage into the reservoir at 1920 acres, or three square miles, and computes from data furnished by rain-gauges kept at the new Manchester Water-Works on the west side of the same range of hills, which divide Yorkshire from Lancashire, that it might yield, in the heavy fall of rain which occurred immediately before the bursting of the embankment, 500 cubic feet a second.

This is a very large allowance; but, as the surface of the collecting area is steep, and the fall of rain in that district of country is very great, it is quite possible that there might, in a very great flood, be so much run off as 30,000 cubic feet a minute; though in this neighbourhood I cannot say that I have ever seen quite so much as one-half of that quantity run off an equal extent of surface.

No distinct or authoritative account is given of the quantity of water which the reservoir was calculated to contain, but it has been called 13,800,000 cubic feet; and, judging from the appearance of the valley, which divides into two a little above the embankment, and taking the surface, as it has been stated, to be 11 acres, I should think this computation cannot be very far from the truth.

Taking, however, the contents at 13,800,000 cubic feet, if the reservoir were quite empty at the commencement of the flood, it would contain only 7 hours 40 minutes of the flood spoken of, supposing the outlet sluice to be shut.

It is given in evidence that there was something wrong with the outlet sluice, and that it was only discharging about one-half of its proper quantity; but even if it had been fully opened, it would have done little to keep down so heavy a flood as that spoken of, as the opening has an area of only 1·7 foot, which, even with the pressure due to a full reservoir, would only allow the escape of about one-seventh of the water which was coming in.

It is proper, however, to mention that Mr Leather, the engineer, estimates the drainage area at only 1400 acres.

The stream or river Holme, which runs through the reservoir, and down the valley, falls into the river Calder, which again runs into the Humber.

There is a peculiarity in the construction of the waste weir of this reservoir, which, however, is not very uncommon, I believe, in Yorkshire. Instead of the usual plan in other places of having a wide rectangular notch for an overflow, with an open channel leading from it, cut out of the natural ground at one end of the embankment, and in rock when practicable, the waste weir of the Bilberry reservoir consists of a circular well or shaft, called the waste pit, placed in the inner face of the embankment, and about 50 or 60 feet down from the top.

The shaft is brought up from the solid ground below the embankment, and has a culvert of 6½ feet wide, and 6 feet 4 inches high, with a semicircular arch, and 180 feet long, leading out from it below the embankment, and an open channel beyond that along the hill side, to carry the overflow water, which might pour down over the top of the well to the channel of the stream below the reservoir. This shaft is 12 feet in diameter inside, and 59 feet deep.

There is a large gap or recess formed in the inner face of the embankment leading to the shaft, and in that recess at the foot of the shaft is placed the opening for the outlet, having one sluice outside of the well, and consequently in the reservoir, and also a sluice cock on a pipe within the well, but both on the same orifice. This ordinary discharge-water is conveyed by the culvert and open channel before mentioned, to the intake of the uppermost mill. The side walls of the recess spoken of have detached arches springing across between them, to serve as shores to keep them from bulging out and coming together.

Measuring the circumference of the shaft, it will be seen that a very considerable extent of waste weir, viz., about 37½ feet, is obtained; but this system, which is in principle exactly like that of the waste pipe of a common cistern, is not much to be admired; for there being necessarily a gangway across the top of the shaft, for the convenience of working the sluices, the opening is diminished and divided into two, so that in the not improbable case of a tree being carried on to the top of it by a flood, the gradual accumulation of twigs, grass, and stalks of all kinds, might so far choke up the opening as to render it inoperative as a waste weir; besides which, I think that the fall of so great a body of water from the height of 59 feet, would be very apt to damage the bottom of the shaft, or the pipe and sluice cock placed there, unless they were of an extraordinary strength.

I consider it much better to have the flood-water escaping in the light of day by an open channel, which is much less likely to choke, and which, in the event of its being choked or injured, may be cleared out or repaired. It does not appear, however, that, except on one occasion, immediately on the completion of the embankment, a single drop of water had ever run down this shaft or waste weir, for the bank seems to have sunk in the middle of the valley soon after it was formed, and no means were taken to raise it up again to the proper height, so that it was suffered to remain 2 feet below the level of the so-called waste weir; and, to make matters worse, as I have before stated, when the flood came in February last, one of the outlet sluices had got jammed, and could not be fully opened.

It had been proposed at one time to make an opening into the shaft at the level of 18 feet above the outlet sluice, which would be a very long way below the lowest part of the embankment, but for some reason or other the order for so doing was countermanded.

The people present when the water was rising to near the top of the bank, have been blamed for not throwing off a course or two of the masonry of the shaft, and so allowing the water to escape; but it would not have been an easy matter to do this, as the top course consists of very large stones, forming a cordon moulding; and after the water came to surround the shaft, it does not appear to me that there was any means of access to it, as there is no gangway leading to it from the top of the bank, or from the hill side.

There appears to have been a ladder up to it from the embankment, but it had been removed at the time of my visit. It has been suggested that the shaft might, in the emergency, have been blown down by gunpowder, but then the stones might have fallen into the pit, instead of outside, and so have choked up the outlet culvert.

Some blame the bad quality of the embankment itself, and of the puddle, for being the cause of the bursting; but from that opinion I differ entirely. No doubt there was something very wrong in the construction of the embankment, else it would not have been so leaky, or have sunk so much; and in so far by lowering the top to below the level of the waste weir, it was the indirect cause, but it had come to a bearing long ago, and might have been heightened again, as many other embankments have been, to the proper level.

Although the banking is rather stony, and not so well formed in layers as I should like to see, it is by no means unsubstantial, and the puddle is not at all bad, but, on the contrary, has stood resisting the wash so well, that it quite protrudes beyond the remaining face of the banking.

In fact, the embankment, instead of being merely able to stand a pressure of water up to within 8 feet of its top, for which it had been designed, actually stood until the water was over the top and running down the back slope. It did so run for a considerable time, in a great and constantly augmenting volume, carrying everything before it, until at length everything was washed away outside of the puddle, which was left quite exposed, when of course it eventually gave way, and so allowed a free passage for the remainder of the water to escape, and to carry the inner slope of the embankment along with it.

Judging from the great power of floods, when running with only a very moderate declivity, it will be readily understood that no ordinary material or workmanship will withstand the effects of a torrent running for any length of time down a slope of 2 to 1; and although a case is on record of an embankment near Greenock being overtopped by the bursting of another above, and resisting successfully the effects of the torrent down its back, that must be held to be rather a remarkable and exceptional case, and that the like should happen again is not by any means to be depended on.

One sufficient reason, in my opinion, for thinking that it was simply the overtopping of the low part of the embankment, and not the leaks, or any similar imperfection, which caused the bursting, is, that the south end, a portion of which is very much sunk, and where it was stated there were two large leaks, one below and another above half-way up, and the north end, where there was one leak, have both stood perfectly sound.

The bursting of the Bilberry Reservoir has impressed many people with a great fear of reservoir embankments in general; but in my humble opinion it ought rather to give increased confidence in the stability of any decently constructed embankment, having a sufficiently extensive waste weir, so as to make sure that the water shall never rise to a height at all approaching to the top; seeing that this embankment, which was leaky, had slipped, and was not by any means in good repute, was able to stand so very much more than it had ever been calculated to do, in having been twice overtopped before it gave way.

The waste pit, with its culvert and all the masonry connected with it, have stood perfectly uninjured. The masonry of these, judging from outward appearances, seems to be all very substantial, though it is stated that there were serious imperfections in the culvert.

The stone pitching of the inside slope, of which there is a very considerable portion remaining uninjured, is also good.

The chasm in the embankment is about 30 feet in width at the bottom, not reckoning a narrow channel of about 6 feet, which has either been cut for, or has been worn out by, the stream since the flood, and it appears to be about 150 feet in width at the top.

A short way below the puddle-wall, and within the base of the outer slope of the embankment, there is a deep pool scooped out. With that exception, there is in most places down the valley a deposit of stones, rubbish, gravel, and sand.

One mill-dam was burst by the flood, several bridges were destroyed, and in many places, especially in the town of Holmfirth, two or three miles below the reservoir, the bed of the stream is quite choked up. The flood appears, from marks left on the trees which are still standing, to have been at some places twenty feet in height; but it varied according to the width of the valley, which at some places is confined to narrow gorges, and at others widens out into pretty extensive haughs.

A great number of mills and other buildings are down entirely, there being not one stone or brick left on another; and a number more have portions carried away, leaving the floors and remaining walls in a very precarious situation.

Stones of a very large size, weighing, I believe, several tons, though I have mislaid the measurements which I took of them, have been moved a very considerable distance, and a number of steam-engine boilers have been carried down the valley, and left here and there like stranded vessels.

The most curious thing, however, that I remarked, was in the case of a large mill, which had stood in a gorge a very short way below the reservoir, in which there was not one brick of the walls left standing, and the steam-engine and fly-wheel were all upset and smashed, and yet, notwithstanding, the engine chimney, which is of brick and pretty tall, is standing erect and entire, although the pressure against it must have been very much increased, from the circumstance of the trunk of a large oak tree having been caught by it and been left lying across the valley, with its middle resting against the chimney, and its upper side pressed against by a large collection of stones and rubbish caught by it.

The loss of property has been computed at £250,000. This I should think a high estimate; but there is no gainsaying the lamentable fact, that not less than eighty-three lives were lost.

My researches, however, were confined almost exclusively to the mode of construction and the cause of the failure of the embankment, and scarcely extended to the scene of devastation below. Most probably the description will be felt to be obscure and unsatisfactory, unless to those acquainted with, and interested in, the technicalities of the construction of an embankment; but it may at all events suggest inquiries which, so far as it lies in my power, I shall be most happy to answer.

EDINBURGH, *April* 12, 1852.

Description of an Instrument by which the Variation of the Magnetic Needle can be determined with a greater degree of accuracy than has been attainable in Field Surveying. By John Adie, Esq., F.R.S.E.* (With a Plate.)

SILVER MEDAL AND PLATE, VALUE TEN POUNDS, AWARDED 1852.

The very interesting and remarkable changes which are known to have taken place, and are constantly going on in the angular amount of the variation of the magnetic needle, on the surface of our globe, has in all ages claimed the attention of the observer of natural phenomena. A knowledge of the exact amount of this variation is not only useful and interesting in a scientific point of view, but is of the greatest consequence to the mariner, geographer, surveyor, and miner. The instruments that have hitherto been employed for the determination of this variation are of two classes,—*First*, those for the fixed observatory, as the variation transit instrument and others, from which very accurate results are obtained; *secondly*, those used by the traveller, mariner, and surveyor, as the azimuth compass, theodolite, and instruments of this class. To all of these this grand objection belongs, that you cannot collimate with the sights or telescope and the magnetic needle, which forms the basis of any correct determination of the amount of magnetic variation.

Before describing the instrument I have now the honour of laying before the Society, I may shortly state what is required in such instruments, and the practical methods employed to arrive at this. The most important is to know that the line of magnetism, or the magnetic axis of the needle, coincides with, or is parallel to, the line of sight to which it is to be referred.

In the azimuth compass all that is done is to place the centre of the steel needle as near as possible under the zero on the card, and there fix it. In the theodolite, the usual method is to place a straight edge along the line of the tele-

* Read and exhibited 26th April 1852.

Trans. Roy. Scott. Soc. of Arts. Vol. IV Page 138.

Mr. J. ADIE'S INSTRUMENT FOR FINDING THE MAGNETIC MERIDIAN.

Half Size

Fig. 1

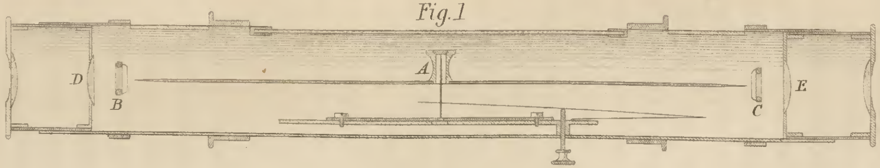
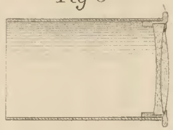


Fig 3



Section through achromatic object glass.

Fig 2

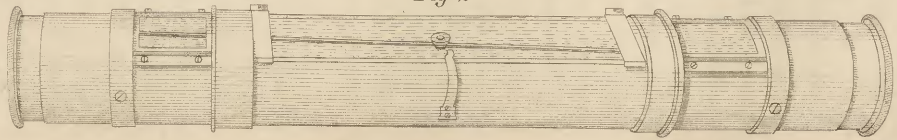


Fig 1 Shows the instrument in section. A the needle B.C the divided glass scale D & E the eye pieces.
Fig 2 Shows the instrument as it is to be placed in the Theodolite
Fig 3 Shows the achromatic object glass to form a Telescope.

S. Leith, Edin.

scope, and another on the compass ring, and bringing the edge of the one parallel to that of the other, a fine line is made on the compass ring, from which line the zero of the compass is deduced.

It will, I think, be obvious to all conversant with these matters, that with such rude means of placing the zero line of the card or needle parallel with the line of sight, no observation can be obtained in which any confidence is to be placed, even to the nearest degree of the circle, and the error may be much greater ; in the azimuth compass, in particular, where the needle is commonly broad and heavy, the axis of magnetism may be very different from that of the needle.

To obviate these defects, the instrument I am about to describe (Plate XX.) was constructed. It consists of a magnetic needle, having its flat sides suspended vertically by an agate on a fine steel point. The case or box in which this needle is suspended for observation is in form exactly the same as the tube of the telescope of the theodolite, on which it is to be used, with openings in the upper side to admit the needle, and also for the admission of light to read its indications. Into these openings glass is fitted, to prevent the action of the air on the needle. It is provided with truly turned collars, the same as those of the theodolite telescope, which, when in use, rest in the Y's of that instrument.

At each end of the tube, and equidistant from the centre, at half the length of the needle, there is placed a glass diaphragm fixed in an adjustable ring, and having fine divisions cut on each side of the centre line. These diaphragms are each viewed by a powerful eye-piece placed at opposite ends of the compass box or tube. The centre division in each is then adjusted, that in turning the box round in the Y's this line remains fixed, or is truly in the centre of the collars on which it rests. The needle is now placed on its point, and the centre on which it is suspended is adjusted by screws provided for this purpose, till the ends of the needle also seen by the microscopes coincide with the centre lines on the diaphragms.

From what has been stated, it will be evident that we have now the means directly of collimating with the needle and the telescope of the instrument; for we know that the optical axis of the telescope is truly in the centre of turning on its collars. We also know, that the centre divisions in the compass tube are in the same line; and if we bring the points of the needle to coincide with these, the reading on the limb of the instrument will give the power of referring this magnetic meridian to any other point. But as it is nearly impossible to make a needle perfectly straight, and also to know that the axis of polarity coincides with the axis of the steel; and this, from irregularity in the structure of manufactured steel, giving it the power of holding a larger and more powerful charge of magnetic influence in one stratum than in another; I proposed to compensate for the want of perfect straightness at each observation or set of observations, by reversing the polarity of the needle, which affords the means of eliminating this source of error, and that from the form given to the needle; the second would be very small. I am, however, indebted to my friend Mr Swan for a suggestion, by which, by one simple operation, we get a perfect compensation for both sources of error, viz., in place of reversing the polarity of the needle, reverse the needle itself; in other words, observe first with the one surface of the needle up, and then with the other. By thus reversing the needle, you will have an equal and opposite error; the mean, therefore, will be the true line of the magnetic meridian, and it now only remains to turn the telescope of the theodolite into the true meridian line, and the difference between the readings of the magnetic meridian and the true will be the magnetic variation sought.

I have only been able to make three sets of observations with this instrument; the first with my friend Mr Jardine in the Observatory grounds, Calton Hill, from which we obtained 24° 42′ for the variation, and two series in the East Princes Street Gardens, which gave 25° 31½′, and 25° 27½′. These last agree very nearly, but differ from that obtained on Calton Hill. This difference may easily be accounted for from the magnetic influence of the hill, as we know that the rock of Arthur's Seat has the power of turning the needle quite round, causing the north end to point south, and the south north ; and the structure of the two hills do not greatly differ.

In conclusion, I give below some of the determinations of the magnetic variation, shewing the change that has gone and is still going on.

May 1804.	Merchant Court, . . .	W. 26°	30′	0″
Oct. 1808.	Mr Roberts observed it in the park in front of Watson's Hospital, . .	27	22	2
Oct. 1808.	Mr Jardine found it, from observations on Calton Hill, ...	27	31	50
Nov. 1809.	Mr Jardine, ditto, ditto, .	27	35	10
Sept. 1812.	Mr Jardine, ditto, ditto, .	28	8	0

From these observations it would appear, from that of 1804, the first we have record of, to 1812, the variation has been increasing to W. ; and from those of the present day, that it has turned, and is now going E., or diminishing, which result is confirmed by the very delicate observations of Mr Broun made at Makerstoun Observatory.

Note.—Since this paper was read to the Society, I have made an addition to the instrument, by which the line of the magnetic meridian may be laid down without the use of a theodolite. The instrument being placed in detached Y's, these may be turned till the needle point to the centre division ; then remove one of the eye-pieces and substitute for it an achromatic object-glass ; we will now have with this object-glass and one eye-piece left in its place, a telescope by which poles may be placed, the line joining which will be the line of the magnetic meridian.

Report of the Committee of the Royal Scottish Society of Arts, on Mr John Adie's description of an Instrument for determining the Variation of the Magnetic Needle.

The Committee have carefully read over this paper, and examined the instrument itself, which Mr Adie has exhibited along with the paper, and are of opinion as follows :—

The variation of the magnetic needle has long formed an interesting and important subject of inquiry, and the object of the instrument now contrived by Mr Adie is to give the means of determining the amount of this variation with greater accuracy than has hitherto been attainable by any of the ordinary surveying instruments commonly in use. In some of the large astronomical instruments fixed up in our observatories, the variation can be determined with great accuracy; but it is well known that in all the ordinary instruments, even the best theodolites, there is no means of determining this element very correctly, owing to the difficulty of setting the magnetic axis of the needle truly parallel to the visual axis or line of sight of the telescope.

This defect the Committee are of opinion Mr Adie has completely obviated, by the ingenious plan now described and exhibited, of placing the needle itself in the line of the axis of collimation of the telescope, whereby the line of sight and the line of direction of the needle can be rendered identical. This Mr Adie has accomplished, by having an additional tube similar in all respects to that of the telescope, and collimating exactly with it on the same Y's. Within the centre of this tube the needle is suspended, and the extremities traversing along the surfaces of glass diaphragms finely divided and observed by magnifying eye-pieces at each end, the position of the needle can be obtained with the greatest accuracy. The means of adjustment seem quite simple; the axis of the tube being determined by collimation, and the centre of the diaphragms, as well as the centre of the needle, truly adjusted in the same manner; and besides this, there is the means of adjusting the needle itself by inverting it on the point of suspension.

The Committee have minutely examined all the arrangements for these adjustments, and, on the whole, are quite satisfied with the instrument; and are of opinion it forms a decided improvement on the present method, and is calculated to prove of essential service not only in the more accurate determination of the magnetic variation, and in giving means of multiplying observations thereon, but also the Committee think will apply as a useful instrument practically in setting, adjusting, and correcting the position of the needle in the various surveying instruments in use. They would beg, therefore, to recommend it to the favourable consideration of the Prize Committee, and they think also the paper itself should be printed in the Transactions of the Society.

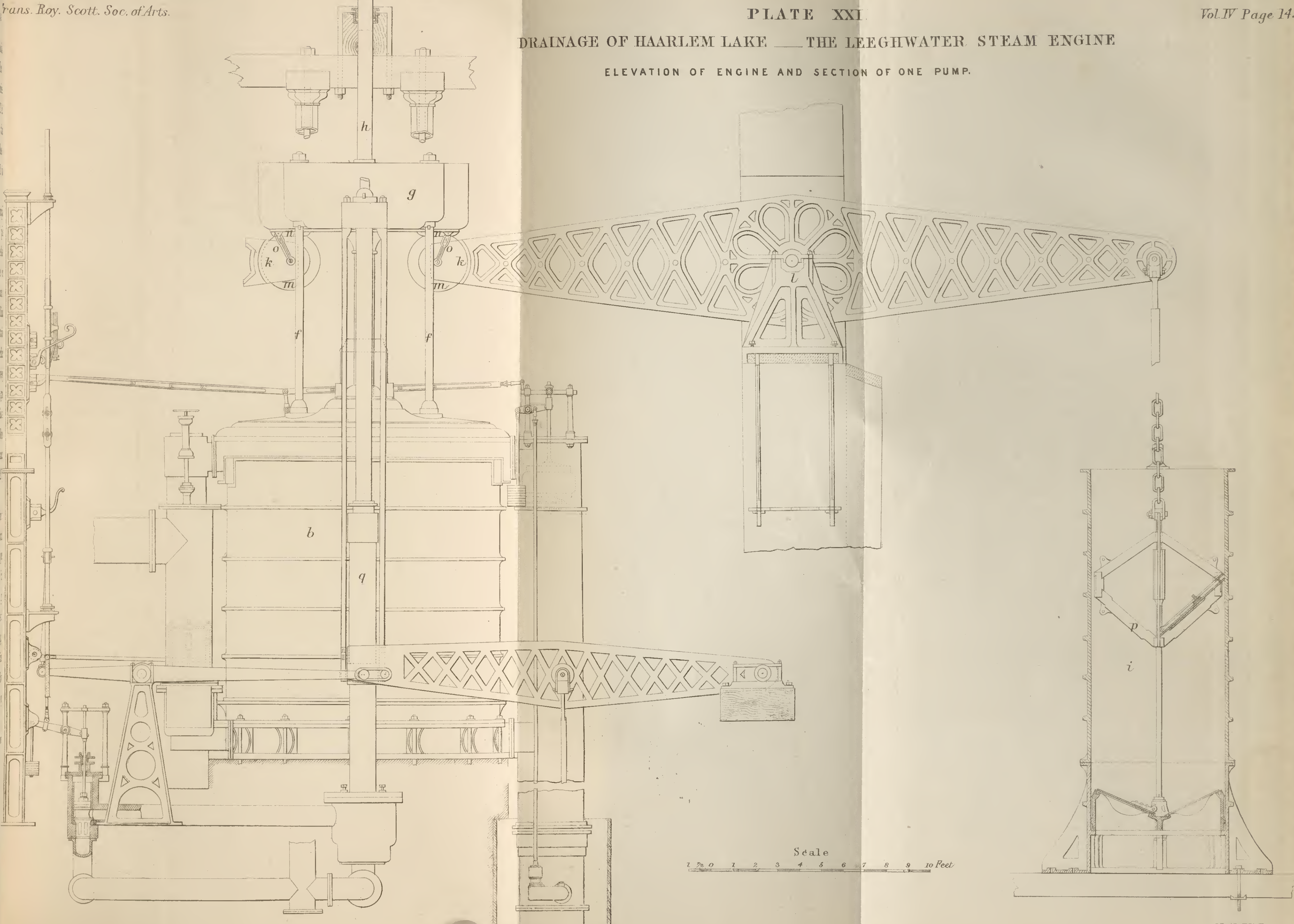
GEO. BUCHANAN, *Conv*[r].

EDINBURGH, 10*th June* 1852.

PLATE XXI

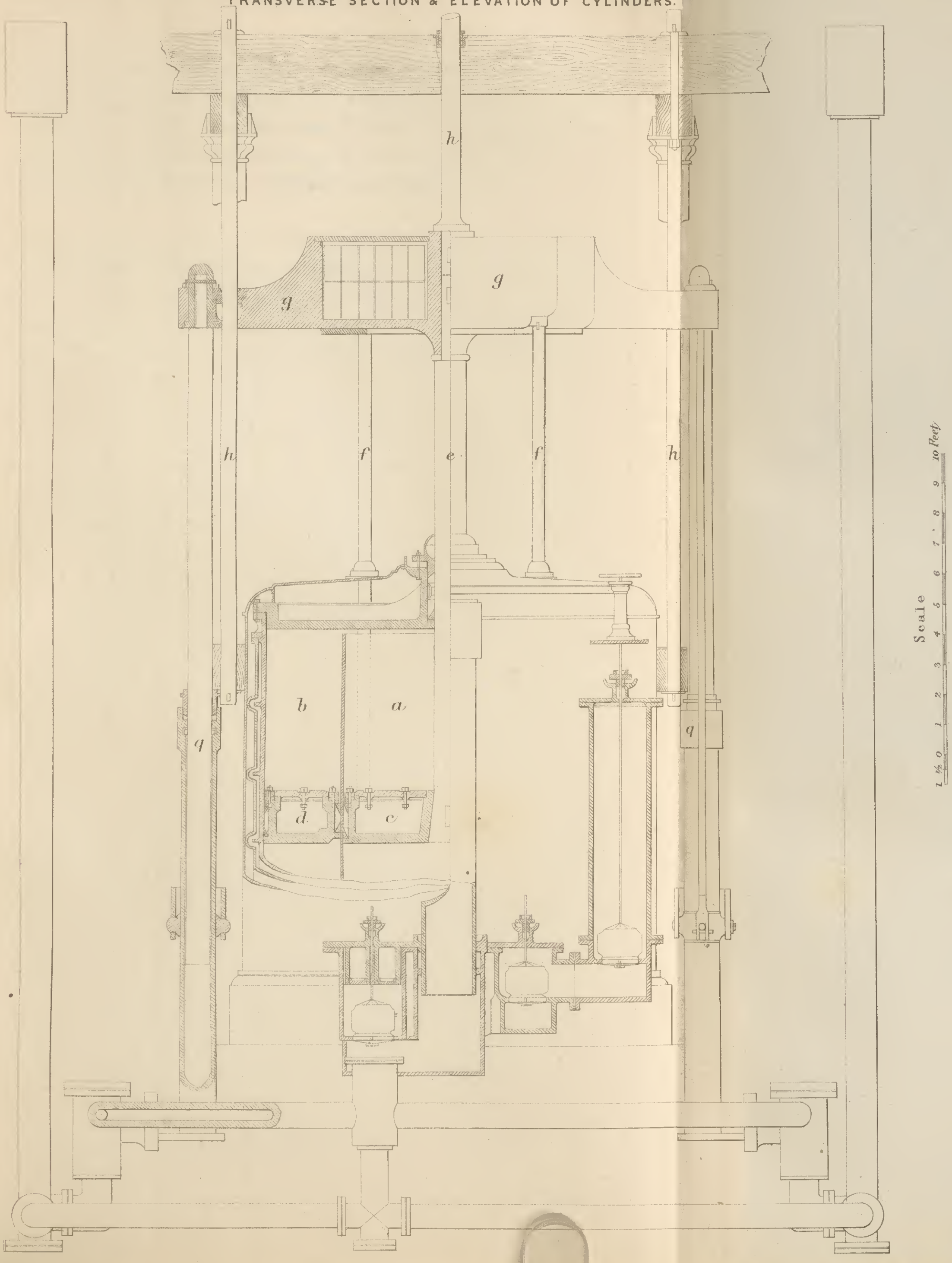
DRAINAGE OF HAARLEM LAKE — THE LEEGHWATER STEAM ENGINE

ELEVATION OF ENGINE AND SECTION OF ONE PUMP.



DRAINAGE OF HAARLEM LAKE — THE LEEGHWATER STEAM ENGINE

TRANSVERSE SECTION & ELEVATION OF CYLINDERS.



Description of the Drainage of Haarlem Meer, an extensive Inland Lake in Holland, by Steam-Power; with some Account of other Engineering Works therewith connected.
By THOMAS GRAINGER, Esq., F.R.S.E., Memb. Inst. C.E., President of R.S.S.A. (With Two Plates.) *

In the address from the Chair at the opening of last Session, I stated that, if my professional engagements would admit, it was my intention to visit Holland, for the purpose of ascertaining, from personal observation, the progress and state of the works connected with the drainage of the lake of Haarlem,—an enterprise which I had watched with considerable interest; and that I would communicate to this Society the import of the information which I might obtain. I now proceed to perform the promise which I then made.

The kingdom of Holland presents, in its physical geography, much that is extremely interesting. It is long since it was characterized by Sir William Temple as "like a sea in a calm, and looks as if, after a long contention between land and water, which it should belong to, it had at length been divided between them." A considerable part of this country, as well as of the northern portion of Belgium, is formed by the alluvial deposit of the Rhine, the Maas, the Scheltd, and other rivers.

It is well known that the greater part of the kingdom of Holland has been rescued from the dominion of the ocean rivers, and inland lakes, by the long-continued efforts and ingenuity of the most industrious nation of the world. Much of it still lies below the level of the sea and adjoining rivers, and must, therefore, be kept dry by artificial means; and from which it must be defended by strong barriers of earth-work well known over the Low Countries by the name of Dikes, which, if neglected, much of the richest and most valuable portions of the kingdom would revert to their primeval condition. These dikes, or ramparts of earth, are of vast extent, and of various heights and slopes; the money expended in their

* Read before the Society 11th December 1850 and 13th January 1851.

construction has been prodigious ; the total annual expenditure in the *maintenance* of dikes, and regulating the water-levels throughout the country, has been estimated at £600,000. Holland is likewise exposed to great danger from internal inundation, by the obstruction of the great rivers by ice, when a thaw sets in. In 1799 the very existence of a considerable portion of this country was threatened from this source. At Nymegen the Rhine rose 7 feet in one hour, by the obstruction or barrier presented by the accumulation of ice. So extensive were the ravages on the dikes, that a large portion of Holland, on both banks of the Rhine and the Waal, was laid under water, the icebergs crossed the *Polders* (a term which I shall by and by explain), sweeping away houses built on the dikes ; and the loss of lives and cattle was enormous. Many other instances might be given of the uncertain tenure by which the Dutch hold their lands, if not their lives. The greater part of what is now occupied by the Zuyder Zee was dry land down to 1287, and it is said that when this inundation took place, upwards of 80,000 inhabitants lost their lives, together with a vast amount of valuable property. The sea which was then connected with, and still remains a branch of, the German Ocean, may be roughly estimated at 2000 square miles in extent. On this subject much that is interesting might be said, but it would be foreign to the object of this paper to prosecute it further on the present occasion.

It is very generally admitted that the engineering of Holland, like its literature, has not received from us that attention which it merits. We find that, in 1754, the year preceding that in which he undertook the building of the Eddystone Lighthouse, the celebrated engineer Smeaton visited the Netherlands ; and it is obvious from his reports on various engineering works, written subsequent to that period, more especially those with reference to river and harbour works and the fen drainage,—that he had during his journey seen much to add to his professional knowledge in every branch of hydraulic engineering.

I also find that the late Mr Robert Stevenson of this city visited Holland in 1819 ; and until lately the only satisfactory description, in our own language, which we possessed, of the great sluices and other interesting works at Katwyk, where the old Rhine discharges itself into the North Sea, was from the pen of that gentleman.

In engineering and the mechanical arts generally, the Dutch have attained a high degree of perfection, more especially in so far as these are connected with the peculiar situation of their country. All kinds of mill-work, particularly such as have wind for the moving power, are found throughout the whole of the Netherlands in considerable perfection, and of infinite variety. It has been well observed, that "the character of Dutch engineering partakes strongly of that nation,—slow but sure, enterprising yet cautious, prudent, and abounding in resources, capable of undertaking great works, and carefully executing the most trivial details." The sluices, lock-gates, drawbridges, &c., incidental to the construction of their canals, with which the country is intersected in every direction, and other hydraulic works, display great ingenuity, efficiency, durability, and economy. The most important branch of engineering in Holland, however, is that which has for its object the recovery of land from the water, and the general regulation of these waters throughout the kingdom. This is regarded as of so much importance to the very existence of many parts of the country, that a Government Board has been established for many centuries, for the administration of the hydraulic works of the kingdom. This Board is well known as the Waterstaat, or Marine Engineers; they enjoy great powers, or rather absolute authority, in all matters involving the protection of the country from encroachment by the sea or rivers. There is also a school expressly for the instruction of young engineers in this particular branch, which has long been maintained.

The engineering work of greatest magnitude which has been executed in Holland during the present century, is the Great North Holland Canal. The object of this great undertaking was to render the navigation between Amsterdam and the Helder practicable for vessels of 1000 tons burden, and for frigates of a large class. Previously to the completion of this canal, the navigation between Amsterdam and the Helder was through the Zuyder Zee, the waters of which were not only very shallow, but were becoming gradually more so from the accumulation of mud deposited by the rivers which flow into it. This canal was begun in 1819, and finished in 1825. It is about 50 miles in length, 125 feet wide at the surface of the water, and 20 feet deep. These dimensions will be found to correspond very closely with those of our own Caledonian Canal. It is nearly level throughout, but the execution of it was attended with many difficulties, arising chiefly from the soft or boggy nature of several of the old polders, or drained lakes, over which it is carried. It seems to have cost about one-and-a-half million sterling, and has always been regarded as a work of very great utility, and one of the most perfect of the kind with which we are acquainted. It was executed under Mr Blanken, an eminent Dutch engineer.

The railway from Rotterdam, by Delft, the Hague, Leyden, and Haarlem, to Amsterdam, is a work recently executed, also of considerable importance in an engineering point of view. In many respects it resembles similar works in this country. Here, too, the soft nature of many parts of the country presented much difficulty, and "fascine work," as it is termed, was very generally employed. As this railway passes over numerous canals at a low level, it was necessary to provide moveable bridges of various construction, to prevent interruption to the navigation. In these great ingenuity has been displayed, more especially in those over the Delft Canal at the Hague, the Spaarne at Haarlem, the Old Rhine near Leyden, and the Warmonder Leede. The gauge of this railway is 2 metres, or $6\frac{1}{2}$ feet, being only 6 inches less than the broad gauge, and 1 foot $9\frac{1}{2}$ inches greater than the narrow gauge of this country. But great and important as these—and other works to which I might have referred—are, they fall far short of the boldness of the enterprise which I am now about to describe.

Before proceeding to do so, however, as I have already used the term Polder, and as I shall have occasion to do so again, it may be proper that I now explain its meaning.—*Polder* may be regarded as a household word throughout the whole of the Netherlands, but it is unknown in this country. It is the name given to a tract of country (generally meadow or pasture land) whose surface is below the level of the water, by which it would be covered were it not surrounded by embankments of earth, or some such material. These polders abound throughout the whole of the Low Country, and are of all sizes and in great numbers. In Middle Holland alone they are said to exceed one thousand ; and are of every variety of level, down to 20 feet below that of the sea. Some of these polders are formed of ground taken from the sea, by a system of engineering, which is much more extensively practised, and hence much better understood, in Holland than it is in any other part of the world ; others—and by far the greater part of them—are formed by land taken from rivers ; others, again, by the draining of natural lakes, such as the Beemster Polder, the Purmur, the Wurmur, and others, in North Holland ; and when the draining of Haarlem Meer is completed, it will form, I presume, the most extensive polder in the kingdom. Polders are also formed in considerable numbers by the digging of turf for fuel (this being the only fuel supplied by the country). The excavations thus formed soon become filled with water, and are called Turf-pit lakes ; these are afterwards surrounded by dikes, the water is pumped out, and the inclosed area thus becomes a polder. Of this class is the polder called Zuidplaas, in the neighbourhood of Rotterdam, which extends to nearly 15,000 acres. Some idea of the extent of land so situated may be formed by the following classification of the different descriptions of land in Rhineland :—

Under water, ...	56,000	acres.
Natural land, above one-third of which is downs,	76,000	„
Polder land, ...	173,000	„
In all, . .	305,000	„

so that only about one-fourth of this area is land situated above the level of the water. It is obvious that these polder lands being below the level of the sea, the *draining* of them must be performed wholly by artificial means. In short, their very existence as arable or pasture lands depends as much upon the sufficiency of their dikes, and the raising and otherwise regulating the water of the district, as do the lives of the passengers and crew of a leaky ship upon the proper action of the pumps. Let a breach occur in the protecting dike, as has but too frequently happened, to the vast destruction of property, or let the pumping-engine be withdrawn, and thousands and tens of thousands of acres would return to their primeval condition as certainly and as rapidly as the ship I have described would go to the bottom, were the action of the pumps in any way impeded.* The failure of the outer dike at Durgerdam, in 1825, laid upwards of 320,000 acres of land adjacent to the North Holland Canal, already described, wholly under water. This may be better understood when I state that the district laid under water is 25 miles by 20 in extent.

The power hitherto employed in the draining of these lakes is wind, machines moved by which have been so employed from time immemorial. They are for the most part simple in their construction, and are of sizes and prices varying according to the area and depth of the polder from which the water is to be raised. A small wheel with a vane turning like a weathercock at the will of the wind, costs about £25; but when the polder is extensive, and the lift considerable, I believe that the mills sometimes cost £2000. The average lift of water raised by windmills is 1·20 metres, or 4 feet when water-wheels are used; and when the Archimedean screw is employed, the lift is from 6½ to 10 feet; thus when the polders are deep, different stages of windmills must be used. It is evident that, by greater concentration of the drainage, the expense of the operations would be much reduced; but the different conflicting private interests often prevent such arrangements. The very high price of coal tends much to prevent its being more generally employed in place of wind.

* This reminds us of the lines in Butler's *Hudibras* :—

"A country that *draws* thirty feet of water,
In which men live as in a *hold* of Nature;
And when the sea does in upon them break,
And drowns a province—does but spring a leak."

The process of taking land from the seas and rivers is still going on in many parts of the Netherlands. At the time of our visit, we found that on the north side of the Y, opposite to Amsterdam, there were nearly 200 acres of water in the act of being inclosed. The dikes had been constructed in 1849 by the unemployed workmen of Amsterdam, and in this way the labour of paupers was rendered so far productive.

Haarlem Meer is a large fresh-water lake, situated in the northern part of North Holland. Its southern verge reaches to within 4½ miles of Leyden. The north-western extremity extends to within two miles of Haarlem, from which its name is derived. The north-eastern limits of the lake stretch to within 4 miles of Amsterdam, the capital of Holland, and the emporium of that extended commerce by which the Dutch for so many ages enriched themselves.

At a point nearly equidistant between Haarlem and Amsterdam, and near a village named Halfwege, or Halfway, the lake is separated from an arm of the Zuyder Zee, called the Y, only by the sea-dike which protects this portion of the coast from the encroachments of the sea, and by the canal and railway from Haarlem to Amsterdam. At this point there are sluices which were used for regulating the level of the waters in the lake, and now for that of the canal by which that lake has been surrounded.

The general outline of the lake is of an irregular oblong figure, its greatest length from south to north being about 14 miles, and its greatest breadth from east to west about 7 miles, the total area being about 44,500 imperial acres. The level of the water was maintained, by means of the sluices at Half-way, as nearly as possible to the mean level of the Y.

But while these were the boundaries and extent of this lake before the commencement of the operations now going on, it is not to be supposed that it has always been of this size; on the contrary, we find by old maps and other records, that it has greatly increased in area since the sixteenth century. In 1531 the space now covered by the waters of Haarlem Lake was occupied by four distinct lakes, of an area not greater than 15,000 acres, with many a fertile field and smiling habitation between. In 1647 the separate sheets of water had united, and the area had reached 35,000 acres; while in 1843 the area under water had increased to 44,500 acres.

In 1531, as I have stated, there were four lakes, named respectively "Spiering Meer",—"Haarlemmer Meer,"—"Nieuwe Meer,"—and Kager Meer," extending together to about 15,000 acres; and it is well known that in the intervening spaces three villages were situated, but the area under water gradually increasing, one of the villages was submerged in 1591, and by 1647 the other two had also disappeared. The four lakes then united, and assumed much of the present aspect of the lake, which still continued to increase, especially towards the north and north-east, until it threatened to form a junction with the large Turf-pit Lakes between it and the river Amstel. It will thus be seen that within the last three centuries, the surface of the water has tripled in extent, chiefly owing to the action of the wind, the effect of which on these unsheltered lakes is altogether incredible. It is found that when the wind blows long and strongly from one quarter, it changes the ordinary level to an inclined plane, driving the water forward, and raising it on the opposite shore. On the lake of Haarlem the difference of level is stated to be frequently as much as one metre, or upwards of three feet. When it blows thus strongly in the direction of the sluices, the draining of the lake is much facilitated; it is also advantageous in raising the water when it blows towards the pumping-engine, by reducing the extent of the lift.

The attention of the Dutch seems to have been directed to the possibility of draining the lake of Haarlem so early as the year 1617; and numerous applications were made to the State from time to time by private individuals, for the privilege of executing the work. In 1643, a millwright, who, from his successful operations in reclaiming submerged lands by pumping, had obtained the name of Leeghwater, published the first detailed plan of this great project. His proposal was to construct a surrounding dike and canal, much like those now in existence, the water being to be pumped from the lake into this canal by means of windmills at successive stages; and from which it was again to be raised by the same power to a superior basin, formed outside the sea-dike in the Y, and above its level, so that the discharge might at all times be independent of the state of the water in the Y. From this time down to 1836, no fewer than fourteen different schemes were proposed; the more important of these I shall briefly notice. In 1742, the Administration of Rhineland caused their engineer to prepare a plan, excluding Kager Meer and Spiering Meer. He proposed the construction of a canal to carry off the drainage water by the Katwyk,—to dispense with the superior basin,—and to use 112 windmills, on four different levels, to raise the water. In 1769, another plan was proposed, excluding Spiering Meer, but recommending the construction of a superior basin, of upwards of 1200 acres, near Spaarnedam, and *inside* the dike, with the windmills arranged as previously stated. In 1820, another plan was proposed, embracing a much greater extent of surface, and including the Lutkemeer and Alsmeer. The waters were to have been discharged directly into the Y, by means of a superior basin near Halfwege, with two stages of Archimedean mills, twenty-five on the upper, and thirty on the lower, stage; another superior basin was to have been formed near Spaarnedam, with fifteen mills.

In 1819, King William the First granted the privilege of performing the draining to three private individuals, with power to raise funds; but it does not appear that they ever did more than mature and publish their plan of operations, which was to surround the lake with a canal and dike, having breaks on the north and south, and discharging the water directly into the Y, by means of eighteen wheels with float-boards, driven by steam, and arranged in three stages.

The year 1836 was an eventful one in the history of the Haarlem Lake. During a violent storm from the west, on the 9th November, the waters were raised to such an extent as to overflow the banks, roads, and polders, as far as Amsterdam; and on the 25th December in the same year, a hurricane from the east propelled the waters towards Leyden, so as to submerge a considerable portion of that town, flooding a large surface of polders, destroying a great amount of property, and requiring the labour of an entire year before the lands could be restored. These disasters compelled the Government to turn their attention to the permanent removal of so formidable and destructive an enemy without further delay, and to devise the best means of overcoming the danger to which the surrounding country was thereby exposed. With this view the king, in 1837, appointed a commission to investigate the whole question, and to prepare plans and estimates of such works as they would recommend. This commission immediately entered on its functions, and issued a report, containing proposals which did not include the draining of Spiering Meer, which was to be added to the basin of the district, so as to assist the escape of the water at Halfwege, when its surface might be depressed by the wind, and to facilitate which another sluice was to be erected there. An additional feature of this plan was the dike and canal surrounding the lake, the latter of which was to be connected with the canal at Katwyk by a new cut, so as to straighten the line of outfall; the old canal being enlarged, and the capacity of the sluices increased. This scheme also embraced the deepening of the river Spaarne,—the connecting of the existing canals with the intended new one, to facilitate the navigation,—the formation of water-gates on the Yssel, for the introduction of water (in dry seasons) to the polders about to be reclaimed. The power to be employed in raising the water was to be derived from wind and steam—sixty-four Archimedean mills being to be placed on three stages, and fifteen mills with wheels and float-boards also on three stages. Outside the great points of discharge —at the Kaak, the Spaarne, and Lutkemeer—three steam-engines were to be erected; and if all these means were found to be insufficient for the effective discharge of the water, it was resolved to erect a steam-engine of 180 horse power at Spaarnedam, and to construct an additional sluice in the sea-dike at that place.

In 1839 a commission was appointed to superintend the works. Before, however, these were commenced, various modifications were made on the original plans, and the means for raising the water—the project finally resolving into the following mode of operation: The entire lake—including Spiering Meer and Kager Meer—embracing an area within the dike of 44,520 acres, to be drained to a mean depth of about 4 metres, or 13·12 feet, besides the leakage from surrounding lands, and rain falling during the operations. The great feature in the execution of the plan was the construction of a dike and canal around the whole area to be drained. The object in view, by the construction of this canal, was threefold;—1*st*, To intercept the flow of water from the adjoining lands, on a higher level; 2*d*, To form a navigation to compensate for that previously afforded by the lake itself, so as to prevent any interruption to the navigation of the kingdom, as it existed before the draining of the lake; and 3*d*, To convey the water pumped from the lake into the sea. The discharge of the water was provided for at three different points:—1*st*, To the North Sea or German Ocean, by the great cut and sluice sat Katwyk; 2*d*, By the sluices at Halfwege, between Amsterdam and Haarlem; 3*d*, By the Spaarne, through the sluices at Spaarnedam, by both of which outlets the waters are discharged into the arm of the Zuyder Zee, called the Y. It might be supposed that when the water has been raised from the lake to the canal just referred to, it would find its way to the sea by its own gravity; this however, although frequently the case, is not always so. At Spaarnedam, when it blows strong from north or north-east, it has been found necessary, in order to carry off the water, to erect a steam-engine, so constructed as to raise a great quantity to a limited height,—which height seems to vary from a few inches to 2½ feet; and the machinery is so contrived as to bring into action a number of wheels, according to the height to which the water is to be raised. It frequently happens, too, that a similar obstruction is met with at Halfwege, to obviate which, it has been proposed to erect a steam-engine, which, however, has not yet been done. At Katwyk, when the tide is high, and the wind blows strong from north or north-west, the water is also prevented discharging itself into the sea; but when this happens, the sluices are closed seaward until the tide has fallen, as the wind abates, sufficiently to admit of the discharge; thus it is only at one place that the second engine power is employed, and at which it is required. The commissioners are empowered to adopt means for supplying the basin with water in time of draught—to provide for the defence of Amsterdam by inundation—to purchase the necessary lands—to divide the soil when drained—and to arrange a system of canals, roads, and bridges. For these objects they were authorized to borrow 8,000,000 florins, or £687,500.

The first work undertaken was the construction of the dike and canal which surrounded the lake. The canal in the northern portion is 45 metres, or 147·6 feet wide at the level of the towing path, which is on the level of the Amsterdam datum, or mean level of the sea at Amsterdam, throughout. On the west and south the width at this point is 40 metres, or 131·2 feet; and on the east it is still further reduced to 38 metres, or 124·7 feet. The depth of the canal throughout is three metres, or 9·84 feet; the towing-path is 6 metres, or 19·68 feet broad. At the depth of $\frac{8}{10}$ths metre, or 2·62 feet below the towing path, two benches of 2 metres, or 6·56 feet, are formed, one on each side of the canal, with the exception of a portion on the east side of the lake, where the bench is formed only on the towing-path side: from the edges of these benches, the slopes of the excavations are at the rate of two horizontal to one perpendicular. During the winter months the water covers these benches. The dike between the canal and the lake is 4 metres, or 13·12 feet wide on the crown, which is slightly convex; the slopes on the side next the lake are at the rate of 5 to 1, and those next the canal are 2 to 1. These dikes were at first thrown up considerably above the level at which it is intended they shall be ultimately maintained, and they will afterwards be reduced to the general level of the polder dikes, which is $\frac{78}{100}$ths of a meter, or 2·56 feet above the Amsterdam datum. The works were commenced on the 5th May 1840, the first turf having been cut by the President of the Commissioners, Van De Poll.

In general, little difficulty was experienced in the construction of the canal, as the excavations were through firm, peaty soil, impervious to water. This was thrown up to form the body of the dike, which was finished off by a layer of turf: still there were portions which presented considerable difficulty in the execution. The narrow neck of land between the Lake of Haarlem and the Turf-pit Lakes near Aalsmeer, is of an exceedingly soft and spongy nature—composed, on the surface, mostly of reeds and aquatic plants, and beneath of soft peat. This land rose and fell with the level of the water in the lake, but the difficulty was overcome in this way:—The position of the canal having been determined, a thin layer of the peaty soil was excavated and thrown to the side to form the dike; this partly subsided, and after being some time exposed to the sun and wind, attained tolerable consistency on the top; another layer was then added, which also sinking and becoming consolidated, another was added, and the process continued until the mass sunk through the soft, peaty soil, and rested on the solid ground beneath; some firmer soil from old dikes was also added, and the proper form afterwards given to the banks, by removing the surplus stuff. At other portions the base of the embankment of the dike was protected by sheeting piles. In crossing canals and creeks, the dike was constructed of successive layers of fascine or faggot-work, which were formed into oblong masses of considerable area, floated to their proper position, and then sunk, by loading them with gravel or sand—the layers being placed so as to cross at right angles, and being secured by stakes driven through them as they were sunk to their places in the general mass. Over this wall of fascine-work earth was thrown to form the slopes of the dike and canal. In addition to the dike between the lake and the canal, it was found necessary in some places to construct another dike between the canal and the Turf-pit Lakes. The ground here, as I have remarked, was of a very soft, muddy nature, and when thrown up it spread to a distance into these lakes; it was therefore necessary to confine it. This was effected by forming the sides of the canal with fascine-work; and at the exterior toe of the slope of the outer bank, a mass of sand, brought at great expense, was thrown in, which, gradually sinking through the soft soil, formed a barrier impervious to the water; between these two walls of fascines and sand, the excavations from the canal were then thrown in, and the dike formed to the proper slopes. These works were carried on with great vigour, and were all but completed in 1843, with the exception of some portions which were left open to prevent interruption to the navigation, until all should be ready for the final closing of the lake; and other portions, where disputes had arisen regarding possession of the land. Owing, however, to difficulties and delays in procuring the steam-engines and pumps, the lake was not finally closed until the month of May 1848.

In the drainage of the Lake of Haarlem, it was resolved to employ pumping-machines of the most approved construction to be wrought by steam power; and the great problem which the commissioners had to solve, was the most economical mode of supplying that power. In order the better to ascertain this, the commmissioners—with the proverbial prudence of the Dutch—availed themselves of the greater mechanical skill and experience of English engineers in the working of the steam-engine. Where pumping-engines are employed in this kingdom, their duty is, in almost every instance, to raise an inconsiderable quantity of water from a great depth. This is more especially the case in the Cornish copper-mines, and the coal-pits of Northumberland and Durham; some of the former being 290 fathoms deep, and of the latter about 200 fathoms. In the case of the Haarlem Lake, however, the object to be attained is to raise a great body of water to a very inconsiderable height. The lift commenced at nothing, and when at the greatest, will not be more than 14½ feet. This rendered necessary many alterations and modifications of the engine and pumping-gear usually employed; in short, the quantity of water to be raised, taken in connection with the very limited lift, involved quite a different arrangement of the ordinary pumping apparatus. Not only so, but the want of coal in the Netherlands, and the high price at which only it can be procured from this country, rendered it essential that very great attention should be bestowed to secure the utmost economy in fuel.

In 1840, three of the Government commissioners were sent to England to make inquiries relative to the best plan to be adopted in the construction of the steam-engines; and to inspect the principal ones erected in this country for pumping operations. Various plans were suggested and considered; and it was finally resolved to employ Messrs Joseph Gibbs and Arthur Dean to furnish complete drawings and specifications of an engine, with their improved system of double cylinders and flange-pumps, to be erected near Kaag, which is not far from Leyden, by the working of which an opportunity would be afforded, before the other two engines were commenced, to effect such improvements as experience might suggest. This engine has been named the "Leeghwater," in honour of the celebrated engineer who first proposed a plan for draining the lake.—See Plates XXI. and XXII., which show the construction of this engine; the reference letters are the same in both plates. It has *two* cylinders, placed one within the other, *united to the same bottom plate;* the inner one not being attached to the cover at the top, a space of $1\frac{1}{2}$ inch is left all round. The inner cylinder *a d* is $84\frac{1}{4}$ inches in diameter; the outer one *b b*, $144\frac{1}{8}$ inches, and is enveloped by a double casing of iron and of wood, to prevent radiation of the heat. The piston of the smaller cylinder *c*, is of the common description; the larger cylinder has an *annular* piston *d*, both having a stroke of 10 feet. There are five piston rods in all; one to the inner cylinder *e*, and four to the outer or annular piston *f f*, all attached to a great cross-head *g g*, formed like a box, which can be loaded with cast-iron when it is necessary to increase the dead weight; provision is also made to receive an additional quantity in the interior of the pistons. This cross-head is furnished with three guide rods *h h*, in the position shown in the drawing. There are two air-pumps of 40 inches diameter and 5 feet stroke, united to one condenser. The pumps *i*, worked by this engine, are eleven in number, and 63 inches in diameter, so arranged round the cylinder as to work in equilibrio; three of them are placed at 120 degrees apart, while the remaining eight are arranged in pairs on opposite sides of the cylinder. In this manner it is possible, when necessary, to work any number of pumps from two up to eleven; while at the same time, the load is distributed equally on the walls of the engine-house, and exactly balanced round the cross-head. And in the event of repairs being required on either of them, the opposite pairs can be detached without much delay to the working of the engine. The pumps have cast-iron balance beams *k k*, which radiate from the centres of the cylinders supported on plummer blocks *l*, attached to openings in the walls of the engine-house, and through which they pass, the pumps being fixed outside. The inner ends of these balance-beams are fitted with cast-iron rollers *m m*, working on guides *n n*, secured to the under side of the great cross-head; each beam is attached to this cross-head by slotted links *o o*, thus insuring the simultaneous rising of the whole, on the up-stroke of the engine. At the outer ends of the balance-beams, the pump pistons *p* are connected by iron rods, with a length of chain at the lower end, and are so constructed as to descend by their own weight with the least possible shock: great facility being also given for passing a large quantity of water, and for the prevention of any mud from gathering about them.

I have said that the pump pistons descend by their own weight, and they are loaded to such an extent that they move as nearly as possible with the same velocity as the steam pistons ; but in the event of any irregularity in their speed, and to allow time for the proper filling of the pumps and the closing of the valves, provision is made for sustaining the dead-weight on the piston rods by a hydraulic apparatus *qq*, for a second or two, until the valves of the pistons have closed, that they may take their load on the commencement of the down stroke of the steam piston without any shock.

The action of the engine is easily explained. When both pistons are *down*, steam is admitted below the inner one, which is thus raised, carrying with it the dead-weight on the cross-head, and the annular piston which is connected with it, and below which a vacuum is always maintained. If the pump balance beams be lagging behind, they also are raised. The steam being shut off at a certain portion of the stroke, varying according to the depth which the water has to be raised, and the quantity of dead-weight on the cross head, the remainder of the stroke is made by the expanded steam; the down stroke is then made after a pause of a second or two, during which the dead-weight is sustained by the hydraulic apparatus before referred to; the steam is then passed from the under side of the inner cylinder to the top of both, and expanding presses upon the upper side of the inner piston, which is thus maintained in equilibrio, while the raising of the loaded pumps is effected by the pressure of the expanded steam on the annular piston, and by the dead-weight suspended in the cross-head.

Before leaving this branch of the subject, I may notice, that by using two cylinders, no greater expansion of steam is obtained than there would be by one; but with two, it is unnecessary to employ a dead-weight to raise the pump buckets, as would be the case were there only one cylinder; the additional power required being supplied by the expanded steam pressing on the upper surface of the annular piston. If the maximum dead-weight were used, no alteration in the power of the engine could be attained, without adding to, or taking from, the dead-weight; whereas, with the two cylinders, great facility is given to the adjusting of the power to the load to be raised, by varying the expansion of the steam in the small cylinder.

The steam is supplied by five cylindrical boilers, 30 feet long and 6 feet diameter, having a fire tube through their centres of 4 feet diameter; the flues return under the boilers to the front, passing along both sides; over the boilers is a steam-chest, 42 feet long and 4½ feet diameter, to which the steam-pipe of 2 feet diameter is attached. This engine having been subjected to numerous severe trials, and having been found to answer perfectly, the commissioners resolved to proceed with the construction of the other two, which have been named "Cruquius" and "Lynden," after two celebrated persons who had greatly interested themselves in the drainage of the lake. They are erected, the Cruquius not far from Haarlem, and the Lynden at no great distance from Amsterdam. These two engines do not differ essentially from the Leeghwater; however, the means which had been adopted with it, to guard against the shock of the pump pistons, having been effectual, it was determined to limit the number of pumps in the case of the two others to eight, and to increase their diameter to 73 inches; the inner ends of the pump-balances, too, are made to rest on the *top* of the great cross-head, in place of under it, as in the Leeghwater, and are connected by stout links; the boilers are increased in number.

These three engines are erected in buildings of the same design. The engine-houses are massive circular towers, in the centres of which the cylinders are placed, and from which, again, the pump-balance beams radiate, and pass through the arched openings in the walls to the pumps, which are placed outside. The boiler-houses are square buildings, attached to the sides of the circular towers. Preparatory to laying in the foundations of these erections, dams were thrown round their sites. The water having been pumped, the areas were dug to a depth of about 23 feet below the mean surface of the lake. Piles were then driven to a depth of about 40 feet below that level, and over them a very strong platform was laid to receive the walls. Concentric with the walls of the engine-house, and at a distance of 22 feet from it, a strong wall was erected, pierced with arches to admit the water to the pumps, which were placed opposite to these arches, and fixed to the platform. At the proper level a floor was laid between these walls, through which the pumps rose, and a conduit was by this means formed to carry off the water to the sluices, which open outwards, and are placed one on each side of the boiler-house. By means of these three engines, the water of this great lake is being raised to the surrounding canal, which carries it to the sea.

I have previously referred to the *steam-engine* erected at Spaarnedam, which, it will be noticed, is not for pumping the water from the lake to the canal, but for the purpose of raising it from the canal to the sea, when its level is such as to prevent this by gravitation.

The machinery erected here consists of a powerful steam-engine, said to be 360 horse power, giving motion to a series of 10 water-wheels, which raise the water from the level of the canal to the height required for running it into the Y.

This engine has a cylinder of nearly 60 inches diameter, set horizontally, with a stroke of about 10 feet, and should work 10 strokes per minute. It is furnished with two massive fly-wheels, 28 feet diameter. The steam is supplied by 4 Cornish boilers, 5½ feet diameter and 38 feet long, worked at a pressure of 40 lb. per square inch. The whole breadth of the water-wheels is 72 feet, so arranged, however, that any required number can be detached at pleasure. When the water is two feet deep, only 6 wheels are used; and when it rises to three feet deep it must be shut out, as the engine cannot work in that depth. The working of this engine has not proved so satisfactory as was anticipated, nevertheless a great deal has been performed by it. This engine was built in Amsterdam.

It was my intention to have examined a little minutely the duty performed by these engines, but I have been disappointed by not having received from Holland certain data, without which it is impossible for me to bring the matter before the Society in so satisfactory a manner as I wish to do. I may, however, state that the coal used at the time of my visit was estimated at about ten tons per twenty-four hours, when the engines were making 5·42 strokes per minute, with a lift of 4·92 feet; and the quantity of water raised 4·92 feet, during that time, being 491,702 tons, it gives the quantity of fuel consumed for each ton of water, raised one foot high, as $\frac{15}{100}$ of an ounce. With regard to the quantity of water raised per minute, when all the engines—27 pumps—are at work, I found it to amount to the enormous sum of 1024½ tons; and it is expected that by using a better kind of coal, the quantity of water raised will not be materially diminished as the lift increases.

I have not obtained the necessary information to enable me to lay before you the regular progress of the drainage prior to February 1850, but I have it in my power to state it with the greatest accuracy from that date.

In May 1848, when the pumping commenced, the level of the water was $\frac{68}{100}$ths of a metre, or 2·23 feet below the Amsterdam datum level. When I visited the works in April last, I found that the surface of the water had been reduced

M 2

to the mean level of 2·18 metres—equal to 7 feet 1·80 inches of our measure—below the Amsterdam standard. The following table will show the progress of the drainage:—

Tabular View of the Drainage.

Date.	Below A. D.			Below Surface of Lake.			Depth lowered per Month.	
	Metres.	Ft.	in. dec.	Metres.	Ft.	in. dec.	Ft.	in. dec.
1848.								
May	0·68	2	2·56					
1850.								
February... 28	1·95	6	4·80	1·27	4	2·38		
March 31	2·11	6	11·04	1·43	4	8·28	0	5·90
April 30	2·18	7	1·80	1·50	4	11·04	0	2·76
May......... 31	2·34	7	8·04	1·66	5	5·28	0	6·24
Juue......... 30	2·60	8	6·36	1·92	6	3·60	0	10·32
July......... 31	2·78	9	1·44	2·10	6	10·68	0	7·08
August ... 31	2·87	9	4·92	2·19	7	2·36	0	3·68
September 30	2·98	9	9·24	2·30	7	6·48	0	4·12
October ... 31	3·00	9	10·08	2·32	7	7·32	0	0·84

or an average progress of nearly 5·12 inches per month during the eight months preceding October last.

From the official reports detailing the monthly progress of the work, it appears that in April, when the lake was lowered only 2·76 inches, the engines were stopped nearly 500 out of the 720 hours in the month by the high level of the water in the canal; and in October, when the lake was lowered only 0·84 inch, one of the engines was being repaired during the whole month, the other two for some days, and in addition a considerable quantity of rain fell.

This progress may at first sight appear to be inconsiderable; but when it is remembered that every vertical inch that the water is lowered involves the pumping of no less than 4,113,189 tons of water, it must be regarded as a very great performance indeed. From May 1848 to 31st October 1850, the lake was lowered 91·32 inches; and assuming the average area of the portion deepened to be 40,000 acres, the total quantity of water per inch of depth is 4,113,187 tons, and the total quantity raised is 375,698,563 tons; but according to the Physical Atlas, 26·70 inches of rain fall on an average in Holland; and allowing 62 per cent. for the months from May to October (a proportion fixed by the same authority), we have a total rain-fall of nearly 70 inches for the two years and-a-half during which the drainage operations have been carried on, making an additional quantity of water raised of 287,923,137 tons; making a total of 663,621,700 tons.*

In making this statement I am keeping in view, that from such an area the quantity of water carried off by *evaporation* must in that time have been considerable; but I assume that this was compensated for by the leakage or oozage from the adjoining lands; so that I consider the quantity above stated to be a faithful estimate of the performance of the engines.

I have stated that the Leeghwater engine was started in May 1848. In April 1849 the other two engines were set to work, since which time the pumping has proceeded, subject, however, to interruptions arising from casualties connected with the engines (which I am informed have been more than usually frequent), as well as from the peculiar nature of the country, and the state of the levels of the sea, with reference to the canal, at the points of discharge.

By a regulation of the Waterstaat of the Rhineland, the pumping from the lake must be stopped whenever the level of the water rises to $\frac{57}{100}$th of a metre below Amsterdam datum. This is necessary to guard against the overflowing of the adjoining polders. In winter, however, in consequence of many of the lower districts being then flooded, the pumping is allowed to be continued until the water reaches $\frac{37}{100}$th of a metre below Amsterdam datum. In either case, the engines

* *The following table shows the progress of the drainage to April* 1852.

Date.	Below Surface of Lake.			Date.	Below Surface of Lake.		
	Metres.	Ft.	In. dec.		Metres.	Ft.	In. dec.
1850				1851.			
Nov......... 30	2·27	7	5·34	August...... 31	2·805	9	2·40
Dec......... 31	2·21	7	2·98	Sept......... 30	2·86	9	4·57
1851.				Oct.......... 31	2·94	9	7·72
Jan.......... 31	2·17	7	1·41	Nov......... 30	2·84	9	3·78
Feb......... 28	2·22	7	3·40	Dec.......... 31	2·885	9	5·55
March...... 31	2·27	7	5·35	1852.			
April....... 30	2·21	7	2·98	June......... 31	2·875	9	5·16
May......... 31	2·36	7	8·89	Feb......... 29	2·845	9	3·98
June........ 30	2·615	8	6·93	March...... 31	2·94	9	7·72
July......... 31	2·685	8	9·68	April....... 27	3·06	10	0·44

at the lake must cease pumping until the water in the canal is lowered by the action of the engines at Spaarnedam, or the recurrence of a favourable wind or tide to lower the level of the sea at Katwyk or the Y, so as to admit of the water being discharged by its own gravity.

With reference to the system of canals and ditches by which the internal communication and drainage is to be maintained after the lake has been laid dry, it is proposed to construct a canal through the whole length of the reclaimed land, the south end being to commence at the Leeghwater engine, near Kaag, and the northern extremity at the Lynden engine, near Lutkemeer; and at right angles to this canal others are to be formed at a distance of 300 metres, or 3280 yards apart, one of which will terminate at the *Cruquius* engine. Parallel with the longitudinal canal, a main line of ditches will be formed, 1000 metres, or 1093 yards apart; and at right angles to these, again, it is proposed to make smaller ditches, 50 metres, or 164 feet apart. These ditches, besides being subservient to the drainage, will form the boundaries of the properties when the land shall have been disposed of.

It now only remains for me to notice the commercial features, or balance-sheet, of the scheme. It is expected by the commissioners that the land, when drained, will sell for about 225 florins per hectare, or about £7, 12s. per imperial acre; and as there are 18,000 hectares, or 44,520 acres, to be disposed of, the produce of the sale will be 4,050,000 florins, or £337,500. But in addition to the price realized by the sale of the lands, there will be a land-tax of 10 florins per hectare, or about 7s. 4d. per acre, amounting to 180,000 florins, or £15,000 per annum, which, calculating the interest at 4 per cent., represents a capital of £375,000; together, £712,500. As the total expense of the works has been estimated at 8,250,000 florins—£687,500—there will thus be an apparent excess of £25,000, over and above the cost of the works, the whole of which, however, may be absorbed by expenses which professional men know well are inseparable from such works.

It is estimated that the annual expense of keeping the polder dry, and of the repairs to the engines and other works, will be between 60,000 and 65,000 florins. This will be borne partly by the purchasers of the reclaimed land, and partly by the Waterstaat of Rhineland. It is difficult to state precisely the proportion which will fall on each, but the principle is to be this:—The proprietors will bear the expense of all the pumping from the lake, which will then be a polder, into the canal, including the repair of the three engines; while that of discharging the water from the canal into the sea will fall on the Waterstaat, the expense of which is defrayed from the government purse. The expense of protecting the surrounding district from the encroachments of the lake, before the commencement of these operations, was about 45,000 florins per annum; from this burden the Waterstaat are now relieved, the saving on which will much more than compensate for the outlay in raising the water from the canal to the sea.

In a commercial point of view, therefore, the undertaking may be regarded as rather remunerating than otherwise; but it must not be lost sight of that a *dangerous* internal sea will have been got rid of, thereby preventing the recurrence of great periodical damage, if not entire destruction, to a very extensive district and much valuable property, and that upwards of 40,000 acres will have been added to the productive soil of the kingdom.

In assuming £7, 12s. per acre as the price expected to be realized by the sale of the drained land, I have been guided by information kindly communicated by M. Gevers, the president of the commission. Compared with the price which fertile meadow-land, such as this is expected to be, would bring in this country, a very low valuation appears to have been put on it, even though there be a burden of 7s. 4d. per acre of land-tax annually, and the expense of maintaining the drainage, which cannot much exceed 2s. per acre.

It now remains for me to notice the works at Katwyk. In the ninth century the mouth of the Rhine was sanded up during the prevalence of heavy gales; and being thus deprived of its natural outlet, found other channels by which to reach the sea, though a considerable portion of its waters continued to flow in the old courses, and were in a great measure absorbed by the vast beds of sand which stretch along the coast of this part of Holland. During floods, however, or when the discharge was impeded by the prevalence of north or north-easterly winds, the obstructed waters of the Rhine did great damage to the country about Leyden, and frequently threatened to inundate the lower parts of Holland. It was not, however, till 1804 that any effectual attempts were made to form a new channel through the downs or sand-hills which run along the whole of that coast, or otherwise to defend the country from the overflowings of the old Rhine. The works undertaken at that time for this object consisted of a new cut or canal about 92 feet wide, and extending from the sea at Katwyk to a considerable distance inland; and to regulate the discharge of the water two sets of sluices were constructed. The outer sluices are situated within high-water mark, and have five arched openings, of a total width of 60 feet, and provided with a triple set of massive gates, which are raised perpendicularly by rack and pinion gearing. The fore-shore channel is lined with large blocks of stone, the sides being raised about four feet above the level of the shore, and rounded over. At low water, and when the North sea is not affected by north or north-easterly winds—that is, whenever the level of the sea is below that of the canal—the gates are raised, and the water is allowed to flow into the sea. On the rising of the tide they are closed, to prevent the admission of tidal waters. It sometimes happens that during the prevalence of north and north-easterly gales the sluice-gates cannot be opened; in this case the water accumulates within, and gradually raises the level of the waters of the district, unless indeed, as frequently happens, the same wind which raises the sea at Katwyk depresses the Y, and admits of an increased discharge at Spaarnedam and Halfwege. The second set of sluices is situated about a quarter of a mile further inland. They originally had the same water-way as those at Katwyk, but with only three openings. Two of the same dimensions have since been added; and as they are not exposed to the force of the sea, the gates are hung in the ordinary manner of dock gates. One set face seaward, and one landward. About half a mile above the upper set of sluices, advantage was taken of a bridge with three arches, of a total water-way of 56 feet (and which carried a road over the new cut), to attach a series of gates to the piers, and which, in the event of any accident to the upper or seaward set of sluices, could be closed, to retain the water until the necessary repairs could be made.

The selection of Katwyk as one of the points of discharge for the drainage of the lake, necessarily involved the alteration and extension of the then existing cut or canal and sluices, to carry off with facility the greatly increased volume of water which must pass through them. In accomplishing these a new canal, 131 feet wide, has been constructed from the river Leede, near Oegstgeet, to join the one previously made, so as to shorten the distance over which the drainage-water should have to flow; the old canal has been enlarged from 92 to 170½ feet in width. This involved the lengthening of the bridges, and two additional openings were added to the upper set of sluices, making five in all; it was not, however, thought necessary to increase the size or number of the seaward sluices at Katwyk.

The works for the relief of the country from inundations of the Rhine cost the state about £40,000, while those constructed to facilitate the drainage of the Haarlem lake cost nearly £50,000. The whole of these works, both new and old, are executed in the most substantial and beautiful manner. The masonry, in particular, is finely built of massive blocks of bluish-gray marble from Tournay, and great attention is paid in keeping the whole in a perfect state of repair.

I have now communicated all the information which I have obtained, and which I conceived would be interesting to the Society, respecting this great undertaking. In doing so, I fear that I may have gone more into detail than some of you may have considered necessary; but on such a subject I felt that even to professional men considerable detail was essential to a proper understanding of it, the more so as works of a similar kind are wholly unknown in this country.

I cannot conclude this communication without acknowledging the valuable aid and assistance which I have received in many of the calculations which it contains from Mr Alexander Lee, a young engineer, now present, and who accompanied me to Holland; from Mr J. M. Mitchell, Belgian consul at Leith, who translated for me some important information which had been forwarded to me in Dutch; from M. D'Gevers, D'Endegeest, the president of the commissioners for carrying out the great work, and who has written a short work on the subject, but it unfortunately is not brought down later than 1843; also, from a most intelligent young Scotchman, the Hon. Henry Elliot, son of the Earl of Minto, and secretary of legation at the Hague.

So important is the information which I have received from M. de Gevers, that I shall have to ask the Society to elect him an honorary fellow—a mark of approbation to which I feel that he is justly entitled.

Description and Drawings of a Cast-Iron Swing-Bridge, constructed for Peterhead Harbour, by Messrs Blaikie, Panmure Foundry, from designs by Messrs Stevenson, Civil Engineers. By J. LAWRENSON KERR, Civil Engineer, Edinburgh.* (With a Plate.)

The swing or turn bridge is of cast-iron, and consists of two leaves or compartments, each resting on rollers, and revolving on a pivot. To give the bridge additional strength, it is provided with moveable trusses or strut frames, which by means of gearing are raised clear of the platform when the bridge is opened. The span of bridge is 41′ 6″, and rise or versed sine 5′ 6″, the breadth over all is 20′ 5″, and the total length 99′ 6″. There is a pathway on each side about 3′ 6″ in breadth, and the intervening carriage road-way 13′ 0″ in breadth, being sufficient to admit of two carts passing at a time.

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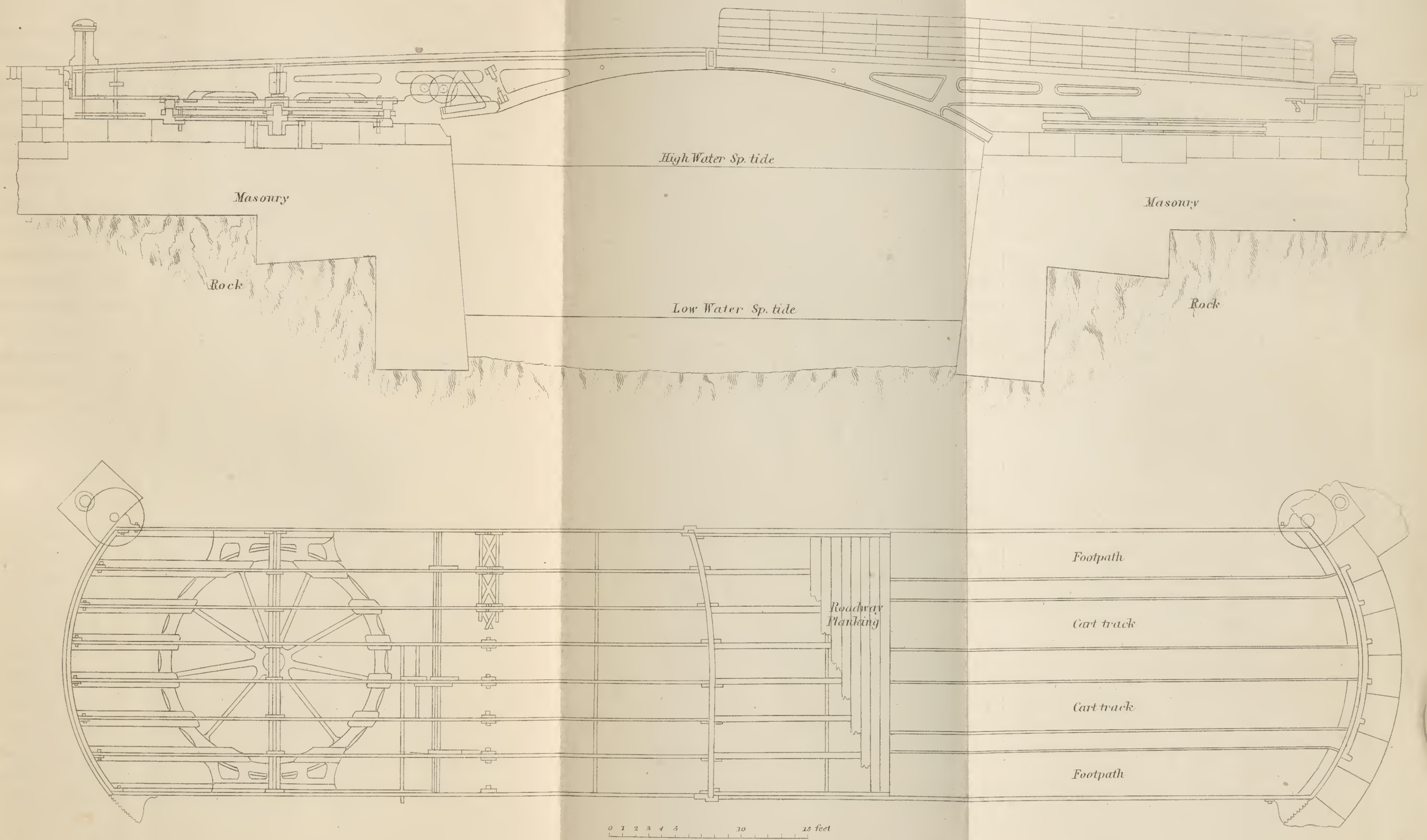
* Read before the Society, 9th February 1852.

PLATE XXIII

PETERHEAD CAST IRON SWING BRIDGE.



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In each leaf there are 8 ribs or girders, all of which, with the exception of the two exterior ribs, consist of two castings joined together by means of a vertical frame, resting on the cross beam of traverse frame (to be afterwards described), and having flanges cast on it, to which are fixed, by $1\frac{3}{4}$ inch bolts, the ends of the castings. All the ribs are 2 in. in thickness, the interior measuring at the crown $11\frac{1}{2}$ in. deep, and the exterior $15\frac{1}{2}$ inches; they are placed 2′ 6″ apart.

The ribs are connected transversely by the back plate 2 ft. 4 inches deep, at the landward end of the bridge;—the vertical frame before mentioned;—the diagonal pieces at the haunch of the arch;—a wrought-iron bolt, one inch in diameter passing through cast-iron tubes;—and the mitre plates to which the ends of the ribs are fixed, and where the extremity of each leaf comes in contact. One-half of these mitre plates is straight, and the other half correspondingly concave and convex, the curve being described from a centre one foot from centre of motion.

As shown in the drawing (Plate XXIII.), at the point where the ribs cross the traverse frame, they have flanges cast on them, resting upon corresponding flanges cast in the frame, and to which they are fixed by $1\frac{3}{4}$ inch bolts.

The traverse frame is cast in one piece of a circular form of 17 feet in diameter, to adapt it to the rollers on which it rests;—it has a cross beam 10″ by 10″, in the centre of which is a socket containing a brass bush, in which the bridge revolves, and the projection on each side is also cast on it, to support the exterior ribs. This is the heaviest single casting in the bridge, weighing 9 tons 4 cwt. The under-surface of circular part of frame which comes in contact with the rollers is accurately turned to ensure easy motion. The rollers are 24 in number, made of cast-iron, case hardened and accurately turned. Each is a frustrum of a cone, 7″ in height, and 9″ in diameter at the base, the apex of the cone being in the axis of central pivot, to which also the axle-pin of the rollers radiate. The roller-frame is cast in two pieces; and for convenience of fitting the axle-pins of rollers, the outer part of frame consists of eight pieces, connected to the main frame in the manner shown in the drawing.

The sole-ring on which the rollers revolve is cast in two pieces or segments, and fixed to the masonry of platform by 12″ bats passing through projecting snugs. The upper surface of the ring is accurately turned in a manner similar to the under surface of circular part of traverse frame.

The central pivots, which are 7″ in diameter at the top and 8″ at bottom, are of malleable iron, accurately turned to fit the nave of roller frame and the brass bushes, which, as before described, are let into the cross-beam of traverse frame. The lower part of these pivots is of a square form, and is let into the socket-plate, which is sunk into the central stone of platform, to which it is secured by four 2″ bolts passing through the stone, and through four arms projecting from the socket-plate, these being sunk flush into the masonry.

In order to adjust the weight of each leaf to the pivot and rollers, and to throw it off the latter, Mr Blaikie introduced above the brass bush a malleable-iron wedge, 30″ long, 6″ broad, 3″ thick at the head, and $1\frac{1}{2}''$ at the point; a corresponding recess having been left in the cast-iron frame to admit of the wedge being driven up.

The strut frames or moveable trusses, are cast in one piece, each strut having a double flange embracing the ribs, to which it is attached by a journal $1\frac{3}{4}''$ in diameter; the strut frames, when the bridge is closed, rest upon an abutment plate formed of cast-iron in one piece, and fixed to the masonry by 9″ lewis bolts.

The gearing for raising the strut frames consists of a pinion $5\frac{3}{8}''$ diameter, working in a spur-wheel 30″ diameter, on the shaft of which is a second pinion $5\frac{3}{8}''$ in diameter, working on a second spur-wheel 30″ diameter. The shaft of this wheel extends the whole breadth of the bridge, and to it are fixed three pinions of $5\frac{3}{4}''$ diameter, working in 3 toothed arcs, 4″·0 radius, giving a mechanical advantage of 163. To the first motion-shaft is fixed also a rachet wheel 16″ diameter, with a catch to retain the strut in its raised position when the bridge is being opened.

The roadway planking is of oak and 4″ thick, resting upon and bolted to flanges, cast on the upper surface of ribs. The carriage roadway has three cast-iron wheel-tracks formed of plates 1 inch thick and bolted to the planking; the centre plate is 2′ 6″ broad, and those at the side 1′ 6″, the latter having an edging 3″ high, to serve as a curb to the footpath.

The gearing for opening the bridge consists of a bevel pinion $5\frac{1}{2}$″ diameter, working into a bevelled wheel 18″ diameter, to whose vertical shaft is fixed a spur-pinion $9\frac{1}{2}$″ diameter, working into a spur-wheel 5 feet in diameter, the shaft of which is also vertical, having fixed to it a spur-pinion $13\frac{3}{4}$″ diameter, working in the toothed rack fixed to the back-plate at landward end of bridge, and whose radius is 17′ 0″, giving a mechanical advantage of 46.

The weight of each leaf, above the level of rollers and pivot is $91\frac{1}{2}$ tons, of which 13 tons are granite blocks used as ballast or counterpoise, and supported on flanges cast for the purpose on the lower surface of ribs, at landward end of bridge. Notwithstanding this great weight, the power of one man only is required to cause the leaf to revolve, and that with extreme facility. The bridge can, indeed, be easily opened with one hand, which, considering the greatness of the weight, $91\frac{1}{2}$ tons, shows that the workmanship must be very accurate. The time taken in first raising the strut frames and then opening the bridge, with one man on each side, is only about $2\frac{1}{2}$ minutes. When lately at Peterhead, I was struck by the ease with which it was effected, especially when I compared it with other bridges of the same description, where I have seen five men required on each side (10 in all) to work the gearing.

The bridge is said to be capable of bearing 20 tons with safety; it was tested shortly after its erection with 9 tons, and Mr Macdonald the superintendent informs me that the greatest weight he had seen on it was more than 13 tons, and that at the same time, there was not the slightest appearance of undue straining.

	Tons.	cwt.	lb.
Total weight of cast-iron, . . .	143	3	0
" malleable iron, . .	6	14	0
" brass, ...	0	4	0
" timber, ...	19	0	0

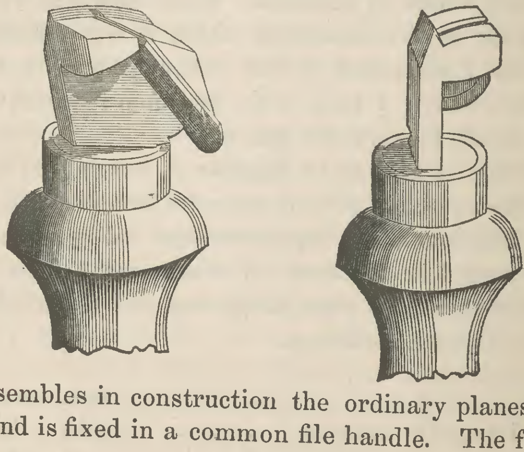
So successful a work as the Peterhead bridge is certainly not more due to the suitable and judicious proportioning of the various parts of the bridge in the design as to the completely satisfactory execution of it by the Messrs Blaikie, it being obvious that in so large a mass, only very superior workmanship and accurate adjustment of the rollers, pivots, and moving powers, so as to reduce the friction to a minimum, could have ensured the requisite facility of movement.

The total cost of the bridge as fitted up in its place was £2032.

Description of a Bootmaker's Plane, for Planing the edges of Boots or Shoes, without the use of a knife, rasp, or other sharp tool, such as is employed at present. By Mr LOUIS NIMAN, Bootmaker, Edinburgh.*

SILVER MEDAL, VALUE TEN POUNDS, AWARDED 1852.

The instrument is intended to supersede the knife used by shoemakers in cutting away the edge of the sole. It very



much resembles in construction the ordinary planes used by joiners and is fixed in a common file handle. The frame for

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* Read and the Instrument exhibited to the Society, March 8, 1852.

holding the blade is iron, the size and general shape are shown in the woodcuts. The face of the plane is slightly convex, to enable it to be more easily moved along the curved edge of the sole; the breadth of the face is fully the ordinary depth of a shoe-sole, and the length twice the breadth. A narrow fillet projects from the face along one side, for resting on the upper surface of the sole, and conducting the face of the plane along the side while cutting; it also prevents the blade from touching the upper leather. The blade is not set square to the edge of the plane, but at an angle of nearly forty-five degrees, which makes it easier to cut with. It is fastened in its place by a small screw-nail. On the face of the plane, in front of the blade, is a narrow opening to allow shavings to fall away, as in the planes used for wood.

Remarks on Projectiles.—The Minié Musket, &c. By JOHN DICKSON and SON, Gunmakers, Edinburgh.*

Projectiles of late have been a subject of general conversation, not only as regards the equipment of the sportsman and deer-stalker, but also as a means of effective defence to the country in the event of an invasion from any foreign power. Rifles have been long known as powerful and efficient weapons in the hands of a steady marksman.

In Switzerland, the peasantry, as well as the landholders, have their rifles; and rifle-shooting forms a constant pastime as well as, it may be said, a truly national amusement; the authorities there always providing a proper and suitable place for rifle-shooting. In these shooting matches, the rich and poor equally mingle, and the fair "*belles*" of the land watch with deep interest the success of those who are dear to them; thus every encouragement is given to those who excel in this art, and at certain periods of the year valuable prizes are given to the successful competitors.

A spirit of emulation is thus excited, and a perfection

* Read before the Society, March 22, 1852.

attained in this art by the natives of that mountain range, far exceeding that of any other country; they thus blend their amusements with utility, and by these means form a steady and determined band of efficient men, fit to be turned out at a moment's notice, to defend their homes, or assert their rights, against any invading force.

The question of forming rifle companies in every locality of this country is at present much agitated; and, no doubt, were such bodies of men formed, properly exercised and practised in the use of the rifle, they would form a powerful auxiliary to the regular army, and prove a deadly foe to any foreign invader.

To the question, however, of rifles. What is the best and most effective weapon? On that now much agitated question, there are many conflicting opinions, as well as regarding the formation of the ball, and which shall prove the most effective projectile for convenience and rapidity of loading to ensure proper success.

The subject of rifles and balls has long engaged our attention, and the question resolves itself into these points, namely, quick loading and perfect efficiency.

On these heads, great differences of opinion exist. Since the days of Robins, as stated by our friend, Mr Buchanan, all sorts and shapes of balls have been tried, and indeed, as far as we know, out of the many now brought forward few can be called new.

The reported success of the Chasseurs de Vincennes in Algeria, and at the siege of Rome, and the wonderful accuracy of their shooting, has roused a spirit of deeper inquiry into this subject than formerly existed. The correct description of a rifle you have already heard from Mr Buchanan. We now beg to give you the results of long experience and practice as shortly as possible; and shall first take notice of the forms of the different balls, and show specimens of them. *Oval balls* had at one time many friends. They were chiefly used in India for buffalo shooting, (two of which we exhibit), but these are now out of repute. *Four*-grooved balls were also once in great esteem, both conical and of the spherical forms (patterns before you); but they did not answer for long distances, the increased friction while passing up the barrel retarded their flight. A few years ago *three*-grooved balls had also advocates and admirers, but after repeated trials at Woolwich, they were also rejected for the same reason as the four-grooved balls, namely, increased friction, and requiring particular attention in loading. We submit for inspection a pattern of this bullet.

About twelve years ago, after many and repeated tests, we adopted the two-grooved rifle, and may remark, that the grooves ought to be cut so as to add to the rapidity of the ball, and for this purpose we find that a quarter turn in a barrel of thirty inches is to be preferred to any other, because that gives the rotatory motion necessary to turn the ball on its axis; and by this reduction of the spiral turn, the ball requires to turn only once on its axis in the space of seven yards or so: a *full* turn shoots as correctly at *short distances*, but at a long range varies a great deal more than the quarter turn. The conical ball we have ascertained has a decided advantage over all others for correct shooting at a long range, and to the sportsman is quite invaluable. However, while aware of its excellency on this point, we *must admit* that as a projectile for active warfare it is totally useless, the lobes or belts on the sides of the ball require correct fitting into the barrel to ensure accuracy in shooting, and this unfits it for the bustle and hurry of warfare, or indeed from being used under any excitement, as it is apt to be thrust the wrong way into the barrel; and this has been fully borne out by the experience and bitter disappointment of our gallant Rifle Brigade in their hour of need.

We shall now shortly advert to what has created so great a sensation, namely, the Minié ball used for the musket now shewn. You observe the form of this ball: there is a hollow made in the back part in order that the centre of gravity may be thrown more forward to assist its flight; into this hollow is inserted an iron cup. This cup, on the ignition of the charge, is forced up into the hollow, causing the ball to expand and fit the grooves, thus receiving the necessary rotatory motion to carry the projectile through the trajectory to the point of aim. This musket for the purposes of general warfare is preferable to any now in use. This arises from the great facility with which it can be loaded.

Anxious to try the effects and ascertain the truth of the many statements circulated about it, we procured this musket (one of those about to be introduced into the regiments of the line), and through the kindness of the Earl of Morton, got permission to use his grounds at Dalmahoy Moss, when we had a fair trial along with our two-grooved and other rifles; the target was five yards square, the shooting at 900 and 1100 yards; the musket and Minié balls shot with surprising accuracy, the balls were carried well forward, and at the end of the shooting the target was fairly riddled.

The two-grooved rifles shot as well, and with this advantage, the balls went quicker to the object, taking, as near as could be calculated, 2½ seconds for the 900 yards, while the Minié balls took from 3½ to 5 seconds for the same distance.

The result may be summed up thus:—The Minié musket, as a weapon for general warfare, is a decided improvement on the old musket; still this musket now shewn might be greatly improved, to increase its efficiency, as well as to render it a weapon easier to handle without detracting from its powers; and if a body of men were picked out of each regiment, properly trained to its use and practised at the long range, they would be a great acquisition to the regiment, besides well fitted for the annoyance of artillery, and even cavalry at a distance, or for guarding a pass or defile powerful and effective auxiliaries.

A great deal more might be said; but I fear we have already trespassed too long upon your valuable time. We shall, however, be happy to give any further explanations.

On a Bullet-Mould. By THOMAS E. MORTIMER, Gunmaker, Edinburgh.*

I feel that an apology is due to you for bringing under your notice so trifling a matter as a Bullet-mould. As, however, the subject of rifles, and Minié balls in particular, has engrossed public attention to a very great extent, I think it a good opportunity for introducing a few remarks relating to various trials and experiments I have made with the Minié and other balls during the last three months, trusting that such may interest, and at the same time convey information to those unacquainted with the subject; the popular impression being, that the improvement lies chiefly in the rifle, whilst in reality it is principally in the ball, the advantages of which may be summed up as follows :—

In the first place, the weight of the ball is thrown more forward, thereby being less likely to turn in its flight.

Secondly, there is less difficulty in loading ; and,

Thirdly (as I shall attempt to prove), by having a space filled with air at the end of the ball nearest the powder, one of three things occurs—

1. The ball by being thinned at the end expands more readily with the explosion of the powder, and thus prevents windage ; or,

2. The air contained in the hollow at the back of the ball causes a more general ingition of the powder ; or

3. The explosion of the powder, coming in contact with the confined air, causing great expansion of that fluid, and possibly in so doing may generate another power greater than either possesses separately ; which of these is the true cause, I am not sufficient chemist to determine.

In confirmation of this view, I may mention that I have been informed that the Swiss are now making their rifles with a projection inside the barrel at the breech end, to prevent the ball going close home to the powder, having found that by this means they attain greater force and velocity.

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* Read before the Society, April 12, 1852.

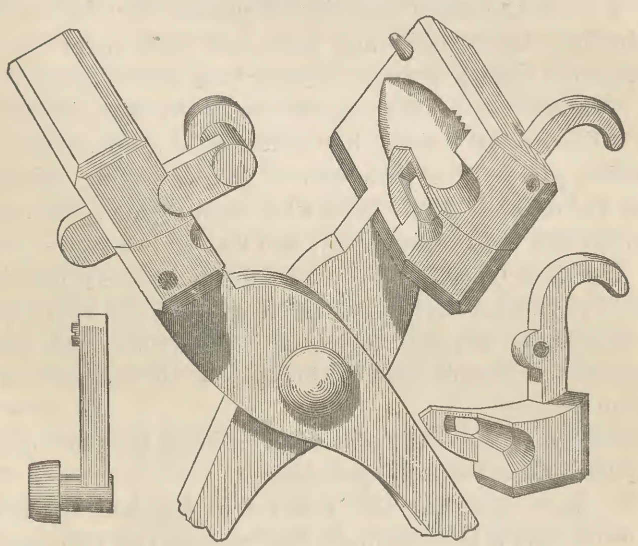
To carry out these experiments, it was necessary, for my own satisfaction, to have a bullet-mould that would cast balls from the opposite end to those generally in use for Minié rifles; and for that purpose I had a similar mould made to the one now before you, which differs from those in general use, in being more portable, very simple in its construction, and I might almost say, self-acting, as a cone being attached to a simple slide, finds its proper place in the mere act of shutting the mould; by this method, also, steel points can be cast on the ball as readily as by the common conical ball-mould, which is a great advantage to our sportsmen in the east, who have much tougher-skinned animals to deal with than we have in this favoured country.

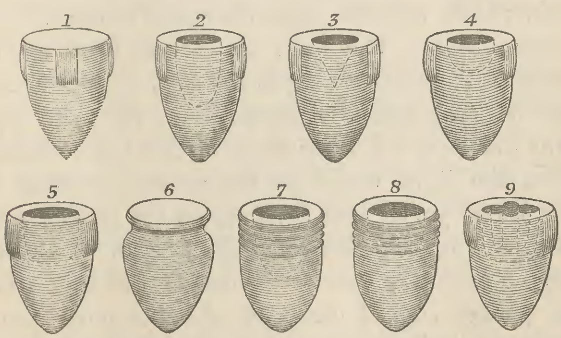
Wishing to make this principle of mould as complete as possible for a gentleman's use, I have introduced a cutter since the drawing was taken, which, although more intricate to make, renders it, if possible, more simple to use.

Having now introduced the mould, I shall enter at once upon the experiments referred to, as it would be tedious to you were I to take up your time by reiterating what has been done and written in former years upon the subject of gunnery. I shall therefore proceed by stating that when I first saw the Minié ball, it occurred to me that the force of the powder alone would be sufficient to swell the ball to fit the rifling without the aid of a capsule, and this, by experiment, has been fully proved.

It must be borne in mind, however, that it will not do to cup out so much of the ball when the capsule is not used. If such were done, the chances are, that a cylinder would go out of the gun instead of a solid ball; a specimen of which I have with me, so that it is necessary to use judgment in not making the cupped out part too deep. I have also brought with me specimens of balls shot at 150 and 200 yards at an iron target, *with* capsules. These, Mr President, are very satisfactory, as shewing the accuracy with which the points have struck the target, a great desideratum for ensuring good shooting. My reason for bringing before you those which have been shot with capsules, is, not that they shoot more correctly than without, but that after hitting the target, the mark the capsule leaves shews how the ball has struck more plainly than can be shewn without it.

Wishing to ascertain the relative strength of different balls, upon the Minié principle, and their applicability to ordinary rifles, I had six targets made of various thicknesses, and placed behind each other at a distance of about 18 inches apart. The first and second were each $2\frac{1}{2}$ inches thick, the third 2 inches, and the remaining three 1 inch each.





I then had five differently shaped balls fitted to a No. 20 bore three-grooved rifle, and the results were as follows :—

Fig. No. 1, solid ball, pierced through 2 and $2\frac{1}{2}$ boards, say average 6 inches. Fig. No. 2, ball with capsules, 4 and $4\frac{1}{4}$ boards, say average 8 inches and a fraction. Fig. No. 3, ball without capsules, 5 boards, or average 9 inches. Fig. No. 4, ball without capsules, 6 boards (nearly), or average $9\frac{1}{2}$ inches. Fig. No. 5, ball without capsules, 6 boards (nearly), or average $9\frac{1}{2}$ inches.

No. 5 would in all probability have passed clean through the last target had it not touched a knot.

I used the same quantity of powder for the five balls, although the capsule and the other balls upon the Minié principle were $\frac{1}{8}$ of an oz. heavier than the solid ball.

There being a difference of weight in these balls, I had 3 balls of equal weight, but differing in shape, made to an ordinary best rifle with eleven grooves, being anxious to try the effect of Minié balls with such rifling; the result of which was most satisfactory, and was as follows:—

Fig. No. 6, solid ball, went through 4 to $4\frac{1}{4}$ boards, say average 8 inches and a fraction. Fig. No. 7, ball with capsules, 5 boards, or average 9 inches. Fig. No. 8, ball without capsules, 6 boards broken through, or 10 inches, not very clean through.

Charge of powder $1\frac{7}{8}$ of a drachm, being the same quantity as used in the former experiment.

In these experiments I was not trying how much wood I could send a ball through, but merely the relative force of different balls with the same charge of powder.

It having been a bad light for correct shooting, during these first experiments, owing to the rays of the sun crossing our line of aim, and wishing to know the accuracy with which the different balls travelled, we tried on a subsequent day, when the light was more favourable, 18 shots at the distance of 330 yards, that being about the longest range I can get at my target with the balls 1, 8, 9.* As regards accuracy of flight it was in favour of the ball with the greatest portion cupped out, and which required from the extra strength it had above the solid ball about 18 inches less of elevation, that is to say, aiming at the same spot the

* A similar ball to No. 5, only rather more cupped out.

solid ball shot 18 inches lower than the other at 330 yards. The same ball with capsules shot lower than the one without capsules, but much higher than the solid ball.

Out of eighteen consecutive shots (not picked-out ones) we had 7 bull's eyes, 4 nearly touching, and the other 7 well into the target (*thus proving that the Minié ball will shoot well without a capsule*); as on other occasions since with the same gun it has been found to do equally well.

Being determined to satisfy myself still further upon this subject, I tried the two principles of rifling now in use at a thousand yards (that is to say, the poly-grooved rifle, the balls for which have no wings on them, and the other principle of rifling, in which the balls have wings to fit the grooves before being put in the gun), and found the same results. At the distance of a thousand yards I was, if possible, more than satisfied; we shot under great disadvantages for fine shooting, as a strong breeze was blowing directly across our line of aim, so much so, that the target was broken by the force of the wind. When fixed up it measured about 9½ feet square, not half the size used by others for a similar purpose.

At the distance of 1000 yards we several times put in 3 consecutive shots, but not more, till we confined ourselves to the balls Nos. 5 and 8, which we did at the close of our shooting, when we put in 8 shots in succession, 9 out of the last 10 shots fired struck the target, and two of these shots were in the bull's eye.

I have before alluded to being more than satisfied with the result of these last experiments, not on account of having made good shooting, but having ascertained that the ball with the greater part cupped out was less affected by the strong breeze that was blowing at the time than any other, and also that it went up to the mark with less elevation, thereby confirming the experiments made at the wooden targets.

I fear, Mr President, I may have detained you already too long, so shall conclude by stating in a few words the conviction I have at present arrived at with regard to the solid and Minié balls. With the former we can at present make such good shooting at ordinary distances, suited for the general sportsman, that it is difficult to beat; at the same time, as the Minié ball shoots stronger and with less elevation than the solid ball, the latter ought to be better for short, and must be better for very long ranges; and also if the bullet is judiciously made, there is no necessity for capsules being used at all.

To prove that the capsules occasionally fall out of the ball in their flight, I have brought several balls, in which the holes are much larger than the capsules, and which were picked up without them after firing, which corroborates what I was lately told by a party who had been firing at Woolwich, that they frequently picked them up half-way to the target. This may be owing to the balls fitting too loosely in the barrel. Were they made to fit a little better, this might not happen.

It may not be out of place to mention here, Mr President, that I think Government would have acted wisely had they tried the Minié principle of ball to their old rifle, and slightly rifled their present muskets, which are sufficiently strong for that purpose, before going to the expense of having entirely new ones made, as a very little depth of rifling is required to give a ball the necessary rotatory motion.

That the Minié principle for military purposes possesses great advantages of facility of loading cannot for a moment be doubted; at the same time the nearer the ball fits the calibre of the barrel, without the grooves being fitted until explosion takes place, the more regular will be the shooting.

As to the accounts we read of hitting a single man at 1400 or 1500 yards with any degree of certainty, before they can do that every gun will need a telescope fitted to it, and a different atmosphere to our own to shoot in, or very different sized men to shoot at, as few men could hold a gun steady enough to hit, supposing their eye-sight sufficiently good for them to see the object.

I shall now take my leave, Sir, by tendering to you and the gentlemen present my best thanks for your indulgent attention, as I fear I have detained you from more interesting subjects.

Since the reading of the foregoing paper, Government has adopted the ball here recommended without a capsule, and some thousands of old muskets have been rifled for the use of the navy.

Address by the President, DAVID STEVENSON, Esq., F.R.S.E., Civil Engineer; *delivered November* 14, 1853.

GENTLEMEN,

I have now to ask your indulgence while, in accordance with what has hitherto been the practice in our Society, I offer a few remarks for your consideration, in opening the Thirty-third Session of our Meetings.

Such opening addresses are, I believe, generally expected to embrace a statement of the progress of discovery, and of the improvements that have been effected in the various branches of the useful arts during the past Session. But, with the view of promoting the interests of our Society, it occurs to me that nothing brought forward in an address such as I have now the honour of submitting can be so useful as a simple narrative of what it has already done. Such a recital, by reminding the members of the Society of its history and efficiency, will tend to stimulate them to increased exertion in upholding it in all its usefulness and integrity; while I am sure that an account of what has been done cannot fail to convince authors of communications and inventions that great benefit may be derived from submitting to us the results of their labours for our consideration. I propose therefore, in accordance with these views, to confine my remarks this evening to a brief recapitulation of the history of our Society, embracing, in so far as its records enable me to do so, a short notice of its Institution—its Membership—its Transactions—and its Premiums.

It is believed that the idea of forming an Institution for the promotion of the Mechanical Arts in Edinburgh was conceived somewhere about the year 1819, and that Sir David Brewster, Sir John Robison, and Mr Guthrie Wright were chiefly instrumental in bringing the proposal into notice. It appears, however, that a considerable period elapsed before the views of the projectors could be fully carried out. As happens in all such matters, difficulties occurred; and we may infer that it was in consequence of these difficulties that this Society was not formally instituted till the 9th July 1821, being two years after its organization was projected. Between July 1821 and March 1823, several meetings appear to have been held, chiefly for the purpose of discussing the arrangements for carrying on the business of the Society, and the best means of bringing it into notice; for the early minutes bear evident marks that the projectors of our Institution had many difficulties to contend with in recommending it to the public. These preliminary meetings were attended, among others, as the minutes shew, by Baron Clerk Rattray, Sir John Hay, Sir Walter Scott, Professor Hope, Principal Baird, Mr Thomas Allan, Mr Leonard Horner, Mr Bryson, Sir David Brewster, Mr Henry Jardine, Sir John Robison, Mr Robert Stevenson, Mr James Jardine, Mr Guthrie Wright, Professor Wallace, Mr James Milne, Mr Whitelaw, Mr L'Amy, and others who, at that period, took an interest in the subject. It is worthy of remark, that one result of these preliminary meetings appears to have been the establishment of the present Edinburgh School of Arts, an institution which has been singularly successful in maintaining a course of instruction for the industrial classes by persons eminently qualified to discharge that duty. In the minutes of our Society of 27th August 1822, it is stated that on considering the expediency of carrying into effect the plan of disseminating useful knowledge amongst the industrious classes, the members resolved to establish permanent Schools of Arts in Edinburgh and in other towns; and in terms of this resolution arrangements were actually made with Dr Fyfe and Mr Galbraith to deliver lectures under the auspices of the Society of Arts during the winters of 1822 and 1823; but at a meeting held on 5th September 1822, the idea of establishing a School of Arts in connection with the Society was abandoned, for some reasons which the minutes do not explain. The present School of Arts was, however, organized immediately thereafter: and thus we are warranted in saying that the original idea of the Edinburgh School of Arts was propounded at the early meetings of this Society.

The meetings alluded to were, as I have stated, of a preliminary nature, and intended mainly for the purpose of determining the best method of carrying out the objects of the Society; but, early in 1823, they assumed the form of regular meetings for business, and in the month of March of that year we find, among other communications, that Professor Wallace read a paper on the Eidograph; Mr Ruthven on a new press for goods; and Dr Brewster on an improvement in the construction of table-lamps; so that the Society was then in actual operation. At that time, however, the meetings appear to have been held only occasionally when a sufficient number of communications were received; and it was not till January 1824, or five years after the first proposal for its organization, that the members resolved to hold regular evening meetings once a fortnight; and these meetings have, since that date, been continued without intermission.

In the year 1841 the Society obtained its Royal Charter of incorporation.

With reference to the constitution of the Society it may be stated, that at an early period of its history it was customary to elect an honorary president, and the Duke of Atholl, the Earl of Wemyss, the Earl of Hopetoun, Lord Melville, Lord John Campbell, Lord Gray, the Duke of Buccleuch, and the Marquis of Tweeddale, acted successively in that capacity. In 1836, however, the system was changed, and the present course of electing the president from among the working members was adopted. It occurs to me that it may be useful, in order more fully to illustrate the comprehensive nature of the object and aim of our Institution, and to shew the varied tastes and pursuits of those who from the first have taken an interest in its proceedings, to enumerate the names of the gentlemen who have presided over its meetings since its formation, including of course those who acted as vice-presidents under the old system, and who were virtually presidents of the Society. They are,—

Sir Samuel Shepherd, The Hon. Captain Napier, Sir George Clerk, Sir George M'Kenzie, Professor Russell, Mr L'Amy, Lord Newton, Lord Napier, Sir Thomas M. Brisbane, Sir John Robison, Mr Crawford, Mr Clerk Maxwell, Rev. Dr Gordon, Sir Thomas Dick Lauder, Mr Robert Stevenson, Mr James Jardine, Sir David Milne, Professor Forbes, Colonel Macdonald, Mr Edward Sang, Sir John Graham Dalzell, Mr Robert Bald, Professor Fyfe, Professor Traill, Professor More, Dr Maclagan, Mr George Buchanan, Mr Cay, Mr Grainger, and Dr Lees. It may further be interesting to state, that the office of secretary has been held successively by Sir John Robison, Mr Guthrie Wright, Professor Wallace, Professor Turner, Mr Aytoun, and our present esteemed secretary, Mr Tod, who has held the office for nearly twenty-seven years; while the Rev. Dr Gordon, Dr Patrick Neill, Mr Crawford, Mr Alexander Adie, and Mr Ponton, have successively acted as foreign secretaries.

It seems only natural to expect that the communications made to a Society whose leading men were theologians, philosophers, engineers, lawyers, and sailors, persons engaged in pursuits so widely different, and who were all, nevertheless, so interested in its welfare as to preside over its meetings, should embrace a very wide field of research, and include a vast variety of topics connected with the arts and sciences; and this expectation, I can confidently affirm, is fully borne out by our printed Transactions.

In order, however, to illustrate, even in a very imperfect degree, the varied character and the great importance of the communications which have been made, I shall, chiefly for the information of those to whom our Transactions are not accessible, venture to name a few of the communications for which premiums or votes of special thanks have been awarded, although I have felt that in attempting to make such enumeration, it is impossible even to approach to a satisfactory selection.

It is interesting and pleasing, however, to be able to introduce my remarks on this subject by stating, that the first premium which the Society appears to have awarded was given to the late distinguished Professor Wallace for his improved Eidograph, a communication which all who know the value of that exceedingly beautiful instrument must admit was worthy of the high approval of our Institution; and I am particular in mentioning this, as it cannot be doubted that the award of this, the first prize given by the Society, must have augured well for its future success, and proved a great encouragement to those who had the labour and toil of originating and organizing it. But passing from this, I may state generally that premiums have been awarded to Mr Whitelaw for his compensation pendulum; to Mr Galbraith, for his papers on the English Arc of the Meridian; to Mr Landale, for his method of conveying low pressure steam to great distances; to Mr Tait, for his method of producing white light from ordinary or artificial light; to Mr Alexander J. Adie, for his experiments on the motion of water in pipes as applied to heating; to Mr Ritchie, for his new method of ventilating public buildings; to Dr Warden, for his application of totally-reflecting prisms to illuminate the open cavities of the body; to Mr Schenck, for his paper on the progress and position of lithography in Scotland; to Mr John Adie, for his dew-point instrument and improved barometer, and for his method of determining the variation of the compass; to Professor Gordon and Mr Hill, for their mechanical arrangement for ascending the great chimney at St Rollox; to Mr M'Candlish, for his account of the Ballochmyle viaduct, designed by Mr Miller; to Mr Paterson, for the machinery employed by him in carrying through the tunnel on the Granton railway; to Mr Leslie, for his inclined plane for canals; to Mr Swan, for his instrument for facilitating the determination of the index of refraction; to Mr James Nasmyth, for several ingenious mechanical inventions, including his safety crane ladle for making heavy castings; to Mr Scott Russell, for his reflector of single curvature for canal boats, and for his new parallel motion and brine gauge for marine engines; to Mr Sang, for his essays on life assurance and other subjects; to Mr John Maxton, for his self-acting stopper for winding engines, and his improved long-slide valve for condensing engines; to Mr Ramsay, for his street-sweeping machine; to Mr Wilson, for his paper on what is required to improve the dwellings of the working-classes, and for his plans of houses erected by him in furtherance of that object; to Mr Gray, for his double-acting secure lock, and improved Kinnaird grate; to Sir David Brewster, for his notice of a chromatic stereoscope; to Messrs Fox, Henderson, and Co., for their description of an iron roof erected at Liverpool; to Dr George Wilson, for his skeleton crystallographic models; to Mr Stuart, for his paper on water wheels; to Dr Douglas Maclagan, for his analytical account of gutta percha; and to Mr Robert Bryson, for his method of rendering Baily's compensation pendulum free from hygrometric influence.

It is, however, as you are no doubt aware, a difficult task from so great a number and variety of subjects to make a selection; and I shall only add on this subject, that the Keith Medal, which is the highest prize offered by the Society, has been awarded to—

Sir John Robison, for his improvements in the construction of taps and dies;

Mr Edward Sang, for his apparatus for cutting surfaces of glass for optical purposes, and his paper on that subject;

Professor Fyfe, for his paper on the use of chlorine as an indication of the illuminating power of coal gas;

Mr Erskine, for his improvements in machinery for working coal-pits;

Mr Thomas Stevenson, for his holophotal system of illuminating lighthouses; and to

Mr John Sang, for his platometer.

Besides these communications, many valuable and interesting expositions have been made to the Society, at the request of the Council, by Professor Forbes, Mr Sang, Mr Buchanan, Mr Glover, Mr Grainger, Mr Rose, Dr George Wilson, Professor Piazzi Smyth, Dr Lees, and others.

But I fear I am overtaxing your patience by laying before you so great an array of names and subjects, without at the same time giving somewhat of interest to the enumeration, by explaining the nature of the different communications alluded to, which our time this evening will not admit of, and I shall therefore hasten from what has been done during past years, to notice very briefly what is the present state of our Society, with a view more particularly to indicate our prospects for the future.

Our list at present numbers 397 members, 17 of whom have been elected during the last session. I have, as usual in such addresses, to notice the losses which the Society has sustained by death or by the removal to other countries of valuable members. The late M. Arago, perpetual secretary of the Institute of France, was elected an honorary member in 1834, shortly after his visit to Edinburgh, on occasion of the meeting of the British Association for the Advancement of Science in that year. The ordinary fellows whose deaths I have to record are, the Earl of Stair, Mr Charles Inglis Anderson, Mr Eagle Henderson, Mr Charles F. Davidson, W.S., Mr Ralph Richardson, Mr John Taylor, the Earl of Wemyss, and the Rev. Dr Gordon, who, in addition to his high attainments in the most important and honourable of all vocations, had devoted considerable attention to the study of mathematics and natural philosophy, and acted as foreign secretary and vice-president of this Society; thus affording a striking and pleasing example of high religious principle and ardent love of physical science united in the same mind. Dr Daniel Wilson, one of our present vice-presidents, has left this country to fill the chair of Professor of Literature in the College of Toronto; and in him we have lost an active and accomplished member, who carries with him the good wishes of a numerous circle of friends.

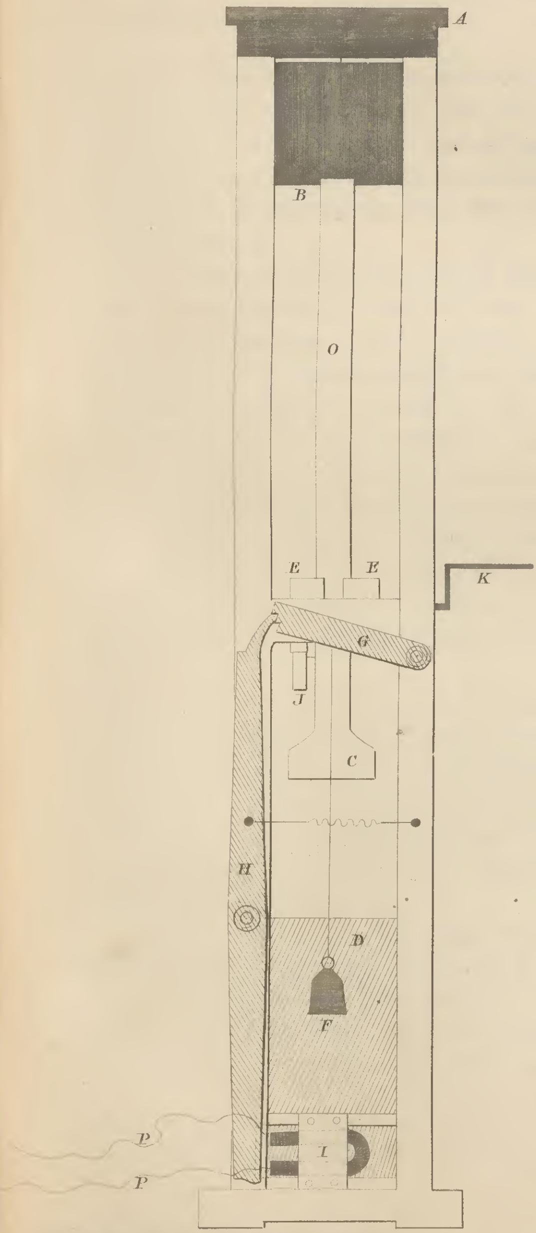
With reference to the communications made to us during last session, I think I may safely congratulate the Society; not certainly on their number, but what is of more importance, on their quality. The prize-list about to be submitted to you will intimate the premiums to be awarded; but I think it right to remind you that some important communications made during the last session are either unfinished, or are of such a nature as to render them inadmissible in the prize-list. Of these, I may simply recal to your recollection the exposition of the total eclipse of the sun in 1851, which was given by Mr Swan on the first meeting of the session;—

the communication by Mr Bow on the construction of roofs, which is still unfinished;—Mr Campbell's paper on Anti-Lunar Tides;—and Dr George Wilson's researches on Colour-Blindness, or Chromato-pseudopsis, which he has been requested by the Society to prosecute further, in the belief that his investigations may lead to highly important results.

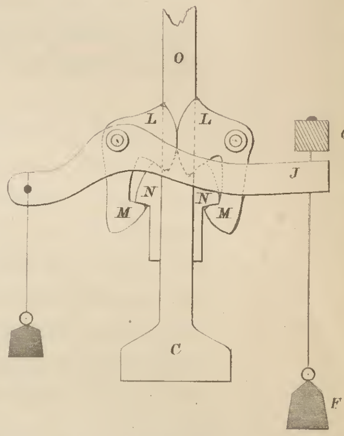
I have thus, Gentlemen, ventured to lay before you this slight sketch of the past and present history of our Society, in the hope that the recollections and associations connected with the names of men of eminence who have interested themselves in its behalf, many of whom are now no more, may incite the members present to use increased exertions in maintaining in its usefulness an institution which has so completely fulfilled the objects for which it was founded. I also venture to express a hope that what has been said may be the means of inducing those who are not members to co-operate with us in the good work, by intrusting the Society with their communications; and I think, if anything were wanted to guarantee the continued prosperity of our Institution, it would be the countenance of the gentleman (Professor Kelland) whose name I shall this evening have the pleasure of proposing to succeed me as President.

If the remarks I have offered shall have the effect in any measure, however small, of exciting an interest in our institution, I shall conceive that my occupation of your time this evening has not been altogether mis-spent. In conclusion, permit me to express my sense of the high honour you have done me by placing me in this chair, and my thanks for the uniform support and indulgence which I have received at your hands.

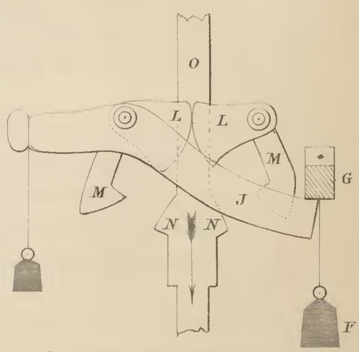
MODEL WOODEN TIME BALL



Elevation of the Wooden Time-Ball with the Ball hauled up ready for dropping.



Sideview of J on the arm of the retaining hool



The above when the trigger has been pulled & has allowed the dropping weight F to act.

S. Leith. Edin.

Notice of the Time Ball at the Royal Observatory at Edinburgh. By Professor C. PIAZZI SMYTH, F.R.S.E.* (With a Plate.)

After alluding to the praiseworthy exertions of the late astronomical institution, for the purpose of communicating the true time to the public; and to the successive steps since taken by the Government in the furtherance of those views; the author mentioned the time ball as the last addition that had been made.

The principle of this method of publishing the true time, viz., by the sudden dropping of some large and heavy body, was due to Captain (now Admiral) Wauchope, who, about 1829, frequently memorialized the Admiralty on the subject, and was at length rewarded for his trouble by seeing the erection of the signal, so useful to navigators, at the Greenwich Observatory. Within a few years after, so many were the practical advantages found in consequence, similar time-signals were adopted at Portsmouth, Madras, St Helena, and the Mauritius. And Captain Wauchope, himself going out to the Cape Station on duty in 1835, succeeded before long in having a time-ball established at the Observatory there.

The author had had several years' personal experience within 1837 and 1845 with this ball or balls, for several were made, and literally used up, so difficult was it found, with mere simple workmanship, to secure the perfect action, which Mr Field, of the firm of Maudslay and Field, had obtained by the adoption of a cylinder of compressed air to break the force of the ball's descent.

In 1841, when the Edinburgh Observatory was in full astronomical activity, and everything but the machinery of a time-ball possessed, the erection of one was agitated for by Admiral Milne, Captain Basil Hall, Captain Dall, and others, but unfortunately without success. An interesting mark of

* Given at the request of the Council on 12th Dec. 1853. A working model and *diagrams* were exhibited.

this first surge of public opinion has been left behind, in a brass model which Captain Dall had made on the well-tested plan of the Greenwich time-ball, and of which he circulated lithographed copies amongst his friends.

In 1846 another attempt was made; for having had the honour of being appointed to the direction of the Edinburgh Observatory, and having received many representations of the urgent importance to Edinburgh and Leith of the establishment of a time-ball, the author reported the same to the Secretary of State for Home Affairs. Soon after, Captain Washington, R.N. and Captain Veitch, R.E., Tidal Harbour Commissioners, were appointed to examine and report on the case; and they did make a minute examination of the locality and the interests of the inhabitants concerned, and strongly recommended the erection of the time-ball; but yet, strange to say, it was ignored by higher authorities. Again, however, an interesting mark of the occasion was produced in the Rev. Temple Chevallier's model of a "transit" time-ball. For having heard complaints that the precise instant of the drop of the ordinary time-ball was very difficult to be observed, he contrived one, where, by giving the ball a uniform rate of descent, it was made to pass in succession behind several equidistant horizontal bars, in the manner of a star traversing the wires of a transit instrument, and thus to afford several easily visible observations.

The necessity for the erection of a time-ball by no means decreasing with these official difficulties thrown in its way, as the representations of the Edinburgh Chamber of Commerce continued to shew, I brought the matter forward again in 1848, in the printed report addressed to the recently-appointed Board of Visitors of the Royal Observatory. The Board seeing the importance of the subject, took it up warmly; the President, Professor J. D. Forbes, in the following spring in London, waited on the then Lord Advocate, the Right Hon. Lord Rutherfurd, who, already much interested in the subject, immediately advocated it so powerfully in the Treasury, that it was forthwith ordered to be undertaken, on the necessary estimates having been procured from Parliament.

The procuring of the ball, with the money so obtained, was put into the hands of the Officers of Woods and Forests; and they, knowing well how admirably the Greenwich time-ball had performed, applied to Mr Field to make a similar one for Edinburgh, with all the additional improvements that had been suggested by the Astronomer Royal, Mr Airy, who took much personal interest in the execution of the machine.

The ball is 5 feet in diameter, is painted black, and rises and falls through 10 feet. To annihilate the effect of the varying friction between the ball and the mast on which it slides, as caused by the greater or less side-pressure of wind, the ball is made very heavy, say 15 cwt. The celerity and certainty of the first part of its descent (all that is required for the observation) is thus insured, while the latter part is effectually checked through the action of the air-cylinder—a tube which, closed below, receives from above a piston on the end of a long staff attached to the lower side of the ball, and, being pretty nearly air-tight, affords at last so complete a resistance that the ball in the piston is brought to a stand on the air before it strikes any solid body. By opening or closing a small stop-cock below, the strength of this air-spring admits of very nice adjustment; for when completely closed, the ball is thrown back half-way up the mast again, while, when fully open, it comes down with the report of a cannon.

The ball is raised by crank wheel-work acting on a pinion, which can be put in or out of gear by a rack edge on the ball-staff; and when the ball is raised up to the cross-pieces on the top of the mast (its first descent from which is the instant of the fall to be observed), the piston, a mere iron disc, rendered close fitting by a plentiful lubrication of tallow, is lifted clear out of the cylinder about two feet, so as to offer no friction to oppose the rapidity of the first part of the descent.

Again, to this end, the detents which hold the ball up when on high, and by whose movements it can be dropped, are made to catch into hooks on *either* side of the staff, and to work precisely together by a toothed sector gearing, so that there may be no side-pressure of the great weight then in suspension.

Still, although the detents and hooks are made of polished steel, there is more force needed to loose them than a magnet could well overcome, especially as it would have to act through a considerable distance, from the touching surface of the supporters being made long enough (0·5 inch) to guard against the vibration of the ball and staff in a high wind. But if, as is found, $\frac{1}{300}$ of 15 cwt., or 10 lb., will pull the trigger of, and drop, the big ball; then $\frac{1}{300}$ of 10 lb., or $\frac{1}{2}$ oz., will be enough to drop a 10 lb. weight inside the apparatus, so as to fall on, and efficiently to pull, the great trigger. This is the plan adopted; and as this smaller or dropping ball is not exposed to the wind, a very slight notch serves for its trigger, and a moderate magnet suffices to free it.

The electro-magnets are two in number, of the horse-shoe form, surrounded by close coils of fine wire covered with silk, and further saturated with wax, to guard against the damp of the top of the monument; and the communicating wires, covered with gutta percha, pass down the side of Nelson's Monument in a wooden casing, and thence under ground in iron pipes to the Observatory, where they rise through the floor, and are connected with the voltaic batteries and the contact-machine on the case of the transit clock.

The batteries consist of *ten* pots, each containing a pair of Smee's plates, 3 inches square, with Shepherd's self-amalgamating contrivance; they are excited by a solution of $\frac{1}{20}$ of sulphuric acid in water, and have preserved a very uniform action during the month they have been at work.

The contact-machine is a very delicate sort of finger-note of brass, armed with a platinum point, touching a platinum plate on slight pressure; and this being within a few inches of the face of the transit clock, beating its seconds audibly, enables a person to drop the ball on the top of the monument to a degree of accuracy of certainly less than $\frac{1}{4}$th of a second.

Such, then, is the signal-ball apparatus, as fitted up by

Messrs Maudslay and Field; and very effective it is as far as it goes, but the official use of it has not yet been begun, though it has been experimentally dropped every day at one P.M.

The reason is partly, that the Observatory has not yet two disposable persons,—one to go to the top of the Nelson Monument to wind up the ball, and one to drop it from the Observatory by the galvanic touch. Partly also, because although it *is* possible for a skilful person to drop the ball to the tenth of a second by the present means, still, after the time has passed, there is no record, no certain proof that he did so—nothing, in fact, to shew whether he made the signal within one minute of the time. Now this should not be in a public establishment, especially one where all the previous parts of the operation are so recorded and certified; for the original observation of the stars in determining the error of the clock in the Edinburgh Observatory are published, together with all the steps of the calculations, and the measures taken for ascertaining the instrumental adjustments by which the clock error is at last obtained, to the minute fraction required for astronomical purposes.

A plan, however, to obtain this desirable end is in progress, and when in working order, a public notification of the commencement of official responsibility for the accuracy of the time signal will be made.

The author then concluded his account by exhibiting to the meeting a model of the time-ball, nine feet high, made in wood; and while illustrating all the essential principles of the great time-ball, was altered in shape so as to suit a construction in wood. Inasmuch as in hazy weather our time-ball, even though mounted on the Calton Hill, cannot be seen far, it becomes important to know if they can be multiplied cheaply, seeing that where local means are employed to raise them, they can all be dropped by one and the same galvanic touch. Accordingly, it had been found in the present instance, that by translating the metal form into the spirit of carpentry, replacing curved forms by straight, and generally adopting a triangular construction, a time-ball apparatus, nine feet high, with ball, windlass, air cylinder, detents, and hooks, dropping-ball, and electric trigger, had been constructed, during last week, by one man in the employ of Mr Gibb, house-carpenter in Leith Street, for from L.3 to L.4.

The magnet and battery employed were lent by Dr G. Wilson; and in acknowledging his assistance, the author felt bound to acknowledge also the amount of readiness of the assistance afforded in the electrical matters connected with the great ball, by M. De Chesnel and the other officers of the Electric Telegraph Company, and more particularly in the means they afforded for determining, during the summer, the difference of longitude between the observatories of Greenwich and Edinburgh.

References to Plate XXIV.

A The black top of the tripod stand.
B The ball, also painted black.
C The piston on the lower end of the ball-staff.
D The air-cylinder, into which the piston descends, and has its velocity retarded therein by the resistance of the confined air.
EE Guides for the ball-staff.
F The "dropping" weight.
G The setting arm of the dropping weight.
H The trigger arm, having at its lower end the keeper of the magnet.
I The electro-magnet.
J The end of the arm of the retaining hooks.
K The crank arm for winding the ball up.
LL Sectors fixed to the axle of retaining hooks and arm J, and gearing in with one another, so as to make the motions of the hooks simultaneous.
MM The retaining hooks.
NN The fixed hooks on the ball-staff.
O The ball-staff.
PP The wires leading to the voltaic battery and the clock.

Suggestions for a Simple System of Decimal Notation and Currency, after the Portuguese Model. By JAMES ALEXANDER, Wine-Merchant, Edinburgh.*

Some change in our present complicated system of money notation and currency has long formed an object of desire to the mercantile community of this country. For although we are the most mercantile nation on the face of the globe, insomuch that we have been not inaptly termed "a nation of shopkeepers," yet in this department of scientific reckoning we are not only confessedly behind almost every other European nation, but also far in arrear of the United States of America—an offshoot from our own stock. And now even Canada, one of our own possessions (but possessed in this particular of independent action), has already taken the start of us. From an object of desire this change has latterly become an object of expectation, for we are aware that certain steps have been taken towards it; but, like the deceitful mirage of the desert, the wished-for consummation seems to vanish from our longing eyes just as we think ourselves likely to reach it: in fact, we seem to proceed towards it by steps of strictly decimal progression. It is just about ten years since a parliamentary commission on the subject of weights and measures advised the adoption of a decimal scale in reference to them, but recommended, as a preliminary step, the previous decimation of the coinage, which was not properly before them; and it is only now, in the second decennial period, that we have had a Parliamentary Committee on the coinage and currency, whose report was presented at the close of last session. It is, at all events, refreshing to find that that committee has not shelved the coinage and currency for another decennial period, by recommending, in accordance with previous precedent, that the weights and measures should first be decimated; for the report undoubtedly directly recommends the decimation of coinage, currency,

* Read before the Society, 12th December 1853.

and accounts, and even points out, with some degree of distinctness, the mode in which the committee propose that this should be done, deduced from the evidence and recommendations of many eminently scientific men, who appear carefully to have considered the subject; but this further progressive step, giving *apparently* the hope of a speedy realization of our wishes, is to a great extent neutralized by a single sentence in the evidence of Sir J. W. Herschel, the talented master of the Mint, and one of the most important, if not the most important witness examined, who, after fully developing his *theory* of the important change, says, " I should feel disposed to assign somewhere about twenty years from its commencement, as a probable term for the completion of the process (meaning the process of transition) and the introduction of a totally new coinage. That is the idea I have of the way in which the new system might be introduced." In this idea as to time, Sir John is corroborated by other witnesses; and therefore I much fear that the question will arise with the present generation of mercantile men, Whether they will submit to the infliction of the many inconveniences which a change, however slight, in money matters necessarily entails, in order that their grandchildren may enjoy a better system of accounts, or whether they will not rather be inclined to " bear the ills (and the coins) they have, than fly to others that they know not of?"

The chief obstacle which appears to have appalled even the most strenuous advocates for a change, is the important fact, that " it is absolutely necessary that the greatest deference should be paid to existing circumstances, and that the present relative notions of value, so deeply rooted in the public mind, should be disturbed as *little as possible;*" and on this the very threshold of the question, the anomalous "pound sterling," and the much more ancient penny, stand arrayed in deadly feud; for it is held to be absolutely impossible, under the new system, that they can longer *co-exist.* The pound seems to have found most favour with the majority of the witnesses, who appear to regard the retention of it as the "unit of account" and of value as a *sine qua non;* and the committee have, therefore, done little more than hold the scales betwixt the pound and the penny, and have at length decided that the pound has the preponderance, and that the penny must "go to the wall." They appear, however, to be so sensible of the great difficulties which surround this part of the question, and the prejudice likely to be created among the great masses of the people, that they shrink from the responsibility of "closing the record," and qualify even their recommendation by saying: "An obstacle of so undefined a nature as a vague popular feeling, based upon habit and association, and not upon reason, cannot be dealt with on any general and abstract principle; and your committee, therefore, purposely abstain from seeking to fetter the executive on that part of the subject." In my humble opinion, this is tantamount to a leaving open of the entire question, for popular feeling and prejudice is the most important element to be dealt with in the matter, for which it is open to any one to suggest means of palliation, even from a different course of treatment to the one proposed. Now this simple change in the name and value of the present penny involves considerations of such magnitude, that just before the prorogation of Parliament one of Her Majesty's ministers stated that it was not to be thought of, or entered upon, without the most weighty deliberation. And I think, having regard to popular feeling, that he was right; the very name of the penny is enshrined in the affections of the people by the part which it bears in many a familiar saying and proverb. But besides this ideal attachment, a long array of tangible fixtures of value already present themselves against the change. Those in the van are marshalled by Government—penny-postage, receipt and newspaper stamps—statutory tolls and pontages—income-tax and railway mileage-rates—payment of troops, and customs duties; and these are followed by penny and threehalfpenny publications, and a long line of private interests,—an addition to which, upon slight consideration, will suggest itself to the mind of almost every tenth man in the community; added to this, the change is to fall, not upon the educated classes, who could best appreciate the advantages which it would bring about in another direction, but upon the masses of the people, whose prejudices it is much easier to excite than to allay—that people whose ancestors, exactly a century ago, clamorously demanded back from the executive the eleven days of which they believed themselves to have been robbed by the change in the calendar—a belief which, in these latter times of intelligence and spreading knowledge, may be universally admitted to have been most irrational and absurd. But even where it excites a smile, is it not practically homologated, by the persistent adherence, in many districts, to what is termed the "Old Style," in the fixing of terms of service, much to the inconvenience of other districts, and while every annually recurring 1st day of January brings to the denizens of towns, and their immediate neighbourhood, cessation from toil, and the joyous feelings with which the commencement of every new year is hailed? In many country districts, this day is altogether overlooked, high holiday being held upon the 13th. In these days of cheap travelling, it is certainly a most anomalous sight for us citizens, just as we are beginning to settle quietly down, after our new-year's festivities, with the chastened feeling that another year has many days since gone down the stream of time into the ocean of eternity, to find our streets paraded by bands of holiday-making country people, and on inquiring the occasion, to be told that "this is New Year's day!" If this does not evince a still lingering belief in the justice of the cause of their last century predecessors, it at all events holds out an emphatic warning against any inconsiderate or violent interference with popular prejudices or predilections, no matter how evident, to those having the power of doing so, the advantages of the change may appear. Having, therefore, long had an idea of my own for changing the currency and accounts of this country to a decimal character, without the necessity of any violent change in the circulating coinage, while I shrink from placing myself in opposition to the systems developed by the many eminent men who have come forward on this important question, still believing, as I do, that for those on whom the ultimate responsibility of the change is to rest—while a Scylla boils on the one hand, in the proposed abolition of the present penny and its subdivisions, Charybdis is not far distant on the other, in the deferred hopes and expectations of the community—I think that a middle channel may be discovered, through which the currency bark, heavily laden though she be with the entire circulating coinage, may yet pass, with flowing sail, and without the aid of the screw, into a harbour of refuge, resulting ultimately in a shortened and successful voyage into the desired haven. Certain features of that channel were indeed pointed out to the committee, but they appear to have stopped at the very entrance, from a misapprehension of the direction in which it was to lead; and it is to prosecute that inquiry that the present paper is now, but still with considerable diffidence, presented for your consideration. On a matter of so very debatable a nature, it would be the height of presumption in me even to anticipate your approval; but I trust you will at least receive it with indulgence, as an humble contribution to the consideration of this important, and now much agitated question; and if it have only the effect of leading some of our more comprehensive minds to take up the matter, it will not have been made in vain.

The advantages of a decimal system of notation or statement of written accounts, over that which we now pursue, I need hardly state are very great, getting quit, as it would do, of our present complicated compound system, and enabling us to state all accounts in simple numerals, thus saving an immense amount of labour to our clerks, and in a great degree decreasing the liability to error. The subject, however, to my view at least, manifestly divides itself into two distinct branches, and I think that in the consideration of it, the not duly preserving this distinction has led to a considerable amount of complication. The keeping of money accounts in books, and the calculations necessary to do this correctly, and the actual handling, in payment or receipt of veritable coin, are in my opinion two almost totally distinct things, and the one only dependent in but a very slight degree on the other. Of the many thousands of clerks employed in keeping the records of our immense commerce, with the various ramifications of banking, &c., I should say that perhaps fully one half of them never see or handle a coin in connection with the accounts which they keep: it may be said that while writing out these accounts, the actual money which they express is present to the "mind's eye;" but how far this is true may be judged from the fact, that in mercantile houses doing business with foreign countries, and the clerks in which must necessarily be acquainted with exchange transactions, you will find them talking as learnedly and familiarly of dollars and cents, kreutzers and stivers, ducats and roubles, as if they had circulated around them during the whole course of their existence—the truth probably being, in nine cases out of ten, that they not only never set eyes upon a single coin of any of these denominations, but had never been out of Great Britain in their lives. It will, therefore, appear, that in regard to the written records of our mercantile transactions, the greater bulk of which are effected without the actual passing of money, *it is not so much coins that we want, as a simple and easily manageable denomination of accounts.* It is no doubt of importance that, if possible, the coins in circulation should be as much in harmony with that denomination as possible; still, when it comes to the actual payment of money, one coin is just as good as another, *provided its specific value in the denomination in which accounts are kept be easily ascertainable;* and people are too much accustomed to look at both sides of a shilling to hand it over for less than its legitimate value. If the subject, therefore, divides itself to a certain extent into two distinct branches, the proposed systems of decimals also take two different directions—the one of progression, the other of retrogression, from a given point; and I have a strong idea of the ease with which the one system can be imparted to the minds of an uninformed public, in comparison with the other; just in proportion as a man acquires a thorough knowledge of the principles of construction of any fabric or piece of work which his own hands have reared, in comparison with taking to pieces the work of some other pair of hands, would, I think, be found the difference of the two systems, which, however, when attained to, are perhaps equally simple. We are not, however, to legislate for the *convenience* of those merely who have already, from education, acquired a knowledge of decimal computations, but for those who are as yet entirely ignorant; and our primary object should be to place it before them in the simplest form. In our arithmetical teaching, multiplication always precedes division; when we commence a boy with arithmetic, we set him down to learning the table of numeral progression—"units, tens, hundreds," and so on; and he gradually acquires a knowledge of the immutable laws of the progression of numbers; but would he acquire the same knowledge in the same time if we set down on his slate, as a beginning, a figure 1 with half a dozen of ciphers after it, and told him "that was the expression of a million," and that by rubbing out the figure 1 and the cipher next to it, and again setting down the 1 in the deleted cipher's place, he would make it a hundred thousand, and so decreasing, step by step, till the figure 1 stood alone, as a simple numeral, and he is told *that it is now a unit*, would he not be much more apt to be mystified than instructed? How much more natural and easy would it be, first, to make him thoroughly comprehend what *a unit is*, and then a knowledge of the *ascending power* of numbers would speedily follow. I think, therefore, that in teaching a new system to a people, it is best to take any previous knowledge as little for granted as possible, and to stick as closely to elementary principles as we can.

Although the Parliamentary Committee have presented us with a goodly-sized Blue Book, I cannot help saying that I think there is very material evidence wanting, which, had it been brought out, would have been of the very highest value, in a proper consideration of the question. It will be observed, that almost all the evidence we have is *theoretical;* that is to say, that each witness simply develops his own theory of what he would propose as a system of decimals for this country, and only incidentally and generally are other countries and their systems alluded to. Now, decimal notation and currency, though still only a theory with us, is "a great fact" with the majority of other civilized nations, and I would therefore have desiderated at least one witness to develop particularly the systems of each country where the decimal system now obtains. There could have been little difficulty, I feel assured, in obtaining among the merchants of London witnesses fully conversant with the monetary system of the respective countries with which they more particularly have mercantile relations, and who, probably from residence there, would have been enabled fully to expound the decimal systems of each, its circulating coinage, and nature of its subdivisions; its system of bookkeeping and accounts, and number of columns employed; its habits of oral enumeration of sums of money, and whether in these all the separate decimal gradations were preserved; its system of exchange with this country, and other important particulars;—a knowledge of all which could not fail to have been highly interesting, and a collation of which might have afforded us valuable materials for construction. We have now the term "experience" applied to insurance, investment, and other public companies, adopted, I suppose, to induce a belief that they have *profited* by the experience of all who have preceded them, and I think we would have found it an advantage to be in something like this position in reference to our proposed decimal system.

With these views, I purpose, to the best of my ability, to supply this deficiency of evidence in respect of one country with whose system alone I am at all conversant,—I mean Portugal; and whose simple decimal system of accounts I not only take as a model for our imitation, but venture upon the assertion that, with a simple change of denomination, and another superadded feature which I shall presently notice, it will be found analogous in almost every particular with our present circulating coinage in its sub-divisions. That I should, at this date, be at all able to expound the monetary system of Portugal, after an interval of twenty-two years' absence from the country, without since having had the slightest practice in its accounts, will, I think, argue favourably for its simplicity, which, indeed, is borne testimony to in the evidence of Dr Bowring, whom I shall afterwards quote upon another point to which he does not appear to have paid *so much* attention. I went to Portugal in early youth for mercantile tuition, not long after my emancipation from the schoolroom, and have still a vivid recollection of the ease with which I fell into the system of money reckoning and accounting. I cannot say that I even cast a thought upon its being decimal; I only knew that it was novel, and much easier than our own,—that, while our's was compound and perplexing, it was simple and perspicuous to a somewhat dull comprehension; and I am happy in having preserved my juvenile bookkeeping of current expenditure, which has served to revive my recollections.

The mode of keeping accounts in Portugal, then, is *in one simple denomination*, that of "rees" (literally "things"), and milrees, which of course merely mean thousands; but it is possessed of a feature appertaining, I think, to this country alone. The monetary system of all other countries is based upon some tangible and veritable coin, or expression of value, and therefore to the uninitiated a "ree" would at once be understood to be a coin; but there is actually no such coin in existence as a ree, the money denomination is entirely imaginary; and the lowest circulating coin, analogous in position, and nearly similar in value with our farthing, is of the nominal value of five rees. This principle may be characterized as an exceedingly cunning device, for it takes advantage of the decimal system of computation in the simplest form, and consists in just stamping the lowest circulating money value with the expression of the *decimal unit* 5, the effect of which is, that, in all money calculations, every sum ends in a cipher, except there be one or three farthings (so to speak) present, in which case it ends in 5; in fact, 5 being the lowest expression of value, and all the other coins or expressions of value being of necessity multiples of it, it is the only numeral of the whole 9 known in the monetary system of Portugal as a "simple number;" and the ease which it entails on all calculations will be appreciable by those who can recollect the easy and plain sailing through the fifth line of our multiplication table, after the difficulties of those previously encountered. It appears to me that the man who conceived this principle of the Portuguese monetary system (how long ago I am unable to say) is entitled to rank as the first professor of homœopathy. In this country we are wedded to the tangible and real; and the etymology of our farthing is "the fourth of a thing,"—that thing being the penny; but the

Portuguese has made his analogous coin to consist of five infinitesimal things, which he has not rendered palpable "to feeling or to sight," the beneficial effects upon the system from the "exhibition" of which (to use the professional term) are, however, much more easily demonstrable than those of the infinitesimal doses of the present day.

Under this imaginary denomination of account, then, Portugal has an ample array of circulating coins of various values, which I here place in juxtaposition with our own, to bring out the analogy. It will at once be understood that I do not adduce them as on a par of exchangeable value; for the legal tender in Portugal being one-half Government paper, which is always, unfortunately, at a considerable though fluctuating discount, the exchangeable value of the coins is thereby affected, but not the analogy of what coins are found *most convenient* as betwixt a decimal and a non-decimal country. The lowest circulating coin has assigned to it the nominal or imaginary value of—

	Writen thus in Rees.	And	Analogous to our
5 rees	‖005	the 960th part of a moidore	farthing
10 rees	‖010	half vintem	halfpenny
A vintem	‖020	the 240th part of a moidore	penny
A half testoon	‖050	$2\frac{1}{2}$ vintems	proposed new cent of $2\frac{1}{2}$d.
3 vintem piece	‖060	. . . .	threepenny piece
Testoon	‖100	. . . .	proposed double cent of 5d.
6 vintem piece	‖120	. . . .	sixpence
12 vintem piece	‖240	or half crusado, the 20th of a moidore	shilling
Crusado novo	‖480	24 vintems, the tenth of a moidore	florin
Half moidore	2‖400	pronounced "2 mil. 4"	half sovereign
A moidore	4‖800	" "4 mil. 8"	sovereign or pound.*

Accounts are all stated in books, &c., in rees and milrees, and kept in two columns, one for mils, the other for rees; and in bills and other documents, where no columns exist, a columnar sign ‖ is placed betwixt the mils or thousands and hundreds of rees. I would beg to recommend the adoption of this,

* From this it will be seen that the number of farthings respectively in our own coins, multiplied by 5, exactly tally with the coins of Portugal.

at least, under any system we may fix on, as being much superior to a *simple decimal* point, which it is evident could easily be obliterated, and a figure either inserted in its place, or at either end of the sum, thus affording facilities for fraudulent alterations; but in the Portuguese system, as there never can be more than three figures to the right of the sign, vitiation of an amount on a bill or cheque is rendered more difficult; it is also the practice to place the sign Rs. immediately before the figures to the left of the sign ‖ same as we now put £, and which answers the same purpose. Retail prices are quoted optionally, either in the denomination or in the distinctive names of the coins, generally the latter. To the question, "What is the price of such a thing?" would be answered, "three vintems," "a crusado," "two testoons," "half-a-moidore," "two moidores," and so on, just as we quote prices—as twopence, half-a-crown, two shillings, &c.,—and the ready registration of corresponding transactions *in rees* is, from practice, a matter of ease and speedily acquired. But what I here wish to draw particular attention to, is the fact, as will be seen from the above table, of the almost *exact similarity* which subsists betwixt our present supposed non-decimal coinage, and the decimal of Portugal, always keeping in view the before-mentioned feature of imaginary value. It will be seen that as our lowest expression of value is contained 960 times in our highest expression—a pound—so their lowest coin, five rees, is contained 960 times in the corresponding moidore, and so their two other copper coins, the half vintem and vintem, being the same multiples of their lowest coin, as our halfpenny and penny are of the farthing, so they are similarly contained 480 and 240 times respectively, both in the moidore and pound. Passing to the silver coins, it will equally be seen, that the crusado and half-crusado (corresponding to the florin and shilling), and respectively the tenth and twentieth of the moidore and pound, contain each twenty-four and twelve vintems and pence respectively. From this I think I am entitled to adduce the argument, that practice is better than theory, and that what has been done in one country can surely be done in Great Britain. Here, then, is a country which offers a model for our imitation—a model, moreover, apparently exactly suited to the circumstances and relations of our already existing coinage.

But I do not mean to allow the advantages of the Portuguese system to rest upon my simple statement; hear Dr Bowring's testimony, (Evidence, No. 1525),—"I have been much in Spain and Portugal; and mention, as an example, that in Spain, in consequence of the absence of a decimal system, accounts are kept with considerable difficulty, and their correctness is seldom to be depended on. I had often occasion to see the perplexities and mistakes of the commissariat functionaries in Spain, during the Peninsular war, while just crossing the frontier into Portugal; where there exists a decimal system of coinage and account, inaccuracies were very rare, and all money operations recorded with great facility. I may also mention, in reference to the coinage of Spain, that as the different Spanish colonies emancipated themselves from the mother country, they every one, without exception, adopted the decimal system, and the universal adoption of that system has everywhere been recognised as a great benefit and blessing to the people. The system in Spain is as absurd and inconvenient as most of the other non-decimal systems. The accounts are kept in reals of vellon, every one of which represents 34 maravedis; *but it is less inconvenient than the English system, where the divisions are by* 4, 12, *and* 20."

Alas! for the Doctor's perspicacity; little did he apparently dream that it was simply the *easily manageable denomination*, and not the *division*, that made the difference, and that the system he was so highly and justly lauding, and that he was so sweepingly condemning, were in this respect, so far as regards the coins, as nearly as possible identical: only see them in juxtaposition—

British.			Portugal.		
4 farthings	make	1 penny.	4 fivereis	make	1 vintem.
12 pence	...	1 shilling.	12 vintems	...	1 half-crusado.
20 shillings	...	1 pound.	20 half-crusados	...	1 moidore.
10 florins	...	1 pound.	10 crusados	...	1 moidore.

Nor have the Portuguese stood still in the onward march of improvement, for the Parliamentary Committee themselves bear testimony to their intelligence in this respect (*vide* Rep. p. 4),—" Your Committee are not aware of any instance in which a country, after adopting the decimal system, has abandoned it. The tendency, on the contrary, has invariably been in the direction of a further adoption of the system, the most recent instance being that of Portugal, where the mode of reckoning has long been based on the decimal system, and where a decree has been published, within the last few months, providing for the introduction of the French decimal metrical system of weights and measures."

Now it will be evident from these extracts, that Portugal is fully alive to the *improvement* of her system; and it may therefore be argued, that in passing to the weights and measures, she does not think her monetary system either susceptible of improvement, or requiring it; a fair inference from which is, that she has not found that large amount of (or indeed any) inconvenience from the relation of her existing copper coins to her higher expressions of value, which appears to have been erected into such a bugbear in this country. I am unable to say whether these coins were brought into existence with the decimal system, or were in previous circulation, but, at all events, there they now are, as the 240th and 480th and 960th parts of her moidore or pound, instead of the 250th, 500th, and 1000th parts, which seem to be considered a matter of such *absolute necessity with us;* and it may, I think, be assumed, that in the onward progress of that country to decimal perfection, (more especially as the will of the executive is *pretty nearly absolute*), this alteration would long ago have been made, if it had been considered *a matter of any moment.*

Having thus placed before you a living model, as it were, of a simple decimal system, I will now attempt to adduce some arguments in the light which it throws upon a much controverted point, and indeed the only point on which there is any room for argument, viz., as to what should, in a change to a decimal system, be our

UNIT OF ACCOUNT.

Putting it merely as a hypothetical suggestion, that if we could get the people to comprehend it, we might do worse than adopt the Portuguese system of imaginary value, in which case our farthing would find an appropriate name as a "quintune," and the penny a "ventune," you will be quite prepared, from what has preceded, to expect, that I argue for the *retention of the present farthing* and penny without alteration, as the system least likely to give rise to jealousy or suspicion on the part of the people. In the adoption of the farthing unit, then, in antagonism to what is called the "retention of the pound as the unit of account," which is the proposition of the committee, and in which I am bound to say they are joined by most chambers of commerce, and other public bodies who have "pronounced" upon the question, it is utterly impossible to examine minutely the evidence in favour of the one, and *per contra* in condemnation of the other. The farthing unit only found one supporter before the committee, in the person of Mr Headlam, M.P., for Newcastle, whose system, of the advantage of which he expresses his strong conviction, still appears, so far as can be gathered from his evidence, to be based upon mere *theoretical opinions*. With this exception, the entire Blue Book is, I admit, against the system I now advocate; but it is a trite saying, that "an ounce of practice will at any time outweigh a pound of theory;" and having, so far as I can see, only *theory opposed to us*, we need not altogether despair of even yet attaining a preponderance in the scale. I must, in the first place, object to the phrase "retention of the pound as the *unit* of account," leading to the inference that other systems tend to the deposition of the pound from that highly elevated and respectable position. So far as I understand the English language, and the first principles of arithmetic, we have at present in our compound system no less than four, or at least three, "units of account;" we have units of farthings (in the character of fractions of the penny), units of pence, units of shillings, and units of pounds. The pound as the highest may, *par excellence*, be styled *the unit*, but I think we start fair as to position, and that the pound is no more a *unit* than the penny. Now it is simply to do away with this inconvenient *complication* of units that the decimal system has been at all brought forward; and it is of the very utmost importance that we should retain that through which we can most easily initiate (for that is the word) the great masses of the public into a knowledge of the system. I have a strong feeling that we will never be able to do this, *through* "*the pound*," as the "*unit of account*." It is all very well for thoroughly educated arithmeticians to expound a system which *begins* at the pound, and decimates it *downwards*,—to them it is an easy matter; but to the great mass of the people, the moment you set down a pound 1·, and place a decimal point after it, you invest the whole matter with a *mystery* and *superstitious feeling*, which it is almost impossible to get over; and as for making them comprehend the value of a figure, by its *distance* from the decimal point, such as 1·5—1·02, it is my belief that you may as well "talk to them in Greek."

There is scarcely one of us who has not a very vivid juvenile recollection of the sort of mysterious awe with which we regarded "Decimals," as set forth in our arithmetical school-books, as, vexed with multiplication, doubly so by division, puzzled by the rule of three, and fairly demented by practice, we occasionally turned over to the *terra incognita* which lay beyond, to estimate what further trouble was in store for us; and the great body of the public are just in this very position. Somehow or other, our teachers, or arithmetical authors, have succeeded in investing the division of decimals with a *prestige* of *mystery*, from which all our efforts to effect its emergence will prove ineffectual. In the same position, I may say, stands the application of the term "*unit*," *now proposed*. To an educated arithmetician, it may be and is as easy to descend decimally from unity, as to ascend; still the *public will insist* on ascribing to the term "unit" the meaning which *all dictionaries of the English language give to it*, viz., "the lowest number;" and that portion of the public who know little of arithmetic but the elements, will insist on its being "*the right hand number of any combination of simple numbers*." Decimal *division* of unity, then, cannot be effected without the exhibition of the mysterious full decimal period; decimal progression *from* unity is the natural law of numbers, taught in the very first page of every school arithmetic book, of which it is the alphabet; it does not require the decimal point, but only the simple "comma," to mark the gradation to thousands, and it invariably results in the production of a *simple number*, which can be treated and spoken of as such, whatever *subsequent, quasi* "compound, character" may be given to it. Decimal division from unity, moreover, is principally resorted to to find a definite quantity out of an indefinite—to pursue fractional numbers of a given whole, *to any* degree of *minuteness*—in fact, into the realms of infinity, for which purpose it is carried on, "till it either terminate or repeat." But an *existing circulating coinage* is not in the position of an *indefinite* quantity. We have already, by almost common consent, terminated the decimal; we have ascertained the definite quantity, and thereby we procure a simple number, that is to say, if we eschew decimal points, and fill up each place in the account with a cipher, into which another figure is not found to fall. It would be our wisdom, in my humble opinion, to adopt this mode, if we expect it to take hold on the comprehension of the public, or conquer their prejudices. Our immortal Shakspeare has put into the mouth of one of the finest creations of his genius, as a dying request, the beautifully modest petition to be spoken of as he is—"Speak of me, I pray you," says Othello, "as I am—nothing extenuate or set down aught in malice." Might I respectfully parody this petition, in an appeal to our eminent philosophers, actuaries, and astronomers, who are so deeply read and continually working in the deeper arcana of arithmetical science, that they lose sight of the starting-point to speak of a decimal currency as *it is*, or, at least, may be—"Nothing complicate—or set down aught in mystery." Dr Bowring says, that in the columns of an account, it is much better that "the integer should be divided, than that the integer should be multiplied." His meaning here is rather obscure, seeing that if it result as it will infallibly do in a *simple number*, decimal division from the left is just decimal multiplication from the right; but I would desiderate the doing away with all columns but one, as a division betwixt the *thousands* and lower figures in the account. The proposal of the committee is to keep accounts in pounds, florins, cents, and mils, and to keep up from the very first both the columnar arrangement and denominational nomenclature. Taking thus the sum of £3, 15s. 7¾d., and admitting the proposed depreciation of the copper, it would be stated thus ;—£3, 7*f*. 8*c*. 1*m*. The mode of division by which this is arrived at *mentally* will not, I think, be very obvious to those who have not given close attention to the subject ; but after all, what has been arrived at? Stripped of its columns and denominational gradations, of which without violence you can denude it *of all but one*, it is nothing more than a simple number of mils or farthings. You may, indeed, in the denominational view, by "ringing the changes" on the various combinations of these, enunciate this amount orally in seven different ways, but there is only *one* way in which you are *absolutely shut up to state it*, and which you cannot by possibility ignore, and that is, just calling it *w at it is*, "three thousand seven hundred and eighty-one mils or farthings," or shortly (the lowest denomination being understood), "three mil seven hundred and eighty-one." From this, then, will be evident the proposition which I started, that the keeping of accounts decimally in any country is simply stating them in cumulative amounts of the *lowest coin* in circulation. It may be startling at first, to our millionaires and merchant princes to be told, that henceforth the records of their wealth and great commercial operations must hereafter be kept in farthings—a coin which they have hitherto been accustomed to treat with contempt, and have studiously excluded from their books; but a little consideration will make it appear that this is *inseparable* from any decimal system that may or can be adopted. With these views, I propose that, as the first step in the transition, we simply reduce all sums in business-books, &c., into our present farthings, and then proceed in accordance with the Portuguese system—this being a mere change in the *denomination* of account without a change in value. It would not affect the terms or value of any pending contract, engagement, or obligation whatever, the number of farthings in which is just as easily ascertainable as the number of pounds or shillings; and proceeding, moreover, upon principles well known and recognised by the entire mercantile community, it would certainly not be necessary for the present generation to have nearly passed away before the change could come *fully into operation*. The principles of reduction and conversion of all our present denominations of account to the lowest, and into one another, forms a very great portion of present scholastic arithmetical practice; and the correctness of the reduction of any sum into farthings, by the ordinary mode, can be thoroughly checked by another method, which I do not recollect being taught at school, but which I shall submit to you.* This change (as in the plan proposed by the committee) would require to be accompanied or preceded by the introduction of a new coin of the value of ten farthings, or 2½d., called by the committee a cent, (but a more appropriate name under *this system* might perhaps be found for it); adopting it, however, in the meantime, this "cent" is a necessity, and the double and quadruple would also be found a convenience; to the latter of which I would give the name of *Victoria.*

Let us now recur to our former example, £3, 15s. 7¾d., which the proposal of the committee would convert into £3, 7f. 8c. 1m., and which by this system would appear as 3,631 farthings—a mere simple sum in the first instance, or 3‖631, adopting the Portuguese sign for thousands. Now, though at *first sight* this sum of farthings does not appear to give any indications of the coins with which to pay it, and certainly does not, I admit, *throughout all its gradations,* yet it will be found that, supposing we have a new cent coin, the two lowest gradations will *always indicate correctly,* either with the present or depreciated copper coins, in any sum under 2s. or 2s. 0¾d.,—thus relieving from all anxiety of calculation the transactions of the humbler classes up to this amount, and indicating in cents and farthings the coins necessary to discharge it—2s. 0¾d. being equal to ‖099, nine cents nine farthings, and the four per cent. of difference, up to this *mark,* falling on the unit only. The advantage of indication at sight, however, has I think been greatly *exaggerated,* and the difficulty of calculation without it, from being *merely theoretical, over-rated.* When accustomed by familiarity with the system, it is astonishing how the mind adapts itself to circumstances, and, in the first instance, the change could be aided by copious tables of conversion, such as I have appended to this paper.†

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* See Appendix to this Paper, No. iii., p. 233. † Ibid., No. i., p. 230.

But the difficulty which is now to be met is, that long accustomed to a higher integer of value in our anomalous expression "a pound sterling," than most other nations—although our brethren in America have long ago discarded it for the dollar, as their highest expression of account, value little more than a fifth, without, as the Committee's report states, "any inconvenience having appeared to attend the change,"—it is held to be repugnant to the feelings of the people of *this country* to express large amounts in a small denomination; and that if a man who wished to convey the information that he was worth £10,000, had to say that he was worth nine millions six hundred thousand farthings or mils, it would be utterly intolerable, and completely disturb or upset all our established notions of value; it is, therefore, held that the pound "is a British institution, so engrained into all our notions of value that it is impossible to oust it," and that any proposition to call a pound other than what it is, cannot be listened to. But I think this difficulty will vanish, if we can find a familiar and generally recognisable term for the expression of a thousand farthings, as a *new integer*, distinct from the pound or sovereign, but with a fixed relation to it, as the *unit* or *standard of value*, though not of account. To the suggestion of such a term I would now humbly lay claim. Before we got the pound sterling (at least in the form of the sovereign), we had a coin in this country which was the highest expression of value; as a coin it has long ceased to circulate, and taken its place in the collections of the antiquary; as a denomination of paper currency, it was found necessary to render it *illegal*, and no banker dare issue it "under a penalty of £20 for each offence;" notwithstanding all which, it is still clung to as an *expression of value* by certain professional classes, and even by the mercantile, in such payments as subscriptions, &c. Therefore, having tried all that we can, and unsuccessfully, to oust the "old guinea" from its hold on the affections of the country, not excepting the *dernier* resort of an Act of Parliament, I would now restore it to the full honours of circulation, as an expression of value for one thousand farthings or mils. At present it is unknown to commerce or banking, and is a mere recognisable term for a sovereign and a shilling, or "one pound one;" and as the change would be no great one, and inflict no hardship or confusion, it cannot be doubted that the country would generally at once fall into its use, as an expression of the value we require for our decimal system, 20s. 10d. = 1000 farthings or mils. It will be observed that this would in no way interfere with the especial prerogative of the *sovereign*, which still remains the tangible standard of value, and circulates as a coin of the value of 960 farthings or mils. We merely, in the internal commerce of the country, disregard it, or rather do not employ it as a money of account, same as we at present disregard the crown-piece and other coins. It may be said that it would be necessary to give the guinea of 20s. 10d. an actual representation as a coin, but I cannot see that this is at all necessary; at present we have no difficulty in paying it when the sum is stated in that term, by laying down a sovereign and a shilling, and we should have as little difficulty with the depreciated guinea, if we got a quadruple cent or victoria, value 10d., which would exactly supply the necessary odds to the pound. I would say that the sovereign, as a British institution, remains entire in its hitherto material and political status; but it now requires the *superadded virtues* of the *victoria* to give it that domestic character which confers a blessing on the country. Those who are incorrigibly wedded to old habits, when asked for a guinea, can lay down the sovereign and the shilling as formerly; it will afford them an opportunity of generosity in the practical exercise of the phrase, "Never mind the coppers;" and they would have the satisfaction of entering it in their accounts as 1‖008, instead of 1‖000. We have, however, an efficient means of giving representation to the new guinea in our paper currency—for of course all bank paper would of necessity require to be issued in the denomination in which accounts are kept; and in Scotland there would be notes of one guinea or 1000 mils, and in Great Britain and Ireland notes of 5, 10, 20, 50, and 100 *guineas*, instead of *pounds* as at present. This change could easily be effected without inconvenience. Notes expressed in pounds, when paid into a bank, would not of course be reissued; and a slight change in the hue of the paper would at once prevent any risk of confusion of guineas with pounds, until the latter were entirely withdrawn from circulation.

Having thus disposed of the units, tens, and thousands of our simple cumulative amount of farthings, it now remains to notice the intermediate gradation of hundreds; this would at present be *unrepresented* by an integral silver coin, and in paying it, or its half and quarter, we would require to add a penny to the florin, a halfpenny to the shilling, and a farthing to the sixpence. This is one of the inconveniences of the transition state; but, before the close of this paper, I shall adduce some considerations which, in my humble opinion, tend to show that these very coins are in course of applying the remedy to this inconvenience "*ex proprio motu.*" In the transition state, I desiderate the keeping out of view the value of the coins, or their places in any sum, otherwise than as expressions of value for their respective amounts, of the denominational farthing or mil. In fact, accounts would simply be kept in guineas and farthings; and instead of, as in the other system, exciting the prejudices of the people by a change of value in the very coins with which they have been most familiar (and with a right conception of which, or the reasons for it, it would be next to impossible to impress them), the change, I advocate, would surely amount to the very slightest interference with their established habits and modes of reckoning. In drawing attention to the *advantages* of a decimal system, we have promised the people *simple* addition, subtraction, multiplication, and division, instead of *compound;* and this system would amply redeem the pledge. Calculations, and the modes by which results are arrived at, are essentially operations of the mind, almost every man having a different way from his neighbour of arriving at the same point. Over the mind few governments, even of the most despotic character, can ever acquire any effectual ruling power; but when the result of a mental operation comes to be stated on paper, here is a superadded feature with which a government can deal; we should therefore say to the people, "We have no desire violently to interfere with your established ideas of value, or modes of reckoning; continue to think of, speak of, and handle the penny as the penny, and the shilling as the shilling, and the same with all the other coins with which you are familiar; we don't interfere with one of them; all we ask is, simply, that if you have occasion to set down any accounts on paper, state them in farthings, for the doing of which correctly we purpose to afford you every facility and information in our power." It would undoubtedly be an advantage if the value in farthings of each of the circulating coins could be impressed upon them; but as this may not easily be attainable, a government placard, exhibiting in conspicuous characters their several values, and to be for a time exhibited in every place of business, would answer every purpose; and these, with tables of conversion, would materially assist the transition.*

The sovereign, then, being left untouched, as the standard or measure of *value*, besides being available as a coin of 960 farthings, while accounts are kept in a simple denomination, easily *referable to it*, throughout every gradation or circulating coin, I humbly think the committee's objection, that the adoption of the farthing unit "would necessitate the withdrawal of the whole of the gold coinage," untenable. "Gold is our standard of value;" and if, as Sir John Herschel says, "we are lashed on to it," I do not say *we* should "kick in the harness;" but I equally dissent from his proposition, that we should meekly submit to all the "tossings" which it may choose to inflict on us. But gold is only the standard of value, by virtue of the rule of "measure for measure," and not from any absolutely inherent virtue in its appearance; in the sovereign, or pound sterling, most of us have daily painful experience of this fact, in the mulctures to which we have to submit in banking offices, &c., when the too critical eye of the teller detects "abrasion," where we possibly never suspected it, or even if we did, were probably forced to wink at it. Gold, then, is merely a given standard of *fixed value*, by which to estimate the fluctuations of all other property and commodities, and more especially coins. In the sovereign or pound, it only takes a convenient form of application to save trouble;

* See Appendix to this Paper, No. ii., p. 232.

for it is evident, that if it were possible in the daily transactions of life to deal with it in the form of *dust*, transactions could be discharged in the veritable standard itself, to the minutest fraction. To propound, then, that our fetters are so hopelessly riveted to the "pound" as to be a bar to all improvement, is to erect a constitutional sovereignty into a *despotism*.

But even the importance of the pound is surely overrated, when it is stated by the committee and witnesses that "it is the basis on which all our exchange transactions with the whole world rests, and any change *in it* would lead to infinite complication and embarrassment in our commercial dealings." Surely this has been taken too much as a matter of course. That the sovereign, as only *so much bullion* at a fixed market price, may be the medium of settlement of exchanges, I admit; but it is so solely because it is John Bull's "sovereign will and pleasure" that it should be so, and it is neither the habit nor the *interest* of payees to examine too critically or quarrel with the form in which amounts *receivable by them* are *discharged*, so that it be in a form of which they can beneficially avail themselves; and so long as this is the case, most parties are inclined, uncomplainingly, to put up with some trouble or inconvenience. That it is not, however, the *basis* upon which exchange transactions rest, one has only to look into the "course of exchange" to be convinced of, and to see, moreover, that *the present penny, which the committee propose to change*, is more the basis of exchange calculation than the pound. Paris, Rotterdam, Amsterdam, Hamburgh, Frankfort, Venice, and some others, exchange, indeed, as against the pound; but the United States, St Petersburgh, Madrid, Lisbon, Oporto, Madeira, Gibraltar, Leghorn, Genoa, Malta, Naples, Palermo, and Rio Janeiro, perform their exchange calculations by the *present penny*, and therefore any change in *it* would equally introduce complication and confusion,—the balance on this point being much in favour of the retention of the penny. The pound is, in effect, "the British institution," which isolates us from other nations; and is, in fact, almost the only "British institution" which we cannot, *with confidence*, hold up to the admiration and imitation of the world. A little investigation will show, that while the pound, and its *existing* decimal subdivisions in the present silver coins, do not, in almost any instance, sufficiently approximate in value as to be of any practical advantage either to our own people visiting foreign countries, or to foreigners visiting Britain, decimal multiples of our present farthing and penny will be found in almost all countries to converge at *some one point* or *representative coin* to a proximate value, sufficient for all the practical purposes of travellers. On the principle which I have endeavoured to lay down, that a decimal currency can only be built upon the foundation of the lowest circulating coin, the pound would be neither more nor less, in money accounts, than a convenient integral expression for a thousand depreciated farthings, just as a guinea would be for a thousand of the present. Our currency is in the state of an unfinished building, of which the foundation is laid; and the question is, In what style is it to be finished? The present foundation will do for a graceful Grecian superstructure, which will harmonize with the surrounding architecture; to rear a Gothic one, would require the cutting down the proportions, or paring away the sides, of the already existing basement; and to do so would be "Gothic" in the *fullest sense of the term.* But there is a consideration to which I would humbly draw the attention of the architects of this *Gothic* building, and to which I think they would do well to look narrowly, before they proceed to any great length with the superstructure. Will they not be in danger of finding that the materials with which they build are not so solid and unchangeable as they imagined; that while the tear and wear of time generally makes all building materials of *less bulk,* it is likely to be the reverse with the materials they employ; that the pillars of their building, which are already prepared *in the present silver coins,* are even now showing symptoms of a disposition to *swell out* beyond the proportions in which they proposed to lay them, and that, at no distant period, it requires no prophet to foretell that unless repairs are made, the building will fall to pieces, and utter confusion be the result. To drop metaphor, I think it is only necessary to look to the present aspect of the bullion market of the world to see, that though Sir John Herschel, the master of our Mint, concludes, that "we must stick to the pound," the present silver coins which he proposes to take along with him in his adhesion are pretty plainly saying to him, "You may do as you like, but we shall not bind ourselves to anything of the kind; we have been long fettered to the sovereign, but now we are about to take independent action." I allude to the effect which is to be had upon our silver currency by the immense, and still apparently increasing, influx of gold, our sole standard of value be it remembered, which has lately poured like a flood on the markets of the world, from the recent discoveries in our own colonies and other quarters of the globe. Gold is coined in this country at its *bullion* value,—that is to say, that the Mint makes no charge for turning it into coin. If you take an Australian nugget to the mint, they will not only give you back its exact weight in sovereigns, but will also make allowance for the alloy which it has been necessary to put into these sovereigns to allow of their being minted, so that you get in coin to the value of the last grain of gold.

With the silver coinage, however, it is different; on it, a seignorage is charged by Act of Parliament, amounting to about six per cent., I believe, and this takes the form of depreciation of the coin; so that if you were to take 100 ounces of standard silver to the Mint to be coined into crown pieces, they would give you back 100 crowns, but they would keep as much of the silver back as would form six additional crowns. This seignorage is necessary, not only for the purpose of defraying the expenses of the Mint, or making the business of coining bear its own charges, as every business should do, with a profit besides, but the depreciation is absolutely essential, to prevent the circulating medium from becoming merely a great store-house of silver bullion, from which silversmiths could at any time draw supplies necessary for their trade, by merely melting down the requisite number of coins. They have been unable to do this for the last ten years, except at a loss, because the average value of silver being 5s. per ounce, the actual coin, though nominally of this value, does not come up to it by six per cent. Silver bullion for the last ten years has averaged 59½ per ounce, never having fluctuated more than a halfpenny or three-farthings, either above or below the 5s., so that the seignorage has prevented our coins from, being melted or sold as bullion to any great extent. But how if silver rises by a considerable percentage in the marketable value, in relation to that by which all value is estimated, namely, gold?—it will be obvious that it just raises the coin in value as a coin, for it may both obliterate the seignorage, and acquire over and above an additional value as bullion. Now, it is only necessary to look at the present aspect of the bullion market to see that the seignorage is already almost obliterated—silver, in bars, appears quoted in the *Economist* of 26th November, at 5s. 2⅜d. per ounce, with every appearance of permanence. What, then, is to be the result, if this continue or increase? Simply that the relation of the silver coins to the *sovereign* must *of necessity alter*.*

It may be said that this is a delicate point to moot, and that mixing up decimal coinage with a question of currency is likely to put off its adoption to the "Greek kalends;" but though quite aware of its delicacy, I think it is a question which cannot long be shirked, and, in the solution of which, I see the best means of introducing a thorough decimal system. It will be observed that under *any* new system, the executive is required to issue a new silver coin of 2½d., whether of old or new pence, and I propose its double and quadruple. The question, then, will inevitably arise, How are these new coins to be issued?—whether at the *present* or the *former* value of silver, in relation to which our present currency laws of mintage are established. It is not for me to anticipate the decision of the Chancellor of the Exchequer on this point—the present occupant of that important situation is far too acute to require any schooling from so humble an individual—but it occurs to me, that unless, like some flashy advertising traders, "he is determined to give the public every advantage which a large stock, laid in before the late serious rise in prices, will admit of," he will be unable, if the Mint seignorage is to be maintained, to supply them "below prime cost." If, then, the new coin or coins are to be

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* See Appendix, No. v.

issued at the present relation to the golden standard of value, it necessarily follows that they will not relatively harmonize with the florin, shilling, and sixpence, which are in a relation to the standard which will have passed away. What, then, is to be done in such circumstances? It would be no great stretch, while issuing the new coins at the proper relative value, in existing or shortly anticipated circumstances, to decree that, "in consequence of the rise in the value of silver, in relation to the gold standard, the florin, the shilling, and the sixpence shall be held as a legal tender respectively for 2s. 1d., 1s. 0½d., and 6¼d.; and if it be conceded that this or some such measure would require to be resorted to, at any rate on the emergence of such circumstances, even if we were not thinking of a new decimal system at all, it will be seen that with the new coin of 2½d., or 10 farthings, and the appreciation of the florin to 2s. 1d., or 100 farthings, we would construct a *perfect* decimal system, *indicating*, in all *the gradations*, the coins with which to pay, with a familiar integer in the new guinea. I would not accord the same appreciation, of passable value, to the crown, the half-crown, the fourpenny, or the threepenny piece, which are somewhat incompatible with the decimal system; but these would not long continue to complicate the circulation; for in addition to these being called in and made exchangeable at the Mint, every silversmith, from the increase of value of silver, would for the purpose of withdrawal, be in effect an agent of the Mint, as the melting process would be brought to bear on those coins only which were not appreciated; and the coins necessary to our circulation would, instead of becoming bullion, continue the "tokens" which it is absolutely necessary they should be. I do not say that the difference of value would rest here, or can be tied down to this point, but at all events it would give us breathing space, and meet the present aspect of the matter. If silver continue to hold its present, or increase its relative value to our sole standard, there are only two ways of meeting it in the coinage—either by *ap*preciation or *de*preciation; and as you cannot (as with the stroke of a magician's wand) at once withdraw an entire coinage from circulation, in the event of the latter of these being adopted, the concomitant circulation of big and little florins, shillings, and sixpences, and the inconvenience which the necessity of narrowly examining every coin would entail on commerce, would be a serious evil; while as to *ap*preciation, I would suggest whether a precedent may not be found in the Portuguese coinage, which I have taken for my model, and where silver coins will be found in circulation indelibly impressed with the value of 200 and 400 reis, but which *pass for* 240 and 480 without the slightest confusion. We may be upon the eve of changes of value, of which none of us ever dreamt, and in contemplation of even a chance of these, it appears to me that the farthing unit in a new decimal currency is the most rational system we could adopt; it is based upon an already *existing* value, of which there is little risk of our requiring to learn any *new idea*, and, secure in its simplicity, let the silver and gold "toss and tumble" over one another, to use Sir John Herschel's expression, as they may, they affect not our system of accounts. Reared on the firmly-grounded foundation of the *lowest* idea of value, to which the exigencies of our commerce require us to give a tangible expression (and practically knowing no other denomination), the records of our commerce and accounts would remain unaffected by the unstable waves of changing value which might roll further out, and the simple decimal denomination of farthings still maintain a correct expression of accounts, under any circumstances. I would respectfully suggest, also, whether it would not be expedient, if possible, to get quit of the term "pound," as a *money term* upon other grounds. If we succeed in getting our coinage and currency decimalised, we do not expect to *stop there*—the weights and measures must inevitably follow; and of the difficulties of a change in this particular, that to the imperial system, which has not yet, after an interval of 28 years, taken a proper hold on the country, is a foretaste; while in the weights you have at least two different values, of the confusing term "pounds," to deal with.

But I have propounded this system of decimal notation and currency (with a mere "expression" for an integer) solely in deference to what I would take leave to call the bigoted predilection of many for the sovereign *in statu quo*, who seem to think that it would be "impious sacrilege" to touch it. I have, therefore, called it throughout this paper "the standard of value;" but it is not the standard of value as the sovereign, but only as so much bullion; and if we find that our transactions would be more easily met or conveniently carried out by our having a larger piece of bullion at one time than another, why should there be such difficulty about giving it us? If the three most requisite silver coins are leaving the sovereign,—a departure which must either produce inevitable confusion in our present system of accounts, or necessitate a curtailing of the coins,—is there any reason why we should not change the one coin, and bring it up to the ratio?—that is to say, abolish the pound or sovereign altogether, and increase its value by four per cent., to meet both the silver and the most rational system of accounting, under the existing circumstances and relations of our coinage.

It appears to me that few people realize to themselves what the money which passes through their hands really is. Virtually all our transactions of payment, large or small, are only the passing of so much gold, just as much as if we carried a phial of gold dust in one pocket, and a pair of scales and weights in the other. Changing the *sovereign*, then, is a very different thing from changing the *standard* of value, which no government, to keep faith with the public or the public creditor, dare attempt. It would not, under a new decimal system, introduce anything like the change in "our ideas of value," which has been propounded. Parliament would only have to declare it "found, that contracts or obligations made and expressed in 'pounds,' were made and expressed in 'farthings,' at the rate of 960 to the pound sterling;" or otherwise, "that contracts expressed in 'pounds' were made and expressed in the gold standard of value, at 3738 farthings per standard ounce," and thus all current contracts and obligations would by a simple process of calculation be changed into the denomination in which accounts are kept without the slightest change of value. These, however, are mere speculations as to the future, and only indulged in to show that in adopting the "farthing unit" as the first important step in transition, we would adopt a system capable easily by progressive steps of being carried out to perfection on the emergence of possible, if not very probable, circumstances; but, on the contrary, if we take the pound, we not only, at the very outset, confuse and complicate all the transactions into which the present copper coinage enters as an element, but hopelessly yoke ourselves to a vehicle which will budge neither one way nor another.

Various other systems have been proposed, to which it is almost unnecessary that I should allude. They all strike off what is I think incorrectly called "the unit," at some *intermediate stage* betwixt the pound and the farthing—some of them being multiples of the farthing, and others dividends of the pound; but it is absolutely necessary, to harmonize with our present notions of value, or at least our habits of stating value, that we should have a high integral and familiar expression for a considerable amount, and which I think we eminently would have in "the guinea." The only advantage to compensate for a lower integer would be, that we could habitually descend *below the farthing*, in statements of value; but surely this is unnecessary, when we find from the evidence, that an expensive coinage of half-farthings has been for years lying at the mint disregarded and never inquired for. Some transactions indeed descend below the farthing, such as the biddings at cotton or wool sales, which are frequently made in 8ths, in 16ths, 32ds, and even lower fractions of the penny; these, however, being only intended to amount to *something tangible*, on a large parcel, and having no reference to the price of a single pound of cotton or wool, parties making them could without difficulty alter their system of bidding to tenths of a farthing, 5-10ths of a farthing being exactly the 8th of a penny. It is sufficient therefore to know, that these "ghosts of a value," if I may use the expression, are within the "vasty deep, and will come if we do call;" but in mercy to a superstitious and unenlightened public, do not let us parade them on the stage, in the very first act of the piece.

Having thus endeavoured to develop (perhaps at the risk of being charged with tautology) a system of decimals for British notation and currency, not from *theory* but from *analogy*, recapitulation is almost unnecessary. Theorists may insist for a strictly indicating system, but they cannot fail to be struck with the fact, that the Portuguese (who have been so highly complimented for theirs) should not have taken advantage of it, in the very obvious direction of making their milree a *tangible* coin, instead of a mere ideal expression of value, especially as they have indicating coins below it of 100 rees in their "testoon" (and its half), and also in their half vintem or 10 rees; but unless matters are greatly changed, I think I will be corroborated by most of those conversant with the monetary circulation of Portugal, in saying, that the testoon and its half (indicating as they are) are just the silver coins *least used*, and that by far the greater number of prices, transactions, and payments, are made in *duodecimal* multiples of the vintem coins of 3, 6, 12, and 24 vintems or pence, stated as 60, 120, 240, and 480 rees. Now, if the convenience of the Portuguese system arises from the adoption of 5 at the *unit* end of every sum, I consider that the converse convenience to us would arise from the adoption of a "thousand farthings" as an integral expression of value, and of an amount in accordance with our predilections, even without a corresponding coin, and retaining the duodecimal system below it, which seems so ingrained into the human mind as to be almost "impossible to oust it." It has been argued that, as we have made one step in a certain direction, by the issue of the florins, we should go on in the same direction. But it is scarcely a tenable argument, that if we have made one *false* step we should make another, and I therefore hope to see the next coin issued as the "Victoria," of ten *present pence*, and with it and a system of tables, the country would almost *nolens volens* slide into a decimal system itself, with hardly a perception of its progress.

24 "Victorias" would change the sovereign;
25 "Victorias" would pay the new guinea;
5 "Victorias" would pay two hundred farthings;
10 four, 15 six, and 20 eight hundred;

and with very slight knowledge and calculation the ower payments, for which, even without the cent, a multiplicity of coins admitting of all necessary combinations already exist, would soon arrange themselves in accordance with the system. Then surely the ease of transition is something in favour of this system ; and in this respect its advantage over the other cannot fail to be apparent. We have only to reduce all our present amounts and accounts to farthings, by a simple process known to every one, and " proceed as before," every separate item, if required to be so reduced, balancing with its *former* value, and making no difference in the aggregate or sum-total.

But it is evident that the change proposed by the committee, admitted to affect all *fixtures* of a pence value, will also operate the same change in all sums whatever, in business books or accounts, under twopence halfpenny, or their proposed new cent. Such sums *are fixtures of value* whenever they are recorded, and a fractional calculation would require to be gone into in each case, for conversion into the new denomination ; or rather, as the cent is a new coin adjusted to the change in the penny and farthing, would not such calculation necessarily apply to all *tails* of accounts under a florin, the lowest coin of account, of the *present* denomination retained ? If accounts were all to be settled in the aggregate, it might be no very difficult matter of arrangement, betwixt debtor and creditor, which was to lose or gain the differential percentage on such small amounts ; but there is such a thing as a mercantile term of credit, and a large amount in the aggregate may be collected from debtors in many consecutive separate payments of distinct items of current account ; and a separate fractional calculation in such cases, so as to make the account ultimately balance (altogether irrespective of loss or gain to the parties) would be a matter *utterly intolerable.*

Nothing horrifies a merchant more, than the bare idea of having " a mess made of his books ;" and for this very reason fractions of the penny have hitherto been almost invariably excluded from them, even at the sacrifice of strictly correct calculation. In this respect, Government Departments set different examples, the Customs repudiating the fractions, the Excise exacting *the uttermost;* but we have heard of merchants with whom the strictest accuracy to a very penny is matter of the most rigid and unbending principle, instituting a re-examination of the transactions of a whole year to discover an error of sixpence on one side of an account, simply upon the principle, that *if there be error at all*, there is no security that an error of sixpence on one side may not have arisen from one of £99, 19s. 6d. on the other. "A pretty mess" such commercial martinets and their clerks would get into in the transition conversion, and the throwing off or taking on the fractions in the tails of hundreds of separate accounts, which the plan of the committee would of necessity involve!

In conclusion, then, I would say, that were the farthing unit with the guinea integer adopted, the following suppositious paragraph in a Gazetteer, for instance, would convey all necessary information of our system. "In Great Britain money accounts are kept in farthings and guineas of one thousand farthings—various copper and silver coins are in use in the internal commerce of the country, which circulate at their respective values in farthings—but the standard or measure of value is the gold sovereign of a fixed standard of fineness, and of the value of 960 farthings, for which it also circulates as a coin. To this standard all the other coins or monies of account are referable, and in the sovereign all balances of exchange with other countries are settled." Most of you may, on some occasion, have seen a gentleman bargaining for the purchase of a horse, a house, or an estate value from fifty to fifty thousand pounds. He makes an offer less by some pounds than what has been asked. The seller looks contemplative for a little—at length a ray of animation overspreads his countenance—he seems to have discovered some mode of meeting the difficulty: "Make it guineas," he at length cries; and forthwith hesitation and doubt vanish and the transaction is satisfactorily concluded. I feel that the same satisfactory solution would attend a similar settlement in reference to our anticipated decimal system of notation and currency; with which proposition I conclude my plea for the "Old Penny" and a "New Guinea."

Appendix, No. I.

Table for the Conversion of Sterling Pounds into Decimal Farthings or Mils, or Decimal Guineas into Sterling.

Explanation.—Find the number in the black figures. If Sterling into Decimals, look to the right; if Decimal Guineas into Sterling, look to the left.

Sterling. £ s. d.	Pounds or Guineas	Decimals.	Sterling. £ s. d.	Pounds or Guineas	Decimals.	Sterling. £ s. d.	Pounds or Guineas	Decimals.	Sterling. £ s. d.	Pounds or Guineas.	Decimals.	Value of the Numerals in the different Decimal places under a Guinea. Numerals.	1st place to right of ‖. £ s. d.	2d place to right. £ s. d.	3d place to right. £ s. d.
1 0 10	**1**	‖960	32 5 10	**31**	29‖760	63 10 10	**61**	58‖560	94 15 10	**91**	87‖360	‖1	0 2 1	0 0 2½	0 0 0¼
2 1 8	**2**	1‖920	33 6 8	**32**	30‖720	64 11 8	**62**	59‖520	95 16 8	**92**	88‖320	2	0 4 2	0 0 5	8 0 0½
3 2 6	**3**	2‖880	34 7 6	**33**	31‖680	65 12 6	**63**	60‖480	96 17 6	**93**	89‖280	3	0 6 3	0 0 7½	0 0 0¾
4 3 4	**4**	3‖840	35 8 4	**34**	32‖640	66 13 4	**64**	61‖440	97 18 4	**94**	90‖240	4	0 8 4	0 0 10	0 0 1
5 4 2	**5**	4‖800	36 9 2	**35**	33‖600	67 14 2	**65**	62‖400	98 19 2	**95**	91‖200	5	0 10 5	0 1 0½	0 0 1¼
6 5 0	**6**	5‖760	37 10 0	**36**	34‖560	68 15 0	**66**	63‖360	100 0 0	**96**	92‖160	6	0 12 6	0 1 3	0 0 1½
7 5 10	**7**	6‖720	38 10 10	**37**	35‖520	69 15 10	**67**	64‖320	101 0 10	**97**	93‖120	7	0 14 7	0 1 5½	0 0 1¾
8 6 8	**8**	7‖680	39 11 8	**38**	36‖480	70 16 8	**68**	65‖280	102 1 8	**98**	94‖080	8	0 16 8	0 1 8	0 0 2
9 7 6	**9**	8‖640	40 12 6	**39**	37‖440	71 17 6	**69**	66‖240	103 2 6	**99**	95‖040	9	0 18 9	0 1 10½	0 0 2¼
10 8 4	**10**	9‖600	41 13 4	**40**	38‖400	72 18 4	**70**	67‖200	104 3 4	**100**	96‖000				
11 9 2	**11**	10‖560	42 14 2	**41**	39‖600	73 19 2	**71**	68‖160	208 6 8	**200**	192‖000				
12 10 0	**12**	11‖520	43 15 0	**42**	40‖320	75 0 0	**72**	69‖120	312 10 0	**300**	288‖000				
13 10 10	**13**	12‖480	44 15 10	**43**	41‖280	76 0 10	**73**	70‖080	416 13 4	**400**	384‖000				
14 11 8	**14**	13‖440	45 16 8	**44**	42‖240	77 1 8	**74**	71‖040	520 16 8	**500**	480‖000				
15 12 6	**15**	14‖400	46 17 6	**45**	43‖200	78 2 6	**75**	72‖000	625 0 0	**600**	576‖000				
16 13 4	**16**	15‖360	47 18 4	**46**	44‖160	79 3 4	**76**	72‖960	729 3 4	**700**	672‖000				
17 14 2	**17**	16‖320	48 19 2	**47**	45‖120	80 4 2	**77**	73‖920	833 6 8	**800**	768‖000				
18 15 0	**18**	17‖280	50 0 0	**48**	46‖080	81 5 0	**78**	74‖880	937 10 0	**900**	864‖000				
19 15 10	**19**	18‖240	51 0 10	**49**	47‖040	82 5 10	**79**	75‖840	1,041 13 4	**1,000**	960‖000				
20 16 8	**20**	19‖200	52 1 8	**50**	48‖000	83 6 8	**80**	76‖800	2,083 6 8	**2,000**	1920‖000				
21 17 6	**21**	20‖160	53 2 6	**51**	48‖960	84 7 6	**81**	77‖760	3,125 0 0	**3,000**	2880‖000				
22 18 4	**22**	21‖120	54 3 4	**52**	49‖920	85 8 4	**82**	78‖720	4,166 13 4	**4,000**	3840‖000				
23 19 2	**23**	22‖080	55 4 2	**53**	50‖880	86 9 2	**83**	79‖680	5,208 6 8	**5,000**	4800‖000				
25 0 0	**24**	23‖040	56 5 0	**54**	51‖840	87 10 0	**84**	80‖640	6,250 0 0	**6,000**	5760‖000				
26 0 10	**25**	24‖000	57 5 10	**55**	52‖800	88 10 10	**85**	81‖600	7,291 13 4	**7,000**	6720‖000				
27 1 8	**26**	24‖960	58 6 8	**56**	53‖760	89 11 8	**86**	82‖560	8,333 6 8	**8,000**	7680‖000				
28 2 6	**27**	25‖920	59 7 6	**57**	54‖720	90 12 6	**87**	83‖520	9,375 0 0	**9,000**	8640‖000				
29 3 4	**28**	26‖880	60 8 4	**58**	55‖680	91 13 4	**88**	84‖480	10,416 13 4	**10,000**	9600‖000				
30 4 2	**29**	27‖840	61 9 2	**59**	56‖640	92 14 2	**89**	85‖440							
31 5 0	**30**	28‖800	62 10 0	**60**	57‖600	93 15 0	**90**	86‖400							

Conversion Table of all Combinations of Shillings and Pence into Decimal Farthings or Mils.

EXPLANATION.—Find the amount of Shillings in the Black Figure Column to the left, and running the eye along the line, under the Pence will be found the Decimal required; if Farthings are in the sum, add 1, 2, or 3.

£	s.	d.	Farthings.	1d.	2d.	3d.	4d.	5d.	6d.	7d.	8d.	9d.	10d.	11d.
				004	008	012	016	020	024	028	032	036	040	044
0	1	0	048	052	056	060	064	068	072	076	080	084	088	092
0	2	0	096	**100**	104	108	112	116	120	124	128	132	136	140
0	3	0	144	148	152	156	160	164	168	172	176	180	184	188
0	4	0	192	196	**200**	204	208	212	216	220	224	228	232	236
0	5	0	240	244	248	252	256	260	264	268	272	276	280	284
0	6	0	288	292	296	**300**	304	308	312	316	320	324	328	332
0	7	0	336	340	344	348	352	356	360	364	368	372	376	380
0	8	0	384	388	392	396	**400**	404	408	412	416	420	424	428
0	9	0	432	436	440	444	448	452	456	460	464	468	472	476
0	10	0	480	484	488	492	496	**500**	504	508	512	516	520	524
0	11	0	528	532	536	540	544	548	552	556	560	564	568	572
0	12	0	576	580	584	588	592	596	**600**	604	608	612	616	620
0	13	0	624	628	632	636	640	644	648	652	656	660	664	668
0	14	0	672	676	680	684	688	692	696	**700**	704	708	712	716
0	15	0	720	724	728	732	736	740	744	748	752	756	760	764
0	16	0	768	772	776	780	784	788	792	796	**800**	804	808	812
0	17	0	816	820	824	828	832	836	840	844	848	852	856	860
0	18	0	864	868	872	876	880	884	888	892	896	**900**	904	908
0	19	0	912	916	920	924	928	932	936	940	944	948	952	956
1	0	0	960	964	968	972	976	980	984	988	992	996	**1000**	1 004

Appendix, No. II.

Proposed Placard for exhibition in all places of business on the transition to a decimal system of accounts, if the Florin, Shilling, and Sixpence are not at same time appreciated in value.

Whereas from and after the —— of ——— 185 , written accounts of all transactions, instead of being kept in the present money denomination of pounds, shillings, pence, and farthings, are thenceforth to be stated in farthings alone, with a view to a decimal system of accounts :—

TAKE NOTICE THAT CHARGES OF—

One farthing are to be set down thus, ...			‖001
A halfpenny equal to . .	2	farthings thus,	‖002
A penny, ...	4	,, ,,	‖004
A "cent" or "tithe," a new coin,	10	,, ,,	‖010
A threepenny piece, . .	12	,, ,,	‖012
A fourpenny piece, . .	16	,, ,,	‖016
A half Victoria, a new coin, .	20	,, ,,	‖020
A sixpence, ...	24	,, ,,	‖024
A "Victoria," a new coin, .	40	,, ,,	‖040
A shilling, ...	48	,, ,,	‖048
A florin, ...	96	,, ,,	‖096
A half-crown, . . .	120	,, ,,	‖120
A crown, ...	240	,, ,,	‖240
A half-sovereign, . . .	480	,, ,,	‖480
A sovereign or pound, . .	960	,, ,,	‖960
A thousand farthings to be called a guinea, 20/10, being written, ...			1‖000
And the sum of these, to show the system, being by simple addition, ...			3‖073

Or three guineas, seven cents, three farthings.

Appendix, No III.

Example of reduction of the present denomination into farthings, and its proof by another method.

Ex.—Reduce £3 17 10½ into farthings by school method.

```
£3 17 10½
20
———
77
12
———
934
4
———
```

Ans. 3,738 farthings,

or decimally 3‖738; three thousand or guineas, 738 farthings; otherwise denominationally, if the *silver be appreciated*, three guineas, seven florins, three cents, eight farthings.

Proof.

	£	s.	d.
Example, . . .	£3	17	10½
Multiply by .			8
	£31	3	0
And by . .			12
	£373	16	0

Then take half the amount of the shillings and place it as the unit to the sum of pounds, thus 3738, being apparent pounds, but actually the number of farthings in the original amount.

Note. The above proof is simply a multiplication by 960, the number of farthings in the present pound; the halving the shillings and placing them as the unit, it will be seen, is just a short way of working the last multiplication by 10, which changes the shillings into half their amount of pounds, and infallibly results in bringing the apparent pounds in correspondence with the number of farthings in any sum; and if we take the number of figures, it is a shorter process than the other.

Appendix, No. IV.

Multiplication table to be learned for practice of conversion of any sum of decimal farthings under a guinea, at sight, into present denomination and coinage:—

1 farthing is	. . . .		one farthing.
2 farthings are	. . .		one halfpenny.
3 „	. . . .		one halfpenny farthing.
4 „	. . . .		one penny.
5 „	. . . .		one penny farthing.
6 „	. . . .		one penny halfpenny.
7 „	. . . .		one penny three farthings.
8 „	. . . .		twopence.
9 „	. . . .		twopence farthing.
10 or in the second decimal place	1 at	$2\frac{1}{2}$d.	twopence halfpenny.
20 „ „	2 at	$2\frac{1}{2}$d.	fivepence.
30 „ „	3 at	$2\frac{1}{2}$d.	sevenpence halfpenny.
40 „ „	4 at	$2\frac{1}{2}$d.	tenpence.
50 „ „	5 at	$2\frac{1}{2}$d.	one shilling and a halfpenny.
60 „ „	6 at	$2\frac{1}{2}$d.	one shilling and threepence.
70 „ „	7 at	$2\frac{1}{2}$d.	one shilling and fivepence halfpenny.
80 „ „	8 at	$2\frac{1}{2}$d.	one shilling and eight pence.
90 „ „	9 at	$2\frac{1}{2}$d.	one shilling and tenpence halfpenny.
100 or in the third decimal place	1 at	2s. 1d.	two shillings and one penny.
200 „ „	2 at	2s. 1d.	four shillings and twopence.
300 „ „	3 at	2s. 1d.	six shillings and threepence.
400 „ „	4 at	2s. 1d.	eight shillings and fourpence.
500 „ „	5 at	2s. 1d.	ten shillings and fivepence.
600 „ „	6 at	2s. 1d.	twelve shillings and sixpence.
700 „ „	7 at	2s. 1d.	fourteen shillings and sevenpence.
800 „ „	8 at	2s. 1d.	sixteen shillings and eightpence.
900 „ „	9 at	2s. 1d.	eighteen shillings and ninepence.
1000 „ one Guinea			twenty shillings and tenpence.

Appendix, No. V.

Table of the Price of Silver on 1st July of each year from 1841 to 1853, extracted from a recent work entitled "Victoria," by William Westgarth, Esq. of Melbourne.

1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.
5/0$\frac{1}{8}$	5/0	4/11$\frac{1}{2}$	4/11$\frac{5}{8}$	4/11	4/11	4/11$\frac{1}{2}$	4/11$\frac{1}{2}$	4/11$\frac{5}{8}$	4/11$\frac{5}{8}$	5/0$\frac{3}{4}$	5/0$\frac{1}{4}$	5/1$\frac{1}{2}$

Table of the Weekly Price of Standard Silver in bars per Ounce, for preceding three months of 1853, from the "Economist."

Sept. 3.	Sept. 10.	Sept. 17.	Sept. 24.	Oct. 1.	Oct. 8.	Oct. 15.	Oct. 22.	Oct. 29.	Nov. 5.	Nov. 12.	Nov. 19.	Nov. 26.
5/2$\frac{1}{8}$	5/2$\frac{1}{8}$	5/1$\frac{7}{8}$	5/1$\frac{7}{8}$	5/1$\frac{3}{4}$	No quotation.	5/1$\frac{3}{8}$	5/1$\frac{3}{4}$	5/1$\frac{3}{4}$	No quotation.	5/2$\frac{3}{8}$	5/2$\frac{3}{8}$	5/2$\frac{3}{8}$

Making the average price for these months within a fraction of 5s. 2d. per ounce, and rising at the end of the period.

Report of Committee.

Your Committee having met, and carefully considered Mr Alexander's paper on Decimal Coinage, are of opinion that he is entitled to much credit for the ingenuity he has displayed in the conception of his plan, and in the means he proposes for facilitating the calculations connected with it. They do not, however, for various reasons, consider that it is a suitable scheme for adoption by the country.

1. Mr Alexander proceeds on the principle, that it is unnecessary that the coins of account, or those in terms of which books are kept, should coincide with the coins actually in circulation in which payments are made; and, accordingly, the only coin which, in his system, is a coin of account, and also of circulation, is the farthing. In consequence of this, every sum of money must be converted from the coins of exchange to those of account before it is entered in the book, and, conversely, the sums stated in the book must be reconverted into coins of exchange before payments can be made.

Now, your Committee conceive that this process of reduction, requiring constantly to be performed, would tend very much to neutralize any advantage gained by the adoption of decimal notation in book-keeping. They are, moreover, of opinion, that as the object of the proposed introduction of decimal coinage is to get rid, as much as possible, of arithmetical operations, no system should be adopted which is not complete in this respect; and they cannot consent to regard any system as complete in which the coins of account are not identical with those in circulation, so that a sum of money expressed decimally may at once be resolved into coins of exchange by simple inspection, without the aid of any arithmetical operation.

2. In Mr Alexander's system, the only existing coin expressed by unity is the farthing. The penny and shilling are expressed by ·004 and ·048. If, on the other hand, the *pound* were adopted as the unit, the florin would be ·1, and the shilling ·05; or, if *ten shillings* were made the unit, the florin would be ·2, and the shilling ·1. In these systems, it would be easy, by inspection, to read off the pounds and shillings in a sum of money expressed decimally. To complete such systems, the present copper coinage must be altered; but your Committee think that the pound and shilling are the most important coins to the poor man as well as to the rich, and they conceive that less inconvenience would arise from altering the pence and farthings, than would be occasioned by interfering with the shilling and pound.

It would certainly be very desirable to have a system which would retain the penny unaltered, for many reasons; but your Committee fear that no workable system can be found in which the penny can remain as it is.

3. Your Committee conceive that, if a new unit is to be adopted instead of the present pound, it must be some exact submultiple of a pound, and they are of opinion that *ten shillings* might form a very convenient unit. Among other advantages, the shillings in a sum expressed decimally could be read off simply by inspection;—every existing coin above a shilling, as well as the shilling itself, can be retained;—sixpence and threepence can be retained as 5 cent and $2\frac{1}{2}$ cent pieces;—and the copper coinage would approximate very closely to the present penny, halfpenny, farthing, and half-farthing.

4. Your Committee regard it as a further and very grave objection to Mr Alexander's scheme, that the new notes or coins, to the value of £1, 10d., which he proposes to issue, would be so near in value to the present pound that, in conformity with existing habits, they would be used as the unit in estimating large sums; but with this disadvantage, that the new unit can only be expressed in terms of the old, by a very complex fraction $\frac{1000}{960}$ or $\frac{25}{24}$. The consequence of this, your Committee apprehend, would be for a long time to produce mistakes and confusion in transactions where the reduction from the old to the new denomination required to be made rapidly. The near approach to equality in the two denominations might also give rise to error, by causing a sum of money expressed in the one denomination to be taken for one expressed in the other.

Your Committee think that these sources of error would be avoided, by adopting a submultiple of a pound, such as *ten shillings*, as the new unit.

5. Your Committee do not consider themselves in a position to enter upon the merits of Mr Alexander's remarks regarding the alteration in value of silver, and its supposed effect in making the intrinsic worth of the existing coinage adapt itself to his system of a new guinea worth £1, 10d.; they would, however, simply remark, that it is quite impossible to predict the extent to which the value of silver may alter; it is equally impossible to say whether, after any assigned period, the intrinsic value of the present shilling would be an exact decimal of the existing gold sovereign, or of Mr Alexander's new guinea, or of any other assumed gold coin.

Your Committee cannot close this Report without expressing their feeling, that the warmest thanks of the Society are due to Mr Alexander for his very interesting paper; and although they have come to a different conclusion from him as to the decimal system of coinage which will best supply the wants of the country, yet they regard his views as highly deserving the attention of those who may meanwhile wish to adopt a decimal system of book-keeping, and they beg to suggest that his paper, along with this Report, be printed in the Society's Transactions.

William Swan, *Convener.*

Account of some of the East-Indian Arts and Manufactures, with Specimens of the Tools and Manufactured Articles, including Salt, Bombay or Moultan Inlaid Work, Gold Wire, Gold Lace and Spangles, Cambay Stones, and Calico-Printing. By Dr Buist.*

Salt.

The salt revenue of India has for the past ten years averaged in all about two-and-a-half millions sterling. The duty on salt is at Calcutta £6, 10s. 6d., the cost of production £1, 16s. per ton, the selling price about £8, 10s. At Bombay the duty is £1, 16s., the cost of manufacture 3s. 3d., the selling price £2. At Madras the duty is £2, 5s., the cost of manufacture about 15s., the selling price is £3. In Bengal the sea-water, after being concentrated to a certain extent by evaporation, is afterwards dried off by artificial heat, and to these circumstances is probably due the enormous difference of price. About 100,000 people are employed at the latter place in the manufacture, and the occupation is said to be an eminently sickly one; at the former place probably not one-twentieth of this number, and these occupying themselves as cultivators during the remaining part of the year, employing themselves at the salt-work only when field labour is in little demand. At Madras and Calcutta government used to have a monopoly of the salt trade. This system at the latter place is now abandoned, any one being allowed to manufacture or import salt who pays the duty; and, accordingly, since 1845, when this rule came into effect, there have been above 90,000 tons of salt imported annually into Calcutta, of which something less than one-half went from England. The freights from Bombay, amounting to from 10s. to 20s. a ton, seem to have prevented, to a considerable extent, cheap salt from being sent round to the other presidencies. At Bombay the salt-tax is levied in the shape of a simple excise, and its collection occasions no trouble or inconvenience whatever. In other parts of India vast storehouses are maintained by government, and their highly paid

* Read before the Society 27th February 1854.

European superintendents. The salary of the superintendent of salt alone, amounting to about £4000 a-year, would probably maintain the families of the whole 600 or 800 persons who conduct the salt manufacture throughout Western India, where the charge of the salt manufacture at the former place exceeds that of the latter, where the labourer receives one-third more wages, by some £30,000 or £40,000 a-year, or three times the entire amount assigned for educational purposes all over Western India. The consumption of salt in Western India is estimated at 12 lb. a-head per annum; and assuming the wages of the agricultural labourer at 3 rupees, that is 6s. per mensem, it would at Calcutta absorb the income of five days labour to provide the quantity required for the year, or a tax of $1\frac{1}{2}$ per cent. upon his income; with a wife and children, that tax will of course be increased according to the consumption; but so to a certain, though a limited, extent will the income of the family through the industry of its component members. The bulk of these statements are abridged from the statistical papers published by the India House, or the letter of Mr Chapman, published in August, and founded thereon. The following is from personal observation:—

Amongst the numerous islands which fringe the Malabar coast, there are countless narrows, creeks, and inlets, left dry at low tide, the expanse of mud then exposed being often enormous. Off the shores of Lewree the tide at springs retires nearly two miles; and this is nothing at all out of the way in the neighbourhood. When salt-pans are proposed to be established, the first thing is to construct a mud embankment, a foundation for it being selected where the water is never more than four or five feet deep. The crest of the embankment is made to surmount this by two or three feet, the base of it is generally from two to three times its height. Openings are purposely left at intervals in the principal embankment, and from these at right angles to the main line of the wall other embankments are run inland parallel to each other, leaving a current between large enough to admit of a line of salt-banks running up. Immediately behind the embankments the salt pans are laid down. These consist of rectangular compartments from 20 to 30 feet across, and commonly twice as long as they are broad, and from 1 foot to $\frac{1}{2}$ foot in depth. They are separated from each other by little mud walls about 3 feet across at bottom, and 2 at top, more or less, according as little channels for filling the pans are meant to be run along them or not. Two, three, or four lines of pans, according to the extent of the back-water, are carried along the rear of such embankment,—care being taken to leave an area of land capable of being flooded by the sea betwixt the pans and the main land three or four times the size of the pans themselves. So soon as the monsoon is fairly over, all the fresh water that has accumulated in the pans or back-water is run off, and in November or December the sea is admitted to the back-water through a sluice in the embankment. The pans are now carefully cleaned, and their floors and walls made smooth and nice. In about a month after it has been admitted to the back-water, the sea-water, now getting reduced in quantity, and increased in saltness by evaporation, is let into the pans. The first charge requires about six weeks to evaporate; subsequent charges are dried in half the time of the first, thus diminishing as the season becomes hotter, and the brine more strong. The strength of the brine is judged of by its becoming red; in fact, a curious variety of creatures of the volvox kind, which seem never happy unless in a pickle—the same as is to be found in a fossil state in the Punjaub rock-salt, and which often tinges the waters of our sea-shores as if stained with blood—make their appearance just as the salt is ready to crystallize, often tinting the salt itself of a fine pinkish hue. When very nearly dry, the salt, which has now accumulated to the thickness of an inch or two, is raked off; the upper portion, which is beautifully white, and almost quite pure, being first taken; the lower portion, often crystallized in pieces of half an inch cube, is taken up next; it is slightly mixed with clay, and is that generally in use. The white and bluish salt are now piled up separately in conical heaps, about 16 feet in diameter, and ten feet high, which are preserved with a thick thatching of grass during the monsoon. The white salt is as pure as any in the world,—the black salt is mixed with about 1 or 2 per cent. of clay. Both are in a great measure free of the magnesian salts and sulphate which contaminate pan-made salts at home; every thing more soluble than muriate of soda remaining behind in solution is washed away by the rains. Salt-pans are much less efficient when new than afterwards, and they continue to improve as the ground becomes impregnated, for 10 or 15 years. When the first crystallization is unsatisfactory, as it often is, a second charge of brine is let on, before the salt from the first is removed. The evaporation in the back-water goes on, of course, as rapidly as in the pans themselves; and by this contrivance, which requires no care or preparation, an amount of evaporating surface three or four times that of the pans is secured; the pans themselves only require trouble or attention, the back-water requires none. The pans are drawn from three to four times every year; as the rains approach, they are abandoned for the season. The sea is seldom let in more than once or twice into the back-water; were the whole available surface kept covered, double the amount of salt at present manufactured might be made. The supply, however, is so close on the heels of the demand, and the profits are so very low, that there is no reason why production should be extended. Such is the convenience of our shores for the manufacture, and so easily and so cheaply can the process of storing and carrying away be managed, that all the attempts made by Banians to bring salt from Scinde, where it is to be had in unlimited quantity ready made, have proved unremunerative. The upper salt is scarcely surpassed in purity by the finest the Cheshire mines send forth, while the black salt contains as much of the pure muriate of soda as does the common pan-made salt at home. The matter which contaminates the former is conspicuous, and looks very dirty, but then it is perfectly harmless; the subtle contaminants of the latter are eminently mischievous, though invisible. An English adult is supposed to consume at an average of from 15 to 20 lb. of salt annually, so that he will in this way swallow some 3 ounces of mud a-year; it will be a long time before the peck of dirt every one is said to have destined for him in the course of his lifetime be at this rate consumed. In India, numbers of people eat pounds weight of clay by choice.

Blackwood Furniture.

We are so imperfectly acquainted with the history of the Bombay furniture manufacture, that we must confine ourselves to a few details of the process by which it is made. Blackwood (sissoo) is the material almost always employed; it is brought from Cochin, and other places lower down on the Malabar coast. It sells for about the same price as teak, is a brittle and open-grained wood, not at all a favourite with cabinetmakers at home; and the highest prices ever realized for it are, I believe, somewhere about £10 per ton. A quantity of it sent home at this price in 1845 was found unprofitable, and my impression is, that its importation has been wholly given up. The principal furniture-dealers in Bombay—all indeed save Jaffer Sulliman, who is a Mohammedan—are Parsees; the workmen they employ are mostly from Goozerat. The pattern meant to be carved is first carefully drawn on paper, then copied on the wood. The tools used are the native adze, chisel, and drill; the centre-bit and other tools of English pattern, from which so much assistance might be obtained, are never resorted to. The general design of the various pieces of furniture is mostly excellent, the patterns elegant and tasteful, the finish for the most part poor, the joinery always execrable. Considerable quantities of blackwood furniture are sent home annually by the residents in Bombay for their own after use, or for the service of their friends; and those desirous of ornamenting their houses with this beautiful description of carved work, will find that they can do so more economically by resorting to Bombay than by applying to the home market. Excessive freight and trifling injuries are avoided by its being packed up without being jointed or polished, and afterwards put together by English workmen. There are seven principal furniture shops in Bombay, from any one of which supplies may be obtained by writing to the party, and giving a reference for payment on the spot; those of Jaffer Sulliman, Sorabjee Framjee, Lapoorjee Byramjee, Pestonjee Eduljee, Rusbomjee Nowrojee, Jamsetjee Limjee, and Manockjee Nowrojee. They keep from five to ten workmen each, and probably turn out 25,000 to 30,000 rupees worth of furniture amongst them annually. As one of the most important functions of such societies as the present is to make known to the inhabitants of one part of the world the raw material or productions to be found in other parts, and with which they might wish to supply themselves, it might be desirable, should the president require a chair, or the secretary a desk or writing-table, to provide themselves from Bombay, not only with a view of attaining elegance with economy, but with that of showing to others how such things might be obtained. The following are the prices at which the principal articles may be procured—a rupee may be set down at about 2s.

Round table, from 3 to 8 feet in diameter	Rs. 30	to	80
Do teapoys, 2 feet in diameter, per pair	„ 16	„	25
Card-tables, do.	„ 50	„	60
Flower-stands, do.	„ 50	„	100
Pier-tables, do.	„ 100	„	150
Conversation sofas, do.	„ 100	„	150
Sofa-couches, do.	„ 140	„	200
Music-book cases, do.	„ 80	„	140
Easy chairs, each	„ 10	„	50
Low chairs, do.	„ 25	„	50
Drawing-room chairs, with damask cushions	„ 5	„	10
Dressing-tables, each	„ 8	„	75
Side-boards, do.	„ 35	„	70
Screens, do.	„ 20	„	75
Wardrobes, do.	„ 45	„	75
Clothes-presses, do.	„ 25	„	40
Bedsteads, do.	„ 50	„	200
Writing-tables, do.	„ 50	„	100
Bed-room couches, per pair	„ 40	„	60
Chiffonniers, each	„ 60	„	80
Sofa-tables, per pair	„ 60	„	90
Dining-table, in pieces	„ 40	„	50
Chests of drawers, each	„ 25	„	50
Music-stands, per pair	„ 30	„	50

Bombay or Moultan Work.

The inlaid work of ivory, white and dyed, ebony, or other coloured woods, for which Bombay has long been famous, is said to have been introduced from the Punjaub, and is still familiarly known as Moultan work. It consists chiefly of paper-cutters, work-boxes, writing-desks, and other similar articles. The effect of a large mass of it is very poor; the pattern is too fine for being distinguishable, and it fills the eye with a general grayish tint; in articles which do not present more than a foot or two of surface, it is very pleasing. The ground of the inlaid pattern is generally scented cedar or sandalwood, the joinery exhibited in which is very indifferent. The inlaying material is prepared as follows: the wood or ivory is cut into slips of a lozenge or triangular section, as may be required, by a long thin-bladed, fine-toothed saw. The tin is drawn through betwixt a pair of grooved rollers, like those used for laminating or extending iron—they work together by teeth at the extremity; one or two draws-through extends the metal into the length desired. The wires and splints are nearly all either lozenge-shaped or triangular, the triangles being equilateral, the lozenges composed of two equilateral triangles. A pattern being fixed on, the splints are built up into pieces, about eighteen inches long, and from a quarter to two inches in thickness, firmly glued together. In the case of borders or continuous pieces of work, the rods are glued together betwixt pieces of ivory, or wood and ivory alternately, so as to form straight lines on each side of the pattern. When about to be used they are sawn across, the thickness of a sixpence, and arranged in a box divided into compartments, something like a printer's case. They are then picked up in succession, and applied with glue to the box or other article to be inlaid. The following is a list of the prices of some of the most common articles to be met with in the bazaar:—

Work boxes, of sizes, from	. . . .	Rs. 8 to 80
Writing-desks, of sizes, from	. . .	„ 15 „ 60
Portfolios, do. do.	. . .	„ 10 „ 20
Watch-stands, do.	. . .	„ 8 „ 10
Watch-cases, from	. . .	„ 4 „ 6
Envelope-cases, do.	. . .	„ 15 „ 25
Baskets, of sizes, do.	. . .	„ 6 „ 25
Cheroot-cases, do.	. . .	„ 3 „ 4
Card-cases, of sizes, do.	. . .	„ 2 „ 5
Paper-weights, do.	. . .	„ 3 „ 4

Paper-cutters,	do.	. . .	Rs. 1	„ 3
Baskets, openwork,	do.	. . .	„ 12	„ 15
Table-trays,	do.	. . .	„ 10	„ 15
Pin-cushions,	do.	. . .	„ 3	„ 4
Ink-stands,	do.	. . .	„ 10	„ 15
Jewel boxes, of sandal wood, from		. . .	„ 20	„ 50
Paper-stands, of	do. do.	. . .	„ 5	„ 10

Lapidary Operations.

The agates, onyxes, cornelians, and bloodstones of the Raj-Peepla range, and Cambay cornelians, as they are called, from the place where they are mostly cut, and from which they are almost wholly brought to Bombay. The cornelian in the Raj-Peepla range is found in a bed of blue clay—the detritus, probably, of the adjoining rocks. Shafts are pierced in this to the depth of from 30 to 35 feet, and horizontal galleries run in any direction that suits the fancy of the miner; they are distributed promiscuously, and do not appear to be in veins or loads. The galleries seldom exceed 100 yards in length,—they often run into those of other mines; they are generally five feet in height, and four across. To each mine there are thirteen men attached—they work by turns. Each man must send up so many basketfuls of earth and stones before he is relieved. The stones are collected in baskets, and drawn up by a rope run over a roller or pulley. A group of people await them at the mouth of the shaft, and examine them one after another by chipping each on a piece of stone; the compact and fine-grained are the best; and the blacker the hue is at first, the redder it becomes after being burnt. There were, in 1832, about 1000 miners employed; and each man carried home with him a basket of stones every evening. They were spread out on the ground, and for a whole year turned over every four or five days to the sun; the longer they are exposed, the richer become their tints. In the month of May they are burnt. The operation is effected by placing the stones in black earthen pots or chatties. The pots are placed mouth under, a hole being pierced in the bottom of each; over this is put a piece of broken pot. The pots are arranged in single rows; sheep's dung is the only fuel found to answer; the fire is always lighted at sunset, and allowed to burn till sunrise. If any white spots appear on the surface of the pot, the burning is reckoned incomplete, and the fire continued sometime longer. On being removed from the fire, the stones that have flaws are thrown aside as useless, those not sufficiently burnt are kept for next year's burning, and the remainder are sold for exportation. Nearly the whole of the stones are cut at Cambay, the greater part of them are made into blades. The following is the process: The stones are first broken up into pieces of suitable size for the end they are desired to serve. An iron spike is stuck into the ground, point upwards; the stone is placed on this and chipped with a hammer till nearly rounded; it is then passed on to the polisher, who seizes it in a pair of wooden clams, and rubs it against a piece of sandstone placed in an inclined plane before him, turning it round from time to time till it assumes a globular form. It is then passed on to the borer and polisher; a hole is drilled in it with diamond dust, and the beads are finally polished by being put in a bag with some fine emery and rubbed against each other.* The stones for other uses are sawn or ground down; and this brings us to the native lapidary's tools, which are simple and efficient to a degree. The wheel consists of a strong wooden platform, 16 inches by 6, and 3 inches thick. In this are two strong wooden uprights. Between these is a wooden roller 8 inches long, and 3 in diameter, fastened into a head at the one end. This works on an iron spindle or axle at each end. On the one end the axle is screwed and fitted with a nut, by which the saw or grinding-wheel can be made fast. The saw consists of a thin plate of iron, the cutting material consisting of native emery or ground corundum—koorund as it is called. The lap-wheel consists of two circular discs or cakes of lac with ground koorund, coarse or fine according to the work—of a copper disc for polishing, and a wooden one for finishing the work. These are spun backwards and forwards by a bow,

* Thus far on Cambay stones we have mainly abridged from an excellent paper by Captain Fulljames, in the Transactions of the Bombay Geographical Society for 1839.

the string of which passes round the roller. The lapidary sits on his hams, steadying the wheel with his foot, and holding on the stone with his left hand, while he works the bow with his right. For very fine work a small-sized wheel, similar to the English lapidary's wheel, but of smaller size, is used. It is driven by a multiplying wheel, strap, and pulley.

Stone-Cutting.

Before concluding the account of stone-cutting, we must give a short notice of the seal-engraver's tools and wheel. The latter consists of a slight frame, ballasted below to keep it firm, with two uprights about 18 inches in length and 8 inches between. Betwixt the two is a small spindle, which turns at the one end on a screw or pivot, sometimes of cornelian; the shoulder is kept in its place by a neat iron clamp,—it is steadied by a piece of rag wrapped round and inclosed in the collar. Why so much pains should be taken to diminish friction by a cornelian pin at one end, while it was increased by this at the other, we cannot explain. A dozen or two spindles such as this are made use of. The spindle is terminated by a small spike of iron about an inch long, ending in a little circular saw or button, from a tenth up to half an inch in diameter. To this emery paste—that is, powdered corundum mixed with oil—is from time to time applied, while it is spun round with a bow. The engraver holds the seal up betwixt his fingers and thumb, and a sweep or two of the bow causes a mark on the seal. This is deepened and extended as desired,—the larger discs being employed for long straight strokes. The work turned out is by no means very fine, but the celerity of execution is surprising. Diamond dust is very rarely used in India,—corundum, koorund, or samdastone, as it is called, being the chief material employed in polishing gems, marbles, and metals. This mineral is found chiefly in granite, or the detritus of granite rocks, in the Mysore country, and in the neighbourhood of the south-western ghauts. It is met with in abundance on the table-land of the Paree, latitude 24° N. It is brought in considerable quantity to Bombay, and is occasionally exported to Europe. It is packed in orange-shaped parcels with meridianal cordings; the pieces are from the size of filberts to that of the hand; they are generally amorphous or fragments of crystals, often contaminated with felspar, mica, and other granitic minerals. Sometimes fragments of crystals perfectly pure are to be met with, weighing from 10 to 25 lb., but these are rare. Though excessively hard, it is by no means tough; it flies in pieces after a few strokes of the hammer, and is easily pulverized in a mortar. The natives generally beat it on an anvil or stone, keeping it from flying about by a collar of cotton rope. The fine particles are separated from the coarse by sifting; we are not aware that the home process of lixiviation is resorted to. For sharpening swords or burnishing metals it is generally used like a whetstone or burnisher; for polishing gems it is either made up into a cake with lac, or into a paste with oil or grease. It is never employed for the manufacture of emery paper, or anything resembling it. For polishing marble or other stone it is used in two forms. The first of these is a cake of about 8 inches long, 3 across, and 2 deep. This is used by an individual in the hand. For heavier purposes, a cake a foot square or so is employed, placed in a frame. Two men work at this, and the reducing process is very rapidly accomplished by it; it is in fact a file with a lac body and corundum teeth. This concludes our sketch of lapidary observations; we are aware of its being in the last degree imperfect, and shall be thankful to any one who will fill it up, correct, or extend it. We have not been able to discover a single syllable on the subject in any printed book. The diamonds seen in such abundance amongst our native gentry are almost all cut in England, and our principal gems here are the lapis lazuli, rubies, emeralds, opals, garnets, and the whole family of siliceous gems.

The following, from the custom-house returns, gives the value of the traffic in Cambay stones, which averages betwixt £10,000 and £12,000 annually,—one per cent. of the stones finding their way to Europe:—

Cornelians—exports of—value :—

	1844.	1845.
China,	73,443 rupees.	59,653 rupees.
Singapore,	5,352 "	645 "
Arabian Gulf,	935 "	18,197 "
Suez,	... "	40 "
Persian Gulf,	2,269 "	1,257 "
Calcutta,	4,179 "	4,913 "
Coromandel Coast	... "	315 "
Malabar and Canara,	89 "	... "
Ceylon,	2,536 "	1,540 "
Great Britain,	100 "	216 "
Cutch,	... "	28 "
Kurrachee,	... "	35 "
Goa, &c.,	53 "	... "
Concan,	1,062 "	... "
Guzerat,	3,460 "	2,000 "
	93,478	88,849

The chief articles into which they are wrought are paper-weights, knife-handles, miniature-sized cups and saucers, tablets for snuff-boxes, sets of brooches, necklaces, and bracelets, pins, buttons, and studs. A field gun, with all its appointments, is one of the finest ornamental pieces of Cambay stone-work; they sell from 40 to 50 rupees.

Prices of articles of Cornelian in the Bazaar :—

Necklaces, black and green, from	7 to 9	rupees each.
Do. red,	2 to 9	"
Paper-cutters,	2 to 5	"
Knife-handles,	10 to 15	rupees per dozen.
Stones for brooches, from	1 to 2	rupees each.
Snuff-boxes,	4 to 15	"
Cups and saucers,	12 to 15	"
Pen-handles,	1 to 2	"
Studs of all sorts,	1 to 2	rupees per dozen.
Trouser buttons,	1 to 2	rupees per pair.
Coat do.,	12 as. to 1	" "
Bracelet-beads, of all sorts,	12 as. to 1	rupees each.
Paper-weights,	½ to 5	"
Tables, of sizes,	15 to 50	"
Guns, do.,	35 to 85	"
Ear-rings,	1 to 5	rupees per pair.
Finger-rings,	8 as. to 1½	rupees each.

The English reader will be pleased to remember that one rupee is equal to 2s., and that there are 16 annas in a rupee.

On the Composition and Properties of Coal, and the Products of its Distillation. Is Torbane Mineral a Coal? By ANDREW FYFE, M.D., F.R.S.E., Professor of Chemistry, University and King's College, Aberdeen.*

The object I have in view in the following observations is to point out, first, the composition and properties of coal, and of the products of its distillation; and, secondly, from the information thus derived, to endeavour to ascertain whether the Torbane mineral is a coal.

In these remarks I shall confine myself almost entirely to the chemical properties.

The class of BITUMENS has been divided into two kinds—fluid and solid; the former consisting of petroleum, naphtha, and mineral tar,—the latter of asphalt and coal. By far the most important of these is coal, of which there are different kinds, as brown coal, glance coal, and black coal. It is to the last of these that I am now to advert. Black coal has been divided into four classes—caking, cherry, splint, and cannel coal. These vary in appearance, but in their general properties they are very much the same. They all burn with more or less flame, and yield by their combustion carbonic acid and water. The first, owing to the quantity of fatty matter which it either contains or affords by its combustion, is agglutinated, and forms a cake on the surface, and hence its name; the latter burns with a bright flame and with a crackling noise, from which it is called parrot and cannel (candle) coal.

All of these coals, when subjected to heat, excluded from air, yield a large quantity of inflammable gas, tar, and ammoniacle liquor, besides a variety of other products to be afterwards mentioned. The residue in the vessel is coke, which consists of carbon and earthy matter; the former called the fixed carbon, because it is not volatilized by the heat, the latter well known as the ash.

* Read at the Meeting of the Royal Scottish Society of Arts, 24th April 1854.

The specific gravity of coal varies from about 1180 to about 1330, water being 1000.

Analysis of Coal.—Two methods are practised in analysing coal :—1*st*, By application of heat to it contained in closed vessels ; that is, heating it excluded from atmospheric air ; by this means it is resolved into its fixed and volatile ingredients, or rather volatile products : 2*d*, By subjecting it to heat in closed vessels along with substances that yield oxygen, such as oxide of copper or chromate of lead, which is by far the best. The first of these modes, in a commercial point of view, is the most important, because by means of it the proportion of gas that a coal will afford is ascertained, while at the same time we have an indication of the evaporative power, this being in general in proportion to the quantity of fixed carbon in the coke ; hence, after heating the coal in closed vessels till it ceases to yield gaseous matter, the coke left is then burned in air to ascertain the amount of ash, the loss being that of carbon. The second mode of analysis, called the ultimate analysis, gives the proportion of the different ingredients. This is important, not so much in a commercial as in a scientific point of view ; yet commercially it is also of importance, because from the ascertained proportions of the component parts we can to a certain extent determine the commercial value—such as its power of evolving heat by its combustion, and of affording gas by its carbonization. Both taken together indicate the value of a coal ; at the same time, the indications thus given require to be tested by direct trial of the evaporative power of the coal and of its coke, and of the quantity and quality of the gas afforded.

I have made numerous trials by the first kind of analysis. The method followed was to place—say 100 grains from a variety of pieces of the coal—into a covered platinum crucible, and expose it to the heat of a gas furnace till it ceased to emit vapour or flame ; the residue was then weighed, and reduced to powder while warm. One-tenth of the powder was then exposed on a platinum foil to heat and air till the whole of the carbon was burned off, after which the residue was weighed. Thus, if 100 grains heated in the crucible left 54 grains, loss = 46, and 5·4 of the coke burned left 1·1, loss = 4·3, then the composition is—

Volatile matter,	46		Fixed carbon,	43	79·6
Coke, . .	54	=	Ash, .	11	20·4
	100			54	100

Repeating the analysis in this way on different pieces, the average composition of the coal is ascertained. In conducting the analysis due attention must be paid to the mode of applying the heat, and to the facility with which the gaseous products are allowed to escape; for it is well known that according as the temperature is very high or comparatively low, the quantity and quality of the volatile and gaseous matter vary. The results also depend much on the quick or gradual raising of the temperature, as will be afterwards shown.

In the following trials the temperature was always quickly brought up to the full extent, and the volatile matter was allowed to escape rapidly. For the sake of brevity, I give the results in a tabular form:—

Table of the proportions of volatile matter, of coke, of fixed carbon, and of ash, in 100 parts of different coals, and in the Torbane mineral.

COALS. *c*, cannel. *h*, household.	Specific Gravity.	In 100 parts of Coal.		Coke.		In 100 parts of Coke.	
		Vol. mr.	Coke.	Carbon.	Ash.	Carbon.	Ash.
Wigan Ince Hall, *c.*	1255	37·6	62·4	5·6	6·4	89·7	10·3
Do. do., *c.*		37·7	62·3	50·5	11·8	81·	19·
Torbane, household,		38·3	61·7	52·5	9·2	85·	15·
Kinneil, . *c.*		44·4	55·6	44·4	11·2	80·	20·
Donibristle, *c.*	1237	46·5	53·5	49·2	4·3	92·	8·
Capeldrae (2d), *c.*	1310	47·2	52·8	24·3	28·5	46·	54·
Knightswood, *c.*		47·5	52·5	48·5	4·	92·4	7·6
Balbardie, *h.*		43·6	56·4	29·8	26·6	52·8	47·2
Lochgellie, *c.*		50·4	49·6	36·2	13·4	73·	27·
Disco Island, *h.*	1384	50·6	49·4	39·6	9·8	80·	20·
Monkland, *c.*		54·2	45·8	39·5	6.3	86·2	13·8
Lesmahago, *c.*		57·4	42·6	39·	3·6	91·5	8·5
Do., *c.*		58·3	41·7	35·3	6·4	84·6	15·4
Methill, *c.*		59·	41·	18·5	22·5	45·	55·
Capeldrae (1st), *c.*	1238	59·1	40·9	33·2	7·7	18·8	81·2
Wemyss, *c.*		66·6	33·4	21·9	11·5	65·5	34·5
Torbane, *c.*		66·9	33·1	15·6	17·5	47·1	52·9
Do., *c.*		68·1	31·9	14·5	17·4	45·4	54·6
Do., *c.*		68·4	31·6	8·6	23·	27·2	72·8
Do., *c.*		69·	31·	9·3	21·7	30·	70·
Do., *c.*		69·8	30·2	13·1	17·1	43·3	56·7
Do., *c.*		69·8	30·2	6·6	23·2	29·8	70·2
Do., *c.*		70·1	29·1	16·3	12·8	56·	44·
Do., average,	1199	68·8	31·2	11·9	18·3	38·4	61·6
Tree in Torbane,		68·8	31·2	10·8	26·4	34·6	65·4

On inspecting this table, it will be seen that the proportion of volatile matter of the coals varies from about 37 to nearly 67 per cent.; of course the coke varies from about 33 to 63. The proportion of fixed carbon and of ash in the coke also varies, the former being from about 18 to 52—the ash from 3·6 to 28·5.

The average percentage of these ingredients in Torbane mineral is, 69 of volatile matter, 31 of coke, 12 of fixed carbon, and 18 of ash. It does not, therefore, differ from coals excepting in two particulars, viz., that it yields more gaseous products, and less fixed carbon; but even in these the difference is very trifling; being only about 2·4 per cent. more than that of the former from Wemyss' coal; and 8·5 less of the latter than from Methill coal—indeed some of the samples of Torbane contain only 2 per cent. less. The percentage of ash in some of the samples is less than in several of the coals, and the average quantity is not so great as that of Methill and Capeldrae.

I have already said that it is necessary to conduct this mode of analysis in the same way in all the trials, because the results vary according to the mode of heating and other circumstances. No doubt this will not affect the quantity of ash; but the quantity of coke, and, consequently, of fixed carbon, may be altered by the heat acting differently, and occasioning the gaseous elements to unite with varying proportions of carbon. Hence we find that the products of analysis may be made to vary according to the modes of applying heat.

The following table shows the results of my trials, in which the heat was differently applied to coals and to Torbane mineral:—

Coals.	Slowly heated.		Quickly heated.	
	Vol. mat.	Coke.	Vol. mat.	Coke.
Newcastle caking . . .	30·4	69·6	37·2	62·8
Buccleuch	50·5	49·5	55·0	45·0
Halbeith	46·0	54·0	49·0	51·0
Lesmahago	53·2	46·8	58·8	41·2
Capeldrae	38·4	61·6	49·2	50·8
Torbane	66·0	34·0	70·0	30·0

In all of the above the coke is greatest by the slow heating; in other words, as the quantity of ash is not affected, the fixed carbon is greatest. The same occurs with the Torbane mineral; accordingly, in this respect it resembles coal.

In connection with this part of the subject, I may state that it is a remarkable circumstance that in coals in which there is a difference in colour between the upper and under parts of the seam, there is a corresponding difference in the proportions of coke and volatile products. The part of the seam at the top always contains most volatile matter. Thus the following coals and Torbane mineral, heated exactly in the same way in all, yielded—

Coals.	Upper part.		Lower part.	
	Vol. mat.	Coke.	Vol. mat.	Coke.
Capeldrae	51·2	48·8	46·6	53·4
Bathvale	57·2	42·8	51·0	49·0
Methill	70·5	29·5	37·7	62·3
Torbane (1)	65·1	34·9	63·3	36·7
Torbane (2)	72·7	27·3	56·3	43·7

Thus in coals the upper part of the seam contains most of the volatile products. The same occurs in Torbane mineral.

Ultimate Analysis.

I have had few opportunities of conducting the ultimate analysis of coals. I have therefore recourse, on this part of the subject, to the reports given in to the Lords Commissioners of the Admiralty; to which I shall add that of Capeldrae, and also that of the Torbane mineral conducted by myself.

These analyses were conducted in the usual way by heating the coals with the substance yielding oxygen, and ascertaining the quantity of carbon, oxygen, and hydrogen, by finding the weight of the carbonic acid and water produced. The nitrogen and sulphur were also determined by the usual processes of heating the coal with a mixture of potass and lime; and of acidifying the sulphur by means of nitric acid.

Table showing the average proportion of the different ingredients of coal and of Torbane mineral:—

Coals.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Sulphur.	Ash.
Scotch .	80·72	6·1	8·45	1·32	1·25	2·16
Welsh .	81·44	5·01	7·36	0·83	1·66	3·8
Newcastle .	84·3	5·86	6·37	1·28	0·68	1·51
Derbyshire	79·65	4·96	10·17	1·48	1·07	2·69
Lancashire	76·53	4·95	11·52	1·22	1·21	4·51
Foreign .	65·82	3·56	7·17	1·3	1·05	21·1
Capeldrae .	56·77	6·79	8·79	1·9	0·35	25·4
Torbane .	60·25	8·86	3·62	1·53	0·13	25·6

The above table shows that the quantity of all the ingredients varies considerably. That of the carbon is from about 56 to 84; of the hydrogen from 3·5 to 6·79; of the oxygen from 6·3 to 11·5; of the nitrogen from 0·8 to 1·9: the sulphur does not vary so much; the minimum being 0·35—the maximum nearly 2 per cent.

In the Torbane mineral the percentage of carbon is 60, which is above that in Capeldrae coal, and considerably below that in others. The hydrogen is beyond that of the coals. In them the highest quantity is nearly 6·8 per cent.; in Torbane it is 8·7,—making a difference of only about 2 per cent. The oxygen in the different coals varies considerably. In some of the Welsh it has been found as high as 17, and as low as 1 per cent. In coals from other counties it also varies;—ranging from 18 down to 1 per cent. Taking the average of all the results, as given above, it is about 9.

The oxygen in the Torbane mineral is 3·6; which is below that generally found in coals.

The proportion of sulphur in the coals analysed does not vary much. Some have really very little; it seldom amounts to 2 per cent. In the Torbane its very small—indeed, with the exception of the Haswell Newcastle, it is less than in any of the coals.

With regard to the ashes of coal, they vary not only in quantity, but likewise in quality; they are not in greater quantity in Torbane mineral than in some of the coals. Sometimes the ashes are nearly colourless, at other times brownish, owing to the presence of oxide of iron. The ingredients are soluble alkaline and earthy sulphates and muriates; lime in small quantity; oxide of iron, alumina, and silica.

Water boiled on the ash obtained from coal, in general, I have found to be alkaline. The ash, after being washed with boiling water, and then treated with muriatic acid at a natural temperature, gave a solution, which contained alumina. The residue washed and boiled in muriatic acid yielded alumina in solution. The residue fused with potassa and then boiled in water also afforded alumina, from which I infer that the silica and alumina are partly uncombined, partly as silicates.

When the powder of Methill coal is boiled in oil of vitriol diluted, the solution contains alumina; the residue, by being boiled in aqueous solution of potassa, also affords alumina.

With regard to the ash of Torbane mineral, it is in general nearly colourless, but not more so than that of Methill, Capeldrae, and Lochgelly. When treated with water, acids, and potassa, it acts exactly in the same way, and yields the same products that the ash of coal does. The entire coal also by these reagents is acted on, in every respect, in a similar way.

I have found the ash of the Torbane mineral to consist of—

Salts soluble in water,	7
Oxide of Iron,	1
Alumina,	41
Silica with a trace of lime,	51
	100

which is nearly the same as those found by others.

Products of the Distillation of Coal.

I have already alluded to the analysis of coal by which the percentage of coke and of volatile matter is ascertained. With regard to the latter, the products vary very much, not only in quantity but likewise in quality, according to the mode of applying the heat. When coal is quickly heated by being thrown into a retort previously brought to a full red heat, the products are gas, used for the purpose of illumination, tar, and ammoniacal liquor, varying in quantity according to the kind of coal employed. The ammoniacal liquor contains ammonia formed by the union of hydrogen with the nitrogen, and is in combination chiefly with sulphuretted hydrogen, derived also by the union of the sulphur and hydrogen of the coal. It is from it that almost all the ammoniacal salts now used in commerce are obtained. Thus, by the addition of muriatic acid, sulphuretted hydrogen is expelled, and muriate of ammonia is formed, which, by evaporation of the water and subsequent continuance of the heat, is sublimed and is thus freed from impurities; or, by the addition of oil of vitriol, sulphate of ammonia is produced, which, after evaporation, is mixed with muriate of soda and sublimed, by which sulphate of soda and muriate of ammonia are obtained,—the latter being sublimed, the former remaining in the vessel in which the sublimation is conducted. By this last process the previous preparation of muriatic acid from sea salt by means of oil of vitriol is avoided. The tar, after being freed from the ammoniacal liquor, when subjected to distillation, yields naphtha, at first impure and of high specific gravity; but by redistillation becoming colourless and of the specific gravity of common naphtha, or benzole naphtha, as it is frequently called.

During the distillation of the tar, a considerable quantity of naphthaline is also volatilised and condensed in its solid form on the cool part of the apparatus. When the distillation of the tar is carried to a considerable extent, a quantity of an offensive smelling fluid is also brought off and condensed. This is called pitch oil or grease oil. Other substances are obtained from the products of the first distillation of coal, but these are of less importance than the others. Pitch is left as the residue of the distillation.

Naphtha, obtained by the process described, is of specific gravity, about 776. It consists of $C_6\ H_5$. It must not be considered as an ingredient of coal, but as a product of decomposition, formed by the union of the carbon and hydrogen existing in it. The same is the case with naphthaline. Its composition is C_{10} H_4, or a multiple of these proportions. Its specific gravity is about 870.

I have obtained all of these products by the carbonisation of the Torbane mineral in the common process of manufacturing gas from it, for which purpose it is now extensively used along with common gas-coals. Of course, as the proportion of nitrogen in the Torbane is small, the quantity of ammonia which it affords is also small, and is separated from the tar with considerable difficulty, unless water is added, by which the separation is easily effected. Removing the ammonia and subjecting the tar to distillation, I have procured naphtha of the usual specific gravity, and having all the properties of common naphtha; being acted on by reagents in the same way, and by the addition of nitrous acid yielding nitro-benzole, $C_{12} H_8 O + NO_4$. When farther distilled it also afforded naphthaline and pitch oil,—leaving pitch in the vessel; so that, in every respect, the fluid and solid products of distillation of Torbane mineral are the same as those from coal by the same process of decomposition.

With regard to the gaseous products, I have said that these vary in quantity and quality when obtained from different coals. Common household coal yields a gas of low illuminating power; cannel or parrot coals afford, in general, a larger quantity, while the gas is of superior illuminating power; hence their name of gas-coals.

After the gaseous products have been thoroughly purified by passing them through water, lime, and other substances, the gas then consists of hydrogen, carbonic oxide, light hydro-carbon, and olefiant gas; or of a gas having the same relative proportions of carbon and hydrogen, and which is admitted to be the source of light when it is burned in contact with air.

Though I have, on former occasions, given to the Society the results of my trials on the quantity and quality of gas from different coals; yet, as these trials have of late years been greatly extended, and as many of them have been conducted in a different way from those formerly practised, I will now state my results in a tabular form—dividing the table into two parts ;—the first showing the illuminating power by the Bunsen Photometer, which was used in all the trials; the second showing the same as indicated by the amount of condensation by chlorine :—

Table of the quantity of Coke, and of the quantity and quality of Gas from a Ton of different Coals, and from the Torbane Mineral, and of their value in lbs. of Spermaceti, for yielding Light by the combustion of their Gas, as proved by the Photometer.

Coals.	Lbs. of Coke.	Cub. Ft. of Gas.	Sp. Gr. of Gas.	Durab. in Mins. & Secs.	Illumg. power 1 Foot = Candles	1 Foot = Grs of Sperm.	Comp. val. of 1 Foot of Gas.	Value of Coal in lbs. of Sperm.	Comp. val. of Coals.
English caking .	1680	9,746	555	50′ 40″	3·1	372	1·03	531	1·0
Do. Cannel (2) .	1397	12,010	574	48 55	3·0	360	1·0	617	1·36
Ramsay Cannel .	1512	9,746	631	60 40	3·3	396	1·1	555	1·47
Donibristle . .	1220	9,923	593	51 0	7·5	900	2·5	1277	2·22
Lesmahago . .	952	10,176	652	70 0	8·7	1052	2·9	1530	2·86
Capeldrae (1) .	1000	11,500	644	65 25	8·31	997	2·77	1638	3·08
Capeldrae (2) .	1256	9,670	650	73 37	10·0	1200	3·33	1670	3·14
Torbane . . .	760	15,486	726	84 44	10·3	1245	3·45	2755	5·18

In the construction of this table the durability was ascertained by finding the time required to burn a foot of gas, by using a jet with an aperture of $\frac{1}{33}$ of an inch, and a flame of 5 inches in length. The durability is, therefore, given in minutes and seconds. The candle referred to is a spermaceti, burning 120 grains per hour. In the last column the number of grains of sperm per foot, multiplied by the number of feet of gas per ton, gives the pounds of sperm; in other words, gives the value of the coal, taking quantity and quality of its gas into account.

In trying the illuminating power, the gas was consumed by an argand burner.

Table of the quantity of Coke, and quantity and quality of Gas from a Ton of Coals, and from the Torbane Mineral, as shown by the Chlorine process.

Coals.	Coke.	Cubic feet of Gas.	Specific Gravity of Gas.	Duraby. 1 Foot = Minutes & Secs.	Condensation by Chlorine.	Comp. value of 1 Foot of Gas.	Comp. value of Coals.
Bemish caking .	1600	8,545	485	43′ 0″	5·0	1.0	1·0
Leven Splint . .	1120	8,060	492	43 0	5·3	1·06	1·01
Do. caking . .	1600	10,560	550	38 0	6·0	1·2	1·4
Adamson's do. .	1620	12,456	646	38 0	6·3	1·2	1·75
North Lithins .	1280	9,021	555	53 0	10·8	2·1	2·2
Knightswood . .	1164	9,184	557	48 0	9·0	1·8	2·3
Blackwook . .	1200	8,000	645	60 0	13·0	2·6	2·6
Kelvin-side . .	1150	9,007	640	65 0	14·0	2·8	2·9
Grange . . .	1280	9,160	618	67 0	14·0	2·8	3·0
Lumphinnin . .	1200	8,953	622	66 0	14·5	2·9	3·0
Lithin's Glen .	1280	9,500	646	68 0	15·0	3·0	3·2
Marquis Lothian	1074	10,080	590	60 0	13·0	2·6	3·2
Lithin's Hill . .	1200	9,100	690	72 0	16·0	3·2	3·4
Kilbirnie . . .	1200	10,290	624	67 0	15·0	3·0	3·6
Lochgelly . . .	1200	9,054	637	57 30	14·0	2·8	3·7
Capeldrae (2) . .	1256	9,670	650	73 37	17·8	3·56	4·02
Kinneil . . .	1292	9,803	739	75 0	17·5	3·5	4·1
Lesmahago . .	1120	10,176	652	70 0	17·5	3·5	4·1
Monkland . .	1142	10,192	667	67 0	16·0	3·2	4·2
Methill . . .	1198	7,706	683	66 0	15·5	3·1	4·3
Kirkness . . .	1380	9,038	711	78 0	22·0	4·4	4·6
Capeldrae (1) .	999·9	11,500	644	65 25	18·0	3·6	4·8
Torbane . . .	760	15,480	726	84 44	25·0	5·0	9·0

Of the above coals, all are cannels with the exception of the first four.

It will be observed that the comparative indications of the value of gases, when the condensation by chlorine is great, does not correspond with the value indicated by the photometer in the preceding table. This, in my opinion, is owing to our not having the means of burning gas so as to get the full amount of light from it.

Other Products of Distillation.

Another remarkable substance got from coal by distillation is paraffine and paraffine oil. Paraffine has been known for several years as a product of the distillation of wood; but it is only lately that it has been got from coal; and it is now manufactured on a large scale from it, and become an article of commercial importance. The process by which it and paraffine oil are procured, is patented by Mr Young of Bathgate.

In this process, the coal, broken into small pieces, is subjected in iron retorts to a low red heat; by which an inflammable gas (in fact coal gas) is evolved, along with a vapour which condenses in the form of a dark-coloured fluid, having a very offensive odour. This is a mixture of ammoniacal liquor, paraffine oil, paraffine, and naphtha. The fluid thus collected is heated for some hours to a temperature of about 150°, by which the impurities fall to the bottom. The oil is then drawn off and distilled. The distilled product is next mixed with oil of vitriol, and well stirred; and, after remaining at rest for some hours, by which the vitriol and impurities subside, the upper part is drawn off, and mixed with a solution of carbonate of soda, or of caustic soda. The impurities, along with soda and any oil of vitriol which may be present, are then allowed to fall, and the supernatant fluid, by distillation, yields paraffine oil.

From the fluid thus procured, naphtha is obtained by distilling it along with steam passed into the boiler, by which the steam and naphtha come off; and, as they do not unite, they are easily separated by subsidence.

To obtain pure paraffine from the oil, it is cooled to about 30° or 40°, thrown on a filter, and allowed to drip till the fluid ceases to pass through. The residue on the filter is then mixed with a solution of carbonate of soda, stirred and heated to about 140°. It is then allowed to remain at rest, by which the paraffine gradually collects on the surface. It is then to be removed, and the dark part on the lower side of the cake scraped off; after which the process is repeated, and the paraffine is in this way got nearly pure.

By squeezing it in a press, it may be freed entirely from colouring matter.

I have obtained this substance on a large scale from Lesmahago coal, and from the common Household coal in the neighbourhood of Torbane,—what is called Household Boghead coal.

The paraffine from these along with the naphtha is the same in all—the latter yielding nitro-benzole on the addition of nitrous acid. I have obtained also the same products from the Torbane mineral, by conducting the process in the same way. Though it has been said that the naphtha from Torbane does not yield nitro-benzole, I never had any difficulty in obtaining it from it; indeed, it is more easily got from Torbane naphtha, than from the naphtha of any coal I have tried. The naphtha got in this process, like that from coal in the manufacture of gas, also varies very much in specific gravity, according to its distillation. I have found it to be from 870° to 776°.

I have now to allude to other substances to which the Torbane mineral has been assimilated. The first of these is asphaltum; but from this it is easily distinguished.

Different kinds of coal are acted on differently by naphtha; the quantity of soluble matter in all of them being very small.

The following are the results of my trials:—

Coals.	Per cent. of Matter Soluble in Naphtha.
Newcastle Caking,	4·2 5·8 9·8
A Cannel Coal (1),	2·
Do. (2),	3·
Do. (3),	4·
Halbeith do.,	1·5
Capeldrae do.,	0·
Torbane (*Black*),	1·2
Do. (*Brown*),	1·4

From the above it is evident, not only that Torbane is not an asphalt, but that it resembles common coals in its action with naphtha.

Again, it differs from asphalt in its action with heat.

The following are the results of my trials:—

	Asphalt.	Torbane.
By the heat of Tin just melted.	Melted, not Inflamed.	Not affected.
Do. Lead do.	Do. do.	do.
Do. Iron red hot	Do. do.	do.
Do. do. at full red heat.	Do. and inflamed.	inflamed and melted.

Again, the specific gravity of Torbane is about 1180;—that of asphalt is about 1090.

Another remarkable difference between Torbane and asphalt is the electric condition. Asphalt is an electric. Torbane is decidedly non-electric;—in this respect differing from asphalt, and resembling coal, which is non-electric.

I may here remark, that the term bituminous, as applied to coal, is improperly used. We speak of highly-bituminous coals,—by which is meant those that burn with a great deal of flame, and yield a large quantity of smoke. Now, those that do so are the *least* bituminous. The above table shows that the English caking coal, which is a bad gas coal, is more bituminous than others; and so far is Torbane mineral from being bituminous, that it does not yield more than about 1½ per cent. of bitumen to naphtha.

In the experiments above referred to, the coals and the Torbane mineral were boiled for 24 hours in naphtha, under the usual pressure; recourse having been had to means for preventing the evaporation and loss of naphtha.

Another class of substances to which the Torbane mineral has been supposed to belong is shales, especially those belonging to the coal formation.

From the large percentage of earthy matter in Torbane, it has by some been considered to be a kind of shale,—a bituminous shale, or *bitumenite;* but we shall find that it is easily distinguished from them. I have analysed a great many shales, and now give the results of the analyses, taking the extremes along with several of those intermediate in their composition:—

Table of the Composition of Shales.

Shales.	Volatile Matter.	Non-Vol. Matter.	Non-Vol. Matter.	
			Fixed Carbon.	Ash.
Above Dysart Iron Stone, .	19·	81·	7·	74·
Under Craig Coal, ...	7·8	92·2	6·	86·2
Roof of Do.	7·7	92·3	0·	92·3
Do. of Wood Coal, . . .	7·	93·	8·	85·
West Wemyss, ...	13·5	86·5	2·5	84·
Lancashire (1), ...	15·9	84·1	7·7	76·4
Do. (2), ...	13·14	86·86	7·9	78·96
Do. (3), ...	7·7	92·3	8·8	83·5
Average, ...	11·46	88·53	5·98	82·54
Torbane, ...	69·	31·	12·	19·

It will be seen, on inspection of the above table, that there is a great difference between shales and Torbane mineral. With two exceptions, I have never found a shale to have more than 20 per cent. of inflammable matter. In the first of those in the above table the whole inflammable matter, after deducting the moisture in the volatile products, amounted to 20·56. In the Lancashire shales, Nos. 1 and 2, the moisture carried off with the volatile products amounted in the former to 2·1, and in the latter to 2·4; and deducting these, there are of inflammable ingredients 21·4 in the former, and 18·6 in the latter. Thus, taking the extreme as about 20 per cent. of inflammables, leaves 80 of ash. We here observe a wide distinction between the Torbane mineral and shales, the latter having, on an average, about 17 or 18 of inflammable matter, and from 82 to 83 of earthy matter, while the former has the proportions reversed.

These remarks apply solely to shales of the coal formation, such as occur in the stratified beds. Shales of this kind do not yield bitumen to naptha; in this respect they resemble coal; in fact they contain little, if any, bitumen. There are, however, other shales, such as those that contain bitumen, and yield it to naptha, strictly speaking bituminous shales. From these the Torbane mineral differs, in giving very little bitumen to naptha, the quantity not exceeding 1·5 per cent.

It has been said that Torbane mineral, when breathed on, emits an earthy or *clayey* odour, and that, therefore, it in this respect resembles a shale. This, however, is not peculiar to Torbane mineral. I have in my possession pieces of Capeldrae and Methill coal, which emit a similar odour.

There is still another substance to which I have to advert, and to which the Torbane is closely allied; I mean what is called coal rhombs, in other words, an impure coal not worth working.

The composition of two of these I found to be—

	Volatile Matter.	Coke.	Coke.	
			Carbon.	Ash.
Wemyss, ...	33·3	66·7	23·	43.7
Methill, ...	37·4	62·6	30·	32·6

In these the earthy matter predominates, the quantity of volatile products being small. It is remarkable also that though rhombs occur at the upper part of the seam of coal, yet they differ in composition from coal itself, in containing a large quantity of earthy matter. I have already said that in coals, varying in colour in different parts of the same seam, the upper part has always the greatest amount of volatile matter, thus also pointing out a remarkable difference between rhombs and the Torbane mineral.

I have thus shown that the Torbane mineral, in a chemical point of view, resembles coal. It has in it all the component parts of coal, and in nearly the same proportions as in some of them. It does not contain anything that is not found in coals. It yields the same products by distillation, at different temperatures, such as gas for illumination, tar, and ammonial liquor, benzole naphtha, naphthaline, pitch oil, paraffine oil, and paraffine. I have shown also that it differs materially from asphalt, and from shales, and bituminous shales, in containing almost no bitumen. I feel, therefore, warranted in maintaining the opinion I have all along held, and in still continuing to consider it what, in 1850, I reported it to be, when I first subjected it to trial—that *it is a coal*, and *one of a very superior quality, for the manufacture of coal-gas.*

Professor KELLAND'S *Address as President at opening Session* 1853–54.

GENTLEMEN,—In occupying this chair for the last time, it is my first duty to thank you sincerely for the honour you have done me in placing me here, and for the forbearance with which my imperfect presidence over the Society has been tolerated. I assure you I am truly sensible of the kindness which suggested me for the position, and which has retained me in it. The next duty which devolves on me is to pay a tribute to those of our members who have been removed from us by death since our last anniversary. We have lost Mr L'Amy, sheriff of Forfarshire, who thrice filled the President's chair, at a time when it was usually assigned to noblemen, and when the office was merely honorary. Under our new system Mr L'Amy discharged the duties both of President and of Vice-President with great acceptance to the Society. He took an active part, along with the Secretary, in obtaining for the Society the capital sum of £400 which forms the foundation of the Keith Prize. His loss is deeply to be regretted. William Murray, Esq., of Henderland, became a Fellow in the year 1834, and, with his learned and warm-hearted brother, Lord Murray, always took a lively interest in the Society's proceedings. Not in this room only, but throughout the city, will the death of this excellent man be sorely felt. Mr Kemp, a young chemist, who gave promise of advancing the science to which he was attached by his great ability, has been removed from us at an early age. Besides these the Society has lost several who were contributors to the business of its meetings,—such as Mr Robertson, mining-engineer, who gave us valuable papers on Railway Signals and on Persian Tools; and Mr Wightman, contractor, who made an excellent communication on his Derrick Crane.

I turn now to the more pleasing duty of congratulating the Society on the results of its labours during the past session. The communications we have received have been both numerous and valuable, and have been listened to by goodly assemblages of men capable of judging of their merits. Not to mention papers on such exciting subjects as the Torbanehill mineral, so ably discussed by Dr Fyfe, or Investigations on the Phenomena of Abnormal Vision, so clearly and beautifully worked out by Dr George Wilson,—not to refer to inventions so highly important as those which are destined to secure us from the dangers of railway and steamboat accidents, I will, without disparagement of the merits of other papers, take the liberty of particularizing four of those which were read to you, simply because they serve to illustrate a position which I am anxious to insist on, viz., that the twofold office of a society like the Royal Scottish Society of Arts is to hold up excellence as a model and incitement on the one hand, and, by rewards and encouragements, to foster and educe the faintest appearances of rising genius on the other. It has been the Society's good fortune strikingly to exhibit the performance of both these functions during the past session; the one in regard to the papers of Messrs Stevenson and Thomson, the other in regard to those of Messrs Elliott and Scott. To the papers communicated by Messrs Stevenson and Thomson I am not going to refer. The position occupied by these gentlemen,—the one the son, the brother, the co-labourer with the builders of the Bell Rock and Skerryvore Lighthouses, a part and parcel of their firm, no mean branch of the family whose names are destined to descend to posterity along with that of Smeaton,—the other the man chosen by Government to occupy a similar position in the distant straits which form one of the outlets of our Indian possessions—the constructor of the Sincapore Lighthouse,—I say the position occupied by these gentlemen renders praise or blame, of any communication with which they may favour us, equally uncalled for, I had almost said impertinent, on my part. We receive their suggestions as the fruits of practical experience; if we criticise them, it is done modestly and with much diffidence; if we praise them, we do so not to encourage, not to stimulate, but to manifest our interest in their pursuits. If we deal with such papers according to the ordinary rules, it is that we may prove to their authors and to the world that we do not receive the speculations of even the most experienced and the most practical men without exercising the right of examining and judging of them for ourselves. Did we act otherwise, praise would be worthless. To these gentlemen, and to others in similar positions, who have from time to time contributed to the interest of our meetings, I gladly reiterate the thanks of the Society. They come forward, as they are bound to do, to form our centres of support, our points of reference. And in doing so, they are but fulfilling a necessary obligation to society. The position of a scientific man, like that of a parent or a householder, has its duties and its responsibilities, which extend beyond the profession of the one or the family of the other. And if self rules the majority, we rejoice to find that there are some in every relation, social and scientific, who are willing to make a small sacrifice for the benefit of the rising generation.

There are other two papers to which I shall briefly allude as illustrative of the second great object of this Society, in truth its special object, that of offering encouragement, publicity, and reward. The papers to which I refer are those of Mr Elliott and Mr Scott. These contributions have issued from the quiet of a study. Their authors are not practical men, at least not so professionally. They are, in fact, the class of men who are especially in need of such a Society as this to aid them in bringing forward their inventions. Their opportunities for submitting them to the judgment of a higher tribunal, the intellect and capital of the country, are too limited, and but for our aid, they might perhaps hardly excite attention beyond the sphere of their authors' more immediate friends. Of these papers, one had for its object the explanation of the phenomena of precession, nutation, the perturbation of the moon's or a planet's motion, and the stability of Saturn's ring, all of which were beautifully exemplified by models of the simplest construction. The exemplification was, indeed, so happy and so much to the purpose, that it could not fail, when taken in conjunction with its accompanying remarks, to place in a clear light the physical cause of the phenomena, and thus to be ranked amongst the contributions to theoretical knowledge. The other paper had a more immediately practical object. Taking advantage of the fact, that a lighter fluid will find its way to the surface of a heavier, the author exhibited a novel kind of screw-pump, whereby water was raised through mercury, and air through water, thus furnishing a new exhausting air-pump, without piston or valves, or any machinery whatever, save a rotating twisted tube. Such inventions as these, I repeat, could hardly be brought fully before the public but for our Society. We combine and associate for mutual assistance, and it is then, pre-eminently, that such assistance is needed when a machine exhibits the application of some simple principle in a variety of ways, all beautiful, all, perhaps, practically valuable to the next generation, but not for the present likely to be converted into an instrument of economic application. In concluding my brief retrospect of the labours of the past session, I must again congratulate the Society on the value of the papers presented to them, on the attention which those papers have excited, and on the good feeling with which the discussions were carried on. May the prosperity of the Society and the interest of its meetings long continue.

Will you suffer me, before I sit down, to make a few remarks not connected with, or suggested by, what has preceded. I shall address myself to the objects and advantages of a Society like this; what it should strive to effect, what benefits it is calculated to confer; what should be the standard wherewith to judge of its efficiency. It must be evident at once that such a Society will not have the power of controlling outward circumstances: it must yield to them and improve on them. To judge of this Society by comparing it with the Institute of France or the Royal Society of London, would be as preposterous as to compare the latter Society as it is with what it was at its foundation. Perhaps I may be excused if I recal to your recollection the way in which that Society commenced its labours. Hard upon the publication of Lord Bacon's writings—whether consequent on them or not I do not determine—men's minds experienced a shaking in reference to old established notions, and a readiness to seize on new forms of truth. Perhaps the equatorial breezes of the coming spring had even then been wafted in advance to burst some of those buds, which, in after days, bore such a glorious display of fruit. Men were just commencing to make inquiries of nature. Even the axioms of knowledge had to be sought out. The founders of the Royal Society appear to have had a presentiment that they belonged to a transition era; they seemed to have felt that the old foundations of natural knowledge were sliding away; and the consciousness of individual helplessness appears to have driven them to form a combination for mutual assistance, and to throw their intellects into a mass. It may serve as a sample of the style of their proceedings, if I read a few extracts from the minutes of their early meetings. We find the following in Birch's History.

" *March* 20, 1661.—The amanuensis was ordered to make the experiment of the calcination of antimony, whether it increaseth or not, and to weigh it before and after, in and out of the water." He was subsequently ordered to calcine antimony, according to the description of M. Le Febure's book.

" *March* 25.—Mr Boyle was requested to report the name of the place in Brazil, where that wood is which attracts fishes, and of the fish which turns to the wind, when suspended by a thread.

" *March* 27.—It was ordered to enquire whether the flakes of snow are bigger or less in Teneriffe than in England, &c.

" *April* 1.—It was ordered, amongst other things, 'that the amanuensis provide a crooked tube for trying the experiment of water piercing quicksilver, or repelling it by its weight.'

" *May* 8.—It was proposed that the Society write to Mr Wren (Sir Christopher,) and charge him, in the king's name, to make a globe of the moon; and, also to continue the description of several insects as he had begun.

" *July* 17.—It was ordered that the diving-engine be tried at Deptford.

" Mr Croone was desired to keep the slow worm, in order to see whether the young one would eat through its belly.

" *July* 24.—A report was made of the trial of the diving-engine at Deptford on Friday preceding, by the amanuensis, who staid in it twenty-eight minutes under water."

I may mention, by the way, that the poor amanuensis appears to have had a hard time of it. Perhaps, they considered his salary a little high, as it had been recently doubled, *i.e.*, raised from £2 to £4 per annum.

With one other of the experiments of this day, the 24th of July 1661, I shall conclude my extracts.

"A circle was made with powder of unicorn's horn, and a spider set in the middle of it, but it immediately ran out. The trial being repeated several times, the spider once made some stay on the powder."

Perhaps the extracts which I have read, may not appear to give a very lofty conception of the meetings or aims of this Society. But, we must remember that it is characteristic of a true philosopher to examine and try all things, except those which, from the very nature of the case, must be absurdities. This was the rule they acted on, and in the sequel experiments of the highest importance were proposed and made by that little band, headed by such men as Boyle and Hooke, Wren and Newton. The change of circumstances which two centuries have brought about, renders the Royal Society now very different from what it was then. And the same circumstances operate in the regulation of our own body. Individuals not societies, are now the investigators of truth. The duty of societies is to make known, and to encourage or to educe.

To make known.—Many a useful invention has been lost to its author, from his imperfect means of presenting it to the world. In some countries it forms a special exercise of the powers of government, to attend to the necessities of science. With us it is not so. Here each department takes care of itself. The characteristic of the British government is universality; so that the humblest bears his small share in the weight of the state. The people trust little to central supervision for the success of their commercial enterprises, or for that of the application of their capital to manufactures or machinery. Every member of the body politic is self-regulating, self-sustaining. It is this fact, probably, which gives so great a practical value to our scientific literature. Individuals cannot hope to issue their speculations to the world with profit, unless they issue them in a practical form. In a commercial point of view, I am afraid it would not answer to publish the papers of Messrs Stevenson, Thomson, Elliott, and Scott, to which I have alluded, however great may be the merits of those papers. A scientific periodical, termed "The

Enquirer," was started some years ago. Mr Marrat, the editor, states that they printed 750 copies, all of which were sold except thirty complete copies which remained when the work was given up. The publishers and the printers got all the money as the numbers were sold, and at the close of the business the editor was presented with a bill for £130. So he says, "we did all the work and lost £130 into the bargain." This is a natural, I had almost said, a necessary consequence of publishing original unpractical scientific researches. And hence the very great importance of combination, whereby, as in this Society, we constitute ourselves both the publishers and the public. Now it is a very different thing on the Continent. The deepest and most crabbed speculations are published in Germany, and find a sale. There has been issued at intervals for the last twenty years from the press of Berlin a journal called *Crelle's Journal*, very far from practical, very far from popular. When the illustrious astronomer Encke was in Edinburgh, I asked him this question, "How does Crelle maintain his journal?" "Maintain his journal!" was the reply; "maintain his journal! why, it maintains him." It was my turn to cry out now, and I did so, saying, "The thing was impossible." He soon made good his position by showing that what the people could not do for themselves the state did for them. All the colleges, all the scientific initiutions, all the libraries, must take in the journal. The State wills that you be scientific, and scientific you are. In this country matters are arranged very differently: there is neither a coaxing nor a coercive constraint; no constraint at all. And though the result may be, that the lighter bodies swim on the surface and catch the public eye, yet in the end the heavier bodies generally find their way down the stream too, and reach their landing place. Here it is that a Society like our own comes in with its invaluable assistance.

But I have mentioned another of its functions, that *of encouraging and educing.*

If you cast your eyes on the history of science or of literature, you will find that eminent names appear in clusters. This fact, no doubt wisely arranged, is to be traced, as the consequence of a secondary cause, to the awakening of an intellect, which, but for the shaking of the age, had slumbered on for ever. The well-known story of Achilles is applicable to the development or exhibition of mental, no less than of physical propensities. Achilles was disguised as a female, and instructed, for his safety, to act in accordance to his disguise. But the sage Ulysses penetrated to his heart and unmasked the man by presenting to his notice, along with the ornaments appropriate to his dress, the armour suited to his sex and to his taste. The ready kindling of the soul detected the warrior.—In the same way the discoveries of one man laid before the mind of another develop therein a hidden talent for that particular branch of inquiry. No one knows half the power that lies in him until some passing spark causes it to explode. Thus, though the torch of truth may be handed down from generation to generation, it usually serves to kindle the brightest flame in those who move immediately around it. Corneille, Racine, Molière, the three greatest ornaments of the French stage, flourished together. May we not say that Corneille, the eldest, produced the other two? Hooke and Huyghens, and Newton and Wren, and the Bernouillis, were cotemporaries. When a great man appears, there soon cluster round him a swarm of other men, not contemptible, each contributing to the object which he has set agoing. Who would have thought that the phenomena of light and vision, which for centuries had attracted the attention of the greatest minds, could have afforded materials enough to stamp, I may say, for immortality, the names of Malus, Biôt, Brewster, Arago, Fresnel, Young, Cauchy, Fraunhofer, Airy, Herschel, Plateau, Wheatstone, Purkinje. Fifty years ago you would have been told that the science had been thoroughly sifted, that not a grain more could be shaken out. And yet it required but one or two happy experiments to turn men's minds back upon the old and well-trodden path, and see what a marvellous result! We say that intellects strike fire by their mutual frction. In this way it sometimes happens that posterity find it difficult to assign to each man his exact share in every branch of discovery. Hence arises the very great value of such societies as this which tend to circulate information, to let all know what each is working at, to bring minds to bear on each other, to indicate what has been effected, and what is still demanded in this or that direction. The silent influence of our Society is probably much more valuable than the manifested fruits of its labours. There exists in many minds a native inertness which can only be roused into action by the example of others. The quiet of the country, the absence of disturbing excitements, the freedom from cares which at first sight appears conducive to a life of study—these are not in practice found to be the concomitants of high eminence. Our literature and our science, for the most part, emanate from harassed and hard-worked brains, from men actively engaged in the struggle of life. Little, very little indeed, issues from the lone country retreat; and that little, like the poetry of Shenstone, breathes the lazy stillness of its origin. Your Watts and Arkwrights, and Jacquards and Stephensons, have been busy, bustling men, strongly biassed by men and things around them; vividly echoing in every fibre the sentiment that society expects every man shall do his duty. The poet hears the footsteps of beings who watch his progress from the tops of the wind-bent trees of the forest, but the dingy inhabitant of a crowded city, once devoted to study, hears sounds of deeper import and of nobler origin; sounds that emanate from the pulsations of hearts which beat like his own. And thus not solitude but society develops his individuality. These facts, if I have rightly represented them, at once indicate our duty, and demonstrate our importance as an Association for the encouragement of genius and reward of exertion. They place us in the proud position of men who are anxious to see our younger brethren raised up to and above our own level; of men who strive to do something towards fulfilling the injunction "to care for others," an injunction which may be well said to be the touchstone of our humanity. It is the boast of our country that it rests on the social principle as on a broad basis. That principle is commended to us in this Society, Let it be our earnest study, whilst we cherish its privileges to respond to its requirements.

With this wish, and the expression of my sincere thanks for your kindness, I shall conclude.

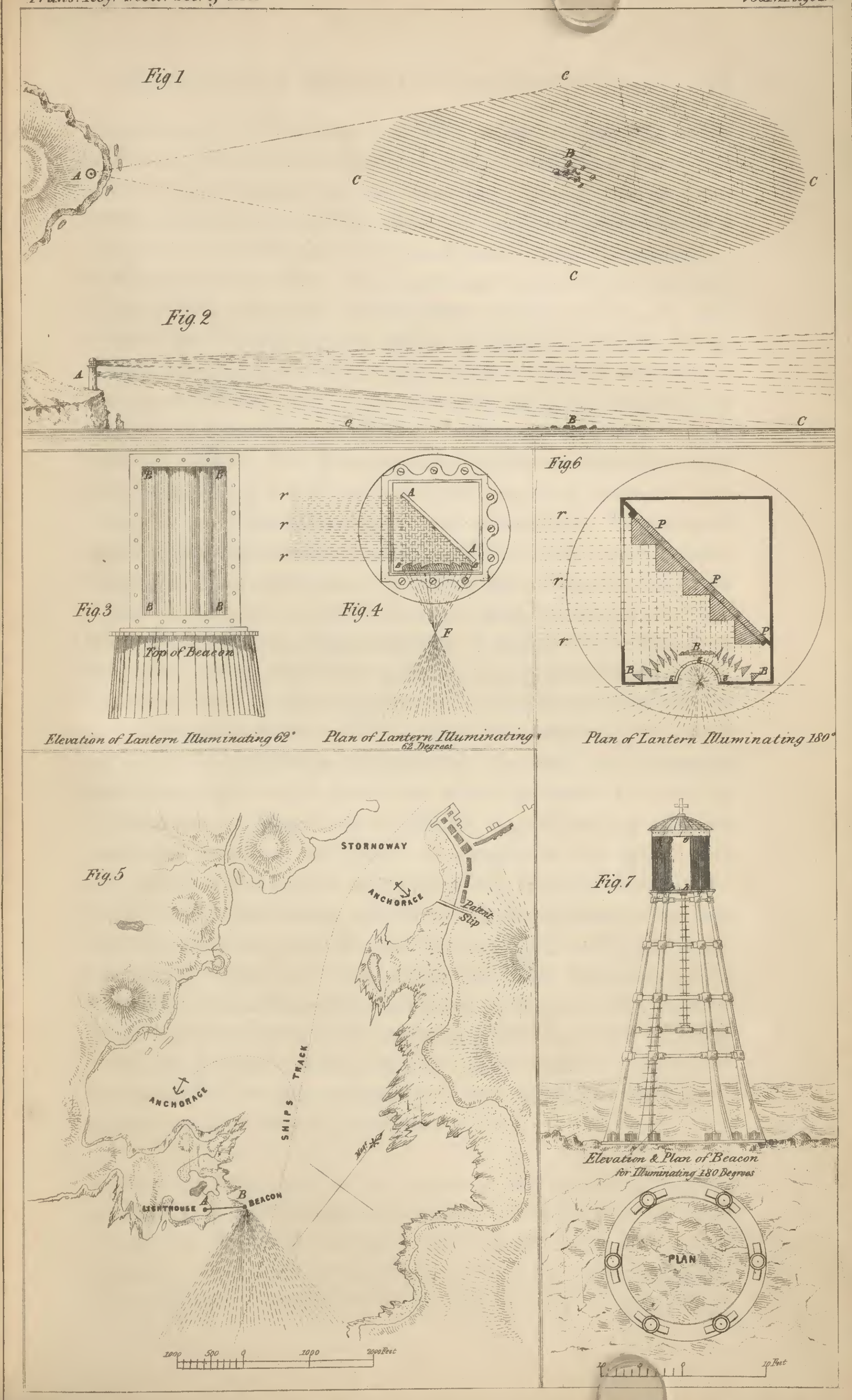
On Dipping and Apparent Lights or Sunk Reefs and Pier-heads of Harbours; with description of an Apparent Light, the illumination of which is derived from a distant lamp situated on the shore, erected in 1851 *by the Commissioners of the Northern Lighthouses, on a Sunk Rock in the Bay of Stornoway.* By THOMAS STEVENSON, F.R.S.E., and F.R.S.S.A., Civil Engineer. (With a Plate.)*

GOLD MEDAL, VALUE TEN SOVEREIGNS, AWARDED 1854.

There are few more decisive proofs of the growth of civilization in any country than an increase in the number of its lighthouses, and a progressive improvement in the apparatus employed for the distribution of the light. Such works and improvements are, however, from their very nature, gradual in their development. The Eddystone, Bell Rock, and similar structures, cannot be all at once undertaken, but must await the arrival of a period when the amount of shipping which would derive benefit from them has become sufficient to warrant not only a great expenditure for their construction, but also a constant heavy annual cost for their maintenance. Highly advanced as our country certainly is, there are nevertheless from this cause many sunken rocks and dangerous shoals, which are still the terror of seamen, having nothing to indicate their position either by day or night. The physical peculiarities of some rocks preclude, indeed, the possibility of erecting upon them towers suitable for containing lighthouse apparatus and the dwellings for the keepers. Such is the force of the waves, and so high does the spray rise, that, for stability and efficiency towers must be constructed of a considerable height, requiring a corresponding width at the base, and the area of many rocks is too small to afford the necessary space without extending the foundation below low water. Where the breadth of the rock is insufficient for a lighthouse tower, a simple beacon is substituted, and in some cases a floating buoy; and as an example of the difficulties which sometimes attend even such works as these, I may instance the Carr Rock Beacon, off Fifeness, at the north-east-

* Read before the Society 23d January 1854.

PLATE XXV



Elevation of Lantern Illuminating 62°

Plan of Lantern Illuminating 62 Degrees

Plan of Lantern Illuminating 180°

Elevation & Plan of Beacon for Illuminating 180 Degrees

ern extremity of the county of Fife, where, during the whole of the first year's operations (1813), there were only forty-one hours' work obtained at the rock, and in the second year (1814), there were only fifty-three. To erect a lighthouse on a rock of such small size would have been all but impossible.

When the erection of a lighthouse on a rock is either deemed too expensive or altogether impracticable, we are thus limited to the use of buoys or beacons, which, being invisible by night, are of no avail at the very time when they are most needed; and it is therefore of great importance that some means be devised of rendering such sea marks visible by night. For this purpose the use of phosphorescent oils for emitting a dull light at night has been proposed, but so far as I am aware has never been attempted. It occurred to me that in some cases gas pipes might be laid, or even submarine electric wires, so as to illuminate a lantern placed in a beacon or buoy. I at once, however, dismissed such schemes from my mind; for, independently of many other difficulties attending them, they are open to one ground of objection which, at least in the present state of our knowledge, seems to be insurmountable. This is based on what may be called an axiom in lighthouse engineering, viz., that it is better to exhibit no light at all than one which is liable to be often extinguished. There can hardly be a greater evil than to decoy the mariner into places of danger, in the belief that he is to have the benefit of a light when there is no real certainty of that light being exhibited. If a large fleet of vessels were to steer in a gale of wind for any light, and from some accident it happened to be extinguished, the mariners would at once conclude that they were out of their course, and in all probability before the morning dawned, many of them would have found a watery grave. Take away from the sailor his confidence in the constancy of our sea-lights, and navigation would in fact be all but at an end.

Dipping-Light.—It is my object in this paper to explain two methods which I have devised for the purpose of indicating the position of rocks and shoals by night. One method which, after considering various schemes, appeared under certain circumstances the best, is what I have called a *dipping-light*, than which nothing can be more simple, and it is to be hoped that experience may prove it to be equally efficacious. The application of this system of illumination, as well as of the Apparent light, has already been hinted at in some notes which were added to the description of the Holophotal system of lighthouse illumination while that paper was in the press; but as neither of them have ever been brought before the Society, I now embrace the opportunity of explaining the Dipping-light as being in a manner prefatory to the description of the successful introduction of the Apparent light at Stornoway, which forms the principal part of this communication.

In all the optical apparatus which is employed for lighthouses, the object is to gather the diverging rays to a greater or lesser extent, and to direct them towards the horizon, so that the vertical axis of the reflecting or refracting apparatus, as the case may be, is placed nearly at right angles to the plane of the horizon. The Dipping-light apparatus, on the contrary, though similar in other respects to the ordinary apparatus, has its axis inclined at some given angle to the horizon, so that the rays, instead of being projected horizontally, will be thrown downwards upon the sea at the same angle as that of the inclination of the axis of the apparatus to the horizon.* To explain the application of this arrangement, let A (Figs. 1 and 2, Plate XXV.), represent a lighthouse placed upon any headland or island; let B represent a sunken rock or dangerous shoal, *c c c c* the outline of the nearest safe *offing*, within which no vessel can come during night without danger. In such a case, all that is required to keep vessels clear of the foul ground is to place behind or in front of the lamp a reflecting or refracting instrument, as may be most convenient, inclined at such an angle as shall throw down the rays on the space *c c c c*, so that whenever a vessel comes within sight of the dipping apparatus it is time to *put about*, as the margin of safety has been crossed. When the lighthouse is required

* Were it necessary to show the dipping-light all round the horizon, the catadioptric prisms, &c., of the fixed light apparatus would require to have their forms so altered as to cast the rays downwards at the required angle, or else reflecting shades should be placed in front so as to encircle the apparatus at the necessary angle of depression.

not only to point out the limits of safety, but to indicate the position of the headland or island on which it is placed, it will be most convenient to make the revolving or fixed apparatus, which is to show the position of the headland, independent of the Dipping-light, and of a different colour. The Dipping-light not being required for distant vision, may be of low power and of a red colour, while the other may be of the natural colour and of greater power. So long as only the white light is visible, there is of course no danger to be apprehended; but whenever the red one is perceived, the margin of safety has been crossed, and it is time to alter the vessel's course.*

The Dipping-light is on the same principle as a night signal, which was proposed for use in railways by Mr Alan Stevenson in 1842, the description of which was printed in the Transactions of this Society. It consisted of an arrangement by which the engineman was warned of his approach to the station by suddenly crossing the dipping beam of rays.

I may also add that the Dipping-light might be shown with advantage during fogs. It unfortunately happens that sea-lights having their rays directed to the horizon, cannot possibly be of use during fogs; whereas were the apparatus hinged, so as to admit of being depressed, the beam of parallel rays might be made to dip during very thick states of the weather, so as to prevent vessels from actually running against the shore close to the lighthouse, as happened near Howth a few months ago. Were it thought better, an independent apparatus might be substituted for the hinged frame. From observations recently made on a light situated about 220 feet above the sea, it appeared that from three-quarters to a mile off the shore the effect was decidedly inferior to what it

* If a Dipping-light were made to oscillate with uniform velocity in a vertical arc, or to move in a vertical plane, the length of time during which the light could be seen would depend upon the distance of the observer; so that were it considered of sufficient importance in some particular locality, a light thus arranged could be so constructed that each second of time during which it was visible should correspond to a mile or certain number of miles' distance; or the distances might be indicated without moving the apparatus, by having rays of different colours dipping at different angles. A naturally diverging light, with shades or masks moving in spherical arcs, would also produce the same effect. I merely mention this as an idea that might perhaps be available in some such way as I have described.

was at greater distances; so that if vessels should not make out the light at a mile off, it cannot possibly be seen at distances nearer the shore. The burning of Bengal and other lights in the foci of reflectors in foggy weather has been proposed, but found impracticable from the presence of sulphureous fumes; while all attempts to employ *sound* as a medium for signals have proved unsatisfactory, from the difficulty of judging accurately of the direction in which it comes.*

Localities for which a Dipping-light is inapplicable.—The device just described, though exceedingly simple, is not on that account the less important, and may, under Providence, be the means of saving life and property. There are, however, many localities where the adoption of this plan is inexpedient; as, for instance, in places where the land is low and the danger comparatively distant, or where, as very often happens, there is little sea room, and the danger, whatever it be, must be passed at a small distance. To this latter class of localities belong rocks at the mouths of bays and roadsteads, where the fairway is not broad; also narrow sounds and the entrances between the piers of artificial harbours, which often require to be rounded very closely in entering. In such cases, sometimes one pier head must be hugged, sometimes the other, according to the direction of the wind; and so critical in stormy weather is the *taking* of a harbour, that even a single yard of distance is often of consequence. Those only who know from actual experience the anxiety which is felt in entering a narrow-mouthed harbour under night, and with a heavy sea running, can appreciate the great importance of knowing, at as great a distance as possible, the exact position of the *weather* pier-head.

It generally happens that there is a light at only one of the entrance-piers of harbours, by which the expense of keeping up two separate establishments is saved. But, in many cases, only one tower is erected, from the impossibility of maintaining or attending a lighthouse on the outer breakwaters over which the waves rise in stormy weather, and along which no one can at such times pass with safety.

* The most promising plan for modifying the effect of sound, seems to be that proposed by Mr A. Gordon of London.

Harbour trustees and others entrusted with the charge of public ports, very properly shrink from the responsibility of erecting lighthouses in situations where their maintenance is hazardous. In some harbours, the outermost breakwater is an insulated one, being entirely disconnected from the shore, and accessible only by boats in fine weather. At Peterhead and Pulteneytown, lighthouses were erected, under my superintendence, on the landward piers instead of the seaward, simply from the greater safety of attending them when placed nearer the land. At another harbour, a lighthouse on the seaward end of the pier was for some time maintained with great difficulty and danger, until on one occasion the sea broke into the tower, and the keeper was nearly drowned, having been for an hour and a half unable to get to the land. After this accident, the light was dismantled and removed to another situation at the landward end of the pier.

Apparent Light.—Enough has been stated to prove that in situations similar to those referred to, the principle of the dipping-light is wholly inapplicable. It was therefore necessary, in such situations, to have recourse to some other expedient. The dazzling reflection of the sun's rays from small fragments of glass or glazed earthenware, when turned up by the plough, in fields even at very considerable distances from the observer, and the brilliant reflections of our street lamps from distant pools of water or wet parts of the road, induced me to think of the following method of illuminating pier-heads and sunk rocks, which has since been tried at the entrance to Stornoway Bay.

The *apparent* light for the sunk rock at Stornoway, about to be described, consists of certain forms of optical apparatus for producing divergence of rays transmitted from a distant lamp placed on the shore. By this method of redispersing the rays, there appears to the eye of the mariner to be a lighted lamp in a position where in fact there is none.

The bay of Stornoway, at the upper end of which lies the town of that name, is a well-known anchorage in the island of Lewis, and its shelter has long been highly prized by the shipping which frequent those seas. It measures about a mile in length, and its entrance is about half a mile in breadth; but available sea-room for a vessel entering is, especially at night, materially reduced by a sunk reef lying off Arnish Point, on the south side of the entrance. For the purpose of opening up this bay, or harbour of refuge, so as to render it more useful and easily taken at night, a revolving light, on the Holophotal system, has been erected by the Commissioners of Northern Lighthouses; and a beacon, on which is placed the apparent light, has also been constructed on the sunk reef which lies off the Point. The erection of a lighthouse for opening up the bay of Stornoway was long talked of; and the danger of the Arnish Rock was so much felt that it was proposed by many to erect the tower on the rock itself instead of on the mainland,—a plan which would have been attended with great cost, both for construction and after-maintenance. The accompanying chart (fig. 5) of the entrance to Stornoway harbour represents the position of the lighthouse and beacon as constructed. A represents the lighthouse, and B the beacon and apparent light on Arnish Rock, which is quite inaccessible unless by a boat or at low water of spring-tides. The dotted lines represent the direction of the rays of light.

The revolving apparatus for the general purposes of navigation is placed in the light-room at the top of the tower on the land, while at the bottom there is a window from which is projected a beam of parallel rays, proceeding from a Holophotal apparatus of glass of the form described at p. 11 of the present volume of the *Society's Transactions*. This instrument is 20½ inches in diameter, with a hemispherical reflector of zinc placed behind, having the light supplied by a single argand burner of the usual size, which is about 1 inch in diameter. The beacon on Arnish Rock is about 530 feet distant from the lighthouse, and also lies somewhat nearer the anchorage, so that the light has to be directed to some extent towards the head of the loch. The beacon is a truncated cone of cast iron, 25 feet high, and upon its top is placed a small lantern, containing the optical part of the apparent light. The centre of the lantern is exactly on the level of the centre of the window at the bottom of the lighthouse tower, where the lamp and Holophotal apparatus are placed, so that the parallel rays proceeding from the window in the tower fall directly upon the lantern on the beacon, and are there dispersed.

In the Notes which, as already stated, were appended to my paper on the Holophotal System of Illumination, I threw out some hints on the possibility of employing Apparent lights, and also proposed various methods of constructing the necessary optical apparatus. I shall therefore only describe what has been found most convenient in this case; and I must at the same time explain, that I was compelled to adopt a method which has the disadvantage of employing unnecessary reflection of the rays, from the difficulty which was experienced at the time, in getting glass of the proper index of refraction in Paris. The whole of the apparatus which is about to be described might be advantageously replaced by a single set of totally reflecting prisms, constructed of glass of the proper index of refraction. I may just observe in passing, that for the great majority of localities such a set could easily be made, although in the case of Stornoway there is some difficulty from the rays requiring to be deflected through a maximum angle of no less than 121°, thereby rendering it necessary to employ glass with a high index of refraction. According to a careful investigation, kindly made for me by my friend Mr Swan, it appears that, in order to fulfil the conditions required at Stornoway by means of single prisms, the index of refraction would require to be 1·58 for the extreme red rays.* Metallic reflection

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* The following table contains the results of Mr Swan's investigation of the *least admissible* index of refraction of glass to be used in constructing a system of four prisms, suitable for such a station as Stornoway.

The second column in the table contains the minimum angles between the rays incident on the prisms, and those emerging from them; the third is the index of refraction of the glass for the extreme red rays of the spectrum; and the fourth the species of glass which might be applicable.

1st Prism,	30° 0′	1·53,	Heavy flint.
2d ...	37° 30′	1·52,	Common flint.
3d ...	45° 0′	1·52,	Plate.
4th ...	52 30	1·52,	Plate.

was preferred to a totally reflecting surface, from the difficulty of getting prisms of glass of the proper size made in Edinburgh. I therefore contented myself with the easily procured and cheap substitute of a silvered plane mirror, although one-half of the whole incident light is thus lost by absorption, which would have been prevented, had total reflection been employed.

The silvered plane mirror is shown in fig. 4 by A A. It is 20 inches broad, and 2 feet 3 inches high. It was fixed on a plate or table, and to the same table was attached a series of glass prisms, B B (figs. 3 and 4), forming a horizontal angle of 45° with the silvered mirror, and nearly touching it at one edge. The prisms which were employed are the solids generated by the motion of a middle section of an annular lens parallel to its vertical axis; so that when the parallel rays (*r r*) impinge (after being reflected by the mirror) upon their curvilinear sides, they will, without suffering refraction in the vertical plane, be refracted in the horizontal, so as to meet in the principal focus F, from which they will afterwards diverge through the same horizontal angle at which they were before made to converge. The glass prisms were constructed so as to disperse the rays over an angle of 62°. They measured 2 feet 3 inches high, as shown in elevation in fig. 3, and were in all 14 inches broad. In this way parallel rays, impinging upon the silvered plane mirror at a horizontal angle of 45°, are deflected horizontally 90°, after which they fall upon the glass prisms, which again disperse them over an angle of 62°. It is thus obvious that they will be ultimately deflected from a minimum angle of 59° to a maximum angle of 121° from their original direction.

This treatment of the rays of light has the same effect as would be produced were a real oil lamp placed in the beacon's lantern, and hence the term of *apparent* has been given to this arrangement in order to distinguish it from ordinary lights, which are illuminated by lamps placed in the focus of the apparatus in the Lantern.

Hermetically sealed Lantern.—From the liability of the silvered mirror to damage from damp air and sea-water, which was found in heavy gales to dash in large quantities, and with great violence, over the beacon, it was considered advisable to have the lantern hermetically sealed. This was done at Edinburgh, in a drying-room or stove, where it was kept for two days before being sealed up, in order that all the parts should be thoroughly dried. It may be useful to notice, as a caution to others, a mistake which was here committed from want of due allowance for the powerful effect of the sun's rays. The lantern, after being hermetically sealed, was taken to Stornoway and securely fixed on the beacon; but from its being painted of a red colour, the absorption of heat was very great. The light was exhibited on 1st January 1852, and during the cold winter months, it remained quite air-tight. But no sooner had the warmth of the summer come round than the putty melted away, and the sea-air got admission to the inside between the pane and the astragal, causing a haze to spread over the glass-work. To remedy this, it was necessary to admit the air freely so as to ventilate the interior, and since then the light has been restored to its former efficiency; but the silvering of the mirror cannot be expected always to hold out against the effects of the damp air, which would have been the case had the air been excluded. A hermetically sealed spare lantern is intended to be made with a lining of felt on the top, covered by a casing of wood painted white; and a different material, such as plaster of Paris saturated with oil, or marine glue, will also be substituted for the putty formerly employed.

Figs. 6 and 7, represent the elevation and details of an Apparent light, capable of illuminating half the circle. The outer pane of glass, (marked *b b b*) is of a semi-cylindric form, in order to prevent the loss of light occasioned by oblique incidence; *p p p* are totally reflecting right-angled prisms.

Limits of Visibility of Apparent Lights.—From want of apparatus of the necessary size, I have been unable to determine, experimentally, the greatest distance to which the system of Apparent lights may be applied. The source of light at Stornoway consists of a single argand burner, one-inch diameter, capable of consuming only one quart of oil per twenty-four hours, with an apparatus in front presenting only about 600 available square inches of surface; so that from the success attending this small apparatus, there seems every reason to believe that the same principle could be applied to places where the light requires to be seen at very much greater distances. A single first-order lens presents 1300 superficial inches, and has a four-wick concentric burner capable of consuming no less than 19 quarts per twenty-four hours; and were a first-order Holophotal apparatus constructed so as to throw all the rays forward in the required direction, it would possess, speaking roughly, and including the totally reflecting spherical mirror, about 56,500 superficial inches of available illuminated surface, being no less than 93 times greater surface than the apparatus in use at Stornoway. Nor does this calculation exhaust the capabilities of such a system of illumination; for could the electric light be sufficiently improved and combined with such powerful optical apparatus as I have referred to, it is difficult to guess to what distances the limits of visibility may yet be found to extend. If the plan were carried out on such a large scale, it would be advantageous to place the flame so far out of the focus as to give that amount of convergence at the distant beacon which experiments should determine to be the most effective. In some cases, it might be sufficient simply to throw the converging rays upon a plane mirror, so as to re-assemble them in a virtual focus from which they would again diverge in the required direction.

Illumination of Floating Buoys.—In situations where beacons cannot be erected, from the depth of water, or from other physical difficulties, I conceive it possible in many cases to have floating buoys illuminated on the same principle by adopting straight cylindric glass prisms, inverted conic or conoidal reflectors, or perhaps some other even simpler contrivances.* The great objection to this plan is, doubtless, the swinging of the buoy. The divergence of even

* The proposal to illuminate buoys by means of phosphoric oil, camphine lamps, &c., has been already made, but the objections seem, in the present state of our knowledge, to be wholly insurmountable.

the annular lens is, however, 5°, and this at a very moderate distance would subtend a breadth more than sufficient to allow for the swinging of a buoy at its moorings. Although, from the tossing and pitching occasioned by the waves a buoy-light could never be steady, its scintillations would probably, from this cause, be not the less striking or characteristic.

It may be expected that I should say something as to the effect of the apparent light when viewed from the deck of a vessel. I regret that I am unable to do this from personal observation, not having had an opportunity of visiting Stornoway since the first exhibition of the light, which is now nearly three years ago. I must therefore beg leave to trouble the Society with written statements which the light-keeper has received from masters of vessels who had come to an anchor near the lighthouse; from which I trust it will fully appear that every useful end has been gained which could have been secured by the erection of a lighthouse on the reef itself, while the great expense of construction and of after-maintenance has been saved.

Statements by Shipmasters as to the utility of the Apparent Light at Stornoway.

I, John Urie, master of the steamer "Islay," at present plying between Glasgow and Stornoway, having been called upon by Mr Campbell, light-keeper at Arnish, requesting to know whether I found any benefit from the illumination of the beacon off Arnish Point, beg to make the following statement:

I have come into Stornoway, I think, three several times at night since it has been lighted, having been detained by bad weather, and the weather bad at the time of entering, and I have found great benefit from the light shown from the perch. Even the light from the tower shows the perch quite distinctly at all times, more especially in rough weather. We leave always at night for Glasgow, and in all kinds of weather; and my opinion is, that it is an excellent invention for showing any foul ground. As an improvement, I would suggest, that if it could be brought to show more round the compass, as it does not show very strong from seaward, only from South by East.* I mean South by East from the beacon. However, *none can approach the harbour without seeing the light shown from the beacon or perch.*—(Signed) JOHN URIE, Stornoway, 23*d March* 1853.

1*st*, I saw the beacon light quite distinctly, making the Stornoway Harbour.

2*d*, I consider the beacon light most useful in a dark night rounding the rock.

3*d*, I have to offer no suggestions for the improvement of the beacon light.

4*th*, I have seen it both in good and bad weather.

5*th*, I consider such as the beacon light of importance on all such rocks on the British coast.—(Signed) JOHN MORISON, *Master of Mail " Packet."*

STORNOWAY, 26*th March* 1853.

SIR,—In answer to the inquiries respecting the beacon light, I have to say ;—

1*st*, That I saw it distinctly at a considerable distance on two occasions, one on a very stormy, dark night, and also last night, which was a clear moonlight night.

2*d*, Its utility is unquestionable.

3*d*, I am not scientific enough to suggest any improvement.

4*th*, This is answered in my answer to the first inquiry.

5*th*, There is no doubt of such a beacon light being highly useful on any rock where it could be adopted.—(Signed) J. MACDONALD, *of the " Rover's Bride."*

GRANTON, *December* 6, 1853. Steam Tender " Pharos."

SIR,—According to your request, Mr Watt and I beg leave to state, that the greatest distance we have seen the apparent or reflected light upon the beacon which is placed upon the reef that lies off Stornoway lighthouse, is, as near

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* This is to some extent occasioned by the oblique incidence of the light near the sides of the lantern upon the outer glass, and the objection arising from that cause could easily be obviated by making the glass cylindric with its centre of curvature coincident with the focus where the rays are re-assembled.

as we can judge, about one mile from a S.S.W. direction, and three-quarters of a mile from a S.E. direction.* We have had several opportunities of observing it while approaching Stornoway Harbour in dark nights, and have decidedly found it of great benefit, especially as we have found ourselves previous to this light being exhibited within two cables' length from the beacon, and could not see it distinctly in consequence of the narrow entrance being darkened by the high land. We can now run with safety and confidence, knowing that we can pick up the apparent light on the beacon at the above distances in *the darkest nights*, and we consider that it is a benefit to all shipping that frequent the harbour of Stornoway.—PETER ANDERSON, *Captain;* WILLIAM WATT, *Mate.*

To THOS. STEVENSON, Esq., &c. &c.

STORNOWAY LIGHTHOUSE, 15*th April* 1853.

I beg to send you the few remarks I have obtained regarding the beacon light. I have called on all I know had a fair opportunity of seeing and remarking on the light at night. Fishermen and small craft think the light on the beacon of more advantage to them than the light in the lantern ashore. When the sea breaks on the beacon the power of the light reflecting on the spray is seen at a considerable distance. When standing on the road about sixteen yards from the Tower door, about W.N.W. from the beacon, and when entering the loch, bearing about S. or S.S.E. from the beacon at these two points, the light on the beacon is about as powerful as one of the old mirror reflectors (formerly used for lighthouses). At other points where the light is seen, it appears like an ordinary ship lantern. All agree that the light on the beacon is most useful, and especially if it could be constructed so as to be seen at other points, the same as the two I have mentioned.*—(Signed) ALEX. CAMPBELL.

STORNOWAY, 4*th January* 1854.

We hereby certify, that we entered the harbour of Stornoway at night, and found the light and beacon most serviceable

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* *Vide* Footnote, p. 279.

in making the harbour. *We saw the light distinctly fully a mile off, the weather being various at the time.*—(Signed) MURDO M'LEAN, *Shipmaster*; JOHN M'KENZIE, *Shipmaster*; JOHN M'LEAN, *Shipmaster*.

SCHOONER "NORGE," *9th May* 1853.

1*st*, I saw the beacon light distinctly at a distance.

2*d*, I consider the beacon light very useful.

3*d*, I consider the beacon light could not be placed better.

4*th*, I *lay-to* off the lighthouse all night with a strong breeze and *thick* weather, and found the beacon and lighthouse of great service.

5*th*, I would recommend similar lights on all rocks round the British coast where such could be established.—(Signed) P. P. STRAND, *of the schooner "Norge"* of Drunton, Norway.

BRIGANTINE "THOMAS" OF BELFAST.

This is to certify that I was riding off the lighthouse of Arnish for three days, during a gale of wind from N.N.E., light bearing N. by W. half W., *one mile and a half distant*, and that I saw the reflection of the light on the beacon *very distinctly every night*, and consider it of great service to vessels entering this harbour.—(Signed) JOHN KEAY, *Master*.

STORNOWAY, 31*st December* 1853.

REPORT OF THE COMMITTEE *appointed by the Royal Scottish Society of Arts on* MR THOMAS STEVENSON'S *paper on Dipping and Apparent Lights*.

Your Committee having met and carefully considered the papers remitted to them with the relative drawings, and a letter from Mr Stevenson in farther elucidation of his views of the subject of dipping lights being rendered available during fogs, have now to submit the following report :—

Your Committee are fully impressed with the importance of the subjects discussed by Mr Stevenson, and agree with him in his doubts as to the feasibility of using, effectively, phosphorescent oils to illuminate any insulated point, and as to the risk of failure attending the use of gas pipes and electric wires for such a situation.

As to the dipping-light, they are of opinion that where the lighthouse is sufficiently elevated, it may in many cases be made available by using either one light, or two in a line, when that is practicable; and that in the case of fogs, a light by being depressed may often be made available for a vessel in a position too near to see the horizontal light distinctly, but still far enough off from the danger to have warning given in sufficient time to avoid it.

They think, however, that it would be attended with danger to allow the light-keeper the discretionary power of depressing the ordinary light, for fogs sometimes clear off so quickly, that the ordinary light might be suffered to remain depressed after it could have been seen at a distance, and ought to have been set again in the horizontal position, so that vessels might be misled by its having been withdrawn; and they therefore think that a separate light, and of a different colour, ought to be provided for the purpose of being depressed, as shown in Mr Stevenson's drawing for the application of a depressed light to indicate the position of a rock.

As to the Apparent Light—Your Committee think that this is a beautiful and ingenious contrivance, and that it may be applied efficiently in many cases where it is almost or wholly impracticable to employ a direct light. They see no reason to doubt its practicability; and if there had been any doubts before, they would now be entirely removed by the successful result of the experiment at Stornoway.

They see the difficulty of making the apparent light nearly as brilliant as a direct light, though they do not despair of improvements being made in the details, so as to increase the illuminating power.

Still, admitting that the illuminating power were to remain decidedly inferior, and that the apparent light could not be seen at any great distance, it must be borne in mind, that for a vessel at a great distance it is quite sufficient to see and steer for the direct light; and that it is time enough to alter the course upon coming within such a distance as that the apparent light shall have become visible.

Mr Stevenson discusses the practicability of illuminating buoys by an apparent light, and there does seem to be reason in what he says as to the less steady and powerful light from a buoy, owing to its constant change of position, being in some measure made up for by startling scintillations; nevertheless there can be no doubt of the greater difficulty in illuminating a floating buoy than a fixed beacon.

It appears, however, to your Committee, that even if it should be found impracticable to light up buoys thoroughly in this way, still that a blaze of light thrown on a large white buoy might make it visible at a considerable distance; at all events, to such a distance as, considering that the main light is visible and its position known, may be sufficient to point out the place of danger before coming too near to avoid it.

In conclusion, your Committee have to express their opinion, that the paper is deserving of the highest commendation of the Society.

James Leslie, *Convener.*
Philip Kelland.
William Swan.

Edinburgh, 9*th February* 1854.

On Collodion Calotype. By THOMAS RODGER jun., St Andrews.*

Agreeably to the desire expressed by the President of this Society at a late meeting, to be furnished with the modes of operation employed by those who practise photography, I now beg leave to submit to the Society the following remarks on calotype :—

In the practice of a new and difficult process, the success of which depends on a number of minute details, which, though they admit of variation, require very nice adjustment, there is much room for ingenuity and improvement. The process of calotype is of this nature, and in the practice of it, many circumstances, of themselves apparently unimportant, frequently occur to prevent success. Hence it is of great importance to simplify the process and render it more certain in its results. These objects I have endeavoured to attain; and, in the following account of the calotype process, my aim will be to detail shortly that process as practised by myself with considerable success and certainty. I shall do so, however, without reference to the modes adopted by others, leaving it to the society to compare the various methods at their convenience.

All the former modes of calotyping have been superseded by the process of collodion on glass plates. The superiority of the latter process will be apparent to every one on a very slight comparison of the results easily procurable by this process, and the most successful results of the old paper process.

Wonderful and beautiful as the pictures by the paper process were considered a short time ago, those by the glass plate process have quite outstripped them, for rapidity of execution, minuteness of detail, for expression, and beauty of finish. It is therefore to this process alone that I confine my remarks.

I need not make particular allusion to the camera, stand,

* Read to the Society February 1854.

and other apparatus necessary, further than to say, that the larger and more perfect the lenses are, the more rapid and certain is our success.

By far the most important and difficult part of this process is the preparation of the chemical materials to be employed, and the nice adjustment of these to one another. In this part of the process there are a great variety of opinions, but most individuals who have practised this art for any length of time, have, after many experiments, adopted certain methods which they have found to be most successful.

In order that there should be a greater certainty of obtaining satisfactory results, it is necessary for the preparation of the various solutions that the chemicals employed should be pure and unadulterated. Great annoyance is often occasioned by using nitrate of silver contaminated with copper or iron;—or again, by using sulphuric ether, adulterated with spirit of wine, or containing sulphuric acid; or, what is infinitely more detrimental, it is often very alkaline, from an excess of alkali having been added to it to neutralize accidental acid in the ether.

As it is my practice to prepare my own collodion I will now describe my method, commencing first with the making of gun-cotton.

Take five and a half ounces nitrate of potash in powder, and add to it in a convenient-sized bowl ten ounces, by weight, of common commercial sulphuric acid. Stir the whole with a glass rod, and introduce as much finely-carded cotton, about two drachms, as will absorb the mixture and be at the same time thoroughly charged with it. Put a cover on the vessel, and allow the action to go on for five minutes. Then remove the cover, and with a glass rod poke and separate the fibre of the cotton. If the action be too intense, which is known by the extreme heat of the surface of the vessel, moderate it by applying a cloth soaked in cold water to its external surface. Then let the cotton be plunged into cold water, and washed so thoroughly that not the slightest trace of acid can be detected. It should then be dried at a very low temperature, and put past in a bottle for use.

The collodion which I have found most tenacious, and most uniform in its action, is made in the following manner :—

Take of sulphuric ether 12 ounces; add to it half an ounce of iodide of potassium, previously dried and bruised in a mortar, and allow it to become saturated by shaking; then add 6 grains of iodide of silver, shake again to dissolve this, and, after it has become clear, pour it off into another bottle. Next add about 72 grains of soluble or gun cotton, or, what is better, add as much soluble cotton as you consider sufficient to make a solution so thin as to pour freely over a plate of glass.

Then in 12 drams of alcohol dissolve 10 grains of bromide of potassium, and after it is entirely dissolved, add as much iodide of potassium as will saturate the spirit. The whole of this is to be added to the above solution of gun-cotton in sulphuric ether, and well shaken.

It must be understood, that according as the ether employed contains more or less alcohol, so will the proportion of iodized spirit vary, which I have recommended. The proportion here given is suited for ether all but pure.

Should the resulting solution, after being allowed to settle, prove to be too thick, it merely requires the addition of iodized ether, along with the proportion of iodized alcohol. If too thin, the addition of a little gun-cotton is the remedy.

As I have found a minute quantity of free iodine to be useful in collodion, 2 grains of it may be added to the above quantity.

(*N.B.*—The preparation now described is especially adapted for negatives. But for glass positives, it also suits exceedingly well.)

The next proceeding is to clean a plate of glass thoroughly, finishing it with a piece of chamois skin or silk, and then to cover one side of it with the prepared collodion, which I do in the following way :—

I fasten a cylindrical piece of gutta percha to the under side of the glass as a handle; and, holding by this the plate in my left hand in a level position, I pour on the collodion from a small phial, in a steady and uninterrupted stream, upon the near right-hand corner of the plate, at the same time altering its level so as to cause the collodion to traverse the whole surface, and then allow the superfluity to run back into the bottle from the farther right-hand corner of the plate. Next, I immediately give the plate a rotatory motion, by means of the gutta percha handle, to render the coating equal, and, after the expiry of from ten to fifteen seconds, according to the temperature, I immerse the plate slantingly in a bath of nitrate of silver, of the strength of 35 grains of the crystallized nitrate, to 1 ounce of pure water. I suspend it in this bath for forty seconds without lifting it, and then raise and re-immerse it three or four times at short intervals, or, until the solution flows freely over the surface and the coating is free from the streaky or greasy appearance, which it has at first. The prepared plate requires now to be dripped for a short time, and then exposed to the image in the camera.

The window of the room in which the plate is rendered sensitive by the bath, and in which the picture is afterwards to be developed, &c., requires to be covered by a double layer of yellow calico.

The lenses with which the accompanying pictures have been taken are German, whole plate size, and ten inches focus.

With a diaphragm of two inches diameter, the plate requires to be exposed from eight to ten seconds, for a negative in summer.

For portraiture I invariably use a shady place, so chosen that the main light shall fall on one side of the subject. An awning or roof is placed about three or four feet above the sitter, to prevent too much light striking directly on the head.

After the plate has been exposed in the camera for the requisite time, it is carried back to the operating room to undergo the process of development.

The solution for this purpose is made as follows:—

Take sulphate of protoxide of iron, 480 grains.
Glacial acetic acid, 1 oz. (fluid).
Water (common) 8 ounces. Dissolve.

This should be poured expertly over the plate beginning at an unimportant part of the picture, and the plate should be agitated until the image appears sufficiently distinct, and intense to copy from, if a negative is wanted.

If a positive on glass is desired, the plate should only be exposed for a third part of the time in the camera, and should be developed with this solution.

Sulphate of protoxide of iron, 96 grains.
Water (common), 8 ounces.
Nitric acid, 16 drops.

The development being now completed, the picture must be thoroughly washed, by pouring a stream of water over it; and then it must be secured from the further action of light and rendered more fit for transferring if a negative, by removing the yellow iodide of silver from the blanks and shadows of the picture. For this purpose I use

Cyanide of potassium (crude cakes), 120 grains.
Water (common) 8 ounces. Dissolve.

After allowing this solution to remove the whole of the spare iodide of silver, the picture is again submitted to a thorough washing, and allowed to dry spontaneously, or by a gentle heat. The picture is now ready for the copying process.

As the collodion is liable to be scratched by the paper or otherwise in copying, it is better to be coated with varnish to prevent this, especially if it is to be frequently copied. The varnish used for this purpose is composed of—

Gum damar, 1½ or 2 drams.
Mineral naphtha, 4 ounces.

Before detailing the method of transferring or copying, I may here state, that when a negative appears to be scarcely intense enough to give a clear, bold, and satisfactory copy, I intensify it by the following process:—

After the picture has been fixed, and CAREFULLY washed, from cyanide of potassium, I pour over it a quantity of the negative developing solution, diluted with an equal bulk of water. Upon this is poured a quantity of a solution of nitrate of silver, in the proportion of 15 grains to 1 ounce of water, and I continue to keep the plate in motion for a time. If the image is made strong enough by this single application, it is well; but if not, a little more nitrate solution and developing liquid should be applied till the desired pitch is obtained. After this, the plate must be well washed, and again submitted for an instant to the cyanide of potassium, and finally washed thoroughly. I have found that this mode of strengthening a negative, though somewhat tedious, possesses the property, more than other methods, of increasing the intensity of the half tints in the same ratio as the brighter parts of the picture.

(*N.B.*—The operation of intensifying ought to be conducted in the least lighted part of the operating room.)

We will now go on to the process of transferring to paper impressions from negative pictures, which, although decidedly more simple and more easily conducted than the previous process, is, nevertheless, often attended with very unsatisfactory results.

Various kinds of paper are suitable for obtaining copies—of these some are better adapted than others. I use several kinds, but at present almost exclusively a paper manufactured by Pirie and Sons. One of the specimens, marked No. 3, is on a cream-coloured wove paper, made by Cowan of Edinburgh; and No. 1 is on Turner's photographic paper, procured from W. and J. Milne, Hanover Street, Edinburgh.

Having got a paper fit for the purpose, the first thing to be done, before applying the blackening agent, is to imbue it with some of the metallic chlorides. A solution of one salt may be used, or a combination of two or more. I use a mixture of two chlorides—viz., terchloride of gold and chloride of sodium, of the following strength:—

Chloride of sodium, 50 grains.
Solution terchloride of gold, 30 drops.
Rain water (pure), 20 ounces.

The strength of the solution of terchloride of gold is 15 grains of the crystallized chloride to 4 drams of distilled water.

This solution being put into a shallow dish of a size suitable for the sheets of paper, they are taken one at a time by two adjacent corners, and are slowly drawn through the solution, first one way and then the other. They are then pinned by one corner on a wooden screen to dry.

To render this paper sensitive to light, I pursue the following method:—Taking a piece of the paper, and driving off any dampness it may have contracted by slightly warming it, I then proceed, with a glass rod or a *pellet of cotton,* to coat its surface with ammonio-nitrate of silver as evenly as possible, and then dry it quickly, by holding it to the fire, or by pinning it up in a dry, darkish place. Dampness, either before or after the sheet is coated, is very apt to cause blotches, and hence it is advisable to use the sheet as soon as possible after it has been prepared.

The pressure frame I use is of the simplest construction. It consists merely of a cross-headed flat board, to which is attached by hinges a frame containing a square of plate glass; the pressure being given by a pinching screw.

The ammonio-nitrate of silver is made as follows:—

Nitrate of silver (crystallized), 110 grains.
Rain water (pure), 3 ounces.

Shake till all the crystals are dissolved, and then add liquor ammoniæ (fortissimus) in small quantities till the precipitate at first formed is almost entirely redissolved. Should too much ammonia be added, a few crystals of nitrate of silver will bring back the turbidity, in which condition I find it most suitable.

When the negative and sensitive sheet of paper underneath have been exposed to the action of the sun's rays long enough to make the copy a shade or two darker than it is intended to be when finished, the copy should be immersed as soon as possible into a bath of hyposulphite of soda to prevent the light from exerting any further influence upon it, or, as it is termed, to fix it. This bath is made thus:—

Hyposulphite of soda, 2 ounces.
Water (common), 16 ounces.

To render this bath from the first capable of giving tints equal to an old bath, there should be added a dram or half a dram of chloride of silver, and 40 drops of chloride of gold solution, of the strength already mentioned. Those pictures, which were from the first rather faint, will be fixed after ten minutes' immersion; and darker ones may be allowed to remain as many hours, or until they assume the desired gradation of light and shadow. The pictures must then be subjected to a thorough washing, so as to remove completely all traces of the hyposulphite of soda bath, which will otherwise be pernicious to the permanence of the colours of the photograph. The copies are then dried; and pressed, or polished on the back.

I have thus endeavoured shortly to describe the manner in which I practise the calotype process, and which I can confidently recommend for certainty and success. I have only given an account of one process, although several others might have been mentioned, being anxious not to confuse or render the description unnecessarily complicated.

The adjustment of the chemical materials to each other is of such importance, that the greatest accuracy is required in their preparation. All the manipulations of the process also require the greatest care.

In conclusion, I trust that my description is sufficiently clear to be understood, and that it may be of use in forwarding the progress of this art, and that it will be followed by accounts of the experience of others.

An Enquiry into the Principles which regulate the Action of Sails and Rudders, with some Practical Suggestions. By Rev. JAMES BRODIE, Monimail, Fife.*

While the practical skill of the British seaman secures for him the foremost rank in his hazardous profession, and while the superior attainments of many of our navigators entitle them to a distinguished place among the cultivators of science, there are not a few questions connected with sailing vessels that have as yet received no fully satisfactory solution. Among these there is none more important than that which forms the subject of our present inquiry; and the author of the following remarks indulges the hope that its importance will plead his excuse for bringing it before the notice of the Society:—

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* Read 9th January 1854; Silver Medal awarded, 1854.

Propelling and overturning Effects of the Wind.

The wind exerts in every case a double influence on sailing vessels; it impels them through the water, and it has a tendency, greater or less according to circumstances, to overturn them.

When a vessel is running right before the wind, these two influences act in the same direction; the one urging it onward in its course, the other tending to depress its head in the water. The latter, however, is in this case so small in proportion to the various forces that tend to preserve the vessel's equilibrium, that no practical danger in ordinary circumstances can ensue from it.

When a vessel is sailing with the wind on the side, the action of the two forces becomes much more distinctly marked, and much more deserving of investigation. In consequence of the oblique position in which the sails are set, one portion of the pressure of the wind acts as an overturning force, the other becomes an impelling one. The buoyancy of the leeward side of the ship, and the weight of the windward side, are the forces that preserve its equilibrium, and, as these are comparatively small, the danger of overturning is much greater than in the former case.

One of the most important problems connected with our inquiry is that which determines the most advantageous angle of inclination for the sail. When the vessel is at rest, the position of the sail in which the impelling force of the wind is greatest is that which forms an angle of about 30° with the line of the keel. In this case, about one-third of the power of the wind becomes, theoretically speaking, a propelling force, the remainder tends to overturn the vessel. When the angle approaches more nearly to a right angle, a portion of the impetus of the wind is lost; when the angle is more acute, and the sail is made to lie more nearly in the line of the vessel's course, a still greater evil arises, for, while the impelling force is diminished, the overturning force is increased.

Another circumstance remains to be taken into account. While the angle of 30° is the most advantageous when the vessel is at rest, it does not continue to be so when the vessel is in motion. In order to produce the greatest impelling power, the angle of the sail's inclination must vary according to the apparent angle which the wind makes with the vessel's direction, or, in other words, according to the comparative speed of the vessel's motion. If a ship, for example, be moving through the water as rapidly as the wind is blowing, the sail slips, as it were, from below the compressing column of air, so that one-half of the impelling impetus is lost. To determine accurately the degree of inclination that should in all cases be given is impossible, but the following rule accords with the results of experience, and is deserving of attention :—*The more rapidly a vessel sails, in proportion to the velocity of the wind, in order to produce the greatest impelling force, the more acute should the angle be which the sail makes with the line of the vessel's motion, and vice versa.*

This is the rule which experience has taught the mechanist to adopt in weathering, as it is called, the sails of windmills. Near the centre, where the motion of the arms is comparatively slow, the sail forms with the plane of its motion an angle of 20° or 30°; but the angle is gradually diminished towards the extremity, where the rapidity of the motion is great, and the angle is proportionally small, varying from 6° to 10°.

We must here recall to mind the remarks we made on the overturning and impulsive effects of a side wind. If the sails are set at too great an angle with the line of the vessel, there is simply a loss of impulsive power ; if set at an angle too acute, there is at once a loss of impulse and an increase of the overturning force. Keeping this fact before us, and applying the rule which we have given, it appears evident, that if anything occurs to impede a vessel's progress, the sail should immediately be slackened, that is, placed more nearly at right angles to the line of the vessel's motion. A tightness of sail, which is at once safe and advantageous when the vessel is moving freely, may involve both danger and loss of speed when the rate of its motion is diminished. A melancholy illustration of this remark occurred some time ago in the Firth of Forth. Some fishermen, coming homewards with their sails set, and the wind abeam, picked up a mast which had floated away from a wreck; they fastened it to the stern of their boat, and proceeded with their sails set as before; but the resistance caused by the mast they were towing behind them so much diminished the speed of their boat, and, consequently, increased so much the overturning power of the wind, that their bark was upset, and several of the crew were drowned.

(The remaining remarks on the Action of the Wind on Sails, with the diagrams illustrating them, are omitted, the author's inquiry into the subject being as yet incomplete.)

Principles on which the Action of Sails and Rudders depends in turning a Vessel round.

The power which the helm possesses is the effect of the water striking obliquely upon it as the ship moves along. This produces a pressure which, acting at right angles to the plane of the helm, pushes the stern to a side, and turns the vessel round. The action of the helm is entirely dependent on the momentum of the ship. When the ship is at rest, or merely moving with the current, the helm is useless. This fact is familiarly known, as is the effect produced on the helm by an increase of the vessel's velocity. The effect of the vessel's weight, including, of course, both ship and cargo, is not so generally adverted to. It is evident, however, that it forms a very important element in our calculations; for the greater the weight the greater will be the momentum; other circumstances being the same, the greater, consequently, will be the power of the helm, more especially in tacking, in which operation the impetus of the wind on the sails is very speedily lost. A ship of war, therefore, with guns and ammunition on board, or a trading vessel deeply laden, will answer the helm much better than a vessel in ballast, or one that is lightly loaded.

In considering the action of the rudder, the form of the hull must also be taken into account. The ease with which any floating body can be turned, depends principally on its shape. The longer and sharper a vessel is, the more difficult it is to turn. An old-fashioned ship, with round bows, and short in proportion to its breadth, requires much less force to pull it round than a sharp-built clipper. Some may object to this statement, and tell us that vessels of the modern shape are as easily steered as those of a more antiquated form. We must keep in mind, however, that vessels of the newer build sail much faster than the others, and that their superior velocity gives greater power to the helm; but, whenever this speed is checked, the difficulty of turning attendant on their length and sharpness of form becomes a matter of very serious importance, as has been shown in not a few of those melancholy shipwrecks that have lately occurred.

It is also proper to remark, that the longer a vessel is in proportion to its draught of water, the more uncertain is the action of the helm in consequence of its liability to be thrown almost, if not entirely, out of the water, when the stern is in the trough of the wave.

The action of the sails in turning a vessel round, in some respects, is similar to that of the rudder, in others, it is very different. The power of the rudder depends on the motion of the vessel through the water, that of the sails depends on the motion of the wind past the vessel. The pressure of a side wind on the foresails has a powerful effect in turning the vessel's head to leeward, while the action of the sails at the stern is precisely the reverse. When the ship is to be turned completely round to another tack, as in wearing and tacking, the sails are uniformly employed as assistants to the helm.

It is necessary to keep in mind the distinction that is to be drawn between the action of the rudder and that of the sail, and more especially to advert to the fact, that though the vessel's head-way be lost, and the rudder, consequently, have lost its power, the action of the sails continues unimpaired, and may be sometimes employed as a means of supplying its place.

We find inadvertencies in regard to this subject even in the treatises of Dr Robison, one of our most distinguished authors on nautical subjects. In the article on Seamanship in the Encyclopædia Britannica, after describing the operation of tacking, he says,—"It frequently happens that in this conversion of her course the ship loses her whole progressive motion. It is evident that in this case there is little hope of success, for the ship now lies like a log, and neither sails nor rudder have any action. This is called missing stays." He then describes the evolutions required either to bring the vessel back to her former course, in order to "try again," or to wear her round, that is, "turning her head away from the wind, going a little way before the wind, and then hauling to the wind on the other tack." It is needless to say that he falls into a mistake when he says that "the sails" have lost their action.

This inadvertence of the doctor we should not have noticed if it had not gone to confirm the idea that when the vessel loses way there is nothing to be done but either to "try again" or "wear her round"—operations which require both time and space, and which circumstances often render impracticable. We feel persuaded that, *if it could be efficiently applied,* the action of the wind upon the hinder sails would be sufficient of itself to accomplish the object in view.

Looking to the subject theoretically, it is evident that if the sail next the stern, whether we call it a mizen or a spanker, were gradually brought more and more to windward as the vessel's head came round, its effect in tacking would be precisely the same as that of the rudder.

In practice we find that it is sometimes thus employed in boats which are provided with such a sail, and some instances have been mentioned of its being thus employed on board a revenue cutter; but in general the force that is required to bring it round, and the number of the crew that must at the same time be attending to other operations, renders it impracticable.

To obviate this difficulty, the following arrangement is suggested:—

Make the boom of the mizen-sail, *a b*, and the gaff, *c d*, as long as convenience will admit; if made to project beyond the stern and sides of the vessel, the greater will be its power. At the ends *a* and *c* fasten swivels; to these swivels fasten yards, *e f* and *g h*, and to these yards fasten the sail.

The swivels are not placed exactly in the middle of the yards, but a little nearer to *g* and *e* than to *h* and *f*, so that

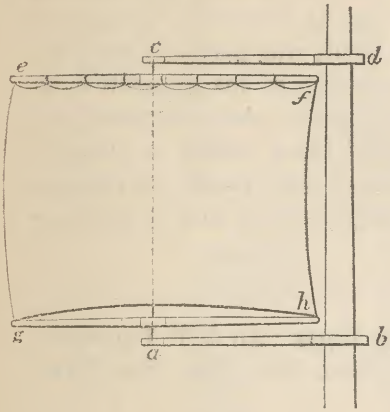


Fig. 1.

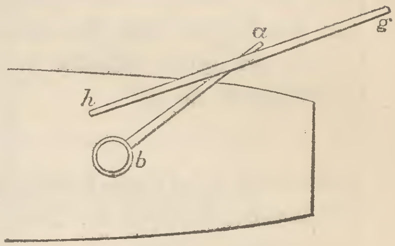


Fig. 2.

the line *c a* divides the sail into two parts, nearly, but not altogether, equal. The yards are fastened to the boom and gaff by means of ropes at *f* and *h*.

When it is desired to employ the sail as a means of bringing round the vessel in tacking, the ropes at *f* and *h* are slackened, the sail wheels round and presents its edge instead of its side to the wind, and the boom is hauled to windward with little difficulty. When brought as far round as may be desired (as in fig. 2), it is fastened, and the sail is then brought round again to offer its side to the wind. This operation requires comparatively little force, as the action of the wind on the one part of the sail is nearly balanced by its effect on the other. It should, however, be done as rapidly as possible, as the sail in the act of turning retards the vessel's motion. When thus brought round it is first brought into a position parallel to the line of the keel, and gradually turned to windward as the vessel's head comes to the wind.

N.B.—The author has not yet been able satisfactorily to test his invention. The result of some experiments on a small scale may be given, in the words of the Committee appointed to examine his paper:—

"We have also witnessed experiments tried with his life-boat, in which the principles it was his object to establish were practically applied; and while in such a boat they wrought at a great disadvantage as compared with one of the ordinary construction, the result was perfectly satisfactory, and established the practicability of his suggestion, at least when applied on a small scale; and altogether we think the principle well worthy of being tested on a larger one, and believe that the owners of such vessels as clippers (which are often difficult in stays) would find it to their advantage to do so."

Description of a Semi-Revolving Light. By J. T. Thomson, F.R.G.S., F.R.S.S.A., Hon. Mem. Nat. Hist. Soc. Newcastle-upon-Tyne.

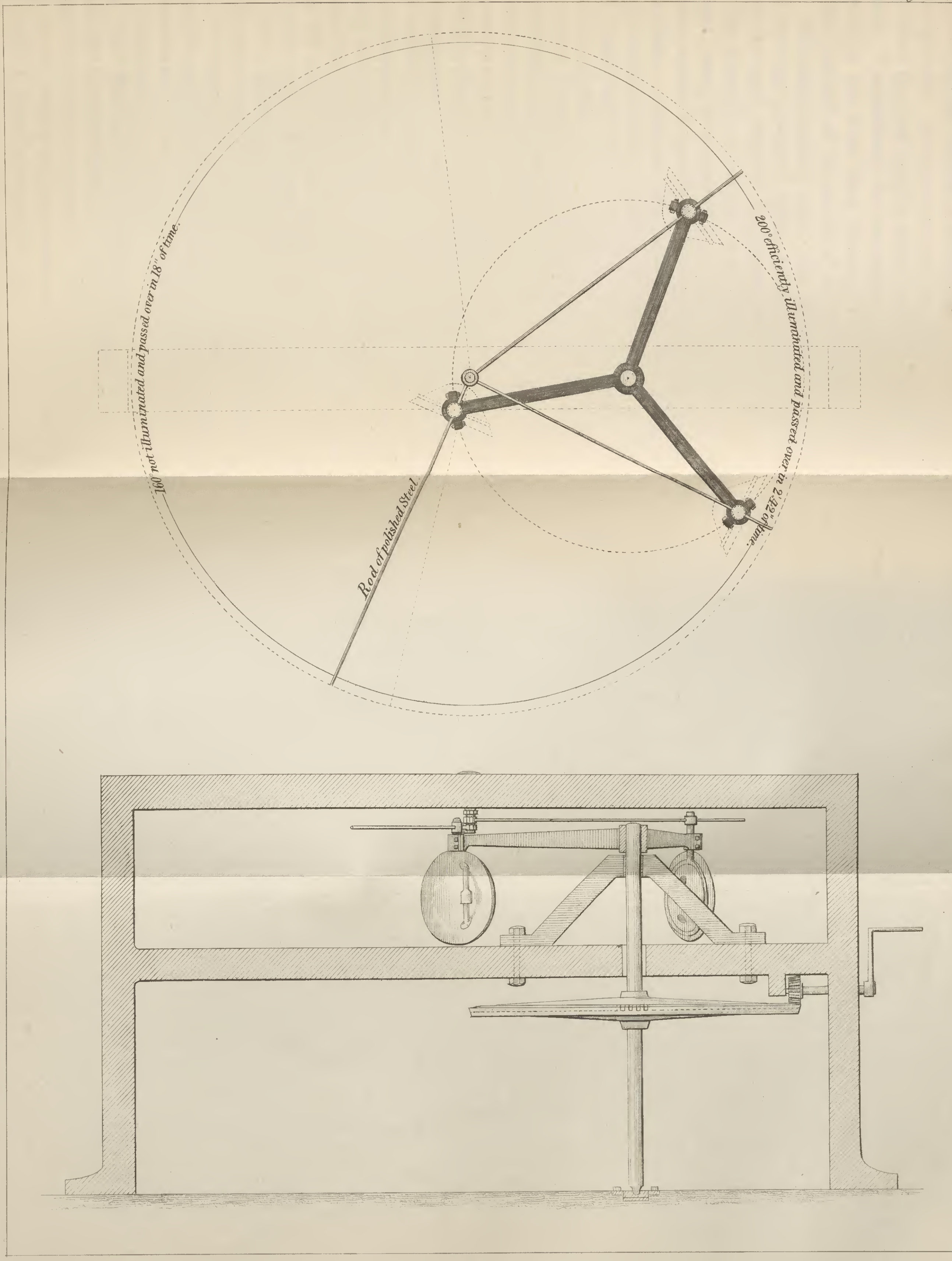
Revolving lights, when placed on small islands, or rocks in open seas, obviously perform to the greatest advantage, for in such situations their light requires to be seen from every direction; but when placed on the coasts of large islands or continents, it is necessary to the requirements of navigation that they should be seen only from seaward. In the latter case, which is a very general one, the revolving light, while performing its circuit, makes half of its power only available, and the other half is dissipated uselessly to landward; thus a constant double expenditure of oil and stores takes place, and the original cost of the apparatus is also greatly enhanced.

This defect of the revolving light has drawn considerable attention, and several plans have been proposed with the view of saving the useless expenditure. So before laying the description of my apparatus before the Society, I will shortly mention what had been done previously.

The first semi-horizon-eclipsing light brought to the notice of the public was the invention of Captain Smith of the Madras Engineers, and has been denominated by him a reciprocating light. The account of this light was published in the Transactions of the Institution of Civil Engineers, vol. ii., page 196, where it will, on reference, be seen the inventor states that the apparatus fulfils the condition of illu-

PLATE XXV *

Trans. Roy. Scott. Soc. of Arts.



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minating one-half the horizon at five-eighths of the expense of revolving lights. The invention was brought to practical use in or about the year 1843 by being placed on the Madras Lighthouse. I understand that an apparatus worked on the same principle has since been placed on the Saugor Lighthouse, lately erected at the mouth of the River Hooghly, in Bengal. The reciprocating light, like the revolving one, shows a brilliant eclipsing light; but here the similarity ends, and the most essential distinctive property of the latter, viz. the equality of periods, is wanting. The reciprocating light, owing to the principle on which its machinery is constructed, varies its duration of obscurity in different azimuths, so that it cannot be distinguished by its periods in the manner of revolving lights ; this defect cannot be considered of much consequence at the remote places where it has hitherto been applied, but it is sufficient to debar its introduction on the coasts of most parts of Europe or America where lighthouses are necessarily numerous, and must have plainly distinctive properties.

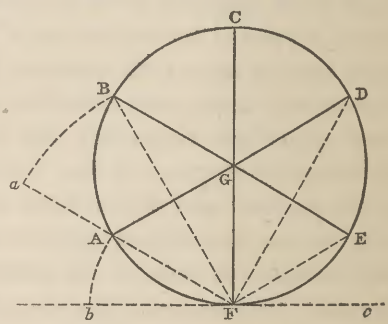
The next invention for an eclipsing semi-horizon light is that of Mr Thomas Stevenson, and as a description of it appears in an appendix to his account of the holophotal system, which is printed in this Society's Transactions, I will require to do nothing more than mention it. The apparatus is most ingeniously simple, and therefore most valuable ; it is calculated to perform rigorously the required conditions of illuminating 180 degrees of the horizon with the same appearances, periods, and distinctions (whether coloured or otherwise), as can be obtained by the common revolving apparatus, and it dissipates none of its power on the other half of the horizon. Mr Stevenson has named the invention a reversing light; and possessing, as it does, the features and capabilities above mentioned, it is a great improvement on Captain Smith's reciprocating apparatus.

At the time Mr Stevenson published the account of his reversing light he was so kind as mention that he had already seen plans of my form of apparatus. My attention was first directed to the subject of semi-horizon-eclipsing lights by reading Captain Smith's account of his. This was in the year 1844, at which time I was engaged in designing a lighthouse proposed to be placed on Peak Rock, situated near the south-eastern extreme of the Malayan peninsula, where a powerful light was required to be shown to seaward, and not to landward. On consideration I was struck with the defects of the reciprocating light, which led me to seek another form.

In the course of an essay on Semi-Horizon Lights, both fixed and eclipsing, which was published in the journal of the Eastern Archipelago, I gave a short notice of the apparatus; but as that journal has only a limited circulation in a remote part of the globe, it is probably known to only one or two members of this Society; further, as several additions and improvements have since been suggested, I trust that in bringing it to the notice of this Society, I will be excused for taking up their valuable time in describing it.

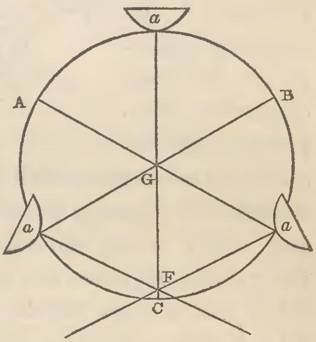
The apparatus I have termed a semi-revolving one. In Prop. XX., Book III., Euclid, it is demonstrated that *the angle at the centre of a circle is double the angle at the circumference upon the same base that is upon the same part of the circumference.*

Let ABCDEF be a circular frame revolving on its centre at G, and let F be a point on the circumference; now, suppose reflectors were placed at the points A B C D E F, which, while revolving on the circle ABCDEF, are at the same time directed in the pointing of their luminous beams by straight rods or trainers, FA, PB,



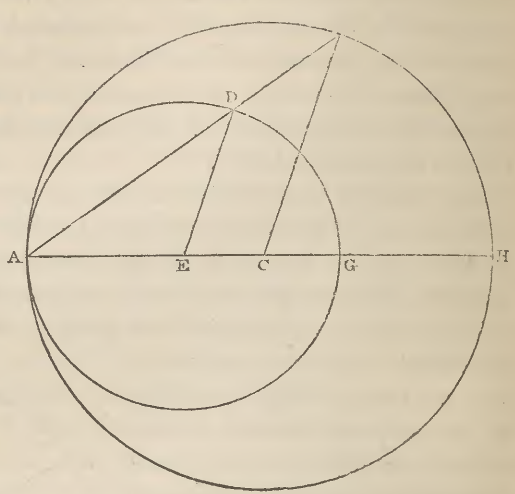
FC, &c., it will be evident that the reflectors, while performing their circuit in passing from F to A, traverse an arc measured by the angle FGA, but the luminous beam of the reflector at the same time will only have traversed an arc measured by the angle AF*b*, which is equal to half the angle AGF, F*b* being a tangent to the circle at F; the arc *b*A, which is measured by the angle AF*b*, is consequently half the arc FA, which is measured by the angle AGF. In the same manner, the reflectors, in traversing from A to B on a centre at G, will describe an arc measured by the angle BGA, which is double the angle BFA; the arc B*a*, which is measured by the angle BFA, is therefore half the arc BA measured by the angle BGA. This will be the same with all other arcs of the circle, so that while the reflectors have performed the whole circuit of 360°, their luminous beams will only have performed 180°.

In a machine constructed exactly on this plan, a practical difficulty would occur in reversing the reflectors at the point F, from *c* to *b*; but as it is anticipated that for practical purposes the principle need not be rigorously adhered to, the object may be easily attained by putting the point F within the circle. Now were reflectors put on a frame, ABC, revolving on its centre at G, then the reflectors *aaa* placed upon it, and being guided in their manner of facing by straight rods or trainers, these being attached to the reflectors, and sliding on a vertical round pin held fast at F, the luminous beams proceeding from the reflectors would closely fulfil the required conditions—viz., illuminate at equal intervals, every part of 180° of a sea horizon, and waste none of their light landward.



In the guiding of the facing of the reflectors, several means may be adopted. The straight rods or trainers may have slots down their whole length, into which the vertical pin at F would be inserted. To lesson friction at the point F, friction rollers could be adopted. Instead of the above, elastic bands, or series of springs, might be introduced to effect the end in view—or, probably, what would be still superior, would be in using hinge-jointed arms, made so as to collapse and expand as the machine went round. If the primary principle of the machine be found worthy of adoption by lighthouse engineers, practical use would no doubt settle what method was the best one in these details.

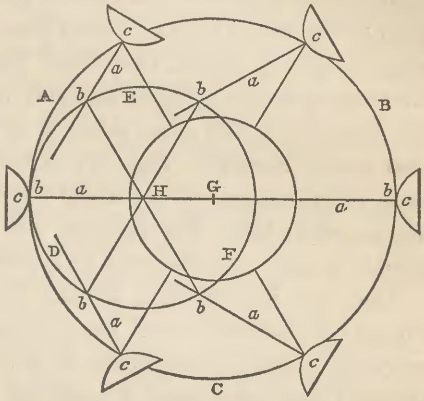
What appears to me to be as effective a plan for producing a semi-revolving light, but which cannot be brought forward as being so simple as the above described, is the following:—



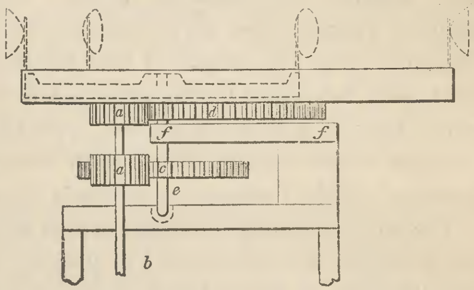
Let ABH and ADG be circles of different sizes, having their respective centres, C and E, in the same straight line AH; also, let their circumferences touch at the point A, the common extremity of their diameters. Supposing both circles were made to revolve in equal times, the radii CB and ED would be constantly parallel to each other; the angles ACB and AED would consequently maintain equality; and as their including sides are proportional, the triangles ABC and ADE will always remain equiangular (See Prob. VI., Book VI., Euclid), so that AB and AD would be in the same straight line, and end in the same point A.

Now the angle BCH being at the centre of the circle ABH, and the angle BAH being on a point of the circumference of the same circle, also both angles being on the same arc, the angle BCH is double the angle BAH (See Prob. XX., Book III., Euclid); and this will be the case at any other part of the circle ABH; thus the divergence of the radius CB, from the diameter AH, will always be double the divergence of AB; therefore, while CB describes the whole circle, AB will only describe half a circle. Such being the case, were D and B each being points on the straight line AB, joined by a sliding-rule, and were reflectors placed at B, and fixed to the rule, the rays proceeding from the reflectors would illuminate half the horizon, while the two circles ABH and ADG traversed the whole 360 degrees.

In carrying these principles strictly out, a practical difficulty will be met in reversing the reflectors at A, as was the case with the former described apparatus ; so like it, a slight departure from these must be made, which is done by disconnecting the small circle a little, so as to be within the larger. Now, let ABC be a circular frame, revolving on its centre at G, bearing the reflectors, and DEF a smaller circular frame revolving on a centre at H, eccentric to the larger, but performing a revolution in the same time ; *aaaa* are straight guide rods, which, being fixed to the reflectors at *cccc*, slide through holes in the heads of the pins *bbbb*, by which means the reflectors will act as required.



The manner in which equal motion is given to the frames will be seen on reference to the next diagram, in which *aa* are two driving pinions of equal size, which are fixed upon the same shaft *b*, and may be connected with the usual light-room machinery. *c* and *d* are wheels of equal size, the former of which is fixed on the shaft *e*, which gives motion to the smaller frame, and the other is fixed to the larger frame ; but instead of turning upon a shaft or spindle, has motion round the periphery of the disc *ff*. It will be observed that the disc *ff* is concentric with the larger frame, but eccentric to the smaller, whose shaft *e* passes through it.



From the above descriptions, it will be seen that the object sought to be attained, may be effected both by the reversing and by the two forms of semi-revolving apparatus, by the former rigorously, and by the latter, it is anticipated, sufficiently so for practical purposes. As neither have stood the test of trial, it would be premature to speculate on their relative merits; but I believe I am so far justified in suggesting, that both being suited to carry every kind of reflector used in common revolving lights, they fulfil the important condition of showing an eclipsing light at equal intervals on the sea-half of the horizon, in the same manner as performed by machines that totally revolve. They are at the same time calculated to save fully one-half of the usual expenditure of oil and other stores, while their original cost will be much less than the machines they are designed to supersede.

The late introduction of the holophotal system of Mr Thomas Stevenson would seem to make the introduction of eclipsing semi-horizon lights of much more importance than before these admirable inventions of that engineer were known, whereby small arcs of the horizon are illuminated by lights (both dioptric and catoptric) of maximum intensity, which, from the nature of their performance, are exceedingly well adapted for eclipsing lights. The eclipsing dioptric lights of Fresnel have no advantage over them with regard to intensity; and the system of that engineer being only suited for totally revolving lights, intended to be seen in every azimuth, they, if placed on a coast, would be worked at double the cost of the semi-horizon lights when aided by the most powerful of Mr Thomas Stevenson's holophotal instruments.

For such positions on coasts which ships *make* from over-sea voyages, and which may at present be lighted, for economy's sake, by the inferior power of a fixed light, powerful eclipsing semi-horizon lights would be introduced at the same or less cost of maintenance, to the great benefit of the mariner, to whom the brilliancy of the flashes would be of the utmost consequence, by enabling him to descry them at great distances; a desideratum best known to, and appreciated by, those who, often uncertain of their true position, are in the habit of approaching dangerous coasts, rendered more dangerous by a stormy and hazy atmosphere, such as we have in these high latitudes.

On a Simple Variation Compass. By WILLIAM SWAN, F.R.S.E., F.R.S.S.A.*

About two years ago, my friend Mr John Adie communicated to the Royal Scottish Society of Arts the description of a new variation compass. His instrument, which is intended to be used along with an ordinary theodolite, was devised for the purpose of ascertaining the magnetic meridian with greater accuracy than is attainable, either by the use of the compass usually attached to theodolites, or by employing the more ordinary forms of the azimuth compass.

Mr Adie's very elegant invention is described in the Transactions of the Royal Scottish Society of Arts, vol. iv., p. 138. It consists of a delicately-suspended compass-needle, inclosed in a tube furnished with collars, which are placed in the Ys of the theodolite, the telescope having been previously removed. The ends of the needle, which are brought to fine points, are nearly in contact with finely divided glass diaphragms; and the needle being viewed through the diaphragms by powerful eye-pieces, has its ends accurately referred to those divisions. It is easy to see how, in this manner, the axis of the tube with its collars,—which, when placed in the Ys, is coincident with the axis of the theodolite telescope occupying that situation,—can be placed parallel to the axis of the needle; and the reading on the horizontal limb of the theodolite corresponding to magnetic north may be obtained.

From actual trial, I was so much satisfied of the excellence and utility of Mr Adie's instrument, that I felt desirous of having something of the same kind applied to a Kater's altitude and azimuth circle in my possession; but as the telescope of that instrument, unlike that of the ordinary theodolite, does not admit of being *removed*, I was obliged to adopt an arrangement totally different from Mr Adie's.

The instrument I devised was constructed for me by Mr Adie in the autumn of 1852; and I now describe it, in the hope that it may be useful to persons who, possessing instru-

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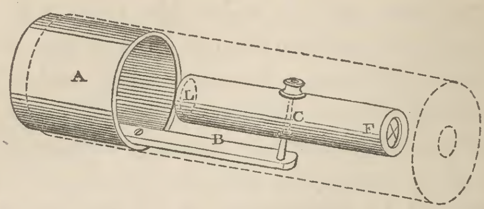
* Read before the Royal Scottish Society of Arts.

ments analogous to Kater's circle or, indeed any form of theodolite, may wish to make observations of magnetic declination.



It consists of a collar A, fitted so as to slide without much friction upon the object-end of the telescope of the theodolite with which it is to be used; an arm B, projecting in front of the telescope, furnished with a fine steel point C; and a small collimating magnet LF, supported on an agate cap, which turns on the point C. The best form for the collimating magnet, would, I conceive, be that of a hollow steel cylinder, carrying at one end a lens L, and at the other a cross of spider-lines F, as represented in the figure,—a construction which has been adopted in various magnetic declinometers. In the instrument made for me by Mr Adie, instead of the cylinder shown in the figure, there are two steel plates, each 5 inches long, 0·3 broad, and 0·02 thick, placed parallel to each other, and connected at the ends by light frames of brass; an arrangement which answers exceedingly well. One of these frames carries the lens L, and immediately behind the other, and between the plate, so as to be out of risk of injury, is placed a diaphragm carrying the cross fibres F. The lens is not achromatic, but as its aperture is only 0·2 inch, while its focal length is 4·7 inches, the image of the cross fibres formed by it is tolerably well defined. I should recommend, however, the adoption of an achromatic lens of greater aperture, and shorter focal length than that which I have described, and the hollow cylindrical magnet instead of the parallel steel plates; for the cylindrical magnet will admit of the lens and cross lines of the collimator being more firmly fixed in their places, while at the same time they will be less liable to derangement from handling the magnet. It is scarcely necessary to explain that the rays of light proceeding from the cross fibres, which are placed in the principal focus of the lens are rendered parallel by the lens, and thus enter the telescope of the theodolite in a fit state to be brought to focus at the diaphragm wires, where they form a distinct image of the cross fibres. A light tube represented in the figure by dotted lines, slides over the whole, so as to protect the magnet from currents of air; and is furnished with an aperture at its end, covered with glass, through which light is thrown by a small reflector to illuminate the cross fibres.

The method of observation consists in first making the image of the intersection of the collimator cross fibres coincide with the middle diaphragm wire of the theodolite telescope, which is easily effected by means of the tangent screws of that instrument, and then reading off the verniers on its horizontal limb. If the magnetic axis of the magnet were parallel to the optical axis of the collimator, the reading on the limb for magnetic north or south would thus be at once obtained; but as such a condition can never be strictly fulfilled in practice, it is necessary, where an accurate result is wanted, to repeat the observation with the needle in an inverted position. For that purpose the agate cap is made to screw into opposite sides of the magnet, which thus admits of being suspended with either side uppermost. By taking the mean of the readings in the two positions of the magnet, any error caused by want of parallelism in the line of collimation and the magnetic axis will be either wholly or nearly eliminated. Half the difference of the readings in the two positions of the needle, carefully determined from a number of observations, may be registered and applied as an index error, when the needle has been observed without having been inverted; and such a mode of observation will probably be sufficiently accurate for the ordinary purposes of the surveyor.

It is desirable that the instrument be adjusted so that the difference of the readings in the two positions of the magnet may not be *great*. For as the correction, for want of perfect adjustment, obtained by taking the mean of those readings, will generally be only approximate, it is well that any residual error should be confined within as narrow limits as possible.

In order to ascertain the variation of the compass, or to apply the observations of the magnet to the ordinary purposes of surveying, it is necessary to direct the theodolite telescope to a meridian mark, or other proper object, and to read off its horizontal limb; and it is desirable that this should be done both before and after observing the magnet. The collar A should be adjusted to the telescope before taking the observations of the meridian mark; and the magnet and its cover should be put in their places, and removed again, with as delicate manipulation as possible, in order to avoid disturbing the theodolite,—the cover for that purpose being made to slide off and on with very little friction. Practically, I have found no sensible discrepancy in the readings for the meridian mark arising from disturbances caused by handling the magnet and its cover; but if it be deemed desirable to avoid altogether the chance of such errors, it may be done by furnishing the aperture in the cover which illuminates the collimator cross, with a piece of parallel plate-glass. The meridian mark may then be seen through this glass, and observed without removing the cover, immediately after observing the magnet. Any error due to refraction will be eliminated by reversing the cover, when it is replaced after reversing the magnet, and again observing the meridian mark; but a good piece of glass, such as that which is used for making the mirrors of sextants, will cause no error from refraction appreciable with the magnifying power of an ordinary theodolite telescope.

It is always proper, however, to reverse the cover, in order to eliminate the effects of any attraction it may exert on the magnet; and for the same purpose, I have always observed with the vertical limb of my Kater's circle facing alternately east and west. I may add, with reference to the observations of magnetic declination given in the sequel, that I have since ascertained that when that instrument was brought as near as was possible to a collimating magnet, suspended by a very delicate silk thread, and observed through a telescope, it caused no perceptible deflection.

The practical limit to the accuracy of observations made by such an instrument as that which I have described, is the friction of the point of suspension. When the needle shows any symptom of not swinging freely, the point should be carefully sharpened on a hone,—a process which any one may learn to perform for himself.

I find that the most consistent readings are obtained, not by waiting until the magnet comes to rest, but by causing the theodolite wire to bisect the arc of vibration of the magnet, by estimation, as soon as that arc is reduced to about 8′ or 10′. If the magnet has come to rest, it is easy to make it vibrate again in a small arc, by cautiously approaching to it a magnet or a piece of iron, which is again removed to a sufficient distance before making the observation.

As an example of the performance of the instrument, I select the last observation of magnetic declination I have made.*

Greenwich Mean Time.	Observed Azimuth of line of Collimation of Magnet: mean of two Verniers.
1854, April.	Before reversal of magnet.
10^d 1^h 30^m	77° 46′ 10″
34	46 10
38	46 5
	After reversal of magnet.
1^h 45^m	77° 43′ 37″
48	43 45
51	42 25
Mean of all, 1^h 41^m	77° 44′ 42″

Azimuth of the magnetic axis of the magnet	=	77°	44′	42″
Azimuth of true north . . .	=	102	48	44
Variation of needle	=	25°	4′	2″ west.

The Kater's circle, by means of which these observations were made, has both its vertical and horizontal limbs 6·5 inches in diameter, each furnished with two verniers, reading 10″. The azimuth of the true north was deduced from transits of the sun, taken near the meridian, in the following manner:—The vertical circle being placed approximately in

* This paper was read on 19th June 1854.

the meridian, the sun's transit over the five diaphragm wires was observed; and the error and rate of the chronometer used were ascertained by comparison with the Edinburgh time-ball within an hour after observing the sun. The Greenwich mean time of the sun's transit across the theodolite wires was thus obtained,—the correction for the *rate* of the chronometer in the short interval between the observations of the sun and the time-ball never exceeding $0^{s} \cdot 1$. The sun's hour-angle, at the instant of his transit across the middle wire of the theodolite, was then easily found from the known longitude of the station; and the deviation of the plane of the instrument from the meridian was calculated with sufficient accuracy by the formula

Sun's hour angle × cos. sun's declination × cosec. sun's zen. dist.

In this manner, on various days, I obtained seven observations for the azimuth of the true north, the greatest difference between any single observation and the mean of the whole being 30″.

I have ventured to give this brief description of the process by which the variation of the needle given above was ascertained, not on account of any novelty it possesses, but merely to enable the reader to judge what degree of reliance is to be placed in the result.

A Description of certain Mechanical Illustrations of the Planetary Motions, accompanied by Theoretical Investigations relating to them, and, in particular, a new Explanation of the Stability of Equilibrium of Saturn's Rings. By JAMES ELLIOT, Teacher of Mathematics, Edinburgh.*

SILVER MEDAL, VALUE TEN SOVEREIGNS, AWARDED.

Orreries, as they are called, have been constructed with much elaborate ingenuity, and rendered capable of exhibiting the motions of the planets to a surprising degree of accu-

* Read before the Society, 27th February and 13th March 1854.

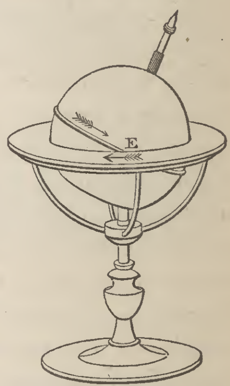
racy; but they are so complicated and cumbrous in their machinery—so constrained in their movements—so totally different from that which they represent, in regard to their moving principles (their toothed wheels, pulleys, and inclined planes being utterly unlike the laws of attraction and inertia)—that they are seldom regarded in any other light than as mechanical curiosities, and are rarely used for *explaining* the subject of astronomy. In them we look in vain for imitations of

"Heaven's easy, artless, unencumbered plan"

(to borrow a description applied to a higher subject), and long for illustrations more simple, and governed by laws more nearly related to those which govern the planets themselves.

On first commencing the study of astronomy myself, and endeavouring to obtain a distinct conception of that motion of the earth which gives rise to the precession of the equinoxes, it occurred to me that I had seen the same motion in spinning a hoop or a halfpenny. Thence I traced it to the top and the te-totum. Afterwards, in teaching the subject, it appeared to me that, if I could reduce their untractable movements to some degree of management, I might obtain a useful auxiliary to my explanations. There is so much difficulty in imparting to learners a distinct idea of the motion alluded to,—in making them conceive the possibility of a rotation of the earth about its axis in one direction, and a simultaneous revolution of that axis itself, carrying the earth with it in the opposite direction, that we naturally look around for any illustration that can be given of it more satisfactory and more natural than turning the model with the hand. About the same time my attention was also more particularly directed to the same point by meeting with a remark in Sir John Herschel's excellent volume on Astronomy. "A child's peg-top," he says, "or te-totum, exhibits, in the most beautiful manner, the whole phenomenon," of the precession of the equinoxes, "in a manner calculated to give at once a clear conception of it as a fact, and a considerable insight into its cause as a dynamical effect." So far well; but this objection comes in the way—an objection which, of course, the writer just quoted did not overlook—that, in all ordinary tops and te-totums, the motion in question is in the contrary direction to that which we are required to illustrate in the planets, the conical revolution of the axis being, in the former, in the same direction with the rotation, while, in the latter, it is in the opposite direction.

I observed, however, that in tops which have short pegs, this motion—the conical motion of the axis—is slower than in those which have long ones; and, in fact, the shorter the peg, the slower the revolution. It therefore occurred to me that, if we could lower the centre of gravity till it coincided with the centre of motion, this movement would cease altogether, and the top would continue to spin with its axis pointing permanently in any direction in which it might be placed. I also concluded that, if we still further extended the same change which gradually annihilated the positive motion, it would re-appear negative, or in the opposite direction. With that view I had an instrument constructed of the form shewn in the annexed cut, consisting of a wooden ball hollowed out in its lower part, so as to admit the support upon which it rests to be raised above the centre of gravity of the ball, and with a screw upon its peg, or axis, to admit of its being raised or lowered at pleasure. I also confined it to one place by forming a small cavity on the support for the point of the peg to run in. This being done, I was much pleased to find my expectations exactly realized. By adjustments of the screw the conical revolution could be quickened, retarded, annihilated, or reversed, as might be desired; and all its motions were brought under perfect control. At the same time it was surrounded by a fixed plane to represent the ecliptic, its own equator being marked upon it; and, by forming the axis of



hard steel, and giving it a support of agate, its velocity could be kept up without much abatement for a long time.*

The rotation is produced in the ball by means of a string and handle, much in the same way as that in which a humming-top is spun.

The case in which, from the two centres coinciding, the axis remains fixed in one direction without any conical revolution, enables us to illustrate clearly what is meant in astronomy by the *Parallelism of the Earth's Axis*, since the model may be carried by the hand slowly round in any circular or elliptic orbit, without any perceptible deviation of the axis from its original direction.

But, when the centre of gravity is brought slightly below the point of support, we are then enabled to show the deviation from parallelism which arises in the direction of the earth's axis after a long period of years, the same motion exhibiting the *Precession of the Equinoxes.* With the centre of gravity so placed, if the ball is made to rotate in the direction marked by the upper arrow, on the figure, or from west to east, the equinoctial point, E, is observed to move slowly in the direction marked by the lower arrow, from east to west. The latter motion may be made as slow as we please; so as to approach, within any degree of closeness, the exceedingly slow precessional movement of the earth's equator.

We have thus succeeded in obtaining, in the model, the precise motion of which we were in quest; but if it can also be established that that motion is not only the same as the corresponding motion of the earth, but arises from the same cause, every object will have been attained that can possibly be desired in a model. To establish that, however, will draw us into somewhat abstruse and lengthened theoretical considerations, to which a patient attention must be requested,

* Since the model described was constructed, my attention has been directed to Bohnenberger's instrument for the same purpose, of which I was not previously aware. While that instrument is exceedingly beautiful, and adapted to various experiments on rotatory motion, for which the model described above is not intended, it wants (as will readily be admitted) the simplicity and capability of precise adjustment of the latter, and is not so well adapted for the particular purpose of *astronomical* illustration.

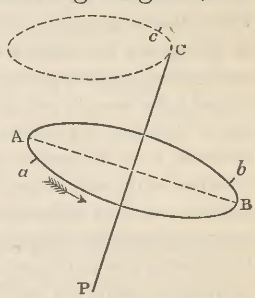
since they are absolutely indispensable not only to a right appreciation of this particular instrument, but to the elucidation of other parts of the subject.

The first point to be ascertained, then, is—what physical cause produces the conical motion of the axis, either in the instrument before us, or in the common spinning-top? and that question throws us back upon another,—what prevents a spinning-top from falling?—in what way does its motion keep it in an erect position?

A popular notion is that the standing of a top is due to its centrifugal force. The fallacy of that idea is very well exposed by Dr Arnott. He shows that (since the force acts equally on all sides of the axis) if the axis is placed upright, the centrifugal force can have no tendency to incline it to one side more than to another, and can have no more effect in doing so when the axis is inclined. The inclination of the top can have no effect in changing the direction of the centrifugal force, which will still act perpendicularly to the axis, and equally on all sides, neither accelerating nor retarding the fall.

Dr Arnott having shown the fallacy of the opinion that centrifugal force is the cause, substitutes, in its place, another equally fallacious. "While the top," to use his own words, "is perfectly upright, its point, being directly under its centre, supports it steadily, and, although turning so rapidly, has no tendency to move from the place; but, if the top incline at all, the side of the peg, instead of the very point, comes in contact with the floor, and the peg then becomes a little wheel or roller, advancing quickly, and, with its touching edge, describing a curve, as a skater does, until it comes directly under the body of the top, as before." This theory may, at first sight, seem plausible, but is liable to three fatal objections. First,—an inclined cylinder, rolling upon one end, never would roll towards the centre, but, on the contrary, would continually deviate further from it, unless its upper extremity were supported. Second,—the cause would cease, and the top would immediately fall, whenever any small hollow confined its point to one spot, as frequently happens. And, third,—if the standing of the top depended upon the thickness of the point, the finer the point the more difficult it would be to keep up the top; and, if the peg could be ground to a mathematical point, the top would invariably and instantly fall. It is needless to say that such a conclusion is contrary to common observation, which shows us that, in mathematical language, the tendency to fall is no function of the fineness of the point.

In comparing the motions of the top with those of the earth, I thought that I perceived the true reason of the top's standing, viz., that the tendency to fall is converted by the rotation into the conical motion of the axis which I have before described. But, to render this clear, let us commence with the common form of the top in which the centre of gravity is above the centre of motion, and let us suppose, for the sake of simplicity, the top to consist of a single circular plate, or, if we choose, we may take a top of any form, and suppose its whole mass to be concentrated in a single circular section perpendicular to the axis, and the whole weight of that section to be again collected into one circumference, as a hoop around an axis. Further, suppose such a top already inclined to one side, as in the following diagram, CP being the axis, AB the circular section, or rather the circumference, just described, and the arrow pointing out the direction of rotation. The top will then have a tendency to turn over towards that side which is lowest, in doing which, the lowest point, B, of the circumference, would, of course, fall; while the highest point, A, would necessarily rise. But the point B, in beginning to fall, is, at the same time, carried forward from B to *b*, conveying the tendency to fall with it, so that the actual fall would take place at a point, *b*, immediately in advance of the lowest; at the same time, the highest point, A, beginning to rise, carries that rise forward to a point, *a*, immediately in advance of the highest.* Now let us observe the effect



* No doubt, every point in the semicircumference next B, has a tendency to fall, and every point in the opposite semicircumference A, to rise. But the

which this has produced upon the top: the point a, in advance of the highest, is raised, and the point b, in advance of the lowest, is depressed: this change tilts the top over, if I may so express it, aside from its former inclination, bringing the higher extremity of the axis from C to c, and making it now lean towards the side immediately in advance of its former position, and, if continued, produces the slow conical revolution of the axis which I have pointed out before, and an accompanying revolution of the lowest and highest point in the circumference, *both* in the same direction as that of the rotation. *Into that conical movement, then, the tendency to fall is converted.**

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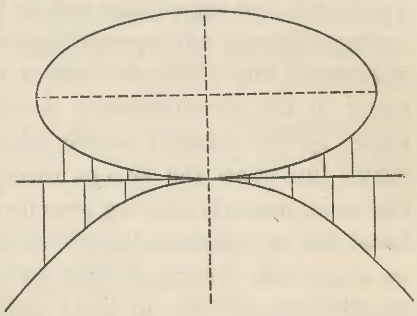
greatest rise and the greatest fall would take place at A and B, and the united effects of the tendencies of all the points in each semicircumference is the same as if the whole were accumulated at one point.

* This explanation of the standing of a top is not so new as I supposed. When the communication was read to the Society, and subsequently, it was pointed out to me that the same thing might be found in Euler's work entitled "Theoria Motus Corporum Solidorum seu Rigidorum," and also in the works of Poisson and Whewell. I admit it *to a certain extent*, although I was previously ignorant of the coincidence. With regard to Euler, however, his investigation is altogether so obscure that it may be doubted whether the theory of the top can be obtained more easily from the top itself, or from Euler's investigation, supposing it accurate. Throughout the whole of it, I cannot find it distinctly brought out that the top's tendency to fall is converted by the rotation into the precessional (or rather retrocessional) movement. That *seems*, however, to be his meaning, but under symbolical expressions. At the same time he clearly and distinctly assigns a cause of the top's rising to a vertical position, not only different from that which I have given, but different from that which he himself appears to assign as the cause of its not falling. He attributes the rise to friction. In chapter xvii. he says expressly:—"Nunquam enim turbo magis fiet erectus quàm fuerat initio, siquidem nulla affuerit frictio." Now the cause to which I ascribe the rise (whether correctly or not), has no connection whatever with friction, and is the very same with that which I have maintained prevents its fall. Practically also I have endeavoured to deprive my model of friction as far as possible, and yet it rises equally well. No doubt the peg is prevented from sliding or rolling from its place by confinement to the agate cup, and if that were what Euler means by friction, or if it served the same purpose, the matter would be simple enough; but he appears himself expressly to say otherwise; for he goes on:—"At frictio cessare nequit nisi cuspis turbinis in eodem loco persistat," indicating clearly that he does not consider confinement of the peg to a particular place as identical with friction. In fact it is on this last statement that a peculiar position is taken by a writer in the Cambridge Journal (in an article also pointed out to

But the demonstration is as yet incomplete; for, although I may have shown that the point which was the lowest at first will no longer be the lowest, unless I can also show that the *new* lowest point will not be lower than that which was previously the lowest point, the top *will* fall, in spite of this secondary preserving motion. How, then, can it be established that it will not be so? It cannot be proved generally: to do so would be to prove too much; for a top sometimes *does* fall: but the same theory, a little extended, will show *under what circumstances* it will fall, and under what it will not.

The same things being assumed as before, let us further suppose our imaginary circumference to be divided into portions equal to the spaces through which any point moves, in its rotation, in given times. Let us also imagine a vertical plane to touch the circle in its lowest point, and the circle, with the points marked upon it, to be orthographically projected upon that plane, as in the annexed diagram. Again, from the points thus projected upon the circumference of the ellipse, let perpendiculars be drawn to a line touching the ellipse in its lowest point. These perpendiculars will be



equal to the abscissæ of the ellipse for the projected points,

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me when the first part of this communication was read to the Society), who attempts to explain and support Euler. He offers to rest the practical proof of Euler's theory on the fact that a top cannot be made to rise when spinning on a very fine point. I showed to the Society a top rising to a vertical position, and spinning perfectly well on the point of a fine sewing needle.

Poisson is much more clear in regard to the conversion of the fall or rise into the conical motion of the axis, but I cannot find that he enters into any explanation of a top of the common form (that is, with the centre of gravity above the point of support) rising towards a vertical position. Still his demonstrations are quite sufficient for establishing my main point, the identity of the top's motions with those of the earth in their principle; and if I had seen his work and set off upon the conjugate axis. Let the same distances be set off upon the tangent line which were previously set off upon the circumference of the circle: these will be the distances through which any point in the circumference would move in the given times, if allowed to advance in a rectilineal direction. Through these points let vertical lines be drawn equal to the spaces through which the lowest point in the circumference would descend in the same times, if the rotation were stopped and the top allowed to fall, turning on its pivot. The curve connecting the lower extremities of these vertical lines will be an approximation to the parabola, and, in fact, for a small portion at the vertex, may be regarded as a parabola, the vertical lines being equal to its abscissæ.

Now, it is a familiar law in dynamics, that, if two forces act upon the same body in the same direction, the resulting force is the sum of the two; but if in opposite directions, the difference; and forces are measured by the motions which they produce in the same mass and in the same time. In the preceding diagram, the perpendiculars on the upper side of the horizontal line show the spaces through which the lowest point in the circumference would be *raised*, in the given times, by the rotatory motion alone; those under the horizontal line show the spaces through which it would *fall* in the same times, if obeying gravity alone. Since these forces, then, are in opposite directions, the resultant force will be equal to their difference, and the resultant motion equal to the difference of the motions which those two forces would produce in the said times. There will, therefore, be a rise or a fall of the lowest point according as the perpendiculars above the horizontal line, or those below, are the greater.

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previously, I might have satisfied myself with quoting it, instead of entering so fully into the subject.

Professor Whewell follows pretty closely in Euler's track, adhering to the same cause assigned by the latter for the rising of the top, viz., friction, but putting it forward with hesitation, and not supporting it by any demonstration. (*Dynamics*, Book iii., Sect. ii.)

I have also been referred to the Lectures and Tracts of Professor Airy. These bring out the theory clearly and explicitly with reference to the earth itself: but in regard to *it*, I have advanced nothing as new: my subject is—not the earth, but the model.

It is, however, the first pair of these perpendiculars—that is, the nearest to the point of contact—which determines the resulting motion: if the first perpendicular, or abscissa, of the parabolic curve be greater than the corresponding abscissa of the ellipse, the lowest point will descend still lower, and the top will fall; but, if less, the lowest point will attain a higher place, and the top will rise towards an upright position.* Now, since the form of the ellipse, corresponding to a given inclination of the top, is constant, while that of the parabola widens or contracts as we increase or diminish the velocity, it is evident that such a velocity may be given to the top that any abscissa of the parabolic curve shall become less than the corresponding abscissa of the ellipse, and that, when such is the case, the top will rise towards a vertical position.

For the sake of simplicity, I have spoken of the distances set off, and consequently the abscissæ and ordinates as of definite lengths; but, to those who have made mathematical subjects their study, it will be evident that, in order to be

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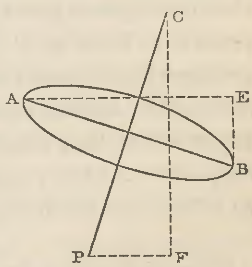
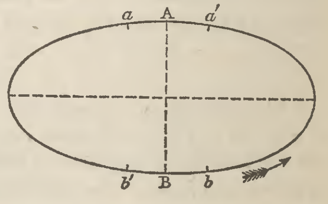
* The tendency to rise or to fall (or rather the excess of tendency in favour of a rise or of a fall) will never cease (the velocity of rotation being constant), but will *continue* to urge the top either to rise towards a vertical position, or to fall to the ground. For, A B being the same circumference which we have supposed throughout, and C P the axis of the top, let the angle of inclination of the top vary: the abscissæ of the parabolic curve above described vary as the force downward (or tendency to fall), and this varies as the sine of the angle of inclination, P C F. The abscissæ of the ellipse vary as the conjugate axis,—that is, as E B; and E B varies as the sine of the angle E A B, or P C F. Therefore the abscissæ of the parabola vary as those of the ellipse. Consequently, if the advantage is in favour of either in any one position of the top, it will continue so in every other; and if the top *begin* either to rise or to fall, it will *continue* to do so, so long as the velocity remains unchanged. But though the *ratio* of the said abscissæ continues the same, their *difference*, when in favour of the ellipse (which difference measures the preponderance of the upward force or of the tendency to rise), will continually diminish. This difference will vary as the sine of the angular distance remaining to be passed over, and ultimately as the distance itself; therefore, I presume the axis will approach the vertical line in an endless spiral, and will never attain an actually vertical position.



strictly correct, the second point in each curve must be taken *in immediate succession* to the first, making the first ordinate and abscissa infinitely small. In this case their relative magnitudes may be calculated by means of the differential calculus; or the result may, I think, be shown to depend upon the following principle, which, *if what I have already said be admitted*,* will be a self-evident consequence of it. *When the radius of curvature of the ellipse, at its lowest point, is greater than that of the parabolic curve at its vertex, the top will fall; when less, it will rise.*

The same theory applied to that form of the top in which the centre of gravity is below the centre of motion will show that the conical revolution of the axis must then be *backward*, or in a contrary direction to that of the rotation; for in this case the tendency of the top, when at rest, is not to fall but to attain a vertical position. The lowest point, B, in the circumference, having a tendency to rise, and the highest point, A, to fall, both these tendencies will, by means of the rotation, produce their effect in advance of the highest and lowest points, depressing the point a and raising the point b. If we stop the motion of the top and produce the same effect with the finger, we shall find that the highest point is thus thrown back to a', and the lowest point also back to b'; and this process, being continued, will produce the *retrograde* conical motion exactly as experiment shows it. In this case we are not required to prove that the top will not fall, since it will not do so when at rest. The only effect of the production of the conical movement will be to retard the tendency towards a vertical position.



* There will probably be some hesitation in accepting the preceding part of this investigation as strict demonstration. I have the same hesitation myself, and rest nothing upon it. I rather throw it out as a suggestion for consideration. It has at least simplicity in its favour, which Euler's theory assuredly has not. My doubts, however, do not extend to the main point,—of the tendency of the top to fall or rise being converted by the rotation into the forward or backward precessional movement. That does not admit of doubt, and is the only part of the theory which I use for astronomical application.

When the centre of gravity coincides with the centre of motion, there will be no tendency either to fall or to rise; consequently, no conical revolution; and the top will continue to revolve in any position in which it may be placed, without any change either in the direction or in the inclination of the axis.*

The theory I have thus attempted to establish is borne out, in its main points at least, by experiment, as we have seen in the different movements of the revolving sphere already described. An additional instance is, that our theory leads obviously to the conclusion that, with any given position of the centre of gravity, the more rapid the rotation the slower will be the conical revolution, and that this is at once confirmed by trial with the same apparatus.

The conical revolution of the axis, in the model, not only illustrates that of the earth, but appears to me to depend on the same or a similar cause. There are, however, some objections to this idea, *in limine*, which it may be as well to dispose of first. I have already stated that this motion of the top depends on the relative positions of the two centres. Where, then, it will be asked, are those centres in the case of the earth itself? Before I can answer this I must come into collision with one of our most common, and, I must admit, most useful ideas in physics,—that of *a centre of gravity*. It is one of those hypotheses or theories which we meet with every day, answering very well all ordinary purposes, and yet only approximately true. Such a thing as a fixed centre of gravity exists not in nature, or at least but one,—the centre of the whole material universe. The idea of a constant centre of gravity in any particular body depends upon

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* There is another movement of the top, to which in this place I can only briefly allude. It may be called its *erratic motion*. When the pivot is not confined to a point, but running upon a smooth and level surface, with the axis inclined, the top describes a circular orbit, by no means capriciously, but subject to given laws. Its periodic time is the same as that of one revolution of the equinoxes, and its diameter is a fourth proportional to the time of one rotation on the axis, the time of one revolution of the equinoxes, and the diameter of the point of the peg where it rolls on the table.

the supposition that the force of attraction is equal at all distances from the attracting centre. Let us conceive a straight uniform rod to be placed in a vertical position, and divided into two equal parts: the lower half will be the heavier, because nearer to the earth's centre; the centre of gravity will therefore be below the middle of the rod. Let us now conceive the position of the rod to be reversed, the upper end exchanging places with the lower: the centre of gravity will then be on the other side of the middle—in that half which was formerly the higher—it will have changed its position in the rod. It follows, then, that in any mass of matter the centre of gravity will not be a fixed point, but will depend upon the position of the mass, and that it will always be in that side of the mass which is nearest to the attracting body.

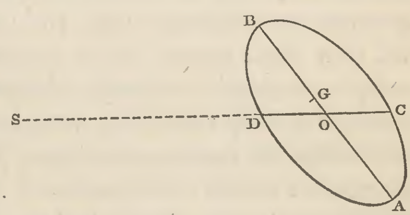
The *centre of momentum*, however, though commonly confounded with the centre of gravity, is not the same; but as this is a rather nice point, and not usually taken notice of, I hope to be excused in saying a few words in explanation.

If two solids, of the same size, differ in weight from a difference in their specific gravity, the heavier has the greater momentum; but if they are alike both in size and in specific gravity, and their difference in weight is caused by a difference in their height above the surface of the earth, then their momenta are equal notwithstanding their difference in weight. Thus, if a cannon-ball were fired from the summit of a mountain, it would strike an object with as much force as it would do if fired, with the same velocity, at the level of the sea, although the weight would be much less.

Apply this now to the case of the straight rod. The lower end is the heavier, but it has not the greater momentum. The centre of momentum is therefore in the middle of the rod, while the proper centre of gravity is not so. In fact, what we commonly call the centre of gravity is truly the centre of momentum. The same reasoning applies to the earth in reference to the sun's attraction: its centre of momentum—the centre round which it revolves in its diurnal motion—is the centre of the sphere (or spheroid); while the varying centre of gravity is always within the hemisphere nearest the sun. Here, then, is the very desideratum supplied, to complete our analogy between the earth's motions and those of the top: here are our two centres,—the one the centre of the mass, the centre of momentum,—the other the proper centre of gravity.

The next difficulty is this. Sir Isaac Newton, as is well known, has demonstrated that the conical revolution of the axis would not belong to the earth were it a perfect sphere, but that it is indebted for it to its spheroidal form; whereas the same motion in the top is independent of its form. The reply to that is, that there is no tendency to such a motion in the top while in a vertical position,—that is, when its centre of gravity is directly above or directly below its centre of motion, because then there is no tendency either to fall or to rise, and that the same thing precisely would be the case with the earth if it were a perfect sphere: the centre of gravity would then be directly between the sun and the centre of momentum. But, in the case of a spheroid, the centre of gravity will be a little out of that line, producing a tendency to fall into it, and this tendency is converted into the motion in question.

Thus, let the point O be the centre of the spheroid AB, and consequently its centre of momentum: let the line AB be the transverse axis, and S the attracting body; and let the spheroid be divided into two half spheroids by a plane, CD, coincident with the line OS, and perpendicular to the plane BOS. Then, since the half spheroid, CBD, is nearer to S than the other half, CAD, the centre of gravity, G, will be in the former half, and consequently out of the line OS. Therefore the axis, AB, will be drawn in towards the line CS, while no such tendency would arise in the sphere, and consequently no conical revolution of the axis.



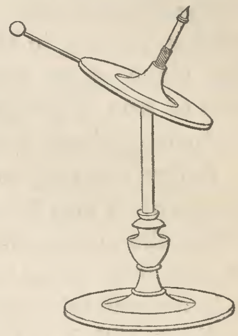
These two objections being set aside, it will readily be perceived that the tendency of the line AB to fall into the line OS, exactly corresponds to the tendency of the top to fall, or to the tendency of the revolving ball of the model, when its centre of gravity is below the point of the pivot, to bring its axis into a vertical position, and, consequently, that the same results must follow. The conical motion produced in the axis of the ball corresponds to that which goes on in the axis of the earth, not only in its existence but also in its cause.

Thus, then, we have two motions of the model agreeing with two corresponding motions of the earth,—viz., the *Rotation* and the *Precession of the Equinoxes*, which is identical with the conical motion of the axis. If we place the instrument, while in motion, upon a stand, and suspend the stand by a cord, from a great height, we may then, as is well known, exhibit the *Elliptical Orbit*, and also the *Progression of the Apsides*.

If we next load the sphere, on one side, *very slightly*, by any means, we obtain an illustration of the *Nutation of the Earth's Axis*, the axis making a multitude of minute conical revolutions round the circumference of the greater conical revolution. Neither are the causes very different in the model and in that which it represents; for the moon's attraction does to the earth what the little weight does to the model: it loads it on one side. The periods of the motions, however, are different in the two; for, in the earth, the period is a lunar month; in the model, a day. This cannot easily be avoided; although, if desired, the period *might* be obtained strictly correct by means of a revolving magnet, representing the moon, acting upon the iron circle which forms the equator of the model earth.

The next motion illustrated by the apparatus is the gradual *Diminution of the Obliquity of the Equator to the Ecliptic*. In the case of the earth itself, Laplace has computed that the diminution is not permanent, but confined within certain limits both of time and of extent, the obliquity, after a long cycle of years, again increasing. In the case of the model, however, the obliquity continues to diminish, an upright position of the axis being constantly approached, but, as I have attempted to demonstrate in a previous note, never attained. The reason of the difference it is not easy to perceive.

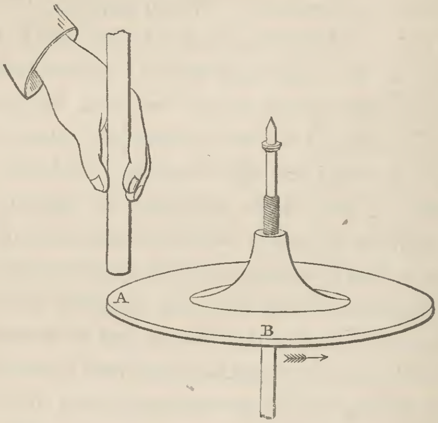
The next piece of apparatus is intended to exhibit the *Retrogradation of the Moon's Nodes.* That phenomenon is similar to the precession of the equinoxes, both in its description and in its cause. In the model, we have the same similarity: we have the plane of the moon's orbit occupying the same place which the earth's equator occupied in the first experiment. Like the plane of the equator, it is inclined to the plane of the ecliptic, the two points in which it cuts that plane, called its nodes, corresponding exactly to the equinoxes in the other case. When the line of the nodes is in the same line with the centres of the earth and sun, we have eclipses of the sun and moon; when otherwise, the moon passes its change and full without eclipses of either luminary. The line of the moon's nodes revolves in a direction contrary to that of the moon's revolution round the earth. There is the same difficulty of conveying a clear idea of this motion by mere words to students of astronomy, that there is in the precession of the equinoxes; but all the difficulty disappears when we can actually show the movement, and that not under the constraint of wheels and bars, but under the impulse of gravitation and inertia.



The cause of the peculiar motion in the model is *similar* to that which produces the corresponding changes of the direction of the plane of the moon's orbit itself, but is not precisely identical with it, inasmuch as, in the model, the force of attraction acts upon the whole plane, while, in the reality, it acts only upon the moon whilst moving in that plane. But the difference is more in appearance than in kind, since we may conceive the solid orbit in the model to consist of a multitude of moons; and, since the effect upon each must be the same, the result will be the same, as in the case of a single moon. The effect will not even be magnified, since the inertia is increased in the same proportion in which the attraction is increased.

Another application of the same model is, to exhibit and illustrate the various kinds of *Perturbation* which one planet exercises on another's orbit. As in illustrating the moon's motion, we use, in this case also, instead of the planet itself, the plane of its orbit, or, more correctly speaking, a solid disc of iron in the position of that plane. The place of the disturbing planet is supplied by a magnet.

Before entering on the astronomical application of the experiment, it may be curious to observe the peculiar way in which the disc is affected by the magnet. When the disc is at rest, if we bring the magnet near it, either above or below, it is immediately attracted by the magnet and brought into collision with it. But if the disc is made to rotate with suf-



ficient rapidity, and the magnet is again brought near it, as before, it now *seems* no longer to be attracted by the magnet, but rather appears to evade it: you might almost be persuaded that the magnet had a repulsive effect upon the disc.* But it evades it in different ways (at least apparently), according as we present the magnet to it in different positions. When the disc is revolving horizontally, the magnet, pre-

* The peculiar fact of the rotating iron disc evading the direct action of the magnet, was first shown to me by a friend, but with no perception, on his part, either of its cause, or of its connexion with astronomy.

sented above or below any point of the circumference, converts that point into one of the nodes, the half orbit in advance of that point inclining upward or downward towards the magnet, and the other half receding from it. Thus, in the preceding diagram, the direction of rotation being from west to east, as indicated by the arrow, and the magnet being suspended over any point A, that side of the disc does not rise towards the magnet, as we might expect, but the side B does so, a quadrant in advance, while the semicircle opposite B sinks. Again, when the orbit is already inclined, if we place the magnet above the highest point of the disc, or beneath the lowest, the effect is not to increase the obliquity of the orbit, as we should anticipate, but to produce a progressive or forward motion of the nodes. If we present it below the highest point, or above the lowest, it does not diminish the obliquity of the orbit, but causes a retrogradation of the nodes. If we apply it below the descending node, or above the ascending, we do not draw that side towards the magnet, as would appear likely beforehand, but we increase the obliquity of the plane to the horizon: if above the descending node or below the ascending, we diminish the obliquity.* When a circular plane, to represent the ecliptic, is fixed round the revolving disc, as shown in the annexed woodcut, the results are more quickly made manifest, and a screw upon the axis of the disc enables it to be adjusted beforehand, so as to be free from any forward or backward motion of the nodes independent of that caused by the influence of the magnet.

Now, the various effects just described are precisely those which the attraction of one planet produces upon the plane of another's orbit, in the eight different positions described.

* A slight touch of the finger on the revolving disc produces exactly the same effect as the magnet applied on the opposite side. The finger must be kept upon the disc with a gentle pressure, rubbing smoothly over it, so as not to stop it.

The *cause*, in the case of the metallic disc, is exactly the same as that which, we saw, produced the precession of the equinoxes. The point immediately under the magnet is attracted by the magnet, but the effect, in consequence of the rotation, takes place in advance of that point. The very same cause produces the reality represented by the model, in the case of the planets. The action of the magnet upon a metallic plate is not really different from the action of one planet upon another, as far as the plane of the orbit is concerned; for we may suppose, as we did before in the case of the moon, every part of the plate to be a planet; and the magnet influences each part, as it passes it, in the same manner that the one planet influences the other.

The circumstance of the magnet's being applied nearer, and more perpendicular to the orbit, than in the case of the planet, does not affect the result except in degree. It is brought near in order to make the effect more apparent; and, as to the perpendicular direction of its action, it may be remarked that, in the case of the planets themselves, the attraction of the disturbing planet, when not in the plane of the other's orbit, may be resolved into two forces—one in the direction of that plane, and the other at right angles to it: the former is employed in changing the form of the orbit, the latter in changing its direction: it is the latter that is represented by the magnet; and, since it is actually perpendicular to the plane of the orbit, the position of the magnet truly represents it.

The effect of the force in the direction of the plane of the orbit, in altering the form of the orbit, might also, perhaps, be shown by means of a magnet acting upon a loose chain, previously made to revolve as a circular ring by centrifugal force; but the result I have not found to be sufficiently decided to be easily observable by the eye.

I come now to my final application of the same principle which has pervaded all the previously described illustrations of the planetary motions. It is well known to those who have studied the subject, that the theory of Saturn's ring involves a difficulty from which it has never yet been satisfactorily freed. It is agreed on all hands that the assumption and maintenance of the annular form is due to the centrifugal force arising from its rotation; but the difficulty is of another kind; it has arisen from a supposed demonstration by Laplace, in which, as far as I am aware, all other astronomers have acquiesced—that a uniform ring, revolving round a centre of attraction, will be in equilibrium only when the attracting centre coincides mathematically with the centre of the ring,—that, consequently, the equilibrium is unstable; so that, if either the attracting object or the ring be displaced in the least, they will inevitably approach each other till they come into collision. But, though the planet Saturn were poised, with mathematical accuracy, in the centre of his ring (a circumstance without a parallel in astronomy), the nice adjustment would not continue a single day, for it would be immediately disturbed by the varying influence of the other planets and of its own satellites. And not only are there abundant and constant causes to disturb that adjustment, if it existed, but it has been shown, as Sir John Herschel states, " by recent micrometrical measurements of extreme delicacy, that no such adjustment exists, but that the centre of the rings oscillates round that of the body, describing a very minute orbit."

If, then, according to Laplace, there is no stability in the equilibrium of a uniform ring, it follows that, unless there were some preserving contrivance—some counteracting circumstance, that beautiful mechanism would inevitably fall to pieces. For this purpose, Laplace has recourse to the expedient of supposing that the ring must be loaded on one side. That load, having of itself a tendency to describe an elliptic orbit round the planet, like a satellite, will drag the rest of the ring with it. The motion will thus belong to the load, the ring, large as it is, being merely its encumbrance.

To that hypothesis, there are serious objections. In the first place, the load is almost hypothetical; for although some slight apparent inequality may be observed in the different parts of the ring, yet nothing to justify Laplace's idea,—nothing which could be regarded as sufficient to bring about the result on which he calculates. In the second place, the expedient seems to be destitute of that elegant simplicity so conspicuous in the laws which govern the other parts of the planetary system. In the third place, if that load were carried round, like a satellite, and the rest of the ring dragged round by the load, the period of revolution would not be identical with that of a satellite at the same distance as the ring; for the attractive force exerted upon the load, being equal to that upon such a satellite, and the inertia greater in consequence of the superadded mass of the rest of the ring, the time would be proportionally greater. But Laplace has himself proved that such a velocity of rotation is absolutely necessary to preserve the very form of the ring. Laplace's reply to this objection would probably have been, that the planet's attraction acts upon the ring also, as well as upon the load. But he does not say so; and if he had said so, it would have entangled him in such complicated laws, involving both ring and load, that he could no more have established the stability of equilibrium with these than with the simple uniform ring—in fact much less easily.

Sir John Herschel, dissatisfied with Laplace's hypothesis of the load, is driven into another, which appears to me to be no less objectionable. He thinks he perceives, he says, "in the rapid periodicity of all the causes of disturbance, a sufficient guarantee for its preservation;" or, in other words, if I understand him right, the displacement which one planet or satellite causes, another planet or satellite (or the same on its return) restores. He afterwards compares this to "the mode in which a practised hand will sustain a long pole in a perpendicular position, resting on the finger, by a constant and almost imperceptible variation in the point of support." His idea would be precisely realized, if, for the balancer's hand were substituted some ingenious piece of machinery, with its motions so nicely arranged beforehand as precisely to adapt itself to every foreseen and previously calculated displacement of the pole; or rather, perhaps, the author would say, with the pole so nicely placed at first, that every little nod would come just in time for the counteracting motion of some one of its wheels. But, it may be replied, there is no other position or arrangement among any of the heavenly bodies in which any extreme precision of original adjustment has ever been detected: instead of that, they have been subjected to laws by means of which every little displacement *produces its own remedy*, and is its own restoring cause. This rule has been proved, I believe, to hold good throughout all the other motions of the solar system, principal and subordinate; and, if this were an exception, it would be the only exception, standing out as a solitary example of its own kind. No doubt, if any *necessary* connexion could be shown to exist between the displacing and the supposed restoring causes, the general law would, in this instance also, hold good; but no attempt is made to point out such a connexion; nor can we even form the least conception in what way it can exist. In addition to this, the force necessary to restore an unstable equilibrium is always so immensely greater than that which has destroyed it, especially if any considerable time has elapsed in the interval, that a singularity and complexity in the restoring powers would be required, such as is altogether inconsistent with the general character of the planetary motions, if, indeed, it could not be demonstrated to be physically impossible.* No machine can be made to sustain a balanced pole. The exertion of intelligence alone can do it.

But let us examine Laplace's supposed demonstration of the instability of equilibrium of a uniform ring round a centre of attraction, and see what it amounts to, for if not conclusive, neither his own hypothesis nor that of Sir John Herschel will be necessary. After a very elaborate process of computation, to determine the proportion which the thickness of the ring should bear to its breadth, or at least the limit of that ratio, and a much simpler computation of the period of revolution which each ring ought to have in order to maintain its form by its centrifugal force, showing that that period must be the same as that of a satellite at the same distance, he proceeds to discuss the question of the stability of equilibrium, by first imagining the ring to be a mere circular

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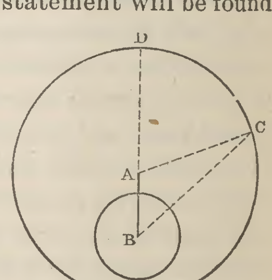
* I sincerely hope I have not misunderstood the sentiments of Sir John Herschel, an author for whom I entertain the very highest regard. Having examined his expressions carefully and repeatedly, I cannot interpret them in any other sense than that which I have attached to them.

circumference, attracted equally in all parts towards a point not coincident with its centre. He then goes on to compute the attraction existing between the centre of the ring and the centre of the planet, and, by a very refined process of integration, he determines that attraction to be *negative*, or, in other words, that these two centres, instead of attracting, repel each other, and consequently, instead of tending to return to coincidence, will continue to go more apart, until the circumference of the ring touch the surface of the planet.

It is not necessary for me to produce Laplace's calculation, since I am not going to find any fault with it as far as it goes, and its aspect is such that I am confident its attractions, for this assembly, would turn out to be of a negative kind—somewhat repulsive. All that I need to say is easily appreciated; and that is, not that the calculation is wrong, but that one of the principal elements is entirely omitted. *Of the symbols introduced into the calculation, not one has any reference to the rotation of the ring:* it is taken as at rest. How an omission so fatal should have been made on the part of so eminent a mathematician, I cannot explain; neither am I called upon to account for the circumstance of the oversight not having been detected by subsequent astronomers. In the previous part of the demonstration, no doubt, the rotation forms a principal element, but not so in that part which we are now considering. My statement will be found borne out by a reference to Laplace's celebrated work, the Mécanique Céleste, First Part, Book iii., art. 46. But to save the trouble of that reference, I will give a short sketch of his process.



A being the centre of the ring, and B that of the planet; the symbol S representing the mass of Saturn; r, the radius of the ring; ϖ, the angle DAC; and z, the line AB;* he then says,—

* The diagram rests on my own responsibility. There is no diagram for this in Laplace's work. It is presumed that no one will seriously maintain that a ring at rest and a ring in rotation, obey the same laws.

$$-\frac{d}{dz}\int\frac{S\,d\varpi}{\sqrt{(r^2+2\,r\,z\,\cos\varpi+z^2)}}$$

will be the attraction of Saturn to the ring, decomposed in a direction parallel to z; the integral being taken from $\varpi=0$ to $\varpi=$the circumference, and the differential being taken with regard to z.

In all this there is no consideration of the ring's rotation, if I can understand it aright. All that is proved is precisely what we should have anticipated without such proof, viz., that if a planet at rest, surrounded by a ring also at rest, were nearer the one side of the ring than the other, it would be drawn towards that side. Still, although this appears *likely* beforehand, it is not self-evident; for, as Sir Isaac Newton has demonstrated, it would not be true in regard to a planet placed within a hollow sphere, which is equally likely. It is very well, therefore, that Laplace *has* demonstrated it, and set the matter at rest, although, from the omission from the calculation, of any element representing velocity of rotation, the result has no bearing whatever upon the actual case of Saturn's ring,* since, as I think I am prepared to show, the very cause of the stability of equilibrium rests on the omitted consideration.

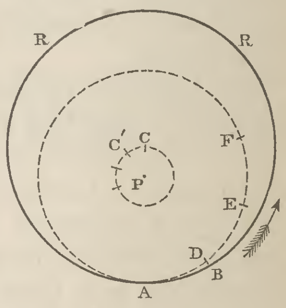
Still, Laplace is not easily understood; and if I have made any mistake regarding his meaning, I shall be glad to be set right.† But, whether or not, it does not affect my result, nor my objection to Laplace's conclusion; for, according to his own explicit statement, the only force he has computed, is that in the direction parallel to AB. I shall at once assume not only that he is right in that in the case of the ring at rest, but also that the rotation of the ring will not affect *that* force. I will therefore commence at the point where he has left off; and start with the assumption that there is a repul-

* It was, however, especially to *Saturn's* ring that Laplace's investigation was directed, and therefore the rotation was an essential element.

† I have been censured for presuming to dispute so high an authority as that of Laplace. I am not at all disposed to question Laplace's very high position as a mathematical astronomer; but the greatest of men are not infallible, and the subject is certainly a fair one for discussion, so long as I assign my reasons, with perfect willingness to retract if proved to be in error.

sion between the two centres, and, consequently, that, if the ring be displaced in the least, it will have a tendency to approach the planet on that side on which it is nearest to it; but that very tendency will produce its own remedy, by giving rise to another and a very peculiar movement, which I am now about to explain.

In considering the theory of the top, it appeared to me, that, if the top were in the form of a ring, and if an attractive force within it, such as a magnet, were substituted for the downward force of gravitation the ring would avoid falling in towards the centre of attraction by an evasive movement, similar to that by which a top avoids a fall, and similar also to that by which, as we have already seen, the iron disc avoids contact with the magnet above or below it,—that, in fact, the tendency towards the centre would be converted into a slow eccentric revolution of the centre of the ring round the centre of attraction, entirely different from the rotation of the ring itself, exactly in the same manner as the tendency of the top to fall is converted into a slow conical motion of the axis. Thus, in the following diagram, let RR be the ring, C its centre, and P the centre of the attracting power, eccentrically placed with regard to the ring, the nearest point of the ring being A. That point A, is then acted upon by two independent forces,—that of the rotation, carrying it forward from A to B, and that of the attracting power, drawing it from B towards P, and is consequently brought to a point D between B and P, while the centre of the ring passes, in consequence, into the position C′. The same movement continued brings the nearest point successively into the position D, E, F, &c., and carries the centre round the curve CC′.



It is only with a certain velocity of rotation, however, that the curve CC′ will be part of a circle. If the velocity is less than that, the point D will be nearer than A to P, and the ring will become more and more eccentric, till it is brought into collision with the attracting object, corresponding exactly to the case of the top when its velocity is not sufficient to prevent it from falling. But if the velocity is greater than that which is necessary to keep the nearest point of the ring at a uniform distance from P, then PD will be greater than PA, and the ring will become less and less eccentric, the circle, or rather the curve, ADEF gradually enlarging till it coincide with the ring, and the curve CC′ gradually contracting till it disappear in the central point. The ring then becomes perfectly concentric with the planet, and the state of stable equilibrium is restored. The latter case corresponds again to the case of the top whose velocity is sufficient to cause it to rise towards a vertical position.*

Such was my theory, formed independently of experiment, but afterwards confirmed by it. After repeated trials, I succeeded, by means of the apparatus represented in the following drawing, in showing it.

M is a magnet supported on a stand, and R an iron ring capable of revolving rapidly. E is a wooden support to contain the ring. D is an appendage employed for the purpose of bringing the centre of gravity of the whole to the same level with the point of support, and so getting rid of any conical motion which the axis of the ring might have independently of the magnet. The ring R, its support E, and the appendage D, revolve together upon a hollow on the top of the stem C, and are set in motion before the magnet is introduced. It is then found that the ring, when revolving with sufficient rapidity, is not, as Laplace asserts, in instable equilibrium, but that the rotatory motion is able to preserve it from collision with the magnet. We find also precisely the same eccentric revolution which was anticipated by theory, and corresponding exactly to that which, as I have previously stated, *is observed in Saturn's ring itself.*

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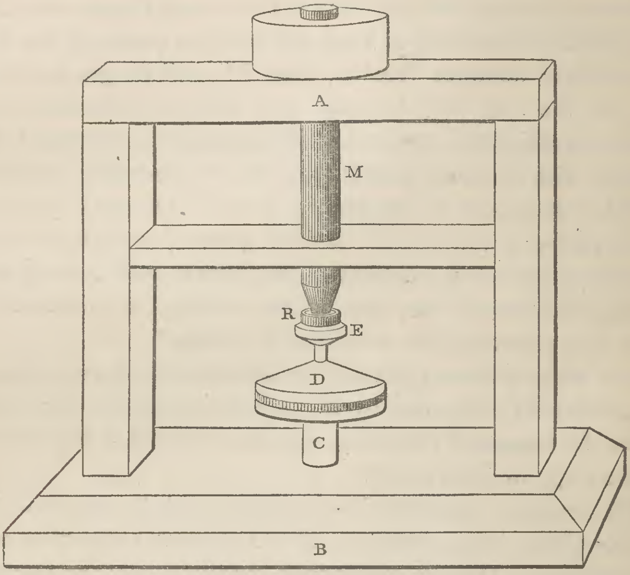
* If the top never reach a *perfectly* vertical position, neither will the ring ever become *perfectly* concentric with the planet. But it is sufficient if we establish that it will constantly tend towards that state, approaching indefinitely near to it.

The power of preserving the equilibrium, in the model, is so decided, that the whole apparatus may be turned consi-



derably on one side, without derangement, the ring accompanying the magnet; and, if so turned before the introduction of the magnet, the magnet will *bring* the ring into a concentric position, permitting its introduction into it, *while a non-magnetic bar cannot be so introduced.* The magnet, instead of causing collision, prevents it.*

I have thus, both by theory and by experiment, attempted to explain that phenomenon, hitherto, as I think, not accounted for in any satisfactory manner, and to show that it rests on the same principle as the standing of a spinning-top, the precession of the equinoxes, the retrogradation of the moon's nodes, and the perturbation of the planes of the orbits of the planets. How far I have succeeded I leave others to decide.

* The loose structure, or fluidity, of Saturn's ring will not affect my theory, so long as there is sufficient cohesion, or mutual attraction, among its component particles, to keep them together as one body, and sufficient velocity of rotation to preserve the annular form.

On an Improved Safe Lock. By George Mitchell, Letter-carrier, Edinburgh.

The following method of making a lock secure has been arrived at, owing to its peculiar (yet simple) mode of construction.

We shall at once refer the reader to the diagrams, where, with the following explanations, we shall endeavour to prove it safe to the extent that it is impossible to open the lock by any other means than with its own key.

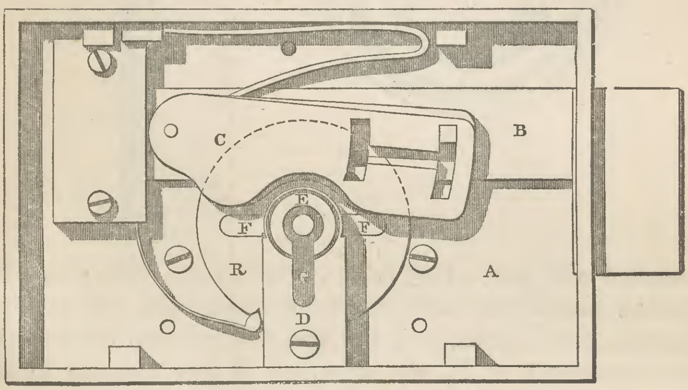


Fig. 1.

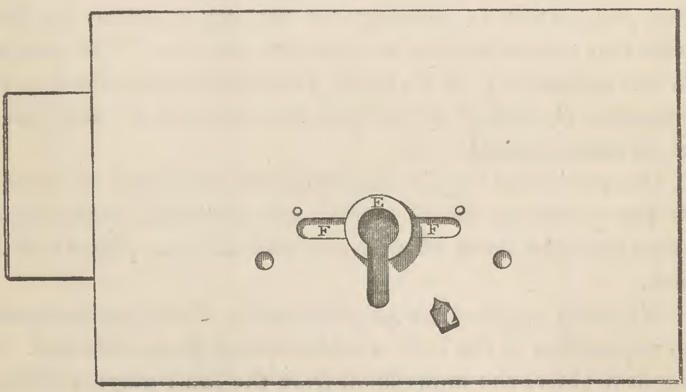


Fig. 2.

A is an inside drawing of the lock; B, the bolt; C, the players; D, the protector; E, the revolver, with the revolving plate, R, which is made fast to the revolver, E, at a distance equal to the thickness of the lock. FF′ (of figures 1 and 2) are entrances to the lock from behind. G, entrance to the false chamber, O, which is made fast to the back of the lock. Fig. 3 is a drawing of the false chamber, which is

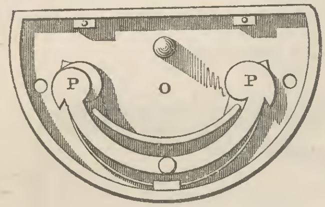


Fig. 3.

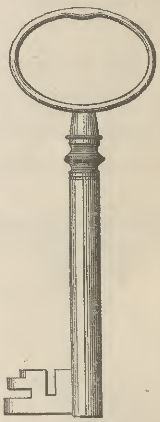


Fig. 4.

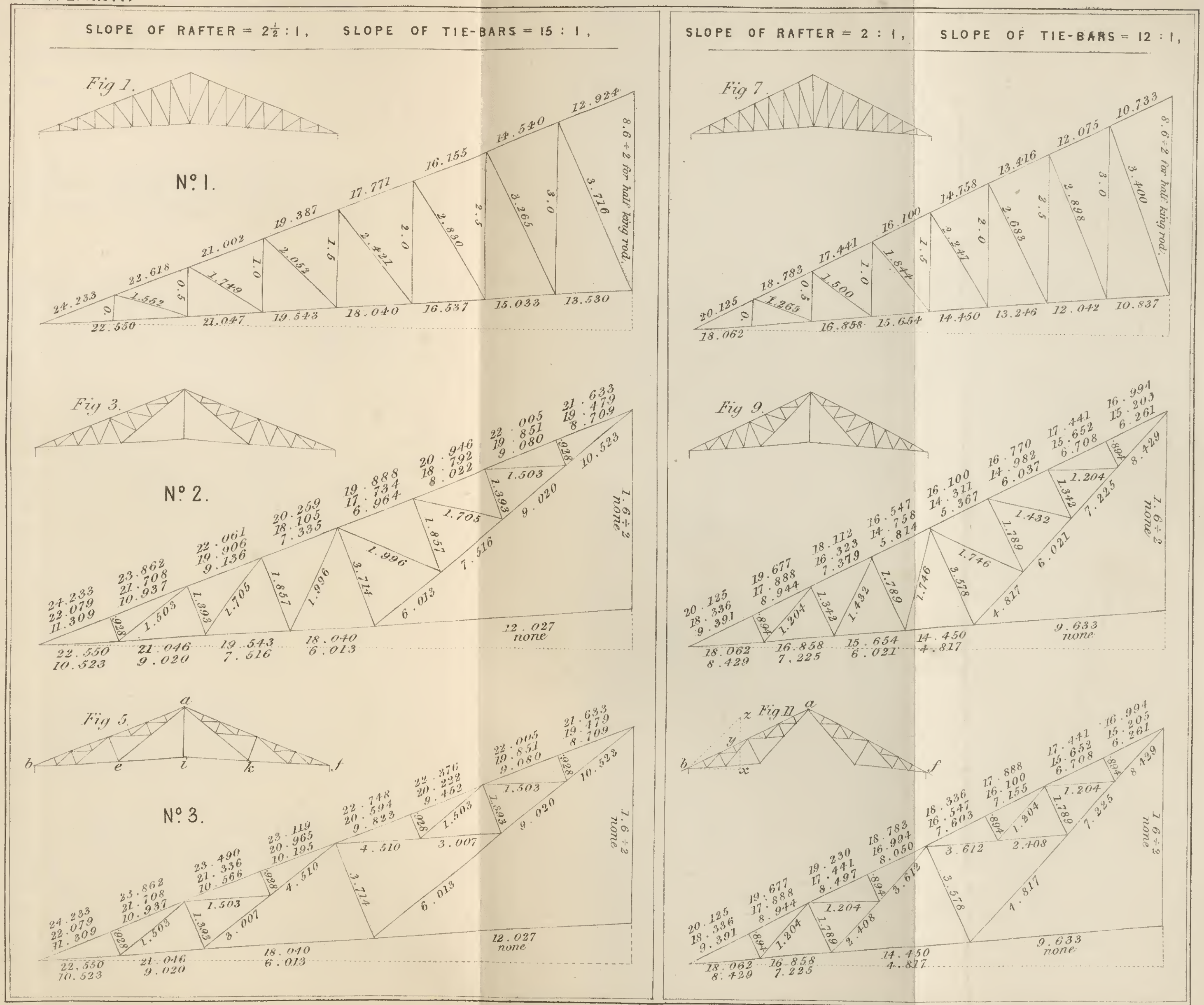
supplied with two sets of false players, $p\,p'$. The key, after having passed the false players of either side, and reached the top of the chamber, is brought forward into the lock by the entrance F or F′, one of which is now exposed by the key's clearance in the revolving plate, R, having reached that point which is necessary for the key to enter the lock, either to lock or unlock as the case may be. But previous to the entrance, F or F′, being exposed to admit the key, the entrance, G, is shut up, so that the entrance to the lock is at no time exposed.

The cut in the key, is made to clear the band on the top of the protector, which secures the revolver, while at the same time the band affords protection to the players of the lock.

We shall suppose, as an illustration, that by some means an impression of the lock is endeavoured to be obtained. In the first place, the impression from the false players (which, by the way, are different on either side) is obtained, the pick-lock passes on into the lock, and gets an impression such as can be got by obliterating the impression it had received

DIAGRAMS IN ILLUSTRATION OF Mr. R.H. BOW'S NEW DESIGNS FOR IRON ROOFS OF GREAT CLEAR SPAN.

PLATE XXVI.



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in the false chamber; returning, he gets the impression from the false players, which are no guide whatever to the work of the lock, which, as a matter of course, the term false implies. Under these circumstances, therefore, the lock may be considered secure.

New Designs for Iron Roofs of great clear Span. By ROBERT HENRY BOW, Civil-Engineer, Edinburgh.* (With a Plate.)

After making some introductory remarks, and insisting upon the propriety of employing roofs of great clear span for principal railway stations, the author institutes a comparison between the different classes of structures employed for the primary supporting frames, or *principals*, of roofs; and deduces that the *triangular frame* (in which the rafters constitute the main compressed member of the fabric) deserves to be preferred before all arched, compound, or other forms, when the nature of the covering to be used demands a considerably inclined surface, as for slates or glass. And he further shows that where untied or abutting principals can be used, rafters, when made straight, and trussed as for bridges, form principals of a very economical character; but that, for such a situation, rigid arched structures are quite imadmissible.

In the designs, Nos. 2 and 3, Plate XXVI., proposed by Mr Bow, each rafter is treated as a bridge. In order to test the merits of these, as suitable forms for long spans, they are compared with the design No. 1, which is the best at present in use.

In the calculations undertaken in order to make the comparisons, the weight of each part is represented by the product of the successive multiplication of its length by its strain, and the allowance of metal per ton of strain. For *ties* the sectional area of metal is estimated at one-eighth of a square inch; for *rafters* at quarter of a square inch; and for the

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* Read 25th April 1853 and 9th January 1854.

struts of the bracing at half a square inch, for each ton of strain.

The accompanying tables give the results of the calculations. In these, however, the effect of that source of economy of material which arises from the peculiar fitness of the proposed forms for cases requiring many supported points in the rafter, is alone made evident. But if the strains in the struts of the several forms be compared (see Plate XXVI.), it will be found that the strains in No. 1 are relatively less than as the squares of the lengths; and, consequently, the allowance of metal per unit of strain should be greater for the struts of that form than would be necessary for the struts of Nos. 2 and 3. And, therefore, were that fact taken into account in the comparison, results would be arrived at still more favourable to the new forms than those displayed in the tables.

Comparative weights of the principals, Nos. 1, 2, *and* 3.

FIRST CASE:

When the sections of the Rafters are proportioned to the strains.

No.	N=16.	N=20.	N=24.
1.	100·000	100·000	100·000
2.	97·325	94·760	91·117
3.	99·674	...	92·129

SECOND CASE:

When the section of the Rafter is uniform.

No.	N=16.	N=20.	N=24.
1.	100·000	100·000	100·000
2.	89·882	88·387	85·796
3.	89·353	...	83·898

N = number of bays in the span.

Comparative weights of the principals, Nos. 1, 2, *and* 3, *when Nos.* 2 *and* 3 *are not tied.*

Number of bays in the span = 16.

No.	First Case.	Second Case.
1.	100·000	100·000
2.	75·690	71·176
3.	78·046	70·653

There are three conditions in which the proposed designs may be employed. The first is that of a tied or non-abutting double-raftered principal, which rests vertically upon two supports of equal elevation. When such a roof principal is deprived of the parts *ei*, *ki*, and *ia*, fig. 5, it is placed in the second condition, or in that of an untied or abutting principal. The strains throughout *be* become reduced by an amount equal to the strain that acted in *ei*, and the strains in the rafters diminished, as they have not now to perform the duty of conveying to the supports the pressure formerly imposed at *a* by the tensile action of the king-rod *ia*. If from the point *b*, fig. 11, a horizontal line, such as *bx*, be drawn, and from the point *x* a vertical line $xz = 2\,xy$; and if half the total weight of the principal and its loading be represented by *xz*, then the amount and direction of the pressure upon the abutment *b*, will be represented by the line *zb*.

If to the principal in the second condition a vertical support be supplied at the point *a*, fig. 11, capable of upholding half the total weight, then each of the extremities *b* and *f* will deliver one quarter only of the total weight, and that in a vertical direction. The only change that will be produced in the strains will be a uniform diminution of compression throughout the rafters. As each half of a principal placed in this third condition is perfectly independent of the other, either may be employed alone and looked upon as a complete principal, to which the name of one-rafted non-abutting principal may be given.

The methods of calculating the strains in the various parts of all the varieties of the proposed designs, when placed in any of these conditions, are described in the appendix to the original paper. Some of the more useful results of such calculations are given in the diagrams of half principals, Plate XXVI. In these diagrams, it is assumed that the supported points of the rafter are at uniform distances apart, and uniformly loaded. The calculated strains for the various parts are given in terms of the weight due to each supported point of the rafter. Compressions are written above, and tensions below the parts strained.

Tied Principal:—The strains for this are written first in the diagrams.

Untied or *Abutting Principal*:—The strains for this, when they differ from the strains for the tied principal, are writen below these.

One-raftered Non-abutting Principal:—The strains for this are those written last in the diagrams of the new designs.

7 South Gray Street, Edinburgh.

On Cauterizing the Dental Nerve by means of Galvanism. By Dr W. A. Roberts, Dentist and Surgeon, Edinburgh.*

Mr President,—I must crave the indulgence of yourself and this Society, in bringing forward a subject apparently of more interest to the dentist or medical practitioner than to the members of this Society, namely, the application of the actual cautery, by means of electricity, for the purpose of destroying or deadening the dental nerve.

It has frequently been a cause of much mortification to myself, and, I doubt not, likewise to others of my professional brethren, to be under the necessity of extracting teeth, after the patient use of all the means usually employed to deaden the dental nerve, and thus enable us to stop the decayed teeth, or place artificial ones on or over the remaining roots, where required.

The importance of this may be readily understood, if we suppose the case to be that of a young lady, in whom one or more of the incisors have been the seat of disease, and have decayed so far as to change the expression of the face, and affect the speech, thus requiring them to be artificially replaced, both for the sake of appearance and articulation.

Here, however, so great may be the sensibility of the dental pulp, that it is impossible to pivot, or stop the tooth, as the case may be, and we are compelled either to extract the tooth or fang, which might otherwise have been valuably employed in supporting a new crown, by means of a gold pivot, or have borne stopping; or else we must have recourse to a gold plate, which, in a young mouth especially, it is always most important, if possible, to avoid.

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* Read 11th April 1853. The Society's Silver Medal and Plate, value ten sovereigns, awarded 1853.

In some cases a severe result, such as abscess and even erysipelas, have followed the pivoting of a tooth, in which there had been but a trifling amount of sensibility at the time of its insertion.

In other instances, when there had been no sensation of pain manifested, yet, in the course of a few hours only, we have seen the suffering become so great, that extraction of the root was the only resort.

On the other hand, in those roots where the pulpy portion is either absorbed by time, or can be completely deadened, there is not a simpler, neater, or safer method of supplying any deficiency that may occur in the incisors of the superior maxilla (or upper jaw) especially, than by pivoting, while the roots frequently maintain their position for many years.

As, in cases of stopping decayed teeth, we have first to remove the carious portion thoroughly by means of small instruments made for the purpose, it sometimes happens that the tooth is so exceedingly tender, that the slightest touch causes so much agony that it would be madness, if not something worse, to persevere while it is in this state.

In such cases, the usual practice is to delay procedure for a time, and to endeavour to reduce the irritability by leeching, the application of the nitrate of silver, chloride of zinc, combined with morphia, &c., &c. All of such measures, however, at times fail to obtain the desired effect, compelling us at last to the use of the forceps.

In America, the dentists in general speak highly of the use of arsenic for the destruction of the dental pulp. I have frequently tried this remedy, and with various results. In some instances the irritation excited by its use seemed to be worse than the disease. Combined, however, with the muriate of morphia, arsenic certainly gave less pain, but was still uncertain in its effects. I quite agree with the opinion of Mr Tomes, an eminent dentist of London, who, in his work called "Dental Physiology and Surgery," says—

"I think arsenic should be struck off our list of dental remedies, seeing that we have other escharotics that are just as effective in destroying the pulp, and if swallowed in the minute quantities we use, can work no harm."

But, independently of these injurious effects, there is great danger that, in employing a stopping of this poison, it may escape from the cavity of the tooth and be swallowed.

In proof of this, I may instance a case of death following this application, recorded in the "American Journal of Dental Science," volume for 1843–4.

The symptoms were decidedly those of poisoning by arsenic. The quantity *said* to have been used in this case was only one-twelfth of a grain, mixed with kreosote, so as to form a paste; but there is either cause to suspect that the quantity was much greater than this, or that the unfortunate patient (a Dr Walcott of Lytchfield, in America) had a peculiar idiosyncrasy.

Taking into consideration, then, the importance of preserving the teeth, for the purposes of general health, mastication, appearance, and articulation, surely the conservation of such a valuable apparatus is more meritorious than their extraction, however dexterously performed; while, if they can be preserved for a few years longer only, how much better and serviceable a *tolerable* tooth of one's *own* is, compared to the best artificial tooth ever produced.

In bringing this subject before the Society, I do not pretend to claim the merit of a new mode of practice, as the use of the actual cautery is by no means a modern application.

But the employment, in dental surgery, of the cautery heated by electricity has not, as far as I am aware, been proposed or practised by any one;* and this, I submit, is deserving of attention, as a more *certain*, and at the same time a less startling mode of applying it.

Almost every dentist must have met with patients who have wished the nerve destroyed, and who would submit to almost any amount of pain for the moment for ultimate relief, but on *no account* would allow the offending tooth to be extracted.

I have occasionally been asked by the patient to apply the

* I may mention, that at the time I first employed the cautery this was the case, but now I have the pleasure of saying it is becoming pretty general. Mr Stevenson, philosophical instrument maker, has sent a battery to the East Indies.

cautery, "or to burn the nerve," as they call it, and have at times complied. But a great drawback to the successful performance of this operation has always arisen from the necessary fineness of the wire required, which, before it can be inserted into the foramen of the tooth, becomes too cold, and the consequence is, violent inflammation like that following a burn is set up, instead of effecting the immediate and total destruction of the pulp, or dental nerve; whereas the platina wire, heated by electricity, is applied at the fullest heat at once.

Among the many methods made use of by the profession of applying the actual cautery, the *coolest*, I think, in *one* sense at least, is that adopted by Mr Kocker, and recorded in his work entitled, "Principles of Dental Surgery," published in the year 1826.

"I require," he says, "for this the following apparatus:—1*st*, A small iron wire, fastened to an ivory handle; the extremity of this wire I file to the size of the exposed nerve, and bend the wire in such a direction as to enable me to touch the tooth or mouth.

"2*d*, A thick tallow candle, with a large wick. I direct the patient to discharge all the saliva he may have in his mouth, then to incline his head backwards against the head support of my operating chair; I put the *candle* into his left hand, and direct him to hold it in such a position that the flame of it may be on a level with his mouth."

Some dentists recommend that a sharp wire should be thrust down into the root of the tooth, and then rapidly twisted round, so as to tear out the nerve.

There are advocates for this plan, who declare that there is *not much* pain in so doing, but that it is an operation rather *pleasant* than otherwise. I doubt much if many will coincide in this view of the matter, more especially the party operated upon.

When the actual cautery is considered necessary in cases of alveolar hemorrhage, the importance of this instrument, heated by electricity, I think will be appreciated, as the point of the *bleeding* vessel may be touched with a wire at a *white* heat, while no other part of the mouth is affected.

The method of applying the actual cautery, which I have now to explain, was suggested to me by seeing the article in the "Lancet," vol. i., for 1851, page 546, in which a proposal was made for excising tumours, &c., by means of wire brought to a white heat by electricity.

I have followed up the idea, and the instrument on the table is the result, and has been in operation since that period.

After several experiments (assisted by Mr Stevenson), I found a battery after "Grove's" plan answered best, being more convenient than Smee's. It is much smaller, and consequently more portable and more easily kept out of sight.

By *one pair* of plates I can produce a more decided result than I could with *six* pairs of "Smee's."

In the glass vessel I have a mixture of four parts of water to one part of concentrated sulphuric acid.

In the porous jar there is a mixture composed of two parts of nitric to one part of sulphuric acid.

At the end of each of the conducting wires you will observe a fine platina wire brought to a point. This wire is fine enough to enter the foramen of any tooth; but where it is used to cure toothache, the merely passing the wire round the decay is sufficient, or for the larger cavities the wire can be rolled up as a small ball.

When the wire is to be heated, the communication is made by gently pressing upon the ivory knob, which pressing down the spring, the contact is at once made.

By taking off the pressure the current is broken off as quickly.

At first I found some difficulty in operating, from the want of elasticity in the wires, as the thickness necessary to convey the electricity sufficient to heat the wire, rendered them very unwieldy.

This was overcome by a plan of my son's, which consisted in filling two small india-rubber tubes with quicksilver, the ends of the copper wires being inserted into the mercury at both ends, and tightly tied. By this means the communication was rendered complete, and allowed of freer motion. Since this was done, we find now *full* freedom can be obtained by using a string of very fine wire tied together, instead of a single thick one.

The advantages, then, to be obtained by this instrument are, its easy application to the desired spot in the mouth, and that perfectly *cold*, instead of alarming the patient by holding a red-hot iron before his face; its being at once raised to the requisite heat, and no more than the mere point of the wire used being heated; also from its being at *once* cooled on simply removing the finger from the spring; and, lastly, there being no appearance of heat to alarm the patient.

If applied for the purpose of arresting hemorrhage, or the deadening of the dental nerve, the cavity should be first well dried out with a piece of lint, and then the desired spot should be rapidly touched, so as not to come into contact with other parts. This can be repeated, if found necessary. The platina must be at least red-hot, as it then acts effectually and instantaneously, and really with little or no pain; otherwise, if not heated sufficiently, it would cause much pain and subsequent inflammation. I need not say, with timid persons the inhalation of chloroform should be resorted to.

I may, in passing, mention, that I have used this instrument in many cases with and without chloroform. I may instance one case without chloroform. A young gentleman, of about nineteen years of age, came to me (now some months ago) to have a front tooth of the upper jaw stopped; and while engaged in scooping out the decayed bone, previous to putting in the gold, from the great pain he was suffering (although he tried to hide it) he fainted. I made him call next day, and applied the cautery: he felt, he said, a peculiar sensation from its action, but he could not call it pain. The next day again, I stopped it with gold, and he is now quite free from either pain or uneasiness.

With these few remarks, Mr President, I will now conclude, and proceed to show the battery in action, which, I trust, will be thought more available than that of the thick *tallow* candle of Mr Kocker, or the instrument employed by a Cambridge friend of Mr Tomes of London, who, it seems, was dreadfully tortured with pain in a carious tooth; and that one day, quite worn out with suffering, he broke off all the prongs of a dinner fork but one; the remaining one he heated red-hot, and in that condition thrust it forcibly into the hole of the aching tooth. The pain, he says, ceased in a moment, and that he has not, from that time to this, a period of nearly *thirty* years, had a single twinge of the toothache.

It is unnecessary to state to such medical men as may be present this evening, that where suppuration has taken place, the cautery will not be applicable; he must therefore treat the case as circumstances point out as being most proper.

I may mention that when the battery is not in use, the plates should be taken out and washed with water, afterwards to be kept dry. The porous jar must also be taken out, and placed with its contents into the second or receiving jar, and the stoppers put on. By this means the acids are always ready for use, and last much longer, and the unpleasant and destructive nature of the acids is guarded against.

At first, when I only used one glass jar, it was necessary, after being used, to pour the acids into separate bottles, but, from the chance of spilling the liquids, and escape of the acid fumes, it was very troublesome and indeed objectionable; but by the means indicated all this is entirely avoided.

Address delivered by DAVID RHIND, Esq., F.R.S.E., *Architect, President of the Royal Scottish Society of Arts, on taking the Chair on 27th November* 1854.

GENTLEMEN,—I have to thank you in the most cordial manner for the high honour you have conferred upon me in electing me to succeed your late distinguished President, Professor Kelland, and I have also to thank you in the name of the Vice-Presidents.

Had the success of the Society of Arts, or its progress, depended on the influence and position of its President, I would have felt much diffidence in accepting the high honour your kindness has conferred upon me; but its uninterrupted prosperity and steady career of usefulness for upwards of thirty years, proves that it is now thoroughly established as one of the permanent institutions of the country. In taking the chair, therefore, it is only necessary for me to express my determination to use every exertion faithfully to discharge its duties, with the hope that at the end of the Session I may have the satisfaction and pleasure of reporting the increasing usefulness of the Society.

I intend as usual to reserve any formal observations I may have to offer until the close of the Session, but meanwhile I may perhaps be permitted, in taking the Chair, to request those gentlemen who have hitherto been in the habit of supplying us with papers, to continue their valuable aid. In particular, I trust the many subjects that have hitherto so largely occupied the business of our meetings, viz., those regarding the safety of railway travelling, the electric telegraph, and other subjects more peculiarly the province of the engineer, will continue to receive a large share of attention. It is not possible to over-estimate the importance of what yet remains to be done for the safety of railway travellers, and it will therefore be for the public interest that this Session should find the gentlemen who during former years have taken up these subjects, still continuing to bring forward suggestions in this department of our labours.

While, however, I think these and other kindred subjects should, as heretofore, receive a large share of attention, I may perhaps be permitted to say, that the selection of an architect for the chair, which I think you have this year done for the first time, would seem to indicate that, during the Session on which we are entering, we will be open to receive papers on subjects connected with building, and also with the different branches of art-manufacture.

It would undoubtedly be of much value both to ourselves and the public, if we devoted some portion at least of the Session to practical subjects connected with building operations, and to an analysis of the results of the Great Exhibition of 1851, as regards art-manufacture. We have all to some extent seen the improvement that has taken place in art-manufacture during the last five years; indeed, it is impossible to have overlooked it, extending as it does to the most common necessaries of life; and it therefore appears to me, that the Society of Arts would do well to take advantage of and improve the bent of popular feeling in favour of art, which has been the result of the visit of all classes from every part of the country to the Exhibition in Hyde Park. It has become evident, as the effect of that Exhibition, and the interest taken in it by all classes, that the time has arrived when even the articles of everyday use in the humblest cottage in the land will require to be of such artistic design and improved execution as to keep pace with the progress and advancement of general taste and refinement. To lead the way in this progress towards refinement, now so happily commenced, is peculiarly within the province of the Society of Arts; and I think it would be a high privilege for us, and peculiarly appropriate to the general objects we have in view, were we to share in the pleasing task of endeavouring to elevate the taste and knowledge of our workmen, by doing something to teach them; that along with the beautiful workmanship that has long been admitted to characterize everything executed in Scotland, a very little additional study only is required to enable them to cope with the manufactures of every country in the world, in novelty, appropriateness of design, and well-selected artistic embellishment.

I would not wish to be supposed here to refer to architecture as a fine art, or to the fine arts generally. These subjects are in other hands. All we have to do with here, is the practical improvement of all that is requisite for the proper construction of our buildings, and such information on art and art-manufacture as is required by the workman for the tasteful execution of his work. It is a pleasing characteristic of our times that workmen are not satisfied with being only able to execute the work they are engaged on in what is called a workmanlike manner, but must also have a sufficient education in art, to admire and appreciate as well as practically to carry out the change now in progress, from the rude form and ornament of former times, or rather, I should say, of a time only now disappearing, to those beautiful designs that are beginning to be called for, and appreciated for useful and ornamental purposes, even for the very humblest objects.

Leaving, however, altogether for the present, the inviting subject of art-manufacture, I would return to building, and in doing so desire it to be understood, as I have already stated, that it is not with architecture and the fine arts this Society has to do. We are restricted here to the improvement of the practical details of our buildings, and the appliances used in their construction. This, however, of itself embraces a wide field of practical usefulness in what concerns our everyday comforts and enjoyments; and, with the permission of the Society, I will very shortly endeavour to point out a few subjects connected with building operations which I think peculiarly within the province of the Society of Arts; and had I not determined to avoid wearying you by doing so, and as inappropriate to the opening of the Session, I would have entered shortly into the requirements suggested under at least some of the more important of them. I will however refrain from doing so, as I believe to most of you the mere enumeration will be sufficiently suggestive of subjects for our improvement.

First.—Confining myself entirely to such subjects connected with building as I consider within the scope of the Society of Arts, I will begin with drainage and sewerage, as of vast importance to all classes of the community, and on which we have many members well qualified to guide us in the collection of valuable practical information. I hope Mr Stevenson will some time during the Session favour us with the result, I trust the successful result, of the operations on which he is now engaged at the Water of Leith.

Of course, as I need scarcely say, it will be understood that on this as on all other subjects, we cannot always have papers brought before us showing great and important results, and we will therefore be ready to receive and encourage those that may be instrumental in even helping us on our way to inventions and improvements; and I think I may further say generally, that on this and all subjects what we desiderate is chiefly, indeed I may say entirely, the practical experience of the members themselves.

Second.—Fire-proof Flooring and Roofing is another subject of great practical importance in our public buildings, and we have members well qualified to enlighten us on the respective merits of the different systems adopted both here and on the Continent, and who can practically explain to us from personal experience their respective advantages, both as regards safety from fire and economy and simplicity of construction.

Third.—Any successful attempt to keep down damp in walls is also within the intention of the Society, and therefore we ought to be open to receive practical expositions of actual results, either successful or otherwise, that have been found to follow the use of asphalt, lead, Caithness pavement, or any other of the expedients usually applied for the prevention of this serious evil.

Fourth.—The heating and ventilation of our public and private buildings are also subjects which I think open to us for investigation; indeed, they have often been before us in former years, and we therefore know, from our own experience, that they are beset with difficulties and discouragements of no ordinary kind. I confidently hope that this Session will not pass without some additional practical information being brought before us, that will increase our knowledge of both heating and ventilation, and at least assist in reducing the subject to something like a system.

Fifth.—Grates, and the prevention and cure of smoke, and also improvements and inventions in the requirements for culinary operations generally, and anything tending to improve and simplify the apparatus used in steam and gas cooking.

Sixth.— Improvements in the construction, supply, and economical application of heating to baths, washing-tubs, &c., and also improvements in the details of waterclosets, urinals, cisterns, and sinks, supply and waste pipes, soil pipes, traps, &c.

Seventh.—Inventions for improving bell-hanging, speaking tubes, and other modes of communication between the different rooms of our great public establishments. Improvements in safe locks, mortise locks, and every variety of fasteners, as well as hinges and spring-hinges for doors, and the hanging and simple and efficient securing of windows and shutters.

Eighth.—The improvements of workmen and labourers' cottages and houses should have a share of our attention; as, while we require a higher standard of education in the workman, and call for a higher class of work at his hand, we ought to be forward with our assistance in elevating his social position, and trying to increase, if we can, the comforts of his home. In what way the Society of Arts can be instrumental in accomplishing this important object will readily occur to our members, many of whom I could name as having been already very zealous in this good cause, by having in former years brought papers before us with a view to extending in every possible way the comforts of the working classes, from a warm and sincere interest in their welfare.

Ninth.—Dry rot in timber is a subject on which our knowledge is very scanty; indeed, we have no information to satisfy us even of the cause of it,—whether existing in the timber itself, from the state of the sap in the tree at the time of its being cut or otherwise; or is caused by damp and the deprivation of a free circulation of air when in its place in the building. This is a subject upon which any practical knowledge would be valuable, it being one of those on which we have everything to learn.

Tenth.—Improvements in tools and machinery for the saving of manual labour in carrying on our works are of much importance; and I am specially led to allude to this subject from having since your last meeting visited the granite works of Messrs Leslie and Macdonald in Aberdeen, where difficulties have been overcome by the use of the steam-engine for cutting and polishing the granite that has made the use of this material for the most delicate form and minute detail a matter of no difficulty, and, considering the material, at an expense comparatively moderate and within our reach for ordinary purposes. We see at these works, as much as anywhere I know, how much saving of manual labour a moderate steam-engine can accomplish in the hands of men who know how to apply and economize its power.

Eleventh.—There is great room for improvement in the machinery of cranes, traversing cranes, &c., and the scaffolding used in carrying on our works, both as regards simplicity and economy of construction, and the safety of the workmen. I am sorry to say there is generally very little importance attached to the subject of scaffolding and gangways. Our neighbours in Paris, as I have myself seen from personal observation within the last few weeks, have the means of giving us valuable instruction on these subjects, and as the attraction of the Great Exhibition next summer will draw many of our practical members there, we may soon hope to see an improvement among us of the appliances used for the erection of ordinary buildings, in the use of which the French, in my opinion, greatly excel us. I say our ordinary buildings, because I believe it will be admitted that in the construction of our great national edifices, such, for instance, as the Victoria Tower, and the Great Transept of the Crystal Palace at Sydenham, the works are carried on with a refinement of machinery for the saving of labour, and a simplicity of scaffolding and other appliances used in their erection, that seems scarcely to leave anything to improve.

Twelfth.—There are various other subjects connected with building operations open for investigation, such as concrete, stone, artificial stone, the improvement of brick-making and tiles for draining, the use of asphalt, and the different kinds of mortar ; the various kinds and quality of timber for building purposes, with their advantages and disadvantages from liability to decay or other causes : the different kinds of metal, such as iron, corrugated iron, lead and zinc, with inventions of any kind regarding these and all other materials used in building, showing either novelty of application or reduction of cost ; and also improvements in the tools used for working them. Everything that goes to make up a building is of practical importance to us : and although many of the subjects I have suggested to your notice may appear unimportant, compared with much that in previous years has been brought before the Society, a very little reflection will show, that although apparently small in themselves they are really of vast practical everyday importance, making up in combination all that is required for the durability, comforts and adornment of our public and private buildings.

Thirteenth.—I will not increase the list of subjects connected with building further than to suggest improvement in calotype as being peculiarly within the province of the Society of Arts. It is not possible to overrate the growing importance of this subject, an instance of which I have felt lately in my own professional experience, having had some very beautiful specimens sent from Rome, and some also from London, giving the most faithful representations of sculpture that was designed with the view of being used in works on which I am now engaged. This is one instance of how it can be useful; and I have no doubt also, that the time is not distant when there will be no clerk of works in charge of a building of any importance without such a knowledge of the art as will enable him to accompany his weekly report with a photographic representation, illustrative of the progress of the work under his superintendence.

I have thus endeavoured to supply a list of subjects, many of which have hitherto very little, and some not at all, engaged our attention, although coming specially within the objects and provisions of the Society; and I have given them as they occurred to me, having had no time to make any attempt at order or classification. It will, I trust, be our desire during the session to give some of them at least a share of our attention.

I hope you will permit me to conclude by saying, that I have had much profitable experience of the Society of Arts during the time I have been a member, and look forward with confident hope, that during my presidency many valuable communications will continue to be brought before us; and I believe I may also express my confidence, that in the discussion that follows the reading of each paper, whatever the subject of it may be, there will always continue to be maintained that courtesy towards each other, and desire to elicit the truth, which has hitherto peculiarly characterized all your proceedings.

I have only now to ask of you on my own behalf, that in assuming the duties of the Chair in which you have done me the honour to place me, the members will extend to me the same support and assistance their kindness has invariably accorded to those gentlemen who have preceded me in the office.

The Secretary moved the thanks of the Society to the President for his excellent address, which were voted unanimously; and on the motion of Richard Hunter, Esq., late H.E.I.C.S., seconded by William Crawfurd, Esq., of Cartsburn, it was resolved to request the President to sanction the printing and circulation of the address amongst the Fellows, to which he kindly consented, though not written with a view to publication.

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*On Railway and Ship Signals in relation to Colour Blindness.** By GEORGE WILSON, M.D., F.R.S.E., Director of the Industrial Museum of Scotland.

In the account of the researches on colour-blindness which I have had the honour of submitting to the Royal Scottish Society of Arts, I have repeatedly referred to the dangers which might result from the signal-men at railway stations, or on board ship, being colour-blind, and in consequence making mistakes in the exhibition or interpretation of coloured signals. I propose, in the present paper, to enter more fully into this subject, and to consider how the evil may be lessened or remedied. As it is desirable, moreover, that this communication should be complete in itself, I shall commence by *dogmatically* announcing the chief facts connected with colour-blindness, referring the reader who wishes confirmation of the following statements, or additional information on the subject, to the works mentioned below.†

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* Read to the Royal Scottish Society of Arts, 8th January 1855.

† 1. Extraordinary Facts relating to the Vision of Colours. By Mr John Dalton, Mem. Lit. and Phil. Soc., Manchester. Vol. v. 1798.

2. Wartmann, 1st Memoir on Daltonism or Colour-Blindness, translated in Taylor's Scientific Memoirs for 1846; 2d Memoir in "Deuxième Mémoire sur le Daltonisme. Genève, 1849."

3. Combe's Phrenology, article Colouring.

4. Cyclopædia of Anatomy and Physiology, article Vision.

5. W. White Cooper on Vision. 1853.

6. Dr G. Wilson, Edinburgh Monthly Med. Journal, 1853–1854; or Researches on Colour-Blindness. Sutherland and Knox, Edin.; 1855.

7. J. C. Maxwell, Transactions R.S.E. 1854–55.

I. *Of the Nature of Colour-Blindness.*

The researches of a great number of the ablest enquirers in England, Germany, France, Switzerland, and America, have, in the course of the last sixty or seventy years, brought to light the existence of a remarkable limitation of vision in reference to colours. This has been variously named, *Idiopsy* (peculiarity of vision); *Chromatopseudopsy* (false vision of colour); *Dyschromatopsy* (bad vision of colour); *Achromatopsy* (no vision of colour); *Dichromic Vision* (the vision of only two colours); and *Daltonism* (vision identical in its peculiarities with that of Dalton); but the terms of Greek origin are not significant to English readers, and are not sufficiently precise and expressive to satisfy even Greek scholars, so that I shall use none of them. Daltonism is an unsuitable and trivial name, so that in referring to the affection of sight under notice I shall restrict myself to the title Colour-Blindness, and call its subjects the Colour-Blind.

Those who are thus named differ from their more fortunate brethren in the following way: Three simple, elementary, or primary colours, properly so called, red, blue, and yellow, are visible by daylight to perfect eyes, besides white, the mutual neutralization of these colours, and black, the absence of them all.*

Perfect natural vision is thus a tricolor, or three-colour vision, and each of the colours of which it is cognizant may be changed by additions of white to it into *tints*, and by additions of black into *shades*, without ceasing to be visible till the paleness of the tint has made a very close approximation to white, and the darkness of the shade a very close approximation to black.

Further, the primary colours may be mixed with each other, so as to produce by the addition of red to blue, crimsons, violets, and purples; by the addition of red to yellow, scarlets and oranges; and by the addition of blue to yellow,

* It is assumed here that the analysis of light by our sensations represents its true constitution, and that red, blue, and yellow, are its simplest ultimate sensational elements. This view is the most convenient in discussing the practical relations of colour, but is quite open to criticism as a scientific analysis of light.

greens; all of which secondary colours are visible both when full, and throughout a long series of tints and shades to a perfect eye; as are also the mixtures of the secondary colours with each other, giving russets (including browns) olives, and citrines.

On the other hand, the colour-blind distinguish white and black as perfectly as others do, and a very few of them have no other perception of colour than that implied in the distinction between light and shade.

The great majority however, of the colour-blind distinguish two of the primary colours, *yellow* and *blue*, but they err with the third, *red*, which they confound with *green*, with *brown*, with *grey*, with *drab*, and occasionally with other colours; and not unfrequently red is invisible to them or appears *black*. The colour-blind thus possess a *bicolor* or two-colour vision, so far as the primary colours are concerned.

Moreover, no one of the secondary colours is uniformly visible to them; orange, if tending towards yellow, appears to be yellow; if inclining to scarlet it is mistaken for green; purple is confounded with blue; and green with red and drab and brown. The tertiary colours, such as olive, russet, and citrine, are also confounded with each other, and with green, dark red, and brown.

Further, the lighter tints (among themselves) and darker shades (among themselves) of *all* colours, primary, secondary, and tertiary, are mistaken for each other, and for white in the case of the tints, and black in the case of the shades, even when not *very* pale or very dark.

The colour-blind thus perfectly distinguish only two colours, yellow and blue, and these only when deep or full; but as they are liable to mistake purple (or other mixtures of red and blue) for blue, they in reality are clearly cognizant only of yellow.

The identification, confusion, or misinterpretation of colours thus occurring, is most important, practically, in reference to red and green; but colour-blindness is most easily detected by the confusion of certain tints of purple, such as pale violet, lilac, or pink, with blue; and if lilac or pink is thus mistaken by daylight, the other mistakes characteristic of colour-blindness may be regarded as certain to occur.

By ordinary artificial light, such as lamps, candles, and coal-gas yield, red is less liable to confusion with green than by daylight; and the redder purples cease to appear only blue. Artificial light thus lessens colour-blindness, but does not abolish it, for mistakes continue to be made of the same kind, though not to the same extent as before.

The false, uncertain, defective, or negative vision of colour, which thus characterizes the colour-blind, is compatible with perfect vision in other respects, and is frequently if not generally accompanied by a very nice perception of form and outline not only in full but in faint light.

II. *Of the Number of the Colour-blind in the Community.*

Colour-blindness occurs in all ranks of the community, and in both sexes, but more commonly in males than females. It is congenital, or at least appears as soon as it is possible to test the vision of colours in infancy, and it does not appreciably alter through life, being, so far as is yet known, totally incurable. It is also hereditary, and has been traced without material modification or abatement through five generations. It descends both by the father and mother's side, but always attaches to the sons rather than to the daughters, and if the family be considerable in number, it occurs in more than one of the sons, so that as many as six brothers have been found to be colour-blind.

It varies in degree, the extremer cases being characterized by the confusion of red (in daylight) with black, and the less extreme, only by uncertainty in the lighter and darker tints and shades of the colours characteristically confounded.

The statistics of colour-blindness are as yet imperfect, and do not include females, but there is every reason to believe that the number of males in this country who are subject in some degree to this affection of vision, is not less than 1 in 20, and that the number markedly colour-blind, *i.e.* given to mistake red for green, brown for green, purple for blue, and occasionally red for black, is not less than one in fifty. The actual number of the markedly Colour-Blind detected in an examination of 1154 males in Edinburgh was one in fifty-five, and the parties thus examined were students, soldiers, and policemen, born in various parts of the British dominions.*

* Edinburgh Monthly Med. Journal, July 1854, pp. 1–101; or Researches on Colour-Blindness, p. 72.

We may thus, according to our present knowledge, regard two in every hundred of the community as *seriously* defective in their perception of colour, supposing the colour-blind to be equally divided amongst the population ; but as direct observation, as well as the prevalence in certain families of colour-blindness, demonstrates that the division is very unequal, it is impossible to calculate the extent of its prevalence in any limited area, whilst it is certain that the evils which it entails on its subjects and others, will be lessened in one district, only by increasing in another.

The following Table, repeated from page 74 of Researches on Colour-Blindness, and page 8 of Edin. Monthly Medical Journal, July 1854, will illustrate this.

DISTRIBUTION OF THE COLOUR-BLIND AMONG 1058 PERSONS.

Profession.	No. of Individuals.	Confound Red and Green.	Confound Brown and Green.
Professor Kelland's Students, meeting daily together for 5½ months, .	150	3	0
Edinburgh Police on duty together, .	158	1	2
Dr G. Wilson's Students, meeting daily together for 5½ months, .	20	2	0
4th Infantry, Edinburgh Castle.			
a. *Two Companies*, . . .	91	1	1
b. *Two Companies*, . . .	88	2	4
c. *Two Companies*, . . .	86	1	5
d. *Two Companies*, . . .	110	2	3
Artillery, Leith Fort.			
a. *Detachment, first day*, . .	64	2	0
b. *Detachment, second day*, . .	59	0	1
7th Hussars, Piershill.			
a. *One Troop, including 2 Officers*, .	47	2	
b. *One Troop*, ...	81	2	
c. *One Troop*, ...	49	1	2
a. Dalton and his Pupils on one occasion, ...	26	3	0
b. Dalton and other Pupils on a different occasion, ...	26	2	0
Resident Medical Officers of a Public Institution, acting together for several years, ...	3	2	0

III. *Of Visible Signals in relation to Colour-Blindness.*

In the guidance of railway trains, and of vessels at sea, signals are in constant use, which, as employed both by night and by day, are, to a great extent, significant, solely by their colour.

Those signals were introduced at a time when colour-blindness had not awakened the attention of practical observers ; and they do not contemplate its occurrence among signal-men. It is important, therefore, now to enquire what alterations the recognised prevalence of this affection of vision renders necessary in our methods of signalling.

1. *Of Railway Signals.*—The railway signals, appealing through colour to the eye, which are employed in this country, are of three kinds, namely :—*a.* Pillar or Mast-Signals, *b.* Flag-Signals, *c.* Lamp-Signals. All are in use through the day ; the lamps being needed in the tunnels even when the external light is brightest, and forming the only available signals during darkness.

When this system is carried out to the full, as it is in the majority of our railways, three *positive* indications, implying SAFETY, CAUTION, and DANGER, are furnished alike by the day and the night signals. On some lines, however, Caution and Danger are alone *positively* indicated,—the absence of any signal implying Safety ; and on certain lines, I believe that Danger and Safety are alone *positively* indicated,—no caution-signal being shown. In what follows I shall generally suppose three positive signals to be employed at all times.

The pillar or mast-signals are of three kinds, namely :—vanes, discs, and semaphores. The two first are the same in general principle, and signal only to one line, but differ in shape ; the vanes being shaped like axe-heads or fish-tails,—the discs, as their name implies, being more or less circular. In the most complex signals on the first system, there is a triple vane cast in one piece of iron, and consisting of two fans in the same vertical plane, and one in a vertical plane at right angles to those two ; so that the whole resembles the sign-post at a three cross-road. The double fan is painted red on both faces ;

the single fan is white on one face, and green on the other. The whole is made to revolve like the top of a turnstile on a vertical axis, and admits of the following movements:— When turned, so as to present the edge of the double or red fan to an approaching train, the single fan points to the left or the right, according to the direction in which the whole is turned. When the signal is to the left of the engine-driver, the WHITE side of the fan is seen, and implies "ALL RIGHT—GO ON!" When the signal is to the right, the green side of the fan is seen, and implies "CAUTION—GO SLOW!" When the single fan points *from* the observer, then the double fan conceals it, and it appears with both its right and left half RED, and the signal is "DANGER—STOP!" On the summit of the triple vane is a lamp turning with it, and showing a differently coloured glass or face along the three edges of the fans, so that at night it shows a *white* light when the single fan turns to the *left*, a *green* when it turns to the *right*, and a *red* when the two arms face the observer. In the simpler vane signals there is only a double fan, red on one face and green on the other, and showing at night lights of corresponding colours. When neither of the faces or lamps is seen, but only the edge of the vane, the signal is "Safety;" green is "Caution," and red "Danger." The triple vane, it will be perceived, appeals to the sense of Form as well as to that of Colour; indicating *Safety*, by pointing, as it were, with one hand to the left; *Caution*, by pointing with one hand to the right, and *Danger*, by spreading out two hands.

The discs correspond to the double fan vanes, and are circular or oval plates, pierced with five or more holes, and placed on vertical spindles or axes, so that the edge of the disc or either face can be turned to any point of the compass. The one face is painted GREEN, and signifies, to a train approaching it, "*Caution—go Slow!*" The other face is painted RED, and signifies "*Danger—Stop!*" The EDGE of the disc turned towards a train implies "*All Right—Go On!*"

On some railway lines the discs are red on one side, and white on the other; and have corresponding lights, so that they signal only *Danger* and *Safety;* but in the more complex system, previously described, the arrangement is such that on the summit of the disc, and turning with it is a triple lamp, showing by night a red light above the red face of the disc, a green light above the green face, and a white light above the edge. This lamp, when *unlighted* as through the day, presents a different appearance, according as the edge or the coloured faces are turned to the observer. Thus, when the green face is towards the observer, the lens-tube of the white lamp points to one side, for example to the right, thus ┌. When the red face is towards the observer, the white lamp points to the other side (to the left), thus ┐. And when the edge of the disc is towards the observer, the red lamp projects on the one side, and the green on the other, so as to resemble the letter ┬. There is thus apart from colour a difference in form in the summit of the disc-pillars, but the amount of lateral projection is very slight, in truth, so small, that it can only be seen from a short distance.

The semaphores are tall pillars or masts, which, in their simplest form, have one arm shutting up within the post, like the blade of a clasp-knife in its handle, and admitting of being opened out and fixed at an angle to the pillar. The arm is painted red on the face turned towards the engine-driver, and white on the opposite face. When shut up within the pillar, it signifies "ALL RIGHT." When raised to an angle of 45°, it denotes "CAUTION;" and when raised to an angle of 90° "DANGER." A triple lamp is also attached to the semaphore pillar, showing, as in the other arrangements, a white, green, and red light.

The flag-signals call for no special description. They consist of pieces of woollen gauze (bunting), a foot or more square, attached to hand-staffs, and are three in number,—one white, one green, and one red.

The lamps are also three in number, provided generally with convex lenses or bull's eyes, of white, green, and red glass. All trains carry at night a white head-lamp in front of the engine, and both by night and by day a red tail-lamp attached to the last carriage. At night two or more additional red lamps are generally carried on each side of the train, and one behind on the right side of the engine.

IV. *Of the Disadvantages attending the Use of Red and Green for Signal-Colours.*

Red, green, and white, have been selected alike for the vane, disc, flag, and lamp signals, as colours readily distinguished by perfect eyes, both by daylight and artificial light. It is worth while, however, to notice that red and green are open to certain objections, even when seen by those who are not colour-blind ; and,

1. *Of the Perception of Red and Green by Daylight.*

1. Red as seen by day on the vanes, discs, and flags, becomes dark or imperfectly visible by faint light, such as that of the setting sun, long before blue and yellow cease to exhibit their characteristic colour.

The researches of Brewster, Dove, and Tyndall, establish this, and indeed more ; for the effect of twilight is to increase positively the visibility of blue, whilst it diminishes that of red.*

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* There appears to be a smaller sensibility of the human eye to red than to blue light, in all circumstances which lessen the acuteness of vision. To this I have specially referred in the Researches on Colour-Blindness, pp. 64–67 ; but I have not referred to another cause of the phenomenon, discussed in the text, the importance of which has been brought under my notice by my friend, Mr W. Swan.

In the Researches, I have referred to Dove's experiments with the stereoscope as establishing the visibility of blue, where red is invisible ; but a stereoscope is not necessary for the demonstration of this fact. It is sufficient to contrast the appearance of the evening sky after sunset, as seen through a red and a blue glass. The former grows darker and darker as daylight departs, and rapidly becomes to all practical intents opaque : the latter, though taken of such thickness as to be darker than the red by full daylight, continues transparent so long as the faintest twilight lasts, and by contrast with the red, appears to increase in visibility and transparency as darkness comes on. Mr Swan's remarks which follow apply to the experiment as thus made.

" I see a reason for the disappearance of the red, and the continued visibility of the blue, as the darkness increases, quite independent of any difference of sensibility of the eye to these colours, which, if I recollect aright, was the explanation given of the phenomenon.

" Suppose the blue glass to be rather more opaque than the red in full daylight ; or, to be more exact, suppose it to transmit a less percentage of the total incident light than the red does, it will then appear darker than the red. After

2. Red and Green, in virtue of their relation as complementary colours, call up each other if either is intently gazed at. The eager watcher of a signal is thus exposed to the risk of mistaking the summons to stop, for that to go slow; so that he exhibits in a very faint degree, the liability to mistake red for green, which is so marked in the colour-blind.

3. Red and green, if of corresponding tint or shade, harmonize as complementary colours to a natural eye, so that it passes readily from the one to the other without the sensation of abrupt transition. It would be better if a harsh contrast existed between the colours of the caution and danger signals, so that the eye might be startled and offended by a passage from either to the other, as the ear is by the shrill discord of the steam whistle.

If those whose vision is normal, are thus liable to mistake by day red and green for each other, those who are colour-blind are still more so. Red and green, with the exception perhaps of lilac and blue, which are too similar however, to all eyes to be suitable for signals, are their greatest stumbling-blocks: to some, when fresh and bright, however near at hand: to others when new, if seen from a little distance: to all increasingly when light is imperfect.

The effect of time and exposure on the opaque signals

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sunset we lose the direct rays of the sun; and as twilight advances we get only rays which have suffered several reflexions in the higher regions of the atmosphere. We know from the blue colour of the sky that light reflected from the atmosphere abounds in the blue rays of the spectrum; and the more refrangible rays are precisely those which will most easily suffer reflexion, and might be expected to abound in twilight: while rays from the red end of the spectrum will be less liable to reflexion, and will probably be wanting in the twilight. The advancing twilight will therefore be made up more and more as darkness approaches, of blue or highly refrangible rays, and less and less of red, or slightly refrangible ones. The consequence will be that the red glass will transmit a constantly decreasing, and the blue glass a constantly increasing proportion of the whole incident light; and at length the red glass will become almost opaque to the light falling on it, while the blue will appear more transparent than before."

Opaque red and blue bodies act in the same way towards reflected light as transparent ones do towards transmitted light. There is thus a twofold objection to the use of red signals by day, for they are least trustworthy when light is fading, when of course they are most needed.

is to darken the reds into browns, and the greens into olives, but such browns and olives are as perplexing to the markedly colour-blind as bright reds and greens, and morover stumble the less extreme subjects of colour-blindness, by whom the purer reds and greens are tolerably well distinguished.

Those observations, it will be remembered, refer solely to the discrimination of colours by daylight. Their general tendency is to show, that by such illumination, red and green are the worst colours that can be selected for colour-blind handlers or interpreters of signals; and that these colours have no such superiority in the case of the normal-eyed as to make their retention specially desirable.

The question then arises, are there any colours visible to the colour-blind, and as visible to the colour-seeing as red and green, which may be substituted for these, as equally suitable for both classes of observers? The answer unfortunately is less satisfactory than could be wished.

To begin with the colour-blind. If a triple system of safety, caution, and danger colour-signals is essential to the proper working of railways, then the colour-blind must be excluded from the office of signallers. They distinguish by daylight only blue and yellow, and these solely when full in tint and well illuminated. It is true that they also see black and white, which in ordinary language are reckoned among colours. But by age, tarnish, imperfect light, snow-storms, fogs, &c., blue becomes indistinguishable from black, and white from yellow: moreover the colour-blind are liable to doubt regarding the particular tinge, or chromatic value of every colour, so that it is useless to expect them to distinguish anything more in the hours that intervene between sunrise and sunset, than one *light* colour from one *dark* colour; and it matters comparatively little what two colours are employed, provided the one approaches to white, and the other to black: in truth were all signal-men colour-blind, and two signals sufficient, white and black would be preferable to colours properly so called.

If white and black were employed, it might be possible to introduce azure or sky blue as a third signal, for it is visible to all (or nearly all) eyes, and in the morning and evening twilight shows distinctly, (for the reasons already given), where red and green cannot be distinguished. But though in favourable circumstances white, black, and blue might be distinguished from each other by the colour-blind, they could not be trusted to deal with three unlike colours under doubtful illumination, especially if taken by surprise as railway servants on occasions of special emergency, must in the majority of cases be. I refer to the matter here chiefly because the value of Blue as a signal-colour has not been recognised in reference to those whose vision is perfect, to whom I now turn.

Seeing that the colour-blind cannot be trusted to distinguish more than two colours, and may not always be confident concerning these, it would plainly be the best plan (if colour-signals are retained) to exclude such persons altogether from the office of signal-men; but as the exhibition or interpretation of signals may occasionally fall to the lot of parties generally engaged in other duties from which it would be difficult and perhaps unjust to exclude them, because their vision of colour is not normal; and as railway passengers have a direct interest in the signals used upon railways being such as all can distinguish and understand, it is desirable that those colours should be preferred which are best distinguished by the majority of persons.

Yellow is unquestionably the colour (properly so called) most visible to all eyes, but it is too liable under imperfect illumination to be confounded with white, to admit of being used along with it, nor could it, with any advantage, be substituted for it.

Blue comes next in visibility to Yellow, and might be advantageously substituted for green in all day signals. An azure or sky blue can be readily and cheaply obtained. It is not confounded with red by the colour-blind. It is as visible to the normal-eyed as green under full illumination, and contrasts more sharply with red than its harmonizing complementary green does. Further, it has the peculiar advantage of remaining visible in faint daylight, and of contrasting strongly with red in such circumstances. Were it employed, the colour-blind would make fewer mistakes, and the colour-seeing would have an additional assistance in distinguishing the caution (blue), from the danger (red) signal, whilst white continued as at present the sign of safety.

2. *Of the Perception of Red and Green by Artificial light.*

Light transmitted through coloured bodies seems more easily distinguished by the colour-blind than that reflected from coloured surfaces. This at least is the case with red and green glass through which artificial light is sent, and accordingly the lamp-signals are less liable to mistake by the colour-blind, so far as colour is concerned, than the vane and flag day-signals. But the liability to confound red with green, though less marked, still continues, even when the lamps are near the spectator; and when the distance is greater, red and green lights are not only mistaken for each other, but also for white lights.

This last mistake, according to the curious observations of Professor Tyndall, may also be made by those whose vision is normal, especially if red and green lights are alternately seen from a distance in quick succession; then apparently the combined impression of these complementary colours cannot be distinguished from that of white light.

There are other objections of more or less weight to the use of red in lamp-signals. Of these I mention three,—

1. Mr Henry Lees, the intelligent secretary of the Edinburgh, Perth, and Dundee Railway, has drawn my attention to the effect in altering the impression of distance, which the darkness of the red lamps as compared with the brightness of the white ones occasions. A red light seen from a distance seems much further off than a colourless light side by side with it, the eye assigning a less proximity to the less luminous lamp, in conformity to its experience of the different apparent brightness of lights of the same colour and luminosity placed at different distances from it. The effect of this misconception of distance must necessarily be to make danger-signals appear less near than they actually are, so that the red tail-lamp of a railway train standing still, will appear to a train following it, further off than it actually is, and the standing train will run a great risk of being run into by the moving one.

There is great reason for thinking that many railway collisions have been occasioned by a miscalculation of distance originating in this way. On one of the English railways (the name of which it might be inexpedient to mention), where, as I learn from one of its engineers, trains follow each other at very short intervals through the greater part of the twenty-four hours, red tail-lamps were found so useless in preventing trains from running into each other, that they were replaced by the oldest perhaps of all night-signals, namely an open iron cage containing burning fuel, which by the dimensions of its glowing mass and the cloud of smoke and flame rising from it was conspicuous at a great distance. Where red lamps are retained, it would seem desirable to associate them with white so as to enable their distance from the spectator to be more accurately determined than it can be when they are seen alone.

2. A second objection to the red lamp was prominently indicated by a writer (who did not give his name) in the Times Newspaper two years ago, in reference to an appalling collision on one of the Irish Railways. I have mislaid the reference, and cannot give the writer's words, but he argued that an engine-driver, who must often assist his stoker in supplying coal to the furnace of the locomotive, and be exposed to the intense fiery glare of the blazing fuel, cannot be expected immediately thereafter to recognize a small red flag or red lamp unexpectedly waved in front of his engine ; and he follows this just remark by the suggestion that red port-fires of great intensity and brilliancy should be shown as danger-signals on sudden emergencies.

In truth an eye, dazzled by the red glare of a locomotive furnace, would not only be unaffected by a smaller flame of the same colour, but in obedience to the familiar optical law of successive complementary contrast, would see or tend to see all lights green or greenish.

3. Professor James Forbes pointed out many years ago, as the result of an observation accidentally made at a railway station, that a light seen at night through steam blowing off from the escape valve of an engine-boiler appears of a deep

orange-red like that of nitrous acid vapour.* Now it must often fall to the lot of engine-drivers to have to watch lamps through such an atmosphere which will convert the (white) safety signal into a danger-signal; completely alter the colour of the (green) caution-signal, and so darken the aspect of the (red) danger-signal as to render it invisible.

There are thus serious objections attending the use of red lamps on railways, yet our choice of coloured glasses is so limited that it is extremely questionable if the substitution of another colour for red would be of any service. The advantages which blue possesses for day-signals do not attend its application to lamps. Blue glass is opaque to full daylight compared with red and yellow, and still more to lamp or gas-light in which blue rays are deficient, so that it is the worst of all colours for a night signal-glass. On the other hand, the abundance of yellow rays in ordinary artificial flames points to yellow glass as one eminently visible by their transmitted rays. But in addition to its costliness it is difficult to secure a yellow which is so deep as to be distinctly distinguishable from white at a distance, and yet so pure and not inclining to orange (as the ordinary silver-stained yellow glasses generally do) as not be mistaken for red. Yellow deserves, however, a trial, either as a substitute for the red or the green signal, or as adding to our means of securing safety by association with them.

It is not to be denied that the employment of one set of signal-colours by day and another by night is a disadvantage; but an increase in the safety of travelling would more than counterbalance this; and as white would remain the safety-signal, and red could be retained as the caution-signal, but one signal would vary, which might be blue by day and yellow by night. The principle which should guide us is plainly that the danger-signal should be the most conspicuously visible of all, and were this principle unreservedly carried out, white lamps would replace red as danger-signals. But as the ordinary lights of the carriages, and at the stations, and in the neighbourhood of buildings are and must be white,

* Lond. & Edinb. Phil. Mag. 3d series, vol. xiv., p. 121.

we are of necessity debarred from the use of uncoloured lights as special signals, and must seek to gain our end in some other way.

5. *Of the necessity of employing the Elements of Form and Number, as well as of Colour, in Railway Signals.*

The hopelessness of providing a triple system of coloured railway-signals, which shall always be distinguishable by the colour-blind, and the imperfection of the existing system in reference even to the colour-seeing, make it desirable to connect different colours with different shapes, and to vary the number of signals, so as to heighten their dissimilarity. The acute perception of form and outline, which characterizes many of the colour-blind, enables them largely to supplement their imperfect perception of colour, and the most clear-sighted and watchful engine-drivers acknowledge that difference in shape is a great assistance in distinguishing the signals at present in use. In answer to queries not dealing with the difficulties of the colour-blind, those who are familiar with railways, have again and again told me, that when an engine is travelling at the rate of 20 or 30 miles an hour in the teeth of a cutting wind, the best eyes, even by day, and in clear weather, are often perplexed to decide at once on the colour of a signal, especially when it is suddenly and unexpectedly exhibited. It need not be added that rain, mist, fogs, high winds, snow storms, &c., must greatly increase this perplexity, or that sudden signals are those which most demand prompt recognition.

On many railways Form is used to supplement Colour, but only in certain of the day-signals, and to a smaller extent than is desirable. Thus in the semaphore, a conspicuous alteration in form is secured by exposing or concealing the moveable arm, and by fixing it at an angle of 45 or 90 degrees. In the triple vane, also, as already shown the *white* arm points to the left of the train which it signals, the *green* arm points to the right, and the *red* signal stretches an arm in both directions. In the symmetrical double vane on the other hand, and in the corresponding disc-signals, unless where a triple lamp surmounts them, the eye has no help from form, except that on the disc, the supporting pillar on which it is fixed like a shield on a soldier's arm, is seen traversing vertically one side; but as the pillar is painted of the same colour as the disc, the difference is very inconspicuous, as it is also in the case of the lamp. In no railway, moreover, so far as I am aware, is there any distinction between the shapes of the coloured flags, nor, unless to a small extent, is anything but colour trusted to in the lamp-signals.

So far as day-signals are concerned, I would urge strongly, that in no case should symmetrical double vanes or discs be employed. They have no advantage over unsymmetrical ones, and deprive the observer of a great assistance in interpreting the significance of a signal. Thus even in clear calm weather, and with an engine going at a moderate speed, if the disc or vane be between the engine and a bright sun, its colour (as I have ascertained from the testimony of engine-drivers), is often indistinguishable, and if it be symmetrical, it is impossible to determine whether it is signalling safety or danger. On the other hand its outline stands out with the greatest distinctness against the bright sky, and if it be shaped like a battle-axe, a broad-feathered arrow, a wind-vane, a weather-cock, a fish, or the like, the pointing of its narrow end to the right or the left of the engine-driver, will be significant of its purpose as a signal. Such unsymmetrical vanes are already in use on several railways, and should be introduced in all where the double vane or disc-system is employed.

It is less easy to apply this principle to flags, (although it forms an essential part of our naval system of signalling), as they are held so low, and generally so much within the shelter of walls and buildings, that they do not "blow out" like ship-flags or pennants, and show their form distinctly. Yet mistakes regarding flags, which at a distance from stations are often the only available day-signals in sudden emergencies, have been the cause of some of the most serious railway accidents on record, and they are, I apprehend, the least satisfactory class of railway-signals in use.

The greatest defects of flags are their smallness and dinginess. Little can be done to remedy the first evil, for they must remain portable, but much may be done to remedy the second. On all our railways, a number of the flags in use, especially those which are red and green, are so dull and discoloured by smoke, dust, and frequent handling, that they cannot be expected to catch readily the sharpest eye not specially on the look-out for them. The stout fabric (bunting) of which the flags are made, is much more durable than their colour, but the latter could at least be refreshed by occasional washing, or still better restored by re-dyeing. Something, however, more abidingly brilliant than our present flags, is demanded on railways; and if they are continued in use, they should at short intervals pass through the hands of the dyer, and some official be held responsible for their condition in reference to colour.

The white flag is the least important on the present system, and if clean, should be sufficiently conspicuous. With the coloured flags, the shape and number might be made different in each. Thus the caution-signal might be *one square* green flag; and the danger-signal, *two red* triangular ones; or in preference, a different figure might be inscribed on each flag, as a white moon-like disc on the green flag, and two white squares at opposite corners, on the red flag, so as to make the latter consist of four squares of equal size, two red and two white.

But the efficiency of all such devices is almost destroyed by the smallness of the flags, the low elevation at which they are held, and the difficulty of swinging them fully, so as to let their configuration be observed; and it is in another direction that we can most hopefully look for increasing their utility as signals.

This direction is the following:—The *motions* of a flag, apart from its colour, are employed as signals on our railways; and from the rapidity with which those motions can be executed by the direct action of a living arm, compared with the cumbrous manipulations of the more complex semaphores and vanes, a very simple set of rules is sufficient to secure safety. Thus, to take one code of signals, the flag held at arm's length in the right hand of the signal-man, and slowly waved or fluttered back and forwards, denotes "*Caution; go slow;*" elevated in front of his body, with the flag-staff held vertically, (like a soldier's sword or musket at the salute,) and kept unmoved, it signifies "*All right; go on;*" and held across the body, with the arm raised and bent, so as to show the flag beyond the left shoulder, it denotes "*Danger; stop;*" and may be rendered more emphatic by being waved rapidly from right to left.

A single flag would thus serve for all the signals at present denoted by three flags; and without insisting on only one being retained, I would draw attention to the fact, that where the disregard of a flag has occasioned accidents on railways, it has more frequently been in consequence of the signal not being seen, than in consequence of its colour being mistaken. No prudent engine-driver who distinctly saw a flag, whatever its colour, waved violently before him, would proceed without slackening his speed.

If a single hand-signal were deemed sufficient, and it took the form of a flag, it should display two colours, the chief one being white, the other black, blue, or red, as a border or fringe, with perhaps a circle or disc of the same colour in the centre, so that the flag might be visible, whether seen against a light or a dark back-ground. Canvas painted white, or leather, which could have a fresh white surface given to it daily if necessary, would probably be preferable to the semitransparent, less conspicuous bunting at present in use, and the entire flag should be considerably larger than those now employed. I would farther suggest, that instead of a flag, it might be advisable to employ a more conspicuous body, such as a polished reflector. A hollow ball of tin or of glass silvered inside, or two vertical vanes of tin or silvered glass, at right angles to each other, and placed at the end of a staff, would reflect light in whatever position they were held, and might catch an engine-driver's eye, where flags failed to do so.

It is of course impossible, to render visible a small signal to an engine-driver, who does not keep a look-out in front, or is engaged in assisting his stoker in managing the furnace-fire, at the time when the warning is given. To meet such a contingency, some eminently startling and conspicuous signal, such as a rocket, a blue-light, or a red port-fire, alone would suffice. Port-fires are in nominal use on one of the English railways, but apparently they are rarely employed. They deserve more attention than they have received, for the great defect attaching to all our occasional or hand-signals, is their smallness and inconspicuousness. An engine-driver knows where to expect stationary signals along a railway line, and looks out for their indications; but an unexpected signal must compel his attention, if it is to be of any service, nor can it ever be seen, or obeyed too speedily.

The night-signals as already stated, whether stationary or moveable, are significant almost solely by their difference in colour. The insufficiency of this system, however, is increasingly attracting attention, especially in reference to the meeting-points of several railway branches, where the risks of collision are especially great.

At the Leven Junction of the Edinburgh, Perth, and Dundee Railway, Mr Bouch, C.E., has erected a very effective compound signal, which illustrates the felt necessity of not trusting to colour alone, and the mode in which it may be combined with form. It employs the combination of colour and form by day as well as by night, in the following way:—

One white Disc denotes SAFETY by day; and *one white* light, safety by night. *One green fish-tail* denotes CAUTION by day; and *one green* light, caution by night. *Two red discs* denote DANGER by day; and *two red lights*, danger by night.

This arrangement was not intended (as I learn from Mr Bouch), to meet the case of the colour-blind, but simply to assist the perception of those whose vision is normal. The day system, however, would remove the special difficulty of the colour-blind, who have the distinctions between a disc, a fish-tail, and a double disc, to guide them in their interpretation of the signals. At night also, the double red lamp which, as the danger-signal, is the most important of all, could not be mistaken for the solitary white, or green light; but a colour-blind person might confound one of these with the other, as one not colour-blind might also in unfavourable circumstances. It would be better, therefore, to vary the numbers still further, by using for example, one white light; two green lights, and three red lights.

Such combinations of colour and form, or of colour and number, admit of endless modifications, but if our engineers are once satisfied of the necessity of employing them, it will very lightly tax their trained ingenuity to vary them, so as to meet all the requirements of railway service.

It is much more difficult to apply the principle indicated above to the hand-lamps and carriage-lamps, than to the stationary signals. So far as the carriages are concerned, the effect of recent accidents in inducing an increase in the number of red tail-lamps has been most beneficial. Three does not seem too many for the last carriage of a train, on lines where there is much traffic, especially where the train is a luggage or parliamentary one, making many halts, and liable to be run into by trains from behind. The three lamps, also, might be arranged in a triangle, or otherwise, so as to indicate, by their relative position, apart from their colour, that they were in the rear of a train, and thus be significant even to the colour-blind.*

The hand-lamps are in the same predicament as the flags, and, as shown on sudden emergencies, their visibility is of more importance than their colour; for a single light, like a single flag, may be made to indicate safety, caution, or danger, according to the direction in which it is held or waved. Were it possible, accordingly, to provide a hand-light of great brilliancy, this, no matter what its colour, would largely add to our means of preventing accidents on railways. There is no prospect of this desideratum being realized with lamps fed with oil or similar combustibles, but it is quite within our reach by those pyrotechnic mixtures which, under the names of blue lights, and red and green fire, are employed as night-signals by our army and navy. The least conspicuous of these

* On some of the English railways the entire back, and part even of the sides of the last carriage of the train, are painted bright red, so as to expose a very large and conspicuous coloured surface. Were this lighted at night by colourless lamps, provided with reflecting shades, it would probably be visible at a greater distance than red lamps would be; but the exigencies of railway service do not always allow the same carriage to be the last in a train.

is the green fire, the most brilliant the blue light, and the most startling the red fire.* They are supplied by firework-makers in cartridges, and can be lighted at a moment's notice. The blue light is the cheapest, and its peculiar lurid flame is not liable to be mistaken for that of an ordinary conflagration, which the splendid crimson blaze of the strontia fire might be. All of them illuminate a wide area; in truth, the only objection I can conceive to their use is, that they might alarm too great an extent of country; but this is an error in the right direction; and it may be safely asserted that more than one appalling night accident would have been prevented had the guards of a train, brought to an unexpected stand still, had the means of suddenly showing a blazing light. The reluctance of guards and stokers to leave their trains and run back some distance with red lamps is brought out at every criminal trial following a night accident on a railway.

The difficulty, also, often experienced in conveying to the nearest stations a knowledge of the fact that there exists an obstruction on the line, is scarcely less notorious. The portfires, referred to, however, would be visible at a great distance, even though kindled close to the train brought to a standstill; and they would often suffice to warn the adjoining stations that an accident had occurred in their neighbourhood.

Red and green lamps are employed as signals at sea, as well as on land; and as peculiar dangers attend their employment on board ship, it will be convenient to consider that subject here, before proceeding to discuss the best modes of testing the colour-vision of signal-men.

6. *Of the Danger attending the System of Red and Green Lights, at present in use on board Steam Vessels.*

In the Admiralty Notice respecting lights to be carried by sea-going vessels, to prevent collision, which came into force in August 1852, and still regulates their system of night signals, the following rules are required to be strictly obser-

* Receipts for these mixtures will be found in works on Chemistry. The green fire is a mixture of sulphur and other combustibles with nitrate of baryta; the red fire, a similar mixture with nitrate of strontia; and the blue light a mixture of sulphuret of antimony, and sulphur with nitrate of potash.

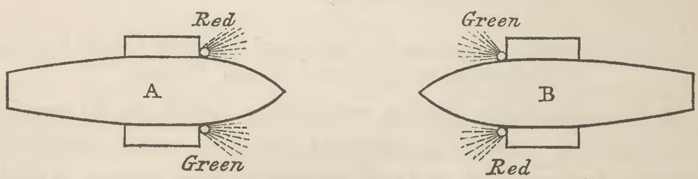
ved by all British steam-vessels. Between sunset and sunrise, when under steam, they are to show a bright *white* light on the foremast head; a *green* light on the starboard side; a *red* light on the port side.

The side lights are, moreover, to be fitted with screens, on the inboard side, of at least three feet long, to prevent the lights from being seen across the bow.

The object of the screens, which are regarded by its devisers as the most novel and important part of their plan, is "to prevent both coloured lights being seen at the same moment from any direction but that of right-a-head;" and the expectation, as stated in the official notice, is, that the effect of the arrangement proposed will be such, "that in any situation in which two vessels may approach each other in the dark, the coloured lights will instantly indicate to both the relative course of each; that is, each will know whether the other is approaching directly or crossing the bows, either to starboard or to port. This intimation is all that is required to enable vessels to pass each other in the darkest night with almost equal safety as in broad day, and for the want of which so many lamentable accidents have occurred."

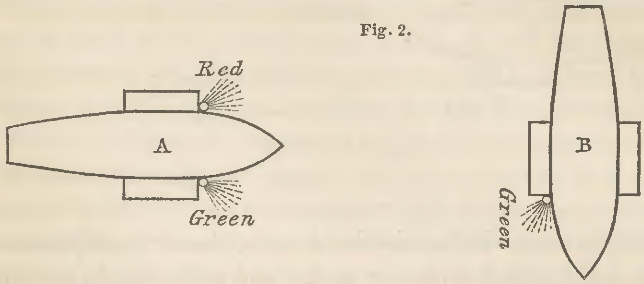
The expectation expressed in the paragraph I have quoted will be realized where two vessels approach each other directly. Let both be steamers, then the steersman of each will, whether colour-blind or not, see a triangle of lights approaching; and, if not colour-blind, will also perceive, as shown in the diagram (Fig. 1), a green light on the starboard side, and a red on the port side of the advancing vessel.

Fig. 1.



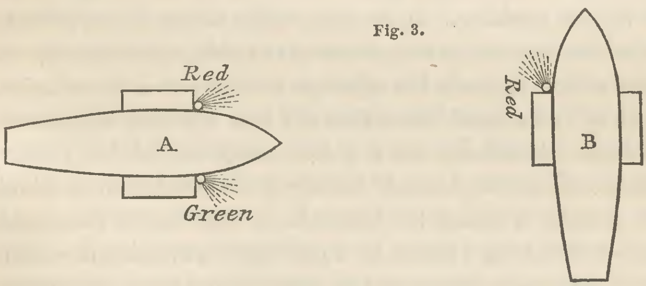
But when vessels are crossing each other's bows, the foremast *white* light goes for nothing, and the colour of the steamer's *one* side-light seen is, to the vessel seeing it, the index whether the steamer is crossing to starboard or port, *i.e.*, in landsman's phrase, to the right hand or left hand of the steersman who perceives only the green, or only the red light. This is shown in Figs 2 and 3, where one vessel is supposed

Fig. 2.



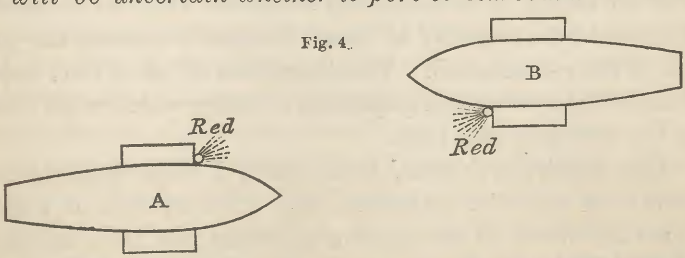
to cross the path of another at right angles ; both are represented as paddle steamers. The steersman of B in both cases should see all the lights of A, and be warned of a steamer's direct approach, whether he distinguished the colour of the side-lights or not.

Fig. 3.



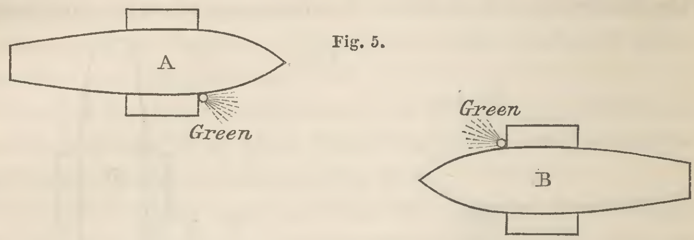
But the steersman of A has only the colour of one of B's side-lights, to tell him, whether as in Fig. 2, B is crossing to starboard (his right hand); or as in Fig. 3, to port (his left hand) ; and if he is the only look-out, and *is colour-blind, he will be uncertain whether to port or starboard his helm.*

Fig. 4.



Again, in Fig. 4, A and B will see each other's red light only, the screens preventing the green lights from being seen ; and both vessels passing to port. In Fig. 5, on the other hand, a

Fig. 5.



green light only will be visible to each, the screens preventing the red lights from being seen; and both vessels passing to starboard.

Now if the pilots of A or B, one or both, are colour-blind, of what service will the colour of the one side-light be? I reply, without hesitation, of less than no service. The red lamp may be mistaken for green, or the reverse, and a collision determined by the mistake. In no case will a colour-blind pilot be absolutely certain as to the colour of the side-light and the vacillation which attends his attempt to come to a conclusion, may not be exchanged for action till it is too late to prevent a collision. Further; as a pilot, conscious of his colour-blindness, will guide himself mainly by the direction in which he sees a light crossing his bows, he is exposed to the disadvantage of watching a green or a red light, which is not visible so far off as a white one, and is also liable from its comparative obscurity to appear further off than it actually is. Moreover, from all my examinations of the colour-blind, I am satisfied that however conscious they may be of their peculiarity of vision, they will always, if given to understand that an object is coloured, try to decide what its colour is, and yet, in the majority of cases, hesitate regarding the justice of their conclusion. The distraction of mind thus occasioned is fatal to that promptitude of action which must often be the first duty of a pilot.

The Admiralty Notice, from which I have quoted, contains in a note the statement, that "the system of night-lights laid down in the above regulations has been adopted in Her Majesty's Service, and by the Governments of the principal Foreign Maritime Nations." This announcement must be read with grave apprehension by all who are familiar with the statistics of colour-blindness; for colour *alone* is relied upon to instruct a pilot how to steer clear of a steamer in a dark night; and the mistake of red for green, or the reverse, would be still more disastrous at sea than on shore, for the object of a railway danger (red) signal would often be sufficiently secured, though it were interpreted only as a caution (green) signal; and the purpose of a caution signal would be more than secured if it were understood as a warning of danger. But at sea, to mistake either of these lights for the other, would equally and inevitably lead to a vessel being steered so as to determine a collision.

In Her Majesty's Naval Service, and in our Commercial Marine, the safety at least of the larger vessels is in charge during night of a whole watch of men; but even in those ships the steering of the vessel is not unfrequently under the guidance of a single pilot, whose word is law, and who may be colour-blind, but unconscious of the fact, or afraid to confess it. And in smaller vessels, especially those not in Her Majesty's Service, it is notorious, that whatever the theory of night-watching may be, the fact is that the safety of a ship is often to all practical intents in the hands of the steersman alone, whose power to distinguish red from green may be null. The Admiralty system of night-lights, accordingly, is trustworthy, only provided the freedom of pilots and look-outs from colour-blindness is guaranteed; and at present no means are taken to determine this. It would be so difficult, however, to render certain the exclusion from the office of pilot or look-out of such members of a large crew as were colour-blind, and so inexpedient to refuse employment on board ship to those who were, but at the same time possessed all the other qualifications of good sailors, that I cannot but urge the desirableness of changing the system of night-lights at sea for one which the colour-blind cannot mistake. This need not prevent coloured lamps from being employed, although it is desirable that on board war-ships and others provided with surgeons, the medical officers should report those of the crew who are colour-blind, so as to prevent their employment (whether by day or night), as special signal-men. By varying the number, or relative position, or both of the port and starboard lights in the way already indicated in the case of railway lamps, or otherwise, it seems quite possible, without depriving those who can distinguish it, of the assistance afforded by difference in colour, to enable the colour-blind to act safely as night-pilots. The mode in which this may best be effected, I leave to the decision of seamen who are satisfied that the prevalence of colour-blindness necessitates a change in the Admiralty system of lights. It is sufficient for me to urge that that system is fraught with unsuspected danger to all who trust in it.

7. *Of the best modes of detecting Colour-Blindness.*

It admits of question, whether the demands of public safety would be best met by excluding colour from railway and ship signals, or by excluding the colour-blind from the office of signal-men.

The answer, however, must be that the alternative is not in our choice. It must necessarily happen, both at land and sea, that those not specially set apart as the exhibitors or interpreters of signals, have at times to act as such, and the most sudden emergencies are exactly the occasions on which the least qualified and least experienced are most liable to a summons of this kind. We cannot, therefore, be too careful to make our signals significant by other characters besides that of colour.

On the other hand, the colour-blind are a minority in the community ; and those peculiarly destined to deal with signals should be selected solely from the majority whose vision is normal. Colour, however, is of great service to them in distinguishing visible objects ; and it should, therefore, assuredly be retained in signals. I have the authority of railway engineers for stating, that frequently when a signal is seen by reflected light,—for example, by the sun's rays shining from behind an engine-driver upon a signal which his train is approaching,—its shape gives no assistance in discerning it if it is projected against a back-ground of its own colour ; as the green signal may be against trees in leaf, or hills in pasture, and the red when tarnished or as seen by twilight, against newly ploughed ground. That this difficulty is generally recognised, I infer from the fact, that on several railways the red side of the signal-vanes is painted with a white border, and on others the centre of the green side, where there is an open star, has its rays painted white. On the North British Railway, in the immediate neighbourhood of Edinburgh, green is dispensed with, and the vanes are red, with a white border on the one side, and red alone on the other.

As the most normal eye thus needs every help in distinguishing signals by their colour, when their form is uncertain, it is desirable that the simplest means of detecting colour-blindness, and of estimating its extent, should be known to those concerned in the appointment of signal-men.

The most testing colours by daylight are red as compared with light-green; brown as compared with olive and dark-green, and lilac, as compared with blue.

By artificial light, in addition to the colours named above as exhibited by flags and painted opaque surfaces, coloured lamps will, of course, be employed; and red, green, and purple glass, viewed by transmitted light, are also useful by day. In all cases the vision of colour should be tested at various distances from the coloured object; and none should be passed who err in the majority of trials regarding a signal seen from the furthest point at which it must be swiftly interpreted to secure safety. For it must not be forgotten that certain of the colour-blind distinguish pretty fairly colours (such as red and green) near at hand, which they confound at some distance. And for a similar reason their vision should be tried under various degrees of illumination, and in particular the visibility of the testing colours by twilight should be specially ascertained.

Candidates for appointments where good eye-sight is required, are not likely to exaggerate their defects of vision. Whenever, therefore, any hesitation in distinguishing colours is manifested, it should be further tried by giving the party under examination, parcels of different coloured cloth, paper, glass and the like, and requesting him to assort them according to their colours. Reds, greens, browns, and lilacs, should form an essential part of these parcels, but not to the exclusion of other tints and shades. No person markedly colour-blind, will, I am persuaded, escape detection if tried in this way, and the kind and number of mistakes which he commits will measure the extent of his colour-blindness.

The mode of examination thus explained is within the reach of railway-superintendents and ship-masters, and will serve every practical end. But where railway-servants, sailors, soldiers, or others, undergo preliminary examination by a surgeon, a more minute examination might be made, and in another way. Mr James Clerk Maxwell, of Trinity College, Cambridge, a mathematician and natural philosopher of the highest promise, has devised a most simple and effectual means of discovering the nature and extent of colour-blindness. It is described in the communication from Mr Maxwell which is appended to this (page 394), and at greater length in a paper which will appear in the forthcoming part of the Transactions of the Royal Society of Edinburgh. To these the reader is specially referred; but it will not be out of place to state here that Mr Maxwell employs a disc of pasteboard, or metal, provided with a spindle, so as to admit of it being spun as a top or teetotum. The spindle is in two pieces, and can be unscrewed so as to allow discs of coloured paper, perforated in the centre to receive the spindle, and with a slit corresponding to a radius of the disc, to be placed on the upper surface of the top, the rim or circumference of which is divided into 100 equal parts. The paper discs admit of being placed above each other, and any portion of one disc may be made to appear above another, by passing one edge of its slit through the slit in the other.

Thus, let a disc of red and a disc of white paper be placed together on the top, the white being the lower of the two; we may then, if we choose, cover the white entirely by the red, so that the latter only shall appear; or at will, bring the white through the slit in the red so as to let one tenth, one twentieth, one twelfth, or the like quantity of the surface of the white cover that amount of the surface of the red. When the top is made to spin, one of the tints (dilutions with white) of red will be obtained, and the quantity of red and white in it may be measured by the graduation on the circumference of the circle.

In the same way a circle of red and a circle of black will give the shades (deepenings with black) of red; and the delicacy of an eye in distinguishing the nicer graduations of colour, may be quantitatively determined.

Again, small discs (half the diameter of the larger ones) of green, and of white or black paper, may be placed on the colour-top above the larger red and white or black discs, so that when the top is spinning, a green circle, surrounded by a red ring will be visible to a normal eye, and these may be compared throughout their tints and shades.

This little instrument, (which however any one can construct for himself), may be had with a series of selected coloured papers, from Mr James Bryson, optician, Edinburgh. I can testify from experience to the rapidity with which it enables colour-blindness to be detected, and Mr Maxwell's papers will demonstrate the number and value of the results which it may be made to yield in the examination of normal and abnormal eyes.

I have lastly to notice, that there is a singular expression in the eye of certain of the colour-blind, which may assist in their detection. It is difficult to describe it, and it is wanting in well-marked cases. But various of the colour-blind, whose cases I have described, have presented a peculiarity of look, which others have recognised on their attention being drawn to it. In some it amounted to a startled expression, as if they were alarmed; in others to an eager, aimless glance, as if seeking to perceive something but unable to find it; and in certain others to an almost vacant stare, as if their eyes were fixed upon objects beyond the limit of vision. The expression referred to, which is not constant, or rather not at all times equally pronounced, never altogether leaves the eyes which it seems to characterize.

Whether its occurence in those colour-blind persons whom I have examined is but a coincidence, (which it may be), or the unconscious expression of a defective sense, I do not attempt to decide; but I mention the matter here that future observers may keep it in view.

On the Theory of Colours in relation to Colour-Blindness. By JAMES CLERK MAXWELL, Esq., Trinity College, Cambridge, in a Letter to Dr G. Wilson.

DEAR SIR,—As you seemed to think that the results which I have obtained in the theory of colours might be of service to you, I have endeavoured to arrange them for you in a more convenient form than that in which I first obtained them. I must premise, that the first distinct statement of the theory of colour which I adopt, is to be found in *Young's Lectures on Natural Philosophy* (p. 345, Kelland's Edition); and the most philosophical enquiry into it which I have seen is that of Helmholtz, which may be found in the Annals of Philosophy for 1852.

It is well known that a ray of light, from any source, may be divided by means of a prism into a number of rays of different refrangibility, forming a series called a spectrum. The intensity of the light is different at different points of this spectrum; and the law of intensity for different refrangibilities differs according to the nature of the incident light. In Sir John F. W. Herschel's *Treatise on Light,* diagrams will be found, each of which represents completely, by means of a curve, the law of the intensity and refrangibility of a beam of solar light after passing through various coloured media.

I have mentioned this mode of defining and registering a beam of light, because it is the perfect expression of what a beam of light is in itself, considered with respect to all its properties as ascertained by the most refined instruments. When a beam of light falls on the human eye, certain sensations are produced, from which the possessor of that organ judges of the colour and intensity of the light. Now, though every one experiences these sensations, and though they are the foundation of all the phenomena of sight, yet, on account of their absolute simplicity, they are incapable of analysis, and can never become in themselves objects of thought. If we attempt to discover them, we must do so by artificial means; and our reasonings on them must be guided by some theory.

The most general form in which the existing theory can be stated is this,—

There are certain sensations, finite in number, but infinitely variable in degree, which may be excited by the different kinds of light. The compound sensation resulting from all these is the object of consciousness in a simple act of vision.

It is easy to see that the *number* of these sensations corresponds to what may be called in mathematical language the number of independent variables, of which sensible colour is a function.

This will be readily understood by attending to the following cases:—

1. When objects are illuminated by homogeneous yellow light, the only thing which can be distinguished by the eye is difference of intensity or brightness.

If we take a horizontal line, and colour it black at one end, with increasing degrees of intensity of yellow light towards the other, then every visible object will have a brightness corresponding to some point in this line.

In this case there is nothing to prove the existence of more than one sensation in vision.

In those photographic pictures in which there is only one tint of which the different intensities correspond to the different degrees of illumination of the object, we have another illustration of an optical effect depending on one variable only.

2. Now, suppose that different kinds of light are emanating from different sources, but that each of these sources gives out perfectly homogeneous light, then there will be two things on which the nature of each ray will depend:—(1.) its intensity or brightness; (2.) its hue, which may be estimated by its position in the spectrum, and measured by its wave length.

If we take a rectangular plane, and illuminate it with the different kinds of homogeneous light, the intensity at any point being proportional to its horizontal distance along the plane, and its wave length being proportional to its height above the foot of the plane, then the plane will display every possible variety of homogeneous light, and will furnish an instance of an optical effect depending on two variables.

3. Now, let us take the case of nature. We find that colours differ not only in intensity and hue, but also in tint; that is, they are more or less pure. We might arrange the varieties of each colour along a line, which should begin with the homogeneous colour as seen in the spectrum, and pass through all gradations of tint, so as to become continually purer, and terminate in white.

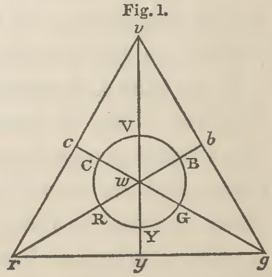
We have, therefore, three elements in our sensation of colour, each of which may vary independently. For distinctness sake I have spoken of intensity, hue, and tint; but if any other three independent qualities had been chosen, the one set might have been expressed in terms of the other, and the results identified.

The theory which I adopt assumes the existence of three elementary sensations, by the combination of which all the actual sensations of colour are produced. It will be shown that it is not necessary to specify any given colours as typical of these sensations. Young has called them red, green, and violet; but any other three colours might have been chosen, provided that white resulted from their combination in proper proportions.

Before going farther I would observe, that the important part of the theory is not that three elements enter into our sensation of colour, but that there are only three. Optically, there are as many elements in the composition of a ray of light as there are different kinds of light in its spectrum; and, therefore, strictly speaking, its nature depends on an infinite number of independent variables.

I now go on to the geometrical form into which the theory may be thrown. Let it be granted that the three pure sensations correspond to the colours red, green, and violet, and that we can estimate the intensity of each of these sensations numerically.

Fig. 1.



Let $v\ r\ g$ be the angular points of a triangle, and conceive the three sensations as having their positions at these points. If we find the numerical measure of the red, green, and violet parts of the sensation of a given colour, and then place weights proportional to these parts at r g and v, and find the centre of gravity of the three weights by the ordinary process, that point will be the position of the given colour, and the numerical measure of its intensity will be the sum of the three primitive sensations.

In this way, every possible colour may have its position and intensity ascertained; and it is easy to see that when two compound colours are combined, their centre of gravity is the position of the new colour.

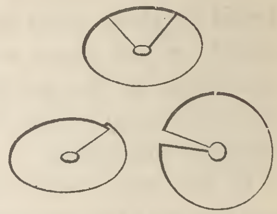
The idea of this geometrical method of investigating colours is to be found in Newton's *Opticks* (Book I., Part 2, Prop. 6.), but I am not aware that it has been ever employed in practice, except in the reduction of the experiments which I have just made. The accuracy of the method depends entirely on the truth of the theory of three sensations, and therefore its success is a testimony in favour of that theory.

Every possible colour must be included within the triangle r g v. White will be found at some point, w, within the triangle. If lines be drawn through w to any point, the colour at that point will vary in hue according to the angular position of the line drawn to w, and the purity of the tint will depend on the length of that line.

Though the homogeneous rays of the prismatic spectrum are absolutely pure in themselves, yet they do not give rise to the "pure sensations" of which we are speaking. Every ray of the spectrum gives rise to all three sensations, though in different proportions; hence the position of the colours of the spectrum is not at the boundary of the triangle, but in some curve C R Y G B V considerably within the triangle. The nature of this curve is not yet determined, but may form the subject of a future investigation.

All natural colours must be within this curve, and all ordinary pigments do in fact lie very much within it. The experiments on the colours of the spectrum which I have made are not brought to the same degree of accuracy as those on coloured papers. I therefore proceed at once to describe the mode of making those experiments which I have found most simple and convenient.

Fig. 2.



The coloured paper is cut into the form of discs, each with a small hole in the centre, and divided along a radius, so as to admit of several of them being placed on the same axis, so that part of each is exposed. By slipping one disc over another, we can expose any given portion of each colour. These discs are placed on a little top or teetotum, consisting of a flat disc of tin-plate and a vertical axis of ivory. This axis passes through the centre of the discs, and the quantity of each colour exposed is measured by a graduation on the rim of the disc, which is divided into 100 parts.

By spinning the top, each colour is presented to the eye for a time proportional to the angle of the sector exposed, and I have found by independent experiments, that the colour produced by fast spinning is identical with that produced by causing the light of the different colours to fall on the retina at once.

By properly arranging the discs, any given colour may be imitated and afterwards registered by the graduation on the rim of the top. The principal use of the top is to obtain colour-equations. These are got by producing, by two different combinations of colours, the same mixed tint. For this purpose there is another set of discs, half the diameter of the others, which lie above them, and by which the second combination of colours is formed.

The two combinations being close together, may be accurately compared, and when they are made sensibly identical, the proportions of the different colours in each is registered, and the results equated.

These equations in the case of ordinary vision, are always between four colours, not including black.

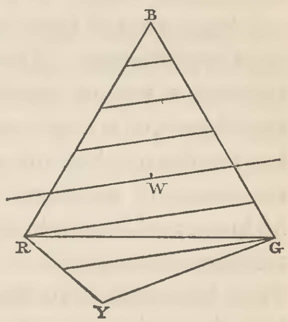
From them, by a very simple rule, the different colours and compounds have their places assigned on the triangle of colours. The rule for finding the position is this :—Assume any three points as the positions of your three standard colours, whatever they are ; then form an equation between the three standard colours, the given colour and black, by arranging these colours on the inner and outer circles so as to produce an identity when spun. Bring the given colour to the left-hand side of the equation, and the three standard colours to the right hand, leaving out black, then the position of the given colour is the centre of gravity of three masses, whose weights are as the number of degrees of each of the standard colours, taken positive or negative, as the case may be.

In this way the triangle of colours may be constructed by scale and compass from experiments on ordinary vision. I now proceed to state the results of experiments on Colour-Blind vision.

If we find two combinations of colours which appear identical to a Colour-Blind person, and mark their positions on the triangle of colours, then the straight line passing through these points will pass through all points corresponding to other colours, which, to such a person, appear identical with the first two.

We may in the same way find other lines passing through the series of colours which appear alike to the Colour-Blind. All these lines either pass through one point or are parallel, according to the standard colours which we have assumed, and the other arbitrary assumptions we may have made. Knowing this law of Colour-Blind vision, we may predict any number of equations which will be true for eyes having this defect.

Fig. 3.



The mathematical expression of the difference between Colour-Blind and ordinary vision is, that colour to the former is a function of two independent variables, but to an ordinary eye, of three; and that the relation of the two kinds of vision is not arbitrary, but indicates the absence of a determinate sensation, depending perhaps upon some undiscovered structure or organic arrangement, which forms one-third of the apparatus by which we receive sensations of colour.

Suppose the absent structure to be that which is brought most into play when red light falls on our eyes, then to the

Colour-Blind red light will be visible only so far as it affects the other two sensations, say of blue and green. It will, therefore, appear to them much less bright than to us, and will excite a sensation not distinguishable from that of a bluish-green light.

I cannot at present recover the results of all my experiments; but I recollect that the neutral colours for a Colour-Blind person may be produced by combining 6 degrees of ultramarine with 94 of vermilion, or 60 of emerald-green with 40 of ultramarine. The first of these, I suppose to represent to our eyes the kind of red which belongs to the red sensation. It excites the other two sensations, and is, therefore, visible to the Colour-Blind, but it appears very dark to them and of no definite colour. I therefore suspect that one of the three sensations in perfect vision will be found to correspond to a red of the same hue, but of much greater purity of tint. Of the nature of the other two, I can say nothing definite, except that one must correspond to a blue, and the other to a green, verging to yellow.

I hope what I have written may help you in any way in your experiments. I have put down many things simply to indicate a way of thinking about colours which belongs to this theory of a triple sensation. We are indebted to Newton for the original design; to Young for the suggestion of the means of working it out; to Prof. Forbes* for a scientific history of its application to practice; to Helmholtz for a rigorous examination of the facts on which it rests; and to Prof. Grassmann (in the Phil. Mag. for 1852), for an admirable theoretical exposition of the subject. The colours given in Hay's "*Nomenclature of Colours*" are illustrations of a similar theory applied to mixtures of pigments, but the results are often different from those in which the colours are combined by the eye alone. I hope soon to have results with pigments compared with those given by the prismatic spectrum, and then, perhaps, some more definite results may be obtained. Yours truly, J. C. MAXWELL.

EDINBURGH, *4th Jan.* 1855.

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* Phil. Mag., 1848.

Description of an improved Boring Machine for Blasting Rocks. By Mr HUGH CLELAND, Craigleith Quarry, near Edinburgh.*

SILVER MEDAL, VALUE £10, AWARDED.

A few years ago a boring machine was introduced into this country by a Mr Nicholson from America. This machine was found to be very ineffective and costly; among other defects, it would not work when inclined, and was easily deranged.

The one I have made is of a simple construction, can work at any inclination, and is not liable to go out of order even when worked by the most ignorant hands. It has now been in use at Craigleith Quarry for four years, and has cost nothing for repairs, except for the unavoidable wear of the mouth-piece or borer.

The machine consists of a timber frame, axle, crank, and fly-wheel. The crank is part of a circle, hollow, with steel rollers set in it; these rollers act on the under side of a metal flange, fixed on the boring-rod by a steel peg; and the flange is shifted up the boring-rod eight or nine inches at a time as the boring proceeds, without much hindrance or difficulty. The crank, by acting on the under part of the flange, turns the rod about a quarter round at every lift, so as to secure, in consequence of the form of the mouth-piece, a perfectly round hole, $4\frac{1}{2}$ to $7\frac{1}{2}$ inches diameter. The fall of the rod is two feet, and the rod itself may be from 20 to 50 feet long, $2\frac{3}{8}$ inches in diameter.

The machine is worked by four men, and in ordinary cases bores from 10 to 15 feet per day; it saves a great deal both of time and of material, and as it bores to 40 feet or more, much larger masses of rock can be loosened than formerly.

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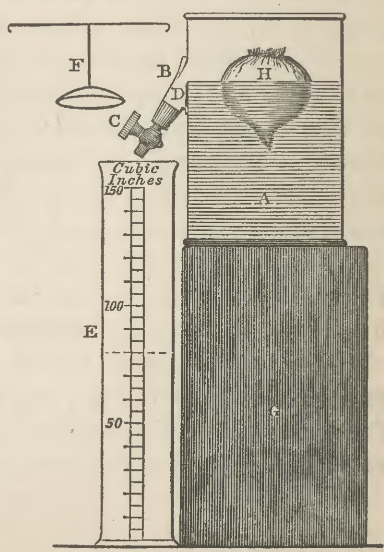
* Read, and working modal exhibited, 27th November 1854.

Description of a New Apparatus for taking the Specific Gravity of Floating Bodies, &c. By PETER STEVENSON, Philosophical Instrument Maker, Edinburgh.*

SILVER MEDAL, VALUE L.7, AWARDED.

The principle upon which this apparatus is constructed is very simple and of great antiquity. Pure water at the temperature of 60° Fahrenheit has long been adopted as the standard of comparison for the specific gravity of all solid and liquid bodies. The principle of specific gravity, first discovered by Archimedes, may be stated thus: a body which floats in water displaces exactly its weight of that liquid; and a body which sinks, or is submerged, displaces precisely its bulk of water. When once the weight and bulk of a body are determined, the specific gravity is found by dividing its own weight by that of its bulk of water.

The principle of displacement has been long known, and a variety of instruments have been constructed, founded upon it, to serve numerous purposes; *yet hitherto no one appears to have been made fitted to determine conveniently the specific gravity of bodies of irregular shape and size.*



This want, it is humbly submitted, this apparatus supplies. It consists of two glass jars, as shown in the annexed sketch, one of which, A, is made 8 inches in diameter by 12 inches in height. Three inches down from the mouth, on the side of the jar, is a large drooping tubular, B, to which is attached a stop-cock, C; across the tubular, inside of the jar, is fixed a gauge of gilded metal, D, having a very thin horizontal straight edge, which determines ex-

* Read and exhibited 28th December 1854.

actly the water-level in the jar, and over which the surplus flows, and is let off by the stop-cock. The other jar, E, is $3\frac{1}{2}$ inches in diameter by 20 inches in height, and is accurately graduated on the sides with three lines of divisions, viz., cubic inches, avoirdupois pounds and ounces, and thousandth parts of a gallon. The brass piece, F, is used to depress the floating body below the water-level, and to retain it there, the upper part of F grasps the rim of the jar A. G is the case in which the whole is fitted for conveyance, and serves as a stand upon which to raise the jar A when in use.

Directions.

Take the apparatus out of the case, place the glasses as shown in the sketch, shut the stop-cock, and fill the jar A with water a little above the gauge; let the water come to rest, then open the stop-cock, and allow the surplus water to run away, so as to adjust the water-level in the jar. Now shut the stop-cock, and introduce gently into the water the body whose specific gravity is to be determined; for example a root that will float as H. The water will immediately rise in the jar; let it come to rest; open the stop-cock, and receive the water that will now run out in the graduated glass jar E. When the water has ceased to flow from the stop-cock, record the quantity which has been received, as shown by the graduations on the different scales.

This is the weight-indication of the root (1). Again shut the stop-cock, and depress the root by using the brass piece F; and when the water has come to rest, open the stop-cock, and let the liquid, which will again flow out, add itself to that already in the graduated jar. When this additional quantity has been received, record the larger amount now received, as shown on the scales. *This is the bulk-indication of the root* (2). Suppose the cubic-inch scale to be used, and the first or weight-indication (1) to be 80 cubic inches, the second (2) or bulk-indication, 100 cubic inches; divide 80 by 100, and the specific gravity is 0·800. To determine the specific gravity of bodies a *little* heavier than water, make a solution of salt, sugar, or muriate of lime, that will float the body; ascertain the specific gravity of the solution used; multiply the weight-indication by this specific gravity, and divide by the bulk-indication, the result will be the specific gravity of the body. Thus, suppose the solution used is specific gravity 1·210, the weight-indication 100, the bulk-indication 105, multiply 100 by 1·210 and divide by 105, the resulting specific gravity is 1·200. This apparatus may also be used in assisting to determine the specific gravity of mineral or other heavy masses; the weight of such masses being first ascertained by a balance, the bulk can be obtained in the manner as above described, then calculate in the usual way.

The sizes of the glasses, as stated above, were adopted as a useful and convenient form of the apparatus, but the principle admits of their being easily made either larger or less, to suit the purpose to which it is to be applied.

PETER STEVENSON,
Philosophical Instrument Maker.

9 LOTHIAN STREET, EDINBURGH,
28*th December* 1854.

On a method of taking Permanent Impressions of Flowers and Leaves of Plants on Glass. By Mr R. SMITH, Analytical Chemist, Blackford, Perthshire.*

In order to produce impressions or outlines by this method, the author first prepares the plants, leaves, or flowers, by pressure in the ordinary way, as the botanist proceeds with his specimens. The one side of the subject to be copied is brushed over with a solution of gum arabic, and placed upon the glass, when the required number is placed upon the glass, a sheet of bibulous paper is laid over them, and upon the paper a board covered with a piece of flannel, and the whole pressed down with the hand. The board and blotting paper is then removed, and if the superfluous moisture be not all taken up, another paper must be applied in the same manner. The glass containing the plants is then brushed over with the following composition, viz.—three parts of tallow, one part of bees' wax, and one part of olive oil. The mixture is melted by means of

* Read before the Society, 12th March 1855.

heat, and laid over the whole of the glass with a brush. As soon as it becomes solid, the end of the stems of the plants or leaves are raised up with a sharp point, when they are easily removed from the glass by the hand; the parts on the glass where the leaves were placed are uncovered with the composition, and a distinct impression left. The glass thus prepared is ready for the fluorine process. The glass is placed in a leaden chamber, into the bottom of which is introduced the beak of a lead retort, containing powdered fluor-spar and dilute sulphuric acid. On heat being applied to the bottom of the retort, fluorine gas is generated and passes into the chamber, the action of which corrodes the glass where the impression is left by the plants, producing a permanent stain, while the other parts of the glass containing the composition is unacted upon. Instead of using the chamber, the glass may be stained with liquid fluorine, or small specimens by covering the glass with powdered fluor-spar, wet with dilute sulphuric acid.

Specimens of impressions of ferns, *Dielytra spectabilis*, *Geranium molle*, *Anemone nemorosa*, and algæ, produced by the above method, were exhibited by the author.

On an improved Method of preparing Siliceous and other Fossils for Microscopic Investigation, with a Description of a New Pneumatic Chuck. By ALEXANDER BRYSON, F.S.A. Scot., F.R.P.S., &c.*

The art of slitting stones and other hard substances by means of impacting diamond powder into the edge of a thin iron plate, seems, in this country at least, to be an ancient one. I have failed to discover the date of its introduction or invention; but most lapidaries who have expressed their opinions on the subject, concur in believing the art to be at least two hundred years old.

On the Continent the art seems to have been but lately practised. In a series of fossil woods sent to me from Paris by the celebrated Brongniart, some bear evidence that, in the capital of France, this method was not practised until within

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* Read before the Society, December 10, 1855.

a few years ago, as they exhibit unequivocal traces of having been cut by the slow process of slitting by means of a copper wire with emery. Sisyphus rolling his stone and a Parisian lapidary slitting one by such a slow method seem almost synonymous.

In India and China the natives slit the hardest gems by a copper wire stretched on a bow, the wire being constantly fed with corundum powder moistened with water. This corundum stone, which is the adamant of Scripture, is cheap and plentiful both in India and China. In the Calcutta market, it only commands the low price of 8d. sterling per pound, yet strange to say, although much harder than either the emery of Smyrna, or that still harder found at Naxos, it has been very much slighted by the British lapidaries. The difference of price may, however, be to them the great objection; but to the amateur, whose consumpt is reckoned only by pounds instead of hundredweights per annum, the corundum is to be preferred.

The method of preparing thin slices of fossil woods and other hard organic substances for examination under the microscope had its origin in this city. But as the claims of two or three eminent individuals (all deserving praise) are conjoined in this improvement, I refrain from considering them.

The usual mode of proceeding in making a section of fossil wood is simple, though tedious. The first process is to flatten the specimen to be operated on by grinding it on a flat *lap* made of lead charged with emery or corundum powder. It must now be rendered perfectly flat by hand on a plate of metal or glass, using much finer emery than in the first operation of grinding. The next operation is to cement the object to the glass plate. Both the plate of glass and the fossil to be cemented must be heated to a temperature rather inconvenient for the fingers to bear. By this means moisture and adherent air are driven off, especially from the object to be operated on. Canada balsam is now to be equally spread over both plate and object, and exposed again to heat, until the redundant turpentine in the balsam has been driven off by evaporation. The two surfaces are now to be connected while hot, and a slow circular motion, with pressure, given either to the plate or to the object, for the purpose of throwing out the superabundant balsam and globules of included air. The object should be below and the glass plate above, as we then can see when all the air is removed by the pressure and motion indicated. It is proper to mention that too much balsam is more favourable for the expulsion of the air-bubbles than too little. When cold, the Canada balsam will be found hard and adhering, and the specimen fit for slitting. This process has hitherto been performed by using a disc of thin sheet-iron, so much employed by the tinsmith, technically called *sheet-tin*. The tin coating ought to be partially removed by heating the plate, and then rubbing off much of the extraneous tin by a piece of cloth. The plate has now to be planished on the polished *stake* of the tinsmith, until quite flat. If the plate is to be used in the lathe, and by the usual method, it ought to be planished so as to possess a slight convexity. This gives a certain amount of rigidity to the edge, which is useful in slitting by the hand; while by the method of mechanical slitting, about to be described, this convexity is inadmissible. The tin plate, when mounted on an appropriate chuck in the lathe, must be turned quite true, with its edge slightly rounded and made perfectly smooth by a fine-cut file. The edge of the disc is now to be charged with diamond powder. This is done by mingling the diamond powder with oil, placing it on a piece of the hardest agate, then turning the disc slowly round, and holding by a moderate pressure the agate and the diamond powder against the edge of the disc, till it be thoroughly charged with a host of diamond points, and becomes, as it were, a saw with invisible teeth. The diamond should be carefully pounded in a mortar made of an old steel die, if accessible; if not, of a mass of steel, slightly conical, the base of which ought to be 2 inches in diameter, and the upper part $1\frac{1}{2}$ inch. A cylindrical hole $\frac{3}{4}$ths of an inch diameter, and about 1 inch deep, is to be turned out in the centre. This, when hardened, is the mortar, which for safety, may be annealed to a straw colour. The pestle is merely a cylinder of steel, loosely fitting the hollow mortar, and having a ledge or edging of an eighth of an inch projecting round it, but raised above the upper surface of the mortar, so as not to come in contact while pounding the diamond. The point of the pestle only ought to be hardened and annealed to a straw colour, and should be of course convex, fitting the opposing and equal concavity of the mortar. The purpose of the projecting ledge is to prevent the smaller particles of diamond spurting out when the pestle is struck by the hammer. But even with this precautionary ledge, some small pieces of the diamond will try to assert their liberty; and I have found it economical, when giving the *cöup de gräce* to a lump of diamond, to place below the mortar a sheet of unglazed black paper, so that the straying particles may be easily recovered. It is not necessary to give many blows in reducing the diamond to powder; after being merely mealed by the hammer, it should be bruised in the slightly-rotatory crushing method ordinarily employed by the apothecary. In regard to the first use of the mortar, I must warn the amateur lapidary, that should he put in two carats weight of diamond, and expect to get the same weight out, he will be most grievously disappointed. This is evident when we consider that the diamond being so much harder than the steel, the mortar becomes in its first use, thoroughly charged and impacted with the diamond powder; so that, in his first experiment, he will find he has lost nearly a carat in making his steel mortar—which thus becomes, both in fact and name—a diamond one. All this is preliminary labour to be gone through, whether working by the usual method, or by that to be described.

Most lapidaries who have availed themselves of water-power, have used directing methods, by which the stones to be slit are pressed slightly against the slitting-plate by mere gravitation, acting in a determinate plane. The lapidaries of Germany have long practised this method, favoured as they are by so many streams in the midst of the rocks from whence they obtain their pebbles. My first idea of slitting fossils by these means for microscopic observation was obtained by observing the excellent method employed by Mr Gavin Young. By means of a water-wheel, he has employed a considerable number of self-acting slitting-plates to perform an amount of cheap and flat work, hitherto a desideratum in Edinburgh.

I have in my collection a Scotch jasper, slit and polished by Mr Young with this apparatus, measuring 100 square inches—certainly a *chef d'œuvre* of lapidary work. The method I have contrived, by which the sections now on the table were prepared, is very simple, speedy, and certain in its action.

The instrument is placed on the table of a common lathe, which is, of course, the source of motion. (*See Woodcut.*) It consists of a parallel motion, with four joints, attached to a basement fixed to the table of the lathe. This base has a motion (for adjustment only), in a horizontal plane, by which we may be enabled to place the upper joint parallel to the spindle of the lathe. This may be called the azimuthal adjustment. The adjustment, in the plane of right ascension, is given by a pivot in the top of the base, and clamped by a screw below. This motion in right ascension, gives us the power of adjusting the perpendicular planes of motion, so that the object to be slit passes down from the circumference of the slitting-plate to nearly its centre, in a perfectly parallel plane. When this adjustment is made accurately, and the slitting-plate well primed and flat, a very thin and parallel slice is obtained. This jointed frame is counterpoised and supported by a lever, the centre of which is moveable in a pillar standing perpendicularly from the lathe table. Attached to the lever is a screw of three threads by which the counterpoise weight is adjusted readily to the varying weight of the object to be slit and the necessary pressure required on the edge of the slitting-plate.

The difficulty first apparent in this self-acting slitting, was to obtain an easy method of fixing the object to the machine. Cements of all kinds were objectionable. Any cement requiring *heat* for its adhesion to the glass on which the object was already cemented by the Canada balsam, would, of course, destroy its condition; and any *cold* process of cementing is to be discarded involving loss of time in drying. I therefore was determined to try a pneumatic method, by which the pressure of the air against the surface of a chuck might give me rapid adhesion, without risk of injuring the Canada balsam. This pneumatic chuck gave me the utmost satisfaction.

It consists of an iron tube, which passes through an aperture on the upper joint of the guiding-frame, into which is screwed a round piece of gun-metal, slightly hollowed in the centre, but flat towards the edge. This gun-metal disc is perforated by a small hole communicating with the interior of the iron tube. This aperture permits the air between the glass plate and the chuck to be exhausted by a small air syringe at the other end. The face of this chuck is covered with a thin film of soft India-rubber not vulcanized, also perforated with a small central aperture. When the chuck is properly adjusted, and the India-rubber carefully stretched over the face of the gun-metal, one or two pulls of the syringe-piston is quite sufficient to hold a very large object to the action of the slitting-plate. By this method no time is lost; the adhesion is made instantaneously, and as quickly broken by opening a small screw, to admit air between the glass-plate and the chuck, when the object is immediately released. Care must be taken, in stretching the India-rubber over the face of the chuck, to make it very equal in its distribution, and as thin as consistent with strength. When this material is obtained from the shops, it presents a series of slight grooves, and is rather hard for our purpose. It ought, therefore, to be slightly heated, which renders it soft and pliant, and in this state should now be stretched over the chuck, and a piece of soft copper wire tied round it, a slight groove being cut in the periphery of the chuck, to detain the wire in its place. When by use the surface of the India-rubber becomes flat, smooth, and free from the grooves which at first mar its usefulness, a specimen may be slit of many square inches, without resort being had to another exhaustion by the syringe.

But when a large, hard, siliceous object has to be slit, it is well for the sake of safety to try the syringe piston, and observe if it return forcibly to the bottom of the cylinder, which proves the good condition of the vacuum of the chuck.

After the operation of slitting, the plate must be removed from the spindle of the lathe, and the flat lead *lap* substituted. The pneumatic chuck is now to be reversed, and the specimen placed in contact with the grinder. By giving a slightly tortuous motion to the specimen, that is, using the motion of the various joints, the object is ground perfectly flat when the length of both arms of the joints are perfectly equal. Should the leg of the first joint on the right-hand side be the longer, the specimen will be ground hollow; if shorter, it will be ground convex. But if, as before stated, they be of equal length, a perfectly parallel surface will be obtained.

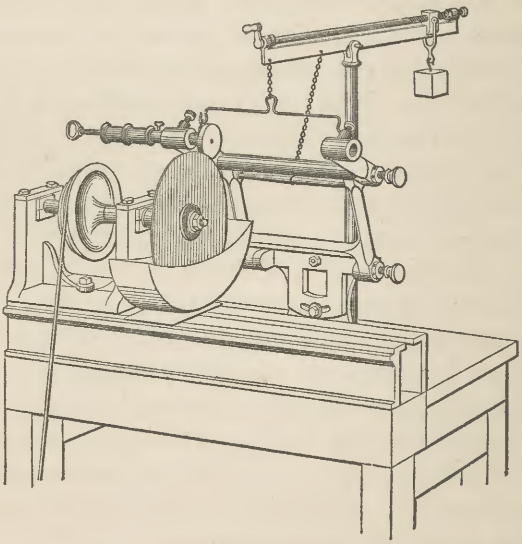
In operating on siliceous objects, I have found soap and water quite as speedy and efficacious as oil, which is generally used; while calcareous fossils must be slit by a solution of common soda in water. This solution of soda, if made too strong, softens the India-rubber on the face of the pneumatic chuck, and renders a new piece necessary; but if care be taken to keep the solution of moderate strength, one piece of India-rubber may last for six months. The thinner and flatter it becomes, the better hold the glass takes, unless a puncture occur in the outer portion, and a new piece is rendered necessary.

Before concluding, I must warn the amateur lapidary against the belief that all hard stones are equally easily slit by diamond powder. As a general rule, the hardest stones are most easily slit (this does not, however, include calcareous ones); but some fossils on which I have operated, though not so hard as others, have completely resisted the action of the diamond powder. For instance, the Yu stone of China, which is by no means so hard as corundum, is much more difficult to slit, and consumes an amount of diamond powder which renders it the horror of the lapidary. This peculiarity is easily understood. If, for instance, we should attempt to saw lead or copper with our diamond slitting-plate, we should find that the diamond powder becomes thoroughly impacted into these metals. In the same way the diamond is taken out of the plate by a soft tenacious fossil, and is impacted in the stone, and no work is accomplished. The method of operating on such specimens is to use emery by the usual method, by which much more speed will be obtained.

The polishing of the section is the last operation. This is performed in various ways, according to the material of which the object is composed. If siliceous, a *lap* of tin is to be used, about the same size as the grinding *lap*. Having turned the face smooth and flat, a series of very fine notches are to be made all over the surface. This is accomplished by holding the edge of an old dinner-knife almost perpendicular to the surface of the *lap* while rotating; so as to produce a series of *criddles*, or slight asperities, which detain the polishing substance.

The polishing substance used on the tin lap is technically called Lapidaries' Rot-Stone, and is applied by slightly moistening the mass, and pressing it firmly against the polisher, care being taken to scrape off the outer surface, which often contains grit. The specimen is then to be pressed with some degree of force against the revolving tin *lap* or polisher, carefully changing the plane of action, by moving the specimen in various directions over the surface.

To polish calcareous objects, another method must be adopted as follows:—



A *lap* or disc of willow wood, three inches in thickness, and about the diameter of the other laps (10 inches), is to be adapted to the spindle of the lathe, the axis of the wood being parallel to the spindle of the lathe, that is, the acting surface of the wood is the end of the fibres, or transverse section.

This polisher must be turned quite flat and smoothed by a plane, as the willow, from its softness, is peculiarly difficult to turn. It is also of consequence to remark, that both sides be turned so as that the *lap*, when dry, is quite parallel. This *lap* is most conveniently adapted to the common face chuck of a lathe by a conical screw, so that either surface may be used. This is made evident, when we state that this polisher is always used moist, and that to keep both surfaces parallel, it must be entirely plunged in water before using, as both surfaces must be equally moist, otherwise the dry will be concave, and the moist surface convex. The polishing substance used with this *lap* is putty powder (oxide of tin), which ought to be well washed, to free it from grit. The calcareous fossils being finely ground, are speedily polished by this method. To polish softer substances, a piece of cloth may be spread over the wooden *lap*, and finely-levigated chalk used as a polishing agent.

Remarks on the Gyroscope, in relation to his " Suggestion of a New Experiment which would demonstrate the Rotation of the Earth." By Edward Sang, F.R.S.E.*

At its tenth meeting of last Session (9th April 1855) the Society was favoured by Mr Elliot with an exposition of the phenomena of rotation, in the course of which he exhibited his beautiful method of producing the disturbance of the axis by means of magnetic attractions and repulsions.

In that exposition, Mr Elliot also gave an account of the experiments which had been performed by M. Foucault at the meeting of the British Association in Liverpool; and he seemed inclined to give the merit of the discovery of the various phenomena to the illustrous Frenchman.

I immediately took the opportunity of stating that, with one exception, the phenomena had been regularly exhibited and

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* Read before the Society, 24th March 1856.

explained by the late Sir John Leslie, during his Lectures on Natural Philosophy, not as at all new, but as well known and well understood results of the acknowledged laws of Mechanics.

The only variety of the phenomena which he had not exhibited is that which refers to the motion of the earth; and I took the liberty of reminding the Society that, many years before, I had proposed that experiment, and illustrated the manner of carrying it out, by the very apparatus which had been used by Leslie, while, at the same time, I had exhibited the previously known experiments.

Several of my friends urged me to lay my claims to priority formally before the public. As I happened to be prosecuting some investigations in which the matter is naturally involved, I delayed until these investigations should have been completed; but the crowd of subjects which, after an absence of thirteen years, all at once claimed my attention, have prevented me from maturing these investigations; and, being unwilling to let another Session pass without formally asserting my claim, I have now to beg the attention of the Society to the general history of the matter.

As soon as the precession of the equinoxes was traced to the attractions which the moon and sun exert upon the protruded portions of the earth, the idea of illustrating this phenomenon by mechanical appliances must have arisen, the more so that the common spinning-top exhibits the recession of the nodes, and that the two phenomena are identical in theory.

Hence the precession machine is a very old instrument. I exhibit one that was presented by M. Arago to Professor Playfair, and which must have existed since 1816–1817. It is the type of most that have been made since. The instrument which belonged to Leslie, and which I exhibited before you twenty years ago, was slightly larger, and much better made. And that one which was procured by Professor Forbes to supply the want of Leslie's, is, I am told, just such another. I am, then, justified in stating that, ever since the year 1817, the apparatus for exhibiting these phenomena has not been wanting in our University; and I feel confident that the full and careful explanations which Leslie gave during my own college days, have ever since been continued by him and by his energetic successor. Nor can I imagine that so interesting and beautiful an experiment can have fallen into abeyance in the universities of France. I therefore think it probable that M. Foucault merely exhibited these phenomena as more prominently brought out by the great velocity which he communicated to the gyrator.

We cannot doubt that the precession machine was first made in France or Germany.

Troughton, anxious to devise some means of improving the observations of altitudes at sea, hit upon the idea of the top which goes by his name, and which, though useless for the intended purpose, has rendered essential service to Practical Mechanics, by the striking manner in which it exemplifies certain principles.

Troughton fixed a flat mirror on the gyrator, and the business was to place this mirror parallel to the principal plane of rotation. The idea of doing this by accurate turning was out of the question; he effected it by means of three plugs screwed into holes bored parallel to the axis, while he adjusted the centre of gravity to be exactly under the point of suspension by the help of three radial plugs. The arrangement of these six adjusting pieces shows that this eminent instrument-maker was intimately acquainted with the whole doctrine of rotation.

At the death of Sir John Leslie one of Troughton's tops came into my possession, and I made many experiments with it. By properly arranged trials I was able to make the plane of rotation so nearly parallel to the mirror that no tremor of the sun's image could be perceived with the telescope of my sextant (power 10), while the centre of gravity could be brought so near to its proper place, that no perceptible agitation was communicated to the box when the highest attainable velocity was given to the instrument.

In the course of these trials it occurred to me that if the centre of gravity were made to coincide exactly with the point of support, the axis of rotation would remain absolutely at rest, and would thus enable us to demonstrate the rotation of the earth. In consequence, I prepared and submitted to the Society of Arts a paper, which I now proceed to read, in order that no room may be left for doubt on the one hand, or for exaggeration on the other.

"No. 355.

"*Suggestion of a new Experiment which would demonstrate the Rotation of the Earth.* (Read before the Royal Scottish Society of Arts, 9th March 1836. Professor Forbes, V.P., in the Chair.)

"Only one experiment, purely terrestrial, has yet been contrived, which demonstrates, without the intervention of astronomical considerations, the fact of the earth's rotation on its axis. That is the experiment of dropping a heavy body from a great height and contrasting the direction of its motion with that of a plumb-line. But this experiment, on account of the small deviation, can only be made in peculiar situations where a great fall can be obtained. The deep shafts of the coal-mines in the neighbourhood of Newcastle afford the only opportunities in this district of verifying, by such a trial, the important fact of the earth's rotation.

"The oblateness of the earth is only known by measurements partly astronomical, and thus could never have led to the knowledge of the rotation of our planet had the stars been concealed from us.

"While using Troughton's top, an idea occurred to me that a similar principle might be applied to the exhibition of the rotation of the earth. Conceive a large flat wheel, poised on several axis, all passing exactly through its centre of gravity, and whose axis of motion is coincident with its principal axis of permanent rotation, to be put in very rapid motion. The direction of its axis would then remain unchanged. But the directions of all surrounding objects varying on account of the motion of the earth, it would result, that the axis of the revolving wheel would appear to move slowly.

"Were the influence of friction and the air's resistance suspended, the axis would appear to perform a circuit daily; it would, in fact, describe the surface of a cone, of which the polar line would be the axis ; and were a telescope placed along it, that telescope would point always to the same fixed star. It would indeed be an equatorial telescope.

" In order to judge of the possibility of such a machine working under ordinary circumstances, we must estimate the influence of friction.

" The friction on the axis of rapid motion would only tend, like the air's resistance, to diminish the velocity of revolution, but would not influence the direction of the axis.

" Suppose that the permanent axis of the universal joint is directed to the pole ; the motion will be one of simple rotation on this axis, and the friction of this joint tending to retard the slow motion of the axis of the fly, will cause it to approach to the polar line, without in the smallest degree affecting the angular motion in right ascension. This very singular result flows from the law of rotation of a body on its axis of maximum momentum.

" But this diminution of polar distance requires a motion on another joint placed in the equator and perpendicular to the meridian of the axis of the fly. And the friction on this joint, directed against the diminution of polar distance, would occasion a motion in right ascension opposed in direction to the motion due to the rotation of the earth, and therefore diminishing the amount of the phenomenon which we wish to exhibit ; and the question of practicability reduces itself to this—Will the motion due to this friction exceed that of the earth's rotation ?

" The diminution of the friction on the intermediate axis is then the principal object for our consideration. The friction on the axis of the fly can be so reduced as to give a motion for an hour or even two hours, as I have reason to think from the performance of Troughton's top. This would give an angular motion of more than 15 degrees ; and thus the certainty of overcoming this difficulty encourages me to examine more minutely the phases of the other frictions.

" The friction on the polar axis can be reduced by means of friction rollers, but the application of rollers to the equatorial axis is almost impossible. The friction of the equatorial axis results from that on the polar one, and we might at first conclude that the diminution of the primary would insure that of the derived resistance. Such, however, is not the case; the friction on the equatorial axis results from the motion in polar distance, and remains the same, whether the motion in polar distance be swift or slow. The success of the trial therefore depends mainly on the reduction of the friction on the equatorial or intermediate axis.

"But there is another consideration which must not be omitted. The angular motion of the axis of revolution caused by a given pressure, diminishes with the increase in the velocity of the fly, while the apparent motion due to the earth's rotation is constant; and thus, by augmenting the rapidity of motion of the fly, the disturbance occasioned by the friction may be so reduced as to leave the progression caused by the earth's motion nearly unaffected.

"Of course, the longer the motion is continued, the more perceptible will the change be; and hence the propriety of diminishing the friction on the axis of the fly, and also of covering the apparatus with a receiver, and extracting the air. "EDWARD SANG."

"*January* 15, 1836."

(*The letterpress of the above quotation has been compared with the original paper in the custody of the Secretary.*)

Between the date of this paper (15th January) and the reading of it (9th March 1836), I investigated the optimum form, and also the modes of adjustment, and I stated verbally to the Society the results of this investigation.

If a line make with the axis an angle of which the cosine is $\sqrt{\frac{1}{3}}$,—that is, an angle of 54° 44′,—every particle of matter excluded from the double cone generated by the rotation of this angle adds to the *stability* of the rotation; every particle within the double cone diminishes the stability. Hence I easily obtained a form which allows of sufficient room for Troughton's three radial and three parallel adjusting plugs.

As the oblate spheroid exhibits a much more elegant appearance, I also examined the best form of spheroid for a given size of ring, and found that the ratio of the polar to the equatorial axis should be that of $\sqrt{1} : \sqrt{3}$; so that the absolutely optimum solid, and the best spheroid, have the same thickness and the same solidity.

Since those particles near the surface of the limiting cone add but little to the stability of the rotation, while they add seriously to the weight, no practical deficiency, but rather the opposite, can result from keeping the solid considerably within the theoretic limits.

Since a bias to either side produces a precessional motion, it becomes important to ascertain that the observed motion does not result from a want of equipoise; and here in truth lies the real difficulty. We must make sure that what we attribute to the slow rotation of the earth does not in reality belong to a fault in the workmanship; hence nothing short of the most exquisite mechanical arrangement can enable us to appeal definitely to the evidence of the experiment. The very flexure of the supporting rings may be sufficient to displace the centre of gravity, and to defy reversional adjustments; and hence the very adjustments have to be founded on a presumption of the truth which we are seeking to discover.

With these considerations in view, I felt that I would not have been justified in expending so much time and so much money as would have been required, particularly when the expected result was not the discovery of a new, but the *quasi* confirmation of a well-established truth. I therefore contented myself with adjusting the little precession instrument to represent the conditions of the experiment, and laid aside my already prepared working drawings till wanted.

A notice of this paper is given in the *Edinburgh Philosophical Journal* for April to October 1836, page 164. On the 7th December the Committee of the Society awarded me their special thanks for the communication, and an intimation of this award is inserted in the *Journal* for October 1836 to April 1837, page 210.

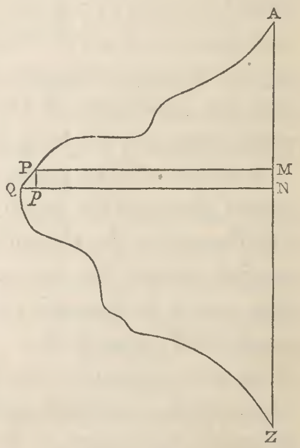
In thus claiming the priority by some eighteen years, I have not the slightest wish to detract from the merits of M. Foucault in regard to this experiment; my interest indeed would rather lie in the exaltation of these merits. Many an invention has been re-invented—many a discovery again discovered; and amidst the multitude of contrivances which surround us, it is a mere fiction to suppose than an explorer is bound to avoid every field that has been explored before. My object is simply to place myself—and I may be allowed to add, to place this Society—rightly in regard to the matter.

March 1856. EDWARD SANG.

Description of a New Form of the Platometer, an Instrument for measuring the Areas of Plane Figures drawn on Paper. By JAMES CLERK MAXWELL, Esq., Trin. Col., Cambridge.*

1. The measurement of the area of a plane figure on a map or plan is an operation so frequently occurring in practice, that any method by which it may be easily and quickly performed is deserving of attention. A very able exposition of the principle of such instruments will be found in the article on Planimeters in the Reports of the Juries of the Great Exhibition, 1851.

2. In considering the principle of instruments of this kind, it will be most convenient to suppose the area of the figure measured by an imaginary straight line, which, by moving parallel to itself, and at the same time altering in length to suit the form of the area, accurately sweeps it out.



Let AZ be a fixed vertical line, APQZ the boundary of the area, and let a variable horizontal line move parallel to itself from A to Z, so as to have its extremities, P, M, in the curve and in the fixed straight line. Now, suppose the horizontal line (which we shall call the generating line) to move from the position PM to PN, MN being some small quantity, say one inch for distinctness. During this movement, the generating line will have swept out the narrow strip of the surface, PMNQ, which exceeds the portion PMNp by the small triangle PQp.

* Read to the Society, 22d Jan. 1855.

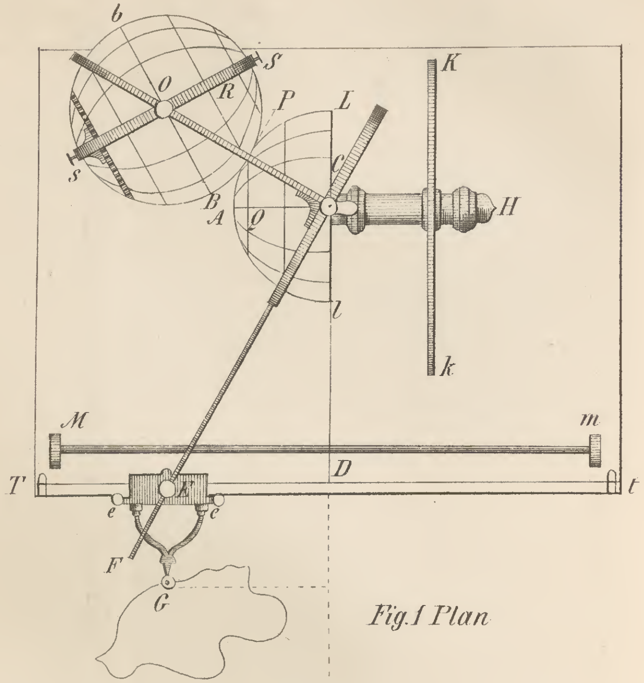


Fig. 1 Plan

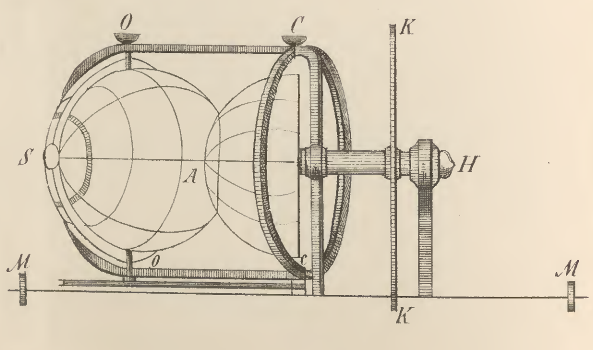


Fig. 2 Front Elevation

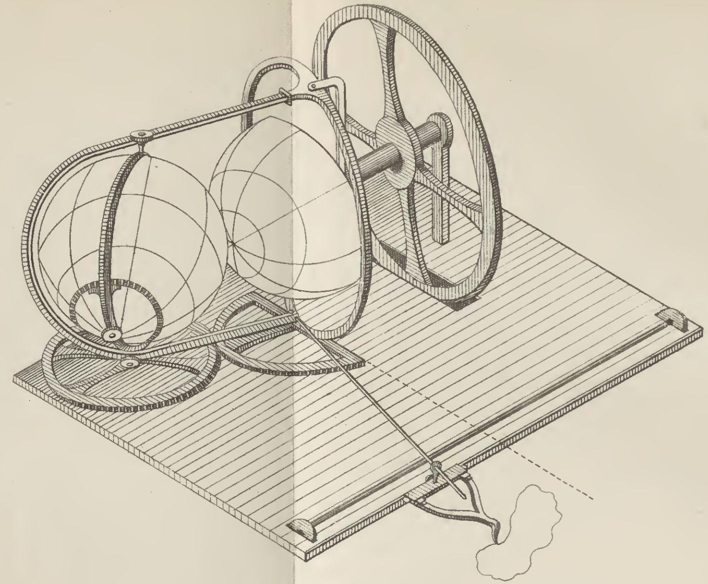


Fig. 3. Isometric Projection.

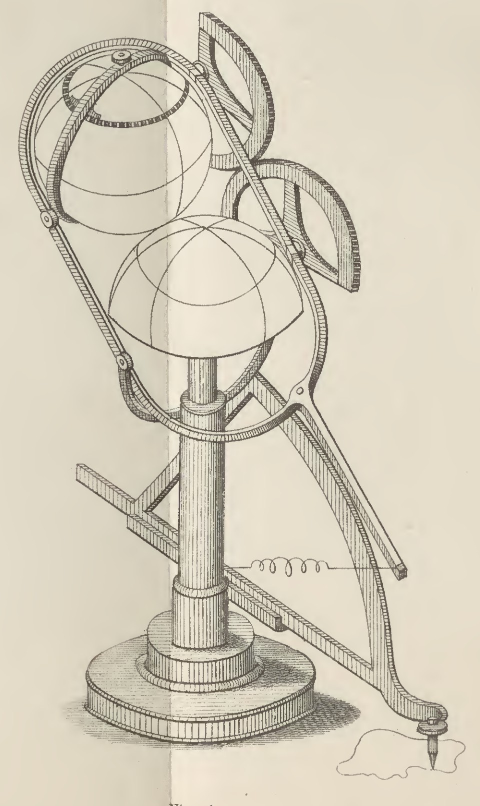


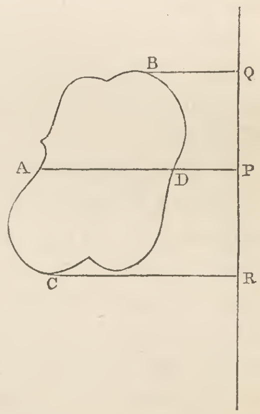
Fig. 4.

Schenck & Macfarlane Edinburgh.

But since MN, the breadth of the strip, is one inch, the strip will contain as many square inches as PM is inches long; so that, when the generating line descends one inch, it sweeps out a number of square inches equal to the number of linear inches in its length.

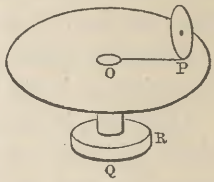
Therefore, if we have a machine with an index of any kind, which, while the generating line moves one inch downwards, moves forward as many degrees as the generating line is inches long, and if the generating line be alternately moved an inch and altered in length, the index will mark the number of square inches swept over during the whole operation. By the ordinary method of limits, it may be shown that, if these changes be made continuous instead of sudden, the index will still measure the area of the curve traced by the extremity of the generating line.

3. When the area is bounded by a closed curve, as ABDC, then to determine the area we must carry the tracing point from some point A of the curve, completely round the circumference to A again. Then, while the tracing point moves from A to C, the index will go forward and measure the number of square inches in ACRP, and, while it moves from C to D, the index will measure backwards the square inches in CRPD, so that it will now indicate the square inches in ACD. Similarly, during the other part of the motion from D to B, and from B to D, the part DBA will be measured; so that when the tracing point returns to D, the instrument will have measured the area ACDB. It is evident that the whole area will appear positive or negative according as the tracing point is carried round in the direction ACDB or ABDC.



4. We have next to consider the various methods of communicating the required motion to the index. The first is by means of two discs, the first having a flat horizontal rough surface, turning on a vertical axis, OQ, and the second vertical,

with its circumference resting on the flat surface of the first at P, so as to be driven round by the motion of the first disc. The velocity of the second disc will depend on OP, the distance of the point of contact from the centre of the first disc; so that if OP be made always equal to the generating line, the conditions of the instrument will be fulfilled.



This is accomplished by causing the index-disc to slip along the radius of the horizontal disc; so that in working the instrument, the motion of the index-disc is compounded of a rolling motion due to the rotation of the first disc, and a slipping motion due to the variation of the generating line.

5. In the instrument presented by Mr Sang to the Society, the first disc is replaced by a cone, and the action of the instrument corresponds to a mathematical valuation of the area by the use of oblique co-ordinates. As he has himself explained it very completely, it will be enough here to say, that the index-wheel has still a motion of slipping as well as of rolling.

6. Now, suppose a wheel rolling on a surface, and pressing on it with a weight of a pound; then suppose the coefficient of friction to be $\frac{1}{8}$, it will require a force of 2 oz. at least to produce slipping at all, so that even if the resistance of the axis, &c., amounted to 1 oz., the rolling would be perfect. But if the wheel were forcibly pulled sideways, so as to slide along in the direction of the axis, then, if the friction of the axis, &c., opposed no resistance to the turning of the wheel, the rotation would still be that due to the forward motion; but if there were any resistance, however small, it would produce its effect in diminishing the amount of rotation.

The case is that of a mass resting on a rough surface, which requires a great force to produce the slightest motion; but when some other force acts on it and keeps it in motion, the very smallest force is sufficient to alter that motion in direction.

7. This effect of the combination of slipping and rolling has not escaped the observation of Mr Sang, who has both measured its amount, and shown how to eliminate its effect. In

the improved instrument as constructed by him, I believe that the greatest error introduced in this way does not equal the ordinary errors of measurement by the old process of triangulation. This accuracy, however, is a proof of the excellence of the workmanship, and the smoothness of the action of the instrument; for if any considerable resistance had to be overcome, it would display itself in the results.

8. Having seen and admired these instruments at the Great Exhibition in 1851, and being convinced that the combination of slipping and rolling was a drawback on the perfection of the instrument, I began to search for some arrangement by which the motion should be that of perfect rolling in every motion of which the instrument is capable. The forms of the rolling parts which I considered were—

1. Two equal spheres.
2. Two spheres, the diameters being as 1 to 2.
3. A cone and cylinder, axes at right angles.

Of these, the first combination only suited my purpose. I devised several modes of mounting the spheres so as to make the principle available. That which I adopted is borrowed, as to many details, from the instruments already constructed, so that the originality of the device may be reduced to this principle—The abolition of slipping by the use of two equal spheres.

9. The instrument (fig. 1) is mounted on a frame, which rolls on the two connected wheels, MM, and is thus constrained to travel up and down the paper, moving parallel to itself.

CH is a horizontal axis, passing through two supports attached to the frame, and carrying the wheel K and the hemisphere LAP. The wheel H rolls on the plane on which the instrument travels, and communicates its motion to the hemisphere, which therefore revolves about the axis AH with a velocity proportional to that with which the instrument moves backwards or forwards.

FCO is a framework (better seen in the other figures) capable of revolving about a vertical axis, Cc, being joined at C and c to the frame of the instrument. The parts CF and CO are at right angles to each other and horizontal. The part CO carries with it a ring, SOS, which turns about a vertical axis O*o*. This ring supports the index-sphere B*b* by the extremities of its axis S*s*, just as the meridian circle carries a terrestrial globe. By this arrangement, it will be seen that the axis of the sphere is kept always horizontal, while its centre moves so as to be always at a constant distance from that of the hemisphere. This distance must be adjusted so that the spheres may always remain in contact, and the pressure at the point of contact may be regulated by means of springs or compresses at O and *o* acting in the direction OC, *oc*. In this way the rotation of the hemisphere is made to drive the index-sphere.

10. Now, let us consider the working of the instrument. Suppose the arm CE placed so as to coincide with CD, then O, the centre of the index-sphere will be in the prolongation of the axis HA. Suppose also that, when in this position, the equator *b*B of the index-sphere is in contact with the pole A of the hemisphere. Now, let the arch be turned into the position CE as in the figure, then the rest of the framework will be turned through an equal angle, and the index-sphere will roll on the hemisphere till it come into the position represented in the figure. Then, if there be no slipping, the arc AP = BP, and the angle ACP = BOP.

Next, let the instrument be moved backwards or forwards, so as to turn the wheel K*k* and the hemisphere L*l*, then the index-sphere will be turned about its axis S*s* by the action of the hemisphere, but the ratio of their velocities will depend on their relative positions. If we draw PQ, PR, perpendiculars from the point of contact on the two axes, then the angular motion of the index-sphere will be to that of the hemisphere, as PQ is to PR; that is, as PQ is to QC, by the equal triangles POQ, PQC; that is, as ED is to DC, by the similar triangles CQP, CDE.

Therefore the ratio of the angular velocities is as ED to DC, but since DC is constant, this ratio varies as ED. We have now only to contrive some way of making ED act as the generating line, and the machine is complete (see art. 2).

11. The arm CF is moved in the following manner:—T*t* is a rectangular metal beam, fixed to the frame of the instrument, and parallel to the axes AH. *e*E*e* is a little carriage which rolls along it, having two rollers on one side and one on the other, which is pressed against the beam by a spring. This carriage carries a vertical pin, E, turning in its socket, and having a collar above, through which the arm CF works smoothly. The tracing point G is attached to the carriage by a jointed frame *e*G*e*, which is so arranged that the point may not bear too heavily on the paper.

12. When the machine is in action, the tracing point is placed on a point in the boundary of the figure, and made to move round it always in one direction till it arrives at the same point again. The up-and-down motion of the tracing point moves the whole instrument over the paper, turns the wheel K, the hemisphere L*l*, and the index-sphere B*b*; while the lateral motion of the tracing point moves the carriage E on the beam T*t*, and so works the arm CF and the framework CO; and so changes the relative velocities of the two spheres, as has been explained.

13. In this way the instrument works by a perfect rolling motion, in whatever direction the tracing point is moved; but since the accuracy of the result depends on the equality of the arcs AP and BP, and since the smallest error of adjustment would, in the course of time, produce a considerable deviation from this equality, some contrivance is necessary to secure it. For this purpose a wheel is fixed on the same axis with the ring SO*s*, and another of the same size is fixed to the frame of the instrument, with its centre coinciding with the vertical axis through C. These wheels are connected by two pieces of watch-spring, which are arranged so as to apply closely to the edges of the wheels. The first is firmly attached to the nearer side of the fixed wheel, and to the farther side of the moveable wheel, and the second to the farther side of the fixed wheel, and the nearer side of the moveable wheel, crossing beneath the first steel band. In this way the spheres are maintained in their proper relative position; but since no instrument can be perfect, the wheels, by preventing derangement, must cause

some slight slipping, depending on the errors of workmanship. This, however, does not ruin the pretensions of the instrument, for it may be shown that the error introduced by slipping depends on the distance through which the lateral slipping takes place; and since in this case it must be very small compared with its necessarily large amount in the other instruments, the error introduced by it must be diminished in the same proportion.

14. I have shown how the rotation of the index-sphere is proportional to the area of the figure traced by the tracing point. This rotation must be measured by means of a graduated circle attached to the sphere, and read off by means of a vernier. The result, as measured in degrees, may be interpreted in the following manner:—

Suppose the instrument to be placed with the arm CF coinciding with CD, the equator B*b* of the index-sphere touching the pole A of the hemisphere, and the index of the vernier at zero: then let these four operations be performed:—

(1.) Let the tracing point be moved to the right till DE =DC, and therefore DCE, ACP, and POB=45°.

(2.) Let the instrument be rolled upwards till the wheel K has made a complete revolution, carrying the hemisphere with it; then, on account of the equality of the angles SOP, PCA, the index-sphere will also make a complete revolution.

(3.) Let the arm CF be brought back again till F coincides with D.

(4.) Let the instrument be rolled back again through a complete revolution of the wheel K. The index-sphere will not rotate, because the point of contact is at the pole of the hemisphere.

The tracing point has now traversed the boundary of a rectangle, whose length is the circumference of the wheel K, and its breadth is equal to CD; and during this operation, the index-sphere has made a complete revolution. 360° on the sphere, therefore, correspond to an area equal to the rectangle contained by the circumference of the wheel and the distance CD. The size of the wheel K being known, different values may be given to CD, so as to make the instrument measure according to any required scale. This may be done, either by shifting the position of the beam T*t*, or by having several sockets in the carriage E for the pin which directs the arm to work in.

15. If I have been too prolix in describing the action of an instrument which has never been constructed, it is because I have myself derived great satisfaction from following out the mechanical consequences of the mathematical theorem on which the truth of this method depends. Among the other forms of apparatus by which the action of the two spheres may be rendered available, is one which might be found practicable in cases to which that here given would not apply. In this instrument (fig. 4) the areas are swept out by a radius-vector of variable length, turning round a fixed point in the plane. The area is thus swept out with a velocity varying as the angular velocity of the radius-vector and the square of its length conjointly, and the construction of the machine is adapted to the case as follows:—

The hemisphere is *fixed* on the top of a vertical pillar, about which the rest of the instrument turns. The index sphere is supported as before by a ring and framework. This framework turns about the vertical pillar along with the tracing point, but has also a motion in a vertical plane, which is communicated to it by a curved slide connected with the tracing point, and which, by means of a prolonged arm, moves the framework as the tracing point is moved to and from the pillar.

The form of the curved slide is such, that the tangent of the angle of inclination of the line joining the centres of the spheres with the vertical is proportional to the square of the distance of the tracing point from the vertical axis of the instrument. The curve which fulfils this condition is an hyperbola, one of whose asymptotes is vertical, and passes through the tracing point, and the other horizontal through the centre of the hemisphere.

The other parts of this instrument are identical with those belonging to that already described.

When the tracing point is made to traverse the boundary of a plane figure, there is a continued rotation of the radius-vector combined with a change of length. The rotation causes the index-sphere to roll on the fixed hemisphere, while the length of the radius-vector determines the *rate* of its motion about its axis, so that its whole motion measures the area swept out by the radius-vector during the motion of the tracing point.

The areas measured by this instrument may either lie on one side of the pillar, or they may extend all round it. In either case the action of the instrument is the same as in the ordinary case. In this form of the instrument we have the advantages of a fixed stand, and a simple motion of the tracing point; but there seem to be difficulties in the way of supporting the spheres and arranging the slide; and even then the instrument would require a tall pillar, in order to take in a large area.

16. It will be observed that I have said little or nothing about the practical details of these instruments. Many useful hints will be found in the large work on Platometers, by Professor T. Gonnellu, who has given us an account of the difficulties, as well as the results, of the construction of his most elaborate instrument. He has also given some very interesting investigations into the errors produced by various irregularities of construction, although, as far as I am aware, he has not even suspected the error which the sliding of the index-wheel over the disc must necessarily introduce. With respect to this, and other points relating to the working of the instrument, the memoir of Mr Sang, in the *Transactions* of this Society, is the most complete that I have met with. It may, however, be as well to state, that at the time when I devised the improvements here suggested, I had not seen that paper, though I had seen the instrument standing at rest in the Crystal Palace.

EDINBURGH, 30*th January* 1855.

Note.—Since the design of the above instrument was submitted to the Society of Arts, I have met with a description of an instrument combining simplicity of construction with the power of adaptation to designs of any size, and at the same time more portable than any other instrument of the kind. Although it does not act by perfect rolling, and therefore belongs to a different class of instruments from that described in this paper, I think that its simplicity, and the beauty of the principle on which it acts, render it worth the attention of engineers and mechanists, whether practical or theoretical. A full account of this instrument is to be found in Moigno's "Cosmos," 5th year, vol. viii., part viii., p. 213, published 20th February 1856. *Description et Théorie du planimètre polaire, inventé par J. Amsler, de Schaffouse en Suisse.*

CAMBRIDGE, 30*th April* 1856.

Notice of a Simple Compressible Syphon. By ALEXANDER BRYSON, F.R.S.S.A., F.S.A. Scot.*

Being engaged in a series of experiments where it is necessary to decant acids from precipitates which are required to be at rest, I have found the usual syphon rather inconvenient.

With the ordinary syphon, one of two methods must be used; either it must be filled with fluid before immersion in that wished to be drained, or the mouth must be applied to empty the syphon of air. In the case of the fluid being strong acid, as in my present experiments, this last method is inadmissible.

The compressible syphon, which I beg to lay before the Society, is exceedingly simple and cheap, and requires no expertness in using. To the end of a small glass syphon I attach a vulcanized India rubber tube (or when it can be obtained a very thin India rubber one without being vulcanized) to the longer end of the syphon. When the proper proportion is kept between the syphon tube and the compressible one, the method of manipulation is very simple. The glass tube or syphon proper is held steadily by the left hand, while with the finger and thumb of the right the India rubber tube is

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* Read before the Society, 22d Jan. 1855.

firmly compressed, and steadily drawn downwards; this of course causes a partial vacuum, which is immediately filled by the fluid in the jar wished to be drained, and the action goes on until the fluid reaches the aperture of the shorter leg of the syphon. When the syphon is of larger interior diameter, than required for chemical experiments, or where the compressible tube bears a small proportion to the syphon proper, a method resembling the milking of a cow is requisite. As in the former instance the tube must at first be grasped by the fingers of the left hand, and the compressible tube by the finger and thumb of the right, the compression continued until the end of the tube is reached. The left hand must now grasp the compressible tube as near the syphon as possible, and the right finger and thumb brought as nearly in contact with the left as possible, and the process repeated as before. This method, in short, becomes an air-pump without valves, or, more properly, the valves are represented by the fingers.

In using the instrument, it will be found that its action is much improved on a second trial, while the interior walls of the compressible tube are still moist. This will be at once apparent when we consider that the moisture makes a more complete adhesion between the two sides of the flexible tube, and thus increases the vacuum in the process of milking the solution. The word milking is certainly ill chosen, as far as regards my present investigation, and for which this instrument was first used, as the more milky portion of the fluid is wished to remain ; but the fact remains : it is really a syphon more on the principle by which milking is accomplished, than any other hitherto used.

On the Angular Disturbances of Ships,—the Measurement of the Amount, and the Elimination of the Effects in certain cases. By Professor C. Piazzi Smyth, F.R.S.E., Astronomer Royal for Scotland.*

Importance of the Subject.—When an astronomer on shore about to make observations considers himself bound to use every method to increase the firmness of the foundations of his instruments, when he even finds the whole mass of a hill shaken, appreciably to him, by a carriage a mile off,—what an untoward situation for his purpose must be the deck of a ship, rolling at every moment on the waves, and having no part of it whatever fixed, either in direction or in space. Yet there, on the heaving deck, must astronomical observations be made; some for the safety of the ship, and some for the benefit of science, when, as often occurs, certain phenomena are only visible at sea.

To satisfy, then, the actual requirements of the present day, the difficulty must be looked straight in the face, and no method left untried which may tend to remove this amongst other obstacles, to the full and safe navigation of the seas. Until it is removed we may be assured that the safety of ships must frequently be jeoparded from the impossibility of obtaining "absolute" altitudes; and equally must naval astronomical science be ever at a very low ebb, so long as no accurate places can be determined in the sky, and no large optical power can be employed.

Every one who has used a telescope on shore knows the importance of steadiness in its stand; and nearly every one in this nautical country must have experienced in person how ships do roll, and pitch, and lurch at sea; upsetting all ideas of stability, even for the ordinary affairs of life, and much more for scientific requirements. On inquiring, however, from even practical men, I have not found them able to give me numerical particulars of the exact amount, and the manner of the occurrence, of these angular disturbances of position

* Read and Apparatus exhibited April 14, 1856.

which occur to a ship while pursuing its onward course; and as some knowledge of this is essential before attempting to devise a remedy, we may with propriety first consider the means of obtaining this information.

Measurement of the Disturbances.—All the various angular motions to which any ship is liable, the translation of the whole ship bodily being of no moment here, are reducible to three, viz.,—to *rolling*, a motion from side to side; *pitching*, from end to end; and *yawing*, or deviating in azimuth. To ascertain the amount of these movements, if the stars be hid, what appears so simple at first sight, as to observe the two first by means of a free pendulum, and the last by looking at the compass! But let the experiment be tried on a table, by having a box thereon containing a plumb-line hanging clear of the sides and a compass needle. Move the box about on the table, and it will be found that though the box be not disturbed from the horizontal plane, but only moved backwards and forwards therein, the plumb-bob is swinging about, and showing immense deviations from such plane in every wrong direction, and the compass is also moving without any apparent reason. Let the experiment then be tried on a ship at sea, where the ship takes the place of the box, and is exposed to angular disturbances as well as bodily displacements; but confining our attention for the present to rolling and pitching, as being of far greater amount than the yawing, let us look at the pendulum or plumb-bob. We may note and make sure of the real character of the ship's movements by observing the mast-head projected on the clouds, and they may be pretty regular; but at the very same time the pendulum performs a series of most extraordinary gyrations, sometimes almost coming to a stand-still, as undulations may chance to oppose, and anon as they combine, the pendulum fetches way and swings through tremendous arcs. Plainly, then, the simple pendulum is not a trustworthy instrument at sea. It *ought* always to point to the centre of the earth, but it will *not* do so when disturbed even by a little horizontal motion; once disturbed it is so very long before it recovers from the effect, that other disturbances befall it, as from every roll of the ship; and so at sea it is never at rest, but subject to most complicated motions which defy the powers of calculation to eliminate them.

Old Ship-Clinometers.—Very ingenious methods have been contrived to check these vagaries and to fit pendulums to act as ship-clinometers, as in Captain Becher's horizon; wherein the pendulum swings in a vessel of oil. But the result is not satisfactory; for the oil itself is disturbed, and while the pendulum's tendency to vibration is not got rid of, its sensibility to angular motion is impaired.

Troughton, again, employed a most elegant method; for, constructing a pendulum of a circular form, like an inverted cup, he set this spinning at a great velocity; and then for a time it seemed to bid defiance to any disturbances in the absolute position of what it rested on, while it showed the angular movements well. Soon, however, the defect predicted by an astronomer became practically apparent, viz., that the forces producing vibration in a simple pendulum were still at work in this rotatory one, and these effects compounded into the spinning movement, at length produced precessional disturbances, which entirely destroyed the accuracy of the indication.

When pendulums fail on shore the surface of a fluid may be used, but not at sea, for the lurching of the ship would pitch the fluid out of the vessel in which it was placed with a force that no floating glass or such contrivance over it would be able to check. Again, a near approach to an effective appliance has been made by half filling with water a thin glass tube bent into the form of a ring and placed with its plane vertical; but here again we find that if the effect of linear disturbance is decreased, it is by the aid of such friction and stiffness of movement that sensibility to angular motion is gone.

New Clinometer.—For ship purposes then we need something that shall be barely influenced by horizontal, but shall be very sensible to angular displacement. Now, this necessary quality of sensibility existing, as is well known, to a high degree in spirit-levels, I first tried modifications of these for naval purposes. The bubbles of air were certainly liable to vibrate after the style of the pendulum by linear movements; but they came to rest almost immediately after the disturbing force had ceased; and a little reflection on the reason of their first movement, immediately made me perceive that it might be reduced indefinitely by decreasing the size of the bubble, and this I found true in practice. But then came the difficulty, that with very small air-bubbles the friction or retardation of their movements greatly increased. A series of experiments, however, on different fluids, indicated that with chloroform the desiderated qualities existed in a sufficient degree for practical purposes, the amount of resistance to movement of small bubbles therein being about $\frac{1}{3}$d of that in ether, $\frac{1}{18}$th of alcohol, and $\frac{1}{100}$th of water.

Safety-Level.—There then remained only to contrive some plan of safety, by which, in a hermetically sealed glass tube, (for no other will confine chloroform) a very small bubble might be employed, without a chance of fracturing the glass when the liquid should expand at a high temperature. This object has been attained by introducing a pierced diaphragm into the tube near one end, and confining therein a large quantity of air, which serves as a safety valve for the fluid from the rest of the tube to press upon when expanding. In ordinary motions of the level, the air does not change its compartment, but when it is held vertical and shaken smartly, small particles of the air may be made to pass from one side to the other of the diaphragm; and thus the bubble may be adjusted in size at pleasure. Mr John Adie has made many of these levels for me with consummate skill, and finds the following the best form of diaphragm or plug which is made of glass and fitted with floss silk.

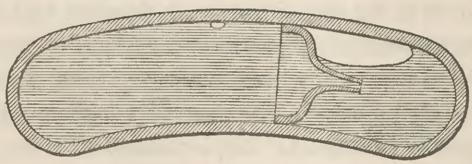

Fig. 1.
SECTIONAL ELEVATION OF THE ADJUSTABLE MINIM BUBBLE-LEVEL.

Application to Ship Purposes.—To apply this principle to a clinometer for use at sea, I have had such a safety chloroform level made to a radius of 6 inches, and an arc of 180 degrees. Being further fitted into a wooden frame with a greyed-glass back, having the angles painted thereon, the smallest bubble is clearly visible, and it will be found to possess, not perfect, but a very high degree of freedom from the effects of horizontal displacement, with, at the same time, an eminent degree of sensibility to angular motion.

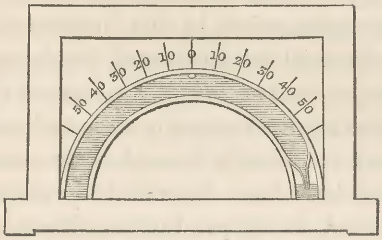

Fig. 2.
Sectional Elevation of the New Ship Clinometer.

This chloroform safety-level or minim-bubble clinometer, is what I propose, and have used for measuring the angular disturbances of a ship's deck from the horizontal plane; and in a steamer off the Bell-Rock Lighthouse (the steamer of the Commissioners of Northern Lights, who are always so ready to assist in the promotion of scientific objects) there was shown to be, on the average, a roll of 15 to 25 degrees every three seconds and a half when in shallow water and a ground swell; afterwards the rate decreased to 4 seconds and 5 seconds, still quite quick enough to account for the proverbial energy of the sea of that neighbourhood in producing sickness amongst unhappy passengers.

The Rotation Clinometer.—The level clinometer, however, does not indicate azimuthal disturbances; and though sufficient and very convenient for most practical purposes, a more perfect instrument is conceivable—one that shall be positively undisturbed by even the most violent lurches, and that shall measure yawing as well as pitching and rolling.

Such an instrument I have now been able to bring forward, by a proceeding which is equivalent to balancing a Troughton's top, placing it in gymbals, and mounting a second similar apparatus on the top of it with its revolving plane crossing the other at an angle of 90°. But as this machine has flowed from the researches I have been making connected with the *elimination* of a ship's movements, presently to be described, I shall only now say that its action as a *differential* instrument for a short space of time is wonderfully perfect. The rolling is shown on one circle, the pitching on another, and the yawing on a third; and any features in which the level-clinometer may fail, are the strongest points in this instrument. For, while absolutely uninfluenced by horizontal displacement, however quick, or violent, or unexpected, still it has not thereby its sensibility to angular motion injured in the smallest degree; and, in a word, it may confidently be said to be entirely free from the defects which have been described to exist necessarily, to more or less extent, in all pendulums, fluids, or generally in gravitation appliances.

Elimination of the Disturbances. Methods hitherto in vogue.—When an object, say a small table, is to be kept level at sea, there is but one method at present employed, viz., to suspend it freely, either in gymbals like a chronometer, or by strings from a hook, as with the trays over a cuddy-table. For the ordinary purposes of life, this method looks very well; for, placed on one of these trays, a tumbler half-filled with water is kept from spilling, when it would have certainly been upset if left on the fixed table below. But still that is no proof that the said tumbler was kept level while the ship was rolling about; for, whether hung from gymbals, or by strings from a point, the water is equally made part of a pendulum which is swinging, and acquiring centrifugal force; and this makes the water tend to place its surface, not so much parallel to the horizon, as at right angles to the radius by which it is swinging—so powerfully too, that if we take the apparatus in our hands, we may swing the tumbler round and round over our heads without a drop falling out.

But plainly by such a proceeding we should not have approached the qualities of a table-stand for astronomical instruments; and as long as we have free suspension of any sort above, and a weight below, we may be sure that our arrangement is but a pendulum, which, as described in the case of the clinometer, must, when at sea, be ever oscillating anomalously; and, therefore, unable to keep itself, it can never on ship-board keep a table steady. Yet this was the only principle of Nairne's celebrated observing-chair, which, though rewarded by Government, utterly failed in practice. Nor does it seem, from the character of any subsequent invention, to have been generally understood by practical men that such a plan could not answer, until Sir John Herschel, in the "Admiralty Manual of Scientific Inquiry," pointed out that free suspension of a heavy pendulum and weight tended rather to perpetuate disturbances than to eliminate them.

Neutralization of Vibrations.—Free suspension, however, of some kind we must have, or our table will be carried over bodily and forcibly with the ship; but let us first try to get rid of oscillations, the effect of horizontal displacements, and afterwards we may more successfully cope with the angular motion. To this end, finding by experience that a pendulum will swing; and, when on a large scale, and with the ship lurching in a heavy sea, *will* swing and pitch away with such terrific violence, as, according to the sailors, to break ropes and spars; we shall find it salutary to hang it from its centre of gravity. Then, with a free suspension still, but as much matter above as below it, the pendulum is made a no-pendulum, or a balanced body; and the lurches of the ship, acting on the two halves with an equal force, but in opposite directions, are completely neutralized. In principle this method is simple and perfect; and in practice, with a model apparatus before me, consisting of a small table mounted on double gymbals and balanced, the correction is so complete that if the fixed frame be taken in the hand, and violently shaken, no vibration or particular disturbance is occasioned. But when a small weight is hung below, the least motion of the outside supporting-frame occasions a pertinacious oscillation of the internal gymbals carrying the table.

Elimination of Angular Movements.—We have thus got rid of the effects of horizontal displacement, and of *lurching*, so terrible in the eyes of sailors, and doubtless therefore most important to be considered, but the effect of angular motion still remains; for it will be found, on tilting the outside fixed frame above described, that the whole of the internal parts tilt over too, and have no power of themselves to maintain any one position more than another. The human hand is continually needed to put them right. If the wind be kept off by a proper screen, no great mechanical force has to be exerted by the said hand, for it has merely to overcome the friction of the weight of the apparatus on the fine pivots of the gymbals. But yet the human hand, head, and eye, combined, cannot keep the table level; for, though assisted by one of our improved clinometers, the deviation from the horizontal plane must *have* taken place before the effect on the clinometer can be seen, and any attempt be made with the fingers to remedy it. When it is also considered that a ship is never at rest, not even for the tenth part of a second, it is plain that we must look to some much more perfect and watchful means than the hand of man, to effect our purpose; something that will in fact correct for the motion of the ship while it *is* taking place, and before it *has* taken place.

The Spinner, or Free Revolver Stand.—On clearly making out to myself, two years ago, the nature of this difficulty, it occurred to me to try for its correction the principle that enables the earth so steadily to keep its pole pointed to one invariable part of the sky while it is being annually swung round the sun, and exposed to so many disturbing forces, which yet are not able sensibly to prevail against it. This principle, the persistence of a free axis of rotation, combined with the composition of rotatory motion, was also particularly known to me by Troughton's Top, or Spinning Pendulum, before alluded to, and by the writings of the Rev. Baden Powell.

Introducing, therefore, into the internal gymbals of the already-described balanced apparatus, a smoothly and rapidly revolving wheel, and balancing it also on the gymbal pivots, and placing its plane horizontal, I had the satisfaction of finding that it was perfectly efficacious in defending the table from any pitching or rolling motion that could be given to its supporting frame, quick or slow, short or long.

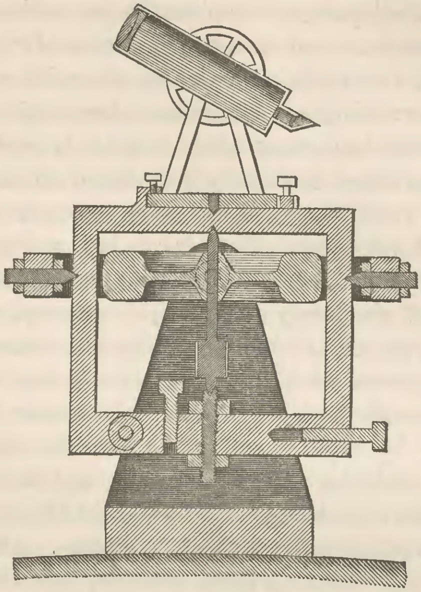

Fig. 3.
SECTIONAL ELEVATION OF SIMPLE REVOLVER STAND.

Practical Points of Construction.—The success as to the principle was perfect and immediate; but it was long before I had obtained the perfection requisite in actual practice with astronomical observations. It is, however, perfectly attainable, and the following *data* are the results of many experiments made on spinners from ½ lb. to 25 lbs. in weight, and from 2 inches to 24 inches in diameter.

1*st*, The Revolver Wheel, for supporting a sextant or small telescope, may weigh 10 lbs., be 1 foot or 1·5 foot in diameter, may turn 80 to 100 times or oftener in a second,—300 revolutions per second may be set before the machinist as an object for his ambition to reach,—be made as a fly-wheel with a heavy rim, but with an internal continuous plate, in place of spokes, and should be polished, and turn on pivots of hard steel, working in sockets of the same: the shape of the bearing parts being curvilinear cones, hollow for the spindle, approaching at the shoulder a direction at right angles to the axis, and at the point being almost parallel with it. Such a form producing equal wear of all parts of the pivot, by proportioning the pressure to the surface, and insuring lightness of "running" by the shoulder, with truth of motion by the point, and generally a power of correcting any looseness between pivot and socket.

But the most important caution of all is perhaps that the gravity of the wheel be equally distributed about the axle and the plane of revolution; otherwise an excessive shaking will occur at high velocities. Perfect turning, and perhaps an actual turning in the lathe, if the substance of the wheel were throughout of absolutely equal specific gravity, would give us all we are in search of; but unhappily it is extremely difficult to get homogeneous metal. My first wheels, cast with the plane vertical, although thought perfect by the turner, failed utterly when tested by rapid revolutions; and the second wheels, though cast with the planes horizontal, and decidedly better, were yet so far from being what they should be, that they made a noise when running like a coach in motion. On finding this, Troughton's six adjusting plugs were applied, and when these were carefully adjusted, the wheels revolved with extraordinary smoothness, and a practical absence of sound and vibration even at the highest velocities.

This method of adjustment was brought to my attention by Mr Sang, and I have found it better than such as I had adopted previously. He had used it with eminent success in 1836 to perfect the Bohnenberg apparatus, and fit it for determining the rotation of the earth. Indeed, without such application the attempt to solve the problem would have been practically hopeless. When, therefore, M. Foucault rediscovered Mr Sang's experiment and performed it successfully in 1854, the gravity plugs formed an essential feature in his apparatus.

2d, The Gymbal Rings and Pivots. These rings should be stiff and light, and may be made of metal cast in frame, or of iron tube, or even, when on a large scale, in a square form, of wood strongly braced at the corners.

But the pivots and their sockets should be always of hard steel, with very nice but firm adjustments, so as to have them neither loose nor tight.

A great deal of the successful action depends upon this adjustment; for if the fit is loose, the whole weight of the instrument shifts through the amount of that looseness, one way or the other, at every roll of the ship, and so altering the balance of the machine, produces precessional movement. Again, if the pivots are too tight, and make much friction in the motion of either of the gymbal rings, they tend to prevent the *composition of rotatory motion*, and so deprive the spinning-wheel of a part of its peculiar virtue.

3d, Although the wheel and the gymbals be, by their moveable pivots, adjustable, so as to correct the balance of the machine, yet other balance means, such as heavy-headed screws, should be placed on the internal gymbal, in such a manner that they can be worked quickly while the wheel is spinning; for then, much smaller deficiencies of weight are made apparent than when it is at rest.

4th, The spindle of the wheel should be driven from *either* side to avoid the friction of a side impulse on the pivots. If toothed wheels are employed, probably the best plan on a small scale, the teeth should be small, say eight to the inch, and cut in iron or steel; for brass will not stand the work; the quickest moving wheel suffering most; and the proportion of wheel to pinion should not be greater than seven to one.

The driving wheel-work has to be brought up to the spinner-axle to set it in motion, and then when the requisite speed is obtained, cleverly disconnected, so as to leave it spinning without experiencing any shock. This has not been found difficult in the apparatus experimented on.

Elimination of Azimuthal Movements. Double Spinner Stand.—The single spinner apparatus described above, though fully able to protect from all disturbances at right angles to its plane, cannot protect from any that coincide with it. But having, by its means, obtained a small platform, which, once put level by hand, keeps itself so, we may on that erect a second spinner in gymbals with its plane vertical; and balancing this on its own gymbals, and also on those of the first spinner, we may then employ its power to protect from azimuthal movements a table or a telescope placed on its outer gymbal ring.

Such table will then be entirely defended from all the possible angular movements of a ship; and a telescope once directed on a star, will keep it in the field without hand, though the ship may pitch and roll and yaw to any extent. And if the telescope be moderate in size, and the eye-piece not far from the centre of motion, and its lens large, an observer would have no difficulty in following its apparent motions, with his eye, really rolling with the ship, and so might keep up uninterrupted observation with a high magnifying power.

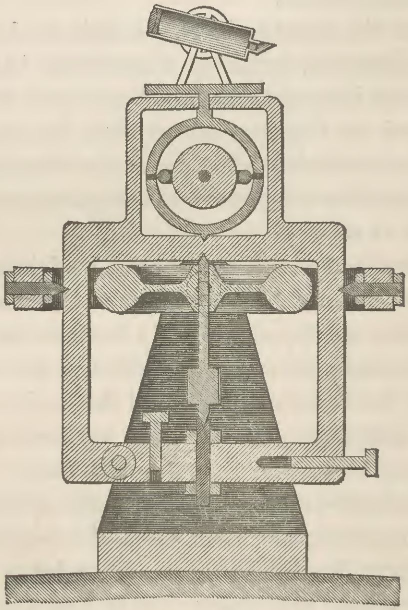

Fig. 4.
SECTIONAL ELEVATION OF COMPOUND REVOLVER STAND.

Of carrying the Observer as well as the Telescope.—If the Astronomer, as well as his telescope, could be carried on the spinner stand, great advantage would evidently result. There is, however, this difficulty: if we merely increase the size of the spinner stand already described, then the smallest amount of change of position in the man would be compounded into the rotatory motion of the horizontal wheel, and produce a precessional movement in the table which would instantly be affected in the accuracy of its position to the full amount of such movement. But if we consider the level only of the outer horizontal ring, and consider the inner gymbal ring carrying the wheel, merely as the apparatus to keep the outer one steady, as in fact has been carried out with the upper azimuthal apparatus, then a disturbing force may long press upon that outer ring without deranging its position at all; the effect being all carried off by the precessional movement which will be found to take place in the inner gymbal and the wheel.

The Precessional Stand.—On this principle, therefore, we may adopt a form of the spinner stand having, in the same general frame, one wheel in a gymbal to correct for rolling only, and another for pitching only, and another for azimuthal variation. Then if any want of balance is produced on the said frame, it is not immediately altered thereby, the first effect being only to make the appropriate wheel turn on its gymbal pivots. If, too, the wheel be heavy and the speed great, this precessional turning will be so slow that there will be time for an attendant to press in the opposite direction on the general frame, and correct the effect of the observer's want of balance before the plane of rotation coincides with the direction of the disturbing force, when the virtue of resistance ceases. Or, if the apparatus be larger still, so as to carry an attendant to each precessional wheel, his duty would be simply to incline to or from the centre of the general frame, so as to keep his wheel near its normal position, or point of maximum resistance. Such a precessional stand I have satisfied myself from a model will work well if the practical points at p. 439 be attended to, and if the principle of the balance stand with which we set out be rigorously preserved.

Practical points to be attended to with the Precession Stand.—To enable the balancing of the instrument on its points of support to have the effect of completely neutralizing vibrations, we must not be content to have the dead-weight part and the spinning-weight part *collectively* balanced on those supports, they must be *separately* and *collectively* balanced, for a disturbing force produces a different kind of effect on the still part and the moving part. Hence, we must have as much spinning matter on one side as on the other of the general point of support, and equally with the correction for rolling, as for pitching and for yawing.

The best form into which I have been able to throw the precessional machine to satisfy these principles is, to place in the centre of the inner of two horizontal gymbal rings an azimuthal apparatus carrying the observing-table as in the spinner stand, p. 439, and of a diameter of only $\frac{1}{3}$d that of the inner gymbal, in the circumferential part of which are to be placed two pairs of opposite precessional wheels, the one so turned as to correct for rolling, and the other for pitching; the centres of these wheels, as well as that of the azimuthal one, being all in one plane passing through the point of intersection of the axes of the two gymbal rings.

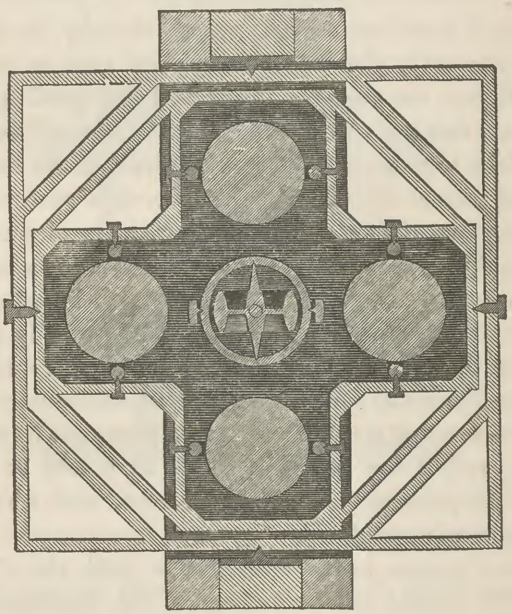

Fig. 5.
Sectional Plan of Precession Stand.

Driving the Spinners.—Having now a stand with five wheels, and being urged to make them as large and heavy as possible, something more powerful than a train of wheel-work, impelled by the hand, is necessary to drive them, and to get up a speed, be it remembered, which is unprecedented in mechanics. When, too, the spirit of the age most properly inclines to all sorts of labour-saving machinery, we ought, in extending the application of science, to avoid all occasion of obliging man to toil at what elementary powers can do perfectly well.

Let it be laid down, then, at once, that our driving-power for the wheels must come from a steam-engine, by endless band, or by water, or by steam-pipe ; then clamping the gymbals of each wheel, a necessary proceeding at sea when driving the spinner to prevent strain on its pivots, let us proceed to examine the case.

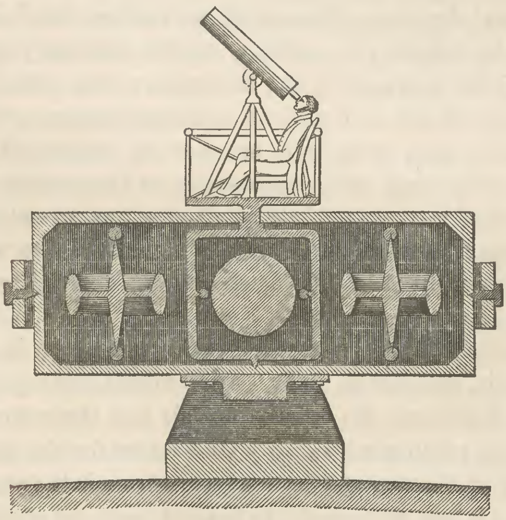

Fig. 6.
SECTIONAL ELEVATION OF PRESSURE STAND.

Endless Band-Driving.—Such band must not be applied to the axle of the spinner itself, for it draws it to one side, spoils the pivots, and is not easy to disengage with safety. But it may be applied to a separate fixed axle below, constructed with very strong pivots, and with a central sliding-rod which can be slided up into the axle of the spinner by a hole through its lower bearing and pivot. This plan I have used on a 10 lb. spinner with velocities up to 80 revolutions per second ; and it is a very effective plan as to the ease of making and breaking connection between the driving axle and the spinners without shock, and without the prejudicial rattle of toothed wheels. But as the said axle is heavy, and spins as rapidly as the spinner itself, it must be adjusted with the gravity plugs also, lest it communicate too much vibration to the spinner. The lower pivot of the spinner for this sort of connection through its bearings, must be larger than if the impulse were communicated between its bearings; but the wheel experimented on ran as lightly and with almost as little friction as could be desired, so that the method is decidedly a practical one, when the band moves quickly enough.

Elemental Driving.—Even with an endless band, however, there will be difficulty in getting up the necessary speed, on account of the slowness of the first mover in a steam-engine. Intervening wheels and pinions multiply expense, vibration, and friction, and, after all, are not so extensively available for multiplying speed excessively as the motion of fluids pressed out of large tubes into small ones; as an extreme case of which may be taken the boiler of a steam-engine with some thousand times the area of the steam-pipe through which all the steam is conveyed away.

This method I have therefore experimented on in the case of water, air, and steam. The same means employed to utilize one will also suit the others; but air and steam are capable of producing much more velocity than water for the same pressure; and of the two aëriform drivers, steam is the more easily applied, as it can be brought to bear at once out of the boiler by a pipe without the intervention of pump machinery. The steam indeed at first proved troublesome, by its heat and moisture, on escaping after it had done its work, but it was soon found quite possible to carry off all this waste by a second steam-pipe placed in a small wooden chimney communicating with the box in which the driving apparatus was contained.

Elemental Driving from a second Axle.—Adopting the same species of axle and connecting-rod as described in p. 445. I applied to such an axle a *double* Barker's Mill according to the elegant method of Professor Redtenbacher for neutralizing the lifting power of the head of water. But the Barker's Mill did not answer; for, to produce high speed with a certain size of pump, or expenditure of water, it was necessary to make the orifices of escape very small, and the radius of motion short; and then it was found that the water leaked so very freely at the joints, or space between the moving and fixed necks, that no sensible power was obtained. Internal leathers were next applied to check this escape of water, on the plan recommended of old by Dr Robison; but the pressure of the water on these locked the whole apparatus immoveably. The depth of the leather collar was pared down by successive degrees; but not until there was no more left to press against the outer neck did any motion take place, and then the escape at the joint was as bad as before. The method might have answered well enough had the arms of the mill been long, and its rate of revolution slow, as in ordinary cases; but that described was necessarily very different.

New Hydraulic-Driver.—The cause of failure, then, being the impossibility of keeping the joint tight, without much friction, and this objection holding equally with the "vortex," and other known wheels for high velocity, it occurred to me to devise a plan by which the water that escaped at the necessary joint should be made to play a useful part; in fact, that all the water should escape at the joint, which would then present no mechanical difficulties in the making or in keeping free from friction. To this end I took away the Barker's Mills and applied around the axle on which they had been fixed a series of vanes on which the water struck in escaping from the upward and downward orifices—these being now freely enlarged, so as to let as great a quantity of water escape there as was to have issued out of the mills. The axle carrying the vanes necessarily passed through the orifices of emission, and the fluid was consequently flashed out in a thin but continuous ring form through the annular space left between the outside of the axle and the inside of the nozzle. The pressure, therefore, exerted on the vanes was very uniform, and these were set at a very large angle to the direction of impact, so as to increase the speed of rotation—at the expense of power, of course—to a greater pace than that of the effluent particles.

As a specimen of the performances of this driver, I may state that, with the area of the annular spaces between the nozzles of escape and the spindle, equal in all to 0·6 of a square inch, and with steam of 25 lbs. pressure, the driving axle, weighing 4 lbs., was driven (per counter) at 140 revolutions per second, and, with the 10 lb. spinner in addition, at 70 to 80 revolutions per second.

The following is the best form I have found for this driver.

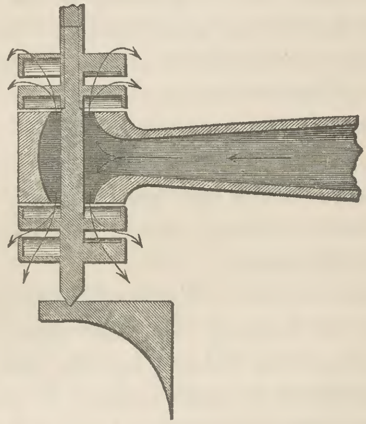

Fig. 7.
LEAKAGE-DRIVER.—SECTIONAL ELEVATION.

Elemental Driving applied to the Spinner direct.—A neater method of driving the spinner by elemental power would be by dispensing with the subsidiary axle and its bearings, and such plan is very desirable for diminishing friction, and preserving truth of motion. To gain this end I have made many experiments, and have concluded with a small turbine on a pin which is fixed into the lower spinner pivot, and projects through its bearings. In the normal position of the apparatus, the turbine hangs down in the inside of the supporting stand or table; the steam or water pipe, fitted with a peculiar nozzle, is then raised so as to enter the void centre of the turbine, and flashes out the fluid in a horizontal sheet through the curved and open sides. The vanes forming these sides are purposely set nearly at right angles to the radii, in order to make the speed of revolution surpass the rate of efflux, and appears in a transverse sectional plan, as in fig. 8.

The power of this method is so great that the wheel moves the instant the steam is applied, the full velocity is obtained in but a few seconds, and the addition of the 10 lb. spinner hardly affects the rate of revolution of the 4 lb. turbine, which is about 70 to 80 per second.

Conclusion.—With these powerful elemental methods of driving, and with large wheels in a precessional stand at high velocities, there seems no reason why platforms should not be constructed for use on ship-board capable of carrying both the observer and his telescope. Even an invalid might have his bed there arranged, so as to alleviate his sea-sickness, by experiencing no angular motion whatever.

TURBINE DRIVER.—SECTIONAL PLAN.

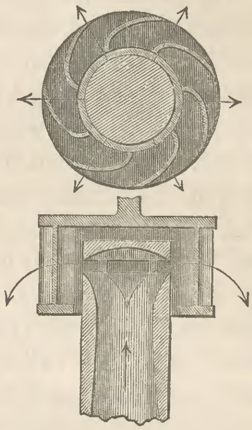

Fig. 8.
SECTIONAL ELEVATION OF THE ABOVE.

Tremor might be feared, because we find it more or less wherever we find mill-wheels revolving; but that is because their centre of gravity is not adjusted symmetrically to their axis of motion. In our case we do employ accurate methods of effecting this important correction, and we may expect, therefore, the large wheels to revolve as smoothly and as silently as the small ones.

APPENDIX.

Before leaving the subject of free rotating machines, there are two or three note-worthy points about them, which, though flowing strictly from the theoretical principles of mechanics, are still new to many persons, and are too often put down when seen as paradoxical, as upsetting previous experience, and as breaking in upon the unity which has been traced so extensively in the works of creation.

Some explanation, therefore, of these cases may both tend to illustrate the true method of philosophizing, and also to give practical men a clearer idea of the principles to be followed in applying rotatory dynamics to useful purposes.

The Apparent Balance.—In one of our local scientific journals appeared, about a year since, an account of a so-called paradox, lately discovered by a German, and to this effect: that a bar was hung by a string so as to balance in the horizontal position; a wheel was put on one end of the bar, and it was, of course, tilted thereby; but when the wheel was made to spin, the balance was restored to the bar.

A correspondent attempted to explain this by saying, that one half of the wheel going down and the other half coming up, when turning in a vertical plane, its weight was neutralized thereby. But gravity acts on bodies in motion as well as at rest; and a rifle ball spinning as it moves onward, drops exactly as far perpendicularly in a second of time as the musket ball, or a simple stone let fall from the hand.

The explanation, therefore, is to be looked for elsewhere, and may be obtained merely by looking again at the experiment, and taking a less partial and contracted view of it, observing in fact *everything* that we see, instead of confining our attention to *one* favourite point only out of many. Examining the experiment then again in this spirit, we find that, at the same time that the spinning of the wheel serves to restore the apparent balance of the bar, a horizontal motion of it about its central point of support takes place; and this, which escaped the attention of the paradox-finder, is the effect of the weight of the wheel compounded into the rotatory motion. The wheel is weighing just as much when spinning as at rest, but the fact of its weight, or the attraction of gravitation on it, is not to be looked for in the downward direction as with quiescent bodies, but in a direction at right angles to it, that is, in the horizontal; and this takes place. Stop that horizontal motion, and the composition of the gravitating with the rotating force is rendered impossible, and the beam tilts again. In this horizontal motion, then, is the desired explanation of the mystery, which turns out after all to be no paradox, no upsetting of previously ascertained laws of matter, but another manifestation of the same mechanical law which equally ex-plains the rolling of the axis of a spinning-top or the precession of the equinoxes of the heavens.

Parallelism of the Earth's Axis.—The difficulty experienced by the early astronomers to explain the *rationale* of the earth's axis keeping parallel to itself, in the annual revolution of the centre about the sun, is also an example of the danger of looking only at one part of a natural phenomenon at a time. They made a model of the earth set in gymbals so as to have the power of turning its axis every way; but when such model was revolved round a centre, the axle once pointed towards it kept turned thereto during the whole revolution; and, therefore, instead of keeping parallel to itself, and always pointing to one direction in space, as, say, the north, it turned successively to every quarter of the heavens, and belied the well-known fact of the constancy of the polar point, and the occurrence of the seasons of the year.

Only the human hand applied to the model was efficient in keeping its axis always in the right direction, unless, indeed, a certain system of wheel-work was introduced stretching all the way between the model sun and the earth, and acting on its polar direction, as may be observed in the very complicated and expensive brass machine, nearly 150 years old, now on the table. But in nature there are no such wheels seen extending through the 95 millions of miles of transparent ether between the sun and earth, so that the difficulty is not assisted thereby.

Consider, however, what does take place in nature, and see if *all* that is represented in the model. The earth revolves around the sun in a year: good, that is imitated. And it revolves on its own axis in 24 hours: ah! that was forgotten by the mechanician. Introduce it, then; make the model earth spin on its axis, and then turn it round the sun, without intervening wheel-work, and instantly we find the little terrestrial axle keeping truly parallel to itself, and always pointing to the same direction in space. We may take it up in the hand, and walk round about the table as the central sun, or round about the house, and always the model earth so turns itself on its supports as invariably to have its axis pointed towards one quarter of the sky, more perfectly than were possible to be compassed by the human hand.

This is but another illustration of the same mechanical law by virtue of which a top, when spinning, is able to stand uprightly and maintain its axis in a constant position, in spite of disturbing forces, which, as they increase in strength, are only able to produce a precessional, not an immediate effect.

Mechanical illustrations by rotatory dynamics of precession, nutation, and other disturbing forces acting on the planets, were ably brought before this society, two years ago, by their vice-president, Mr Elliot, and with the excellent idea of giving to lecture-apparatus a spiritual resemblance, as it were, to the celestial phenomena which they are intended to explain.

Accordingly, while the old complicated orreries and planetariums serve only to mislead and confuse as to the real forces at work in keeping up the celestial movements, Mr Elliot's apparatus exhibited these very forces, and at work, and producing phenomena of a similar order to those actually witnessed in the sky by astronomical observation.

Caution necessary in Practical Applications.—The admirable efficiency of the earth's rotation in preserving its axis always parallel to itself, led me to the contrivance of the free rotation-stand already described, and may lead other persons to many more applications. But, although the principle be so powerful, yet a very little matter will prevent its coming out at all. And when I was engaged in planning my first machine, able engineers expressed doubts of its action, because they had seen no such qualities in fly-wheels, move they ever so rapidly. True, they had never seen such quality; for, though the speed and power of rotation were abundant to bring it out most remarkably, the method of mounting the axis did not give it an opportunity of appearing.

Now, suppose a table turning on a horizontal axis formed by two opposite pivot points; in this table establish an ordinary fly-wheel, with its plane coincident with that of the table. Put it in motion, and it will be found that no rapidity of rotation in the fly will give it any power of preserving the table in a given position on

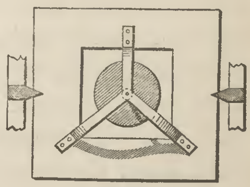

Fig. 9.
Plan OF TABLE ON PIVOTS, CARRYING WHEEL IN *Fixed* FRAME.

its axis of motion. We may revolve the table, for instance, on its pivots of motion as easily when the fly-wheel is spinning as when it is not. The reason is, that the composition of rotatory motion cannot take place.

An abstract free wheel, when spun, will preserve a given position absolutely, if there be no disturbing forces, like an ideal stone thrown through empty space, or like one star launched into an empty universe, moving on for ever in a perfectly straight line. The rotation of the wheel is in fact the motion of a bullet wrapped up in a small space, and into so convenient a parcel that we can examine on our study-table the whole line of its flight.

If a disturbing force acts on the wheel, it is immediately compounded into the force of rotation, and produces so much more or less precessional motion as this disturbing force is greater or smaller than the rotating force. And as this precessional motion takes place 90° from the point where the disturbance takes place, it follows, that *as long as such composition of motion takes place, no effect follows in the direction in which the force acted.*

Looking now at our table apparatus, we find that, from the construction, there can be no precessional movement, therefore no composition of rotatory force. But allow this to take place, by putting the wheel into a vertical gymbal-ring, and giving it an axis of motion on two pivots in the table, at right angles to the pivots of that, and instantly the virtue of the abstract free wheel is manifested. For, if we now try to turn the table on its pivots of movement, it appears locked and clamped; but the precessional wheel turns, at the instant of pressure, more or less on its own pivots, in a direction at right angles to the disturbing force. From this experiment the most important rules for practice are obtained; for it shows that if the disturbing force on the table can be completely resolved into precessional movement of the gymbal, the table will be absolutely unaffected; but if there be any obstruction to such composition, as arises from friction

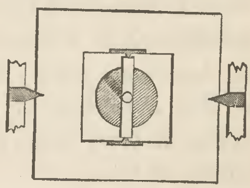

Fig. 10.
Plan of Table on Pivots, carrying Wheel on *Gymbal* frame.

on the pivots, an amount of the disturbance proportional to what is employed in overcoming the friction must affect the table. Hence, the extreme importance of smooth pivots, friction-wheels, if possible, and immense speed, rather than weight, in the spinners.

Application to Moral Philosophy. Freedom and Slavery.—Although the apparatus exhibited (the Free Revolver Stand), be but composed of inorganic masses of metal, yet it is curious, and not a little instructive, to observe, how it comports itself when a certain amount of speed of revolution, and *quasi* vital energy is infused into it. For then, indeed, it exhibits some of the finer qualities of the human mind, and especially one which cannot be too constantly kept in view by a nation of freemen surrounded by countries despotically ruled. This quality is that so abundantly proved in history, that to elicit all the glorious attributes of which man's mind is capable, he must be free. In a free nation the sense of honour and justice and truth will ever be high, because, reasoning, the men know the trust reposed in them, and rejoice in the responsibility; and they will be good subjects in obeying the laws which themselves have made for the common good, and in defending the state from foreign aggression. But shackle them in the smallest degree, compel them to do this, or that, or the other, and although it is something they should do—although you can prove *a priori* that it is good and wholesome for them to do it,—yet the generous fervour of their minds evaporates; they become torpid and effete, and exhibit at last either the stolid indifference of a Russian serf or the senseless animal look of an American slave; they cease to be either good supporters or able defenders of the state of which they form a part. Refuse to trust them, and they will become incapable and unworthy of trust.

Now, in the Free Revolver Stand, we can prove, both theoretically and practically, that to enable the spinning-wheel to preserve the outside gymbal from any disturbing force, its own or the inner gymbal ought to be nearly or quite at right angles to the other. At that point the power of resistance is at a maximum, but decreases as the angle decreases, until, when this is reduced to nothing, or when the one gymbal is in the plane of the other, then all power of resisting the external disturbing force is gone, though the wheel keep on spinning ever so rapidly. To enable the wheel then to do its duty, its gymbal must be in a certain position; and how advantageous apparently to have it fastened in that correct position, so that it cannot get into a wrong one. Yet the moment that we put any such fastening, though for so excellent a purpose,--the moment we doubt its power or intention of keeping in the right path, and refuse to trust it,—that moment the energy and virtue of the wheel are entirely gone; it is as spiritless and incapable as a slave of many generations. But free it from these shackles, and allow it to go wrong if it will; trust implicitly to its innate sense of preferring always to do the right thing rather than the wrong one, when both are set before it,—and instantly its virtue and its power have come back to it; it has become again a most zealous subject, and works with all its energy to protect the commonweal, or the outer gymbal, from being injured by any disturbing force. And the energy with which it works, come from whatever side the enemy may, is so great, as, with the little machine now before me, to raise an involuntary cry of admiration from all who have witnessed its action for the first time.

Necessity of Education.—Let not, however, the conclusion which is inevitable from the above be pushed too far, without reference to other accompanying phenomena. Freedom is good for man, but men may be sometimes in exceptionable states and unable to profit by it; and as the first French Revolution proved, and popular uproars continually prove, liberty is a very dangerous gift to uneducated men.

Precisely the same thing do we find with the free revolver stand—it must be *educated* before we can safely give it freedom, otherwise it will do positive mischief, as well as not do the good it should have done.

The spinner-wheel when at length completely formed in the manufactory where it was born, was apparently perfect in figure and as bright as gold, yet was, so to speak, *uneducated.* It was like those savages of the South Sea Islands, in symmetry of limb above all that civilized nations can show, and living, as the early navigators thought, such pure and innocent lives,

—a perfect repetition of the golden age; yet when our Missionaries went amongst them they were found to be full of ravening and wickedness, and their body-politic reeked with inhuman massacres and cannibal atrocities. So, also, could we look within the beautiful polished wheel of the well-grown but still uneducated spinner, we should find it the seat of unnumbered vices,—of sand flaws, of air-bubbles, of alloys erroneously mixed, or particles imperfectly melted, and having unequal specific gravities, and actually needing to be taken in hand by a rigid system of education, that of the gravity plugs, before it can become a safe and respectable member of the community.

In the case of the wheel now experimented on, and which has revolved all the evening smoothly and silently, though driven at high velocities, let us take out one of the gravity plugs, *i.e.*, a small part of its education, and drive it again, and see what it would have been but for the fatherly care with which the errors and failings of its internal constitution have been ascertained and subjected to discipline and training, and at length corrected. At once we shall find it noisy and unruly; and as the velocity increases, it roars, and shakes the whole table and half the room with its violent vibrations. At the speed of from 200 to 300 revolutions per second it shrieks aloud, or booms with a sullen threatening noise, like a shadowy presentiment of a French revolution, or the poet's "ancestral voices prophesying war;" and if it is not stopped, we shall have screws working loose, or breaking by acquiring a crystallized structure, and the whole machine will tumble to pieces destroyed by the anarchy of its own ill-directed forces.

Workmen employed.—The practical success of the revolver stand must evidently depend in a very great degree on perfection of workmanship; and as so much of this has been attained in the several spinners and precessional stands now exhibited, I have much pleasure in stating that these have all been made in the establishment of Messrs J. Milne and Son, Brass-founders in the Canongate; and the work has throughout been specially superintended with great ability and untiring care, through more than a year and a-half by their excellent foreman Mr James Millar.

APPENDIX.

Proceedings of the Royal Scottish Society of Arts, Session 1850–51.

The Annual General Meeting of the Society was held in the Hall, George Street, on Monday, 11th November 1850,—Thomas Grainger, Esq., F.R.S.E., Memb. Inst., C.E., President, in the Chair.

The President opened the Session with the following address:—

Gentlemen,—Before proceeding with the ordinary business of the evening, permit me to congratulate you on the auspicious commencement of this, the thirtieth session of the Society. It was justly observed by one of my predecessors in this chair, Mr Buchanan, that, "from what he had seen of the proceedings of this Society, the truly useful and practical nature of the subjects brought before it, the free discussions with which they were canvassed at the meetings, and their merits further investigated and sifted in the committees, and rewarded, according to their ability, with a liberal but impartial hand, and the opportunity afforded by the meetings of friendly intercourse among men of all professions and parties, he was satisfied that this Society was eminently calculated to promote the great object of the 'improvement of the useful arts;' and he had no doubt it would continue to flourish and maintain its high character among the important institutions of the country." I have now been a member of this Society since 1828, and having, with much pleasure and no inconsiderable advantage, taken part in its proceedings, more especially during the last few years, I can also bear testimony to the improvements which it is calculated to effect in the useful arts, and in manufactures generally. In the intermediate position which it occupies in our local associations, between the School of Arts on the one hand, and the Royal Society on the other, an extensive field for the improvement of the arts and manufactures of the country is opened; and if proper exertions are made by each of us in our respective spheres, and with that talent, industry, and skill which characterise many of our countrymen, they cannot fail to effect the most beneficial results. With respect to the present state of this Society, it gives me great pleasure to be able to inform you, that, whether considered with reference to the number of its members, the state of its finances, the importance of the communications recently received and expected, and other circumstances, I have no hesitation in stating it to be in a most flourishing condition. The number of members at the commencement of the last session was 345 ; and during the session the new members admitted were no less than *eighty*, a number considerably exceeding that of any former session. I am far, however, from attaching so much importance to the mere *numbers* admitted during last session, as to the eminence and talents of many of the individuals, and to whom I look with great confidence as valuable members of the Society, from the importance and interest which I am sure will attach to the communications to be furnished by them ; and to their attendance at, and taking part in, our proceedings, which cannot fail to make our meetings more and more interesting, and many of whom I am glad to see now present. I may be permitted to avail myself of this opportunity of urging on you the propriety of continuing your efforts to obtain additional members, and by a little individual exertion, I have no doubt whatever that, before the close of the present session, our roll will contain 500 names. While I feel warranted in congratulating you on the number of members recently added to the Society, I cannot but regret that so many have been called from among us by death. The first I shall notice is the late Lord Jeffrey, or, by the name by which he was better known in every quarter of the globe, "Francis Jeffrey." This distinguished individual was a member of our Society from its commencement. I am not aware that he took any direct part in your proceedings, or in mechanical pursuits generally ; nevertheless, the countenance of so distinguished a critic, lawyer, and judge, who may be said to have been without a rival in the charm of his conversation, and the wonderful attraction of his everyday intercourse, could not fail to promote your interests. The next name I shall notice is that of the late Sir James Gibson-Craig of Riccarton. Sir James had been a member nearly twenty years. Of this distinguished townsman, I feel it to be unnecessary in this city, where he was so well known, and where he spent so long and so useful a life, where he lived so much respected, and died so much regretted, by all who had the happiness to enjoy his friendship, to say more. To these I have to add the name of another gentleman, who also spent a long and most useful life in this city, and with whom it was my privilege, as well as that of many whom I now address, to live for many years in terms of intimate friendship. I refer to the late Mr Robert Stevenson, engineer to the Commissioners of Northern Lighthouses. Of the eminence of this gentleman, the Commissioners themselves bear testimony in the following terms :—"The Board, before proceeding to business, desire to record their regret at the death of this zealous, faithful, and able officer, to whom is due the honour of conceiving and executing the great work of the Bell Rock Lighthouse—whose services were gratefully acknowledged on his retirement from active duty, and will be long remembered by the Board ; and to express their sympathy with his family on the loss of one who was most estimable and exemplary in all the relations of social and domestic life." Mr Stevenson was one of the original members of our Society, and took for many years a deep and active interest in all its proceedings—as he did in those of other kindred associations. This gentleman died universally beloved and respected by his relatives and friends for his private virtues and many excellent qualities, and by the profession to which he belonged, as well as by his employers, for his great talents, his professional skill, and his sound practical knowledge. These may be judged of by the eminence which he attained in his profession, and the works with which he was connected, of which the Bell Rock Lighthouse is not the least important. But, while we must all deplore the loss of so distinguished a member, it is some consolation that he has left behind him three sons, each of whom has already attained to eminence in the same profession. These gentlemen are members of our Society, who attend its meetings most regularly, and take an active part in its proceedings, and it must be an additional gratification to us all that the first prize of last session has been awarded to one of them—Mr Thomas Stevenson. I have also to mention the name of Mr William Galbraith, A.M., over whom the grave is but a few days closed. He had been a member since 1835. Many of you are aware that he was regular in his attendance at our meetings, and communicated papers on several important subjects, and frequently took part in our discussions. He possessed considerable mechanical knowledge, was an excellent mathematician, and long a distinguished and successful teacher of that branch of science in this city. I may mention, that in 1837 Mr Galbraith received the Society's Gold Medal for his paper on "The Erroneous Geographical position of several points in the Frith of Clyde;" and which communication tended materially to expedite the order for resuming the Trigonometrical Survey of Scotland. In the same year he also received the thanks of the Society for a very interesting paper "On an extraordinary instance of Refraction." I may also mention the late Mr William Bryden, who was long one of our members, and who was not more distinguished for his skill in the profession in which he was engaged, than for the integrity and uprightness of character which he maintained. I have likewise to notice the names of Sir Thomas Gibson Carmichael and Mr William Keith, accountant, the latter of whom was, I believe, a nephew of the late Alexander Keith, Esq. of Dunottar, to whom the Society is indebted for one of its most valuable annual prizes—the Keith Medal. It seems to be admitted on all hands that the change of our place of meeting from the hall in Princes Street to this place has added materially to our comfort and convenience. What we much want, and what I hope we may soon obtain, either in connection with this hall or in some one equally convenient, is a museum of models and drawings—of which we have already a considerable collection—so arranged as to afford, at hours convenient for workmen, the freest access, and every facility for inspection and making copies. I am not prepared to say that our finances are yet in such a state as would warrant us—at least single-handed—in incurring much expense for this object, but it is one which the Council should keep in view; and if, by co-operating with some other kindred institution, a proper museum could be obtained, and within the pecuniary means of the Society, it could not fail to tend much to its prosperity. Before concluding these remarks, I may be indulged with a few observations on subjects of more *general* interest than those to which I have adverted.

It is exceedingly gratifying to find that the application of the all-powerful "arm of steam" continues to progress to a higher state of perfection. In the application of this power to the *locomotive* engine, nothing deserving of particular notice on the present occasion has occurred, that I am aware of, during the last session. Greater perfection, however, is being attained in the construction of these powerful machines, both by superior workmanship and in the improvement of the material of which they are made. A good deal has also been effected by the better adaptation of engines and carriages to the nature and extent and direction of the heavy traffic and the gradients of the lines on which they are employed—circumstances which, though of the utmost importance, have hitherto been too much overlooked. In the application of steam to navigation still greater advances are being made, more particularly by the screw-propeller. By means of this, as well as by the paddle-wheel propeller, the intercourse between many of the most important parts of the world is now carried on with a celerity, comfort, economy, safety, and, above all, with a regularity and punctuality which, if any one had predicted but a few years ago, would have been considered as under the influence of a disordered imagination, as was the poet Darwin when he wrote the following memorable lines :—

> " Soon shall thy arm, unconquered steam ! afar
> Drag the slow barge, or drive the rapid car."

It is not less interesting than instructive to contrast the present state of navigation by steam with the very imperfect state in which it was about forty years ago. In an advertisement, dated August 1812, it is stated —" 'The Comet,' between Glasgow, Greenock, and Helensburgh, for passengers only. The subscriber having, at much expense, fitted up a handsome vessel to ply upon the River Clyde, between Glasgow and Greenock—to sail by the power of wind, air, and steam—he intends that the vessel shall leave the Broomielaw on Tuesdays, Thursdays, and Saturdays, about mid-day, or at such hour thereafter as may answer from the state of the tide; and to leave Greenock on Mondays, Wednesdays, and Fridays, in the morning, to suit the tide. The elegance, comfort, safety, and speed of this vessel require only to be proved to meet the approbation of the public; and the proprietor is determined to do everything in his power to merit public encouragement. The terms are, for the present, fixed at 4s. for the best cabin, and 3s. the second; but beyond these rates nothing is to be allowed to servants, or any other person employed about the vessel. Passengers by 'The Comet' will receive information of the hours of sailing, by applying at Mr Housten's office, Broomielaw; or Thomas Blackney's, East Quay Head, Greenock. (Signed) Henry Bell. Helensburgh Baths, August 5, 1812." Mr Bell presented this new method of navigation to the British Government at three different times, viz., in 1800, 1803, and 1813, when, after all his exertions, it was thought to be of no utility to Government. After it was denied him in 1803, he thought it very hard that such a discovery should lie dormant, and, on that account, he sent a description of the method of applying steam in propelling vessels against wind and tide, to all the emperors and crowned heads in Europe, and also to America, which last Government put in practice in the year 1806. This subject is still further illustrated by Mr Fulton's account of his first voyage on the Hudson River, in the Claremont, in the spring of 1807; he mentions—"The Claremont, on her first voyage, arrived at her destination without an accident. She excited the astonishment of the inhabitants of the shores of the Hudson, many of whom had not heard even of an engine, much less of a steam-boat. There were many descriptions of the effects of her first appearance upon the people on the banks of the river; some of these were ridiculous, but some of them were of such a character as nothing but an object of real grandeur could have excited. She was described by some who had indistinctly seen her passing in the night, to those who had not had a view of her, as a monster moving on the waters, defying the winds and tide, and breathing flames and smoke." Mr Fulton gives the following account of the same voyage in a letter to his friend Mr Barlow:—"My steam-boat voyage to Albany and back has turned out rather more favourable than I had calculated. The distance from New York to Albany is 150 miles. I ran it up in thirty-two hours, and down in thirty. I had a light breeze against me the whole way, both going and coming, and the voyage has been performed wholly by the power of the steam-engine. I overtook many sloops and schooners beating to windward, and parted with them as if they had been at anchor. The power of propelling boats by steam is now fully proved. The morning I left New York there were not perhaps thirty persons in the city who believed that the boat would ever move one mile an hour, or be of the least utility; and while we were putting off from the wharf, which was crowded with spectators, I heard a number of sarcastic remarks. This is the way in which ignorant men compliment what they call *philosophers* and *projectors*. Having employed much time, money, and zeal, in accomplishing this work, it gives me, as it will you, great pleasure to see it fully answer my expectations. It will give a cheap and quick conveyance to merchandise on the Mississippi, Missouri, and other great rivers, which are now laying open their treasures to the enterprise of our countrymen; and although the prospect of personal emolument has been some inducement to me, yet I feel infinitely more pleasure in reflecting on the immense advantage that my country will derive from the invention," &c. (The engine of this boat was constructed in England by Messrs Bolton and Watt). The steamers recently placed on the Holyhead and Dublin passage, perform the voyage in an average of four hours, being at the rate of eighteen miles an hour. I may also notice that the very low price of iron for some time past has recently led to the application of that and other metals to many purposes for which timber was formerly employed. In railway works, the most important application of iron is the substitution of it during the last year, for stone blocks and timber as sleepers, and for which Mr Barlow obtained a patent. It is expected that this change will add very much to the durability, and lead to considerable economy in the maintenance of railway works. At the close of last session we had a very interesting description of an iron roof for a passenger station of large span. There is this evening exhibited on our walls, drawings of one of still larger dimensions—I believe, upwards of 150 feet span—erected at Liverpool by Mr Richard Turner of Dublin, and of which we are promised a description at an early meeting. Before closing these observations, I cannot deny myself the pleasure of adverting to the approaching Great Exhibition of the Industry of all Nations. With reference to this Exhibition, I have it in my power to state from authority, that many of the difficulties which presented themselves at the outset of the undertaking, have disappeared, and that the building—if building it may be called—is advancing in a very rapid and otherwise satisfactory manner; and so as to leave no doubt that it will be completed in good time for the proper arrangement of everything sent for exhibition before the opening, which is fixed for the 1st of May. The building, as you may be aware, extends over upwards of twenty acres, or 96,800 square yards. Extensive as this is, the applications which have been made for space, from the United Kingdom alone, are more than sufficient to occupy the whole of it. Unless, therefore, the building be much enlarged (which is very improbable), this circumstance will impose a very disagreeable duty on the local committees in rejecting articles well deserving of notice. It has been said, and that most truly, that we judge of every thing best by comparison. In the approaching Exhibition, the means of comparison will be afforded to an extent which no age or country has yet presented; and such as I feel confident will prove of universal advantage in the relations of manufactures, commerce, and the social interests of society. It is now well known that foreigners will contribute largely; and I hope that the articles sent from this side of the Tweed, and for the manufacture of which Scotland is celebrated (as well as for its mineral productions), will bear a favourable comparison with any that may be exhibited; but if otherwise, I trust the result will be to stimulate us to still further exertion. Travellers are but too apt to regard with disfavour everything in foreign countries which differs from what they have been accustomed to in their own. These prejudices—for such in many cases they are—will be very much softened by the intercourse of the inhabitants of different countries which the exhibition will promote; and this, it is manifest, will be effected to an extent which will aid in removing many of the causes of hostility in which nations have been only too often engaged; in short, it will prove the most perfect *Peace Congress* that can well be imagined. Before we part this evening, I understand that it will be my duty—and it will certainly be a pleasant one—to distribute the Prizes of last session. The decisions to which the Prize Committee have come may not be satisfactory to all. I can, however, testify that each subject was carefully and anxiously considered, and with every desire on the part of the committee to distribute the sum at their disposal according to the merit of their communication, improvement, or invention. In these investigations the Prize Committee were most materially aided by our secretary, Mr Tod, of the value of whose services I cannot omit this opportunity of expressing the high sense entertained by me, in common, I am sure, with each member of the Society. I have had many opportunities of witnessing his laudable anxiety to promote the interests of our Association, and you have on all occasions seen the energy, judgment, and zeal with which he conducts the business of the Society. To Mr Scott Moncrieff, our treasurer, we are also deeply indebted for the care and attention with which he manages our funds, and who is on all occasions found to be a most able coadjutor in the conduct of our affairs.

2. An Account of the Chimney of the Edinburgh Gas-Works, with observations on the principles of its strength and stability. By George Buchanan, Esq., F.R.S.E., F.R.S.S.A., Civil Engineer. (3331.)

In Part I. of this paper, Mr B. gave an account of this remarkable structure, and the principles of its strength and stability. It was one of the works particularly alluded to by the President in his interesting introductory address last year, and of which he thought it important that the Society should have some account; and Mr B. having been professionally connected with the work, had much pleasure in complying with the President's request.

It was about the year 1845, owing to the extension of the works, that it became necessary to obtain increased chimney accommodation, both for increasing the draught of the furnaces and for carrying off the smoke and vapours from the works and clear away from the neighbourhood, by raising the chimney to a greater height. Three chimneys were then on the works, the highest of them rising 148 feet, and not exceeding $2\frac{1}{2}$ feet square internally at the top. These gave vent to the smoke and vapours of 68 furnaces, heating 178 retorts, but were inadequate to work these effectually, and to give proper ventilation for cooling and purifying the retort houses for the comfort of the workmen, still less to meet the extensions of the works then contemplated and since executed. Instead of continuing, however, the system of small and low chimneys, and adding to their number, the plan came to be considered of raising one single chimney, sufficiently large and lofty to receive the flues from all the furnaces, and by one powerful column of heated air to work these, and any contemplated extensions, in a more effectual manner than hitherto, and so as to supersede the others and render any addition unnecessary for a long period. The idea had been acted on in some works already, and the magnificent chimney of St Rollox chemical works furnished a favourable example. No way deterred therefore by the anticipated difficulties, or the great cost of the undertaking,* seeing especially that it promised beneficial results to the public, the Directors determined to proceed with the plans made out at their request by Mr Taylor, the company's engineer for the works. Before proceeding, however, with a work of such magnitude, and involving such serious responsibility, the Directors considered it necessary to obtain further professional advice; and having called on Mr Buchanan for his opinion and assistance, he then carefully considered the whole subject, and having examined also the works of the French engineers who had written on the stability of lighthouse towers and other similar structures, he communicated his opinion in two different reports, which were approved of by the Directors.

Mr B. then proceeded to state from these reports some of the facts and principles regarding the work, which apply generally to all similar undertakings. And *first*, in regard to the form of the structure, whether round or square; the square had been usually adopted in the works, but in the case of an altitude from 300 to 400 feet, rising 20 feet above the top of Nelson's Monument, the round form was decidedly to be preferred, as

* The whole cost of the works has been little short of £5000. One of much less magnitude would have been sufficient for immediate wants—but after due consideration they thought it best to do the plan effectually at once.

presenting a less effective surface to the wind, whose violent action in this quarter it was important to diminish by every means. The effect of the wind on a cylindrical surface, as compared with a square, had been calculated by theory in the ratio of two to three. This is the law of resistance so beautifully demonstrated by the commentators on Newton's Principia. Subsequent experiments had proved the effect on the globe and cylinder to be, if anything, rather less than theory, so that we are quite safe in taking it at $\frac{2}{3}$; the result is that with 300 tons, for example, acting on a square tower, we have only 200 on the cylinder of the same diameter, which is most material. The bricks also by being moulded to the circle can be built and bound together with all the strength of the arch. On the lower part of the building, again, which is less exposed, and to be built of stone, the square and pedestal form are preferable.

Secondly, The building being intended to be 300 feet and upwards in height, the question arose how far the ordinary brick could withstand the pressure arising from so lofty a column. This difficulty was provided for by the increasing thickness of the walls of the chimney from the top towards the bottom, whereby the incumbent pressure being distributed over a larger and larger surface in descending, was diminished in proportion. The whole height from the foundation to the top is $341\frac{1}{2}$ feet, of this $77\frac{1}{2}$ feet are occupied by the foundation and square pedestal of stone, and 264 by the brick-work, the thickness of which was diminished towards the top by five successive steps. The upper division extended 83 feet down, and was 15 inches thick, and the internal diameter 11 feet 4 inches at top—the 2d division 58 feet and 20 inches thick—the 3d, 48 feet and 25 inches—the 4th, 40 feet and 30 inches, and the 5th, 35 feet and 35 inches thick, and internal diameter 20 feet. On calculating the weight and pressure on each of those divisions, on the first it was found not to exceed $4\frac{1}{2}$ tons on each square foot; in the middle it increased to 7 tons, and at the base it increased to 8 tons on each square foot. The strength of ordinary brick being estimated at from 20 to 30 tons, the work seemed within the limits of safety; but on finding that a composition brick could be obtained in the neighbourhood, from the brick-works of Mr Livingstone of Joppa, of much superior strength, somewhat similar to those of St Rollox, Mr B. strongly recommended these, and also suggested experiments on their strength, of which he would give farther details on another evening, but found the first specimen tried bore at the rate of 440 tons to the square foot, a degree of strength almost incredible in such material. The results of the other experiments were somewhat similar, and all such as to set at rest any fears of the result. In regard to the sufficiency of the foundation itself, although this sustained the whole mass of the building, amounting to 4000 tons, yet the weight being spread over the entire area of the solid base, 40 feet square, it did not exceed two and a half tons to the square foot. And the material consisting of very hard Till or blaes, of pretty equal solidity throughout, this appeared to form a good and sufficient foundation; and in order to be perfectly secure, the building at one of the angles was carried deeper than the rest, to obtain the same hard and solid bearing throughout. The result of these precautions it is now very satisfactory to observe, the structure standing perfectly upright and entire, without a crack or flaw of any description to be found in it.

The next object of importance that came to be considered was the effect of high winds on the building. From experiments, it was calculated that the force of a storm or tempest is equal to 12 lb. on the square foot of surface directly exposed; a great storm 18 lb., a hurricane 30 lb., and one capable of tearing up trees and oversetting buildings 50 lb. There is no instance, however, of such a hurricane occurring in this country, and we are quite safe in assuming 40 lb. per foot, or 90 miles an hour, as the utmost power of the wind in this country. The French engineer, Fresnel, in an interesting memoir on the stability of the lighthouse of Belleisle and various other lighthouse structures compared with it, has assumed the force of the wind at 55 lb., agreeing with the estimate of another engineer, Navier; but this is evidently much beyond the truth, and the effect was to bring the gas-chimney in Paris below the zero of stability, although it stands as yet quite secure. Consider only the human body, which presents a surface from four to six feet square. Such a force of wind would be equal to a pressure of from 200 to 300 lb., and the power to overset at least equal to 500 lb., which no one could sustain for a moment, and even the ordinary inclosure-walls or chimneys would be immediately prostrated by it. Besides, it appears from observations of wind-gauges, and particularly of one by Mr Adie of this city, that the greatest force indicated on it for several years was only $14\frac{1}{2}$ lb.; and another gauge, kept for several years at Granton Pier, and now at the Observatory, never indicated more than $18\frac{1}{2}$ lb., and this was at Granton on the 9th and 27th of April 1847. If we allow 40 lb., therefore, we are quite safe, this being nearly double what ever occurs.

Another point must be kept in view, that the tendency to overset the structure is greatly increased by the altitude, and this in fact exactly in proportion as the height exceeds the breadth of the base. It might happen also, if the strength of the different portions of the column were not duly proportioned, that it might be overset, not by the base, but at some intermediate point between it and the top. Applying these views, it was found that in the upper division, 83 feet down from the top, the force of the wind was $14\frac{1}{2}$ tons, and this increased by the height, and narrow base to 70 tons, while the actual weight was 270, giving a preponderance of stability of $3\frac{3}{4}$ to 1.

Taking the middle division, 189 feet from the top, the force of the wind was 37 tons, and this increased by altitude to 318 tons; but the weight of the structure being 880, there still remains a preponderance of stability of $2\frac{3}{4}$ to 1.

At the base of the column the force was 63 tons, increased by height to no less than 630, while the weight was 1670 tons, giving a preponderance of $2\frac{3}{5}$ to 1, or rather less than the other points, and showing that the column could not overset but at the base.

At the base of the pedestal, again, the stability was fully greater, being $3\frac{1}{2}$ to 1.

These results appeared very satisfactory, and the execution of the work has strikingly confirmed them. The stability and steadiness of the chimney, even in high winds, is remarkable; and while the old chimney, which is not half the altitude, is seen oscillating most sensibly by the naked eye, it is difficult to detect the smallest movement in the other by accurate telescopic observations with the theodolite. It is only in a violent gale, such as occurred last Thursday, that even then a slight degree of oscillation could be distinctly observed. And when we consider how very usual it is for structures of this kind to oscillate in high winds, and even some of the lighthouses, which are of a more solid character, are not exempt from it, it is a strong proof of the strength of the work.

Drawings were then exhibited, and the comparative stability calculated of the small gas chimney, and of several other chimneys here and in France, all which were considerably below the present, and the French one pronounced by Fresnel as showing great hardihood—also the relative proportions and heights of some lighthouses; and, lastly, a comparison was made, and drawings exhibited and described of the great chimney of St Rollox, 455 feet in height, and consisting externally of a single cone tapering from the base to the summit, but not quite regularly, 41 feet in diameter at the base, and 13 at the top. The walls are in five divisions increasing in thickness from top to bottom.

Another source of danger to be guarded against in these chimneys is the intense heat which often arises from the furnaces, and the powerful draught of the chimney. As a protection, an interior tube or chimney is generally built of brick standing clear of the outer chimney, and on which the effects of intense heat may be expended before it reaches the main exterior chimney. This is very effectual, but still the heat is great in issuing from the inner chimney, which should not be carried too high. In the present case, the inner chimney, 13 feet diameter, and lined with fire-brick, rises only 70 feet, and the walls of the chimney being then 35 inches thick present great resistance, but as an additional precaution he recommended near this part hoops of iron, which have been carried at intervals of 35 feet all the way up within, and inclosed by the brick-work, so that they are not visible.

The only point remaining to be considered, and to which Mr B.'s attention was particularly called, was the expediency of protecting the building by a lightning conductor. He had formerly, when the old chimney was erected, been consulted as to this, and considered it unnecessary, the height being moderate, and doubts being then entertained of the efficacy or expediency of such instruments. Much, however, has since been added to our knowledge and experience on this subject, and on the beneficial operation of conductors, so that he had no hesitation, the altitude also being so much greater, in recommending it. But having requested to be favoured with the views of a friend, and high authority, Professor Faraday, he gave an extract from his letter as follows:— "The conductor should be of ½ *inch copper rod*, and should rise above the top of the chimney by a quantity equal to the width of the chimney at the top. The lengths of rod should be well joined *metallically* to each other, and this is perhaps best done by screwing the ends into a copper socket. The connection at the bottom should be good; if there are any pump pipes at hand going into a well they would be useful in that respect. As respects electrical conduction, no advantage is gained by expanding the rod horizontally into a strap or tube—surface does nothing, the solid section is the essential element.* There is no occasion of insulation (of the conductor) for this reason. A flash of lightning

* The very reverse of what was formerly held by high authorities.

has an intensity that enables it to break through many hundred yards (perhaps miles) of air, and therefore an insulation of six inches or one foot in length could have no power in preventing its leap to the brick-work, supposing that the conductor were not able to carry it away. Again, six inches or one foot is so little that it is equivalent almost to nothing. A very feeble electricity could break through that barrier, and a flash that could not break through five or ten feet could do no harm to the chimney.

"A very great point is to have no insulated masses of metal. If, therefore, hoops are put round the chimney, each should be connected metallically with the conductor, otherwise a flash might strike a hoop at a corner on the opposite side to the conductor, and then on the other side on passing to the conductor, from the nearest part of the hoop there might be an explosion, and the chimney injured there or even broken through. Again, no rods or ties of metal should be wrought into the chimney parallel to its length, and therefore to the conductor, and then to be left unconnected with it."

In answer to some further inquiry, Professor Faraday again writes :—

"The rod may be close along the brick or stone, it makes no difference. There will be no need of rod on each side of the building, but let the cast-iron hoop and the others you speak of be connected with the rod, and it will be in those places at least, as if there were rods on every side of the chimney.

"$\frac{3}{4}$ rod is no doubt better than $\frac{1}{2}$ inch, and except for expense I like it better. But $\frac{1}{2}$ inch has never yet failed. A rod at Coutt's brewery has been put up at $1\frac{1}{2}$ inch diameter—but they did not mind expense. The Nelson column in London has $\frac{1}{2}$ inch rod, $\frac{3}{4}$ is better.

"I do not know of any case of harm from hoop-iron inclosed in the building, but if not in connection with the conductor, I should not like it; even then it might cause harm if the lightning took the end furthest from the conductor."

The rod was constructed nearly according to these directions, of $\frac{5}{8}$ inch copper, and the effect of it was very remarkably exemplified during the progress of the work. It was carried up regularly along with the building, and during storms, or a very electric state of the atmosphere, the electric fluid was distinctly perceived rushing down the rod, by a loud singing noise given out by it, arising from a tremor or vibration into which it was thrown, by a little play in the studs or eyes through which it passed in the building, and during these times the workmen were by no means fond of approaching too near it, but no harm ever occurred to any one from it.

The work of the chimney was commenced by laying the foundation on the 3d of June 1845, and during the course of that season the mason-work of the pedestal was completed, and the work allowed to stand till the spring. The brick-work of the shaft was commenced on the 2d of May 1846, and proceeded rapidly during the summer. The bricks and all the materials were taken up in the inside by means of a steam-engine working at the bottom, and winding a rope over a barrel, and this passing over a pulley on the top of the building, the materials were raised with the greatest facility; and it was curious to observe from different parts of the tower the work gradually rising, and the workmen steadily going on, at the great elevation to which they at last attained. A model was shown of a very simple apparatus, by which the stage for the materials and timbers was raised by successive lifts, as the building rose in height.

The contractors for the mason-work of the stone pedestal were Messrs Gowan, and for the brick-work of the stalk Messrs Bow of Glasgow, to whom much credit is due for the superior style in which they have finished their work; and it may also be mentioned that no accident or casualty of any serious nature occurred during the execution of this great work.

Several observations still remained to be made in Part II. as to the draught of the chimney, but were deferred to another day, as well as Mr Taylor's paper, to give time for the distribution of the prizes for last session.

Thanks voted to Mr Buchanan.

The following Report of the Prize Committee awarding the Prizes for Session 1849–50 was read, and the Prizes delivered by the President to the successful Candidates :—

Report of the Committee appointed by the Royal Scottish Society of Arts to award Prizes for Communications read and exhibited during Session 1849–50.

Your Committee having met and carefully considered the various communications laid before the Society during Session 1849–50, beg leave to report that they have awarded the following prizes :—

1. To Thomas Stevenson, Esq., F.R.S.E., F.R.S.S.A., civil engineer, Edinburgh—for his "Holophotal System of Illuminating Lighthouses." Read and exhibited, 11th March 1850. The Keith Silver Medal, and Plate, value Thirty Sovereigns.

2. To Patrick Wilson, Esq., Vice-Pres. R.S.S.A., architect, Edinburgh —for his "Observations on what is required to Improve the Dwellings of the Working-classes, with Plans of some Model Houses recently erected by him in this neighbourhood," &c. Read and exhibited, 25th February 1850. The Society's Silver Medal, and Plate, value Ten Sovereigns.

3. To Andrew Carrick, Esq., accountant, 14 Holmhead Street, Glasgow—for his "Self-acting Water Meter." Read, and drawing exhibited, 30th April 1849, and working-model exhibited, 24th June 1850. The Society's Silver Medal, and Plate, value Ten Sovereigns.

4. To Mr Alexander Gray, ironmonger and locksmith, 85 George Street, Edinburgh—for his "Double-action Secure Lock." Read, and the lock and a drawing exhibited, 26th February 1850. The Society's Silver Medal, value Five Sovereigns.

5. To Mr Hay Dall, brassfounder, Nelson Street, Tradeston, Glasgow —for his "New Liquor Pump, calculated to prevent the Liquor from being contaminated with Verdigris and Oil in the interior of the pump barrel; also applicable to the pumping of Acids and other corrosive liquids." The description read, and working-model of the pump exhibited, 22d April 1850. The Society's Silver Medal, value Five Sovereigns.

6. To Mr William R. Douglas, mechanic, formerly at Inveralmond,

Midcalder, now in Glasgow—for his description and drawing of a "Machine for Mortising, Tenoning, Boring, and Ripping Timber;" worked by one man; adapted for the Colonies. Read, and the machine exhibited in action, 26th November 1849. The Society's Silver Medal, value Five Sovereigns.

7. To Mr William Shedden, engineer, 1 Laurie's Close, Leith—for his "Simple Rules for determining the Weight of Cast-Iron Bodies by Measurement." Read, 8th April 1850. The Society's Silver Medal, value Four Sovereigns.

8. To Mr Randall Dale, engraver, 5 Buccleuch Place, Edinburgh—for his "Three Drawings or Designs for a grate in the Victorian style, a Candelabrum in the Arabesque style, and a Gas Lustre in the Flemish style;" with a description. Read and exhibited, 22d April 1850. The Society's Silver Medal.

The Committee recommend, that while the thanks of the Society are justly due to all those gentlemen who have sent communications, the special thanks of the Society be given to the following gentlemen, viz.:—

1. To Sir David Brewster, K.H., F.R.S., and V.P.R.S., Edinburgh, for his notice of a "Chromatic Stereoscope." Read, 10th December 1849; and printed in the Transactions.

2. To Messrs Fox, Henderson, and Co., engineers and founders, London Works, Birmingham—for their description and four drawings of a "Large Iron Roof of 136 feet span, recently erected by them at the Terminus of the Lancashire and Yorkshire Railway at Liverpool." Read and exhibited, 24th June 1850.

3. To J. Stewart Hepburn, Esq. of Colquhalzie, F.R.S.S.A.—for the ingenuity displayed by him in his "Plan for detaching the Coupling Chains of a moving Railway Train from the Locomotive, when the latter runs off the Rails." Description and drawings read and exhibited, 26th February 1850.

4. To Thomas C. Gregory, Esq., F.R.S.S.A., civil engineer, Edinburgh—for the ingenuity displayed by him in his "Self-acting Apparatus for disengaging the Carriages from the Tender upon the Engine leaving the Rails." Description and drawings read and exhibited, 11th March 1850.

5. To William M'Candlish, Esq., C.E., resident engineer—for his "Description of the Ballochmyle Viaduct over the River Ayr, on the line of the Glasgow and South-Western Railway," designed by John Miller, Esq., C.E. Read, 11th March 1850.

6. To J. Seton Ritchie, Esq., Stamp Office, Edinburgh—for his proposed method of inducing an "Upward Current of Air in the Upcast Shaft of Coal Mines, to promote Ventilation." Read, 22d April 1850.

7. To James R. Dymock, Esq., F.R.S.S.A., Edinburgh—for his "Description of a Model of a Safety-Strap for Glaziers, Slaters," &c. Read and exhibited, 22d April 1850.

8. To Alexander Cleugh, Esq., 12 Ferry Street, Mill Wall, Poplar, London—for his "Description, with drawing and model, of a Machine for Boring Coal." Read and exhibited, 8th April 1850.

The Committee have further granted, for the purchase of Models, Drawings, &c., illustrative of Papers read during the Session, the sum of Twenty Pounds.

In conclusion, your Committee beg to state, that no report has yet been given in on Mr Smith's Triple Acting Electro-Magnetic Telegraph, owing to the insufficiency of the model. It must, therefore, be postponed till next Session.

All which is humbly reported by

JAMES TOD, *Sec., Convener ex Officio.*

EDINBURGH, 1*st Nov.* 1850.

The Models, Drawings, &c., of Inventions, &c., for which Prizes, &c., have been awarded, were exhibited.

A beautiful model of the proposed General Railway Terminus at Leeds was also exhibited by the President.

PRIVATE BUSINESS.

The following Candidates were elected Ordinary Fellows, viz. :—

1. Adam Bryden, bell-hanger, Edinburgh.
2. David Macdonald, cotton-spinner, Aberdeen.

In terms of Law XV., the Society elected the following Office-Bearers for Session 1850–51, viz. :—

THOMAS GRAINGER, Esq., F.R.S.E., Memb. Inst. C.E., *President.*
RICHARD WHYTOCK, Esq. } *Vice-Presidents.*
ALEXANDER ROSE, Esq. }
JAMES TOD, Esq., F.R.S.E., W.S., 55 Great King Street, *Secretary.*
JOHN SCOTT MONCRIEFF, Esq., Accountant, 15 India Street, *Treasurer.*

Ordinary Councillors.

WM. PATERSON, Esq., C.E.
Professor MORE, F.R.S.E.
JO. CLERK MAXWELL, Esq., F.R.S.E.
T. STEVENSON, Esq., F.R.S.E., C.E.
JOHN CAY, Esq., F.R.S.E.
GEORGE LEES, LL.D.
D. RHIND, Esq , F.R.S.E.
D. WILSON, Esq., F.S.A. Scot.
PATRICK WILSON, Esq.
A. DOUGLAS MACLAGAN, M.D., F.R.S.E.
Rev. Professor KELLAND, F.R.S.S. L. & E.
J. DALMAHOY, Esq., F.R.S.E.

GEORGE WILSON, M.D., F.R.S.E., *Editor of Transactions.*
Mr ALEXANDER JAMESON, *Curator of Museum.*
Mr ALEXANDER KIRKWOOD, *Medallist.*
Mr HUGH JOHNSTON, *Officer and Collector.*

25*th November* 1850.—Thomas Grainger, Esq., President, in the Chair. The following communications were made :—

1. George Buchanan, Esq., F.R.S.E., F.R.S.S.A., civil engineer, read the second part of "An Account of the Chimney of the Edinburgh Gas-Works, with observations on the principles of its strength and stability."

In this paper, Mr Buchanan concluded with some observations on the effects of the draught in the chimney, a subject of great importance in regard to chimneys generally for large furnaces, where enormous quantities of air are continually passing in the act of combustion. This had been estimated by the eminent chemist, Professor Thomson of Glasgow, at 150 cubic feet per minute for every pound of coal consumed, and 50 more for waste—in all, 200. Hence in the boilers of many steam-vessels, for example, consuming one ton per hour, 7400 cubic feet of air per minute must pass up their narrow funnels, and being limited also in height, must be raised to a high temperature, and this, as at present constructed, by a great sacrifice of fuel. In the gas-works, the 68 furnaces consume 34 tons in 24 hours, requiring a current of air at the rate of 10,000 feet per minute, which the old chimneys were incapable of drawing. Mr B. then stated the principles on which the power of draught must be calculated, referring to the article "Furnace" in the Encyclopædia Britannica, last edition, where he had occasion to explain the subject. The power of the draught was directly proportional to the height of the chimney, and the velocity with which the external air rushes in to supply the draught, was proportional to the *square root* of the height of the chimney. The internal heat, however, was the grand moving power, expanding the air within the chimney, and giving it a buoyant or ascensional power. With 488 degrees of temperature, the celebrated chemists, Petit and Dulong, and most accurate observers, had found that air expands into double its volume. With this temperature, therefore, within the chimney, the velocity with which the external air was capable of entering at the bottom of the chimney, or into the furnaces or flues, would be proportional to the square root of half the height of the chimney, and expressed numerically in feet per second, would be equal to six times the square root of half the height, or $V = 6\sqrt{\frac{H}{2}}$ V being the velocity in feet per second, and H the height of the chimney. This forms an easy rule for this particular temperature, and if we apply to it in the present case, taking the height of the chimney from the entrance flue at 330 feet, would give a velocity of about 50 feet per second, or 34 miles an hour, equal in the atmosphere to a very violent gale of wind. Taking the smallest area of the chimney, where it is 11 feet 4 inches in diameter, at 100 square feet, this, with such a power of draught, would be capable of discharging 30,000 cubic feet per minute, which is amply sufficient for the present works and any extensions. The actual results have proved very satisfactory. Not only is there a draught in the furnaces, whereby they are wrought most effectively, and with great economy of fuel, but by making one or more openings at the bottom of the chimney a powerful blast of air sets in from all directions, carrying off vapours and all impurities, and producing a cool atmosphere in every part. On measuring the power of draught with a water pressure gauge, he found it drew up a column $3\frac{1}{2}$ inches high, there being a good deal of wind at the time. The blast of air at the mouth of the opening, it is curious to observe, drawing the hand powerfully in, and a square board covering the opening, it was difficult to withdraw, exerting a pressure of 15 lb. on the square foot. High winds have a sensible effect on the draught, sometimes raising the water-gauge to a height of

6 or 7 inches. A pressure of $2\frac{1}{2}$ inches, which it would be in calm weather, is very nearly equal to a column of air half the height of the chimney, and this agrees very well with the above calculation, as the interior temperature would not exceed 480 or 500 degrees. As a general rule for calculating the power of the draught at any temperature, the following would be found simple and agreeable to the practical results,

$V = 6\sqrt{\frac{n\,H}{488 + n}}$ n being the number of degrees of temperature.

Mr B. then gave a detail of the experiments formerly alluded to, made upon the strength of the bricks for the chimney in fourteen specimens of different qualities and compositions. By far the strongest was the composition of fireclay and ironstone, which bore, making every allowance, from 200 to 350 tons on the square foot; while the common quality did not exceed from 60 to 120. The Hailes stone bore upwards of 450 tons, greatly more than the result found by the experiments already shown to the Society, but which, being on small specimens, 1 inch cube, while the other was 4 inches cube, the effect might partly be due to this circumstance, together with the difference of quality in the specimens.*

David Stevenson, Esq., C.E., expressed himself in terms of much approbation of Mr Buchanan's investigations, and moved the thanks of the Society to him, which were given from the Chair.

2. A detailed Description, with Drawings, of the above Chimney. By M. Taylor, Esq., Engineer for the Edinburgh Gas-Works.

In this paper Mr Taylor gave a minute detail of the dimensions and structure of every part of the work. The foundation was on hard shale or clay; the masonry 40 feet 6 inches square at the bottom, 12 feet below the surface of the ground, 32 feet 6 inches at the surface of the ground; and brought up by steps in hard foundation courses of Craigleith stone, dressed and square jointed. Mason work of the most substantial description, with four eyes for connecting the main flues to the stalk. Square pedestal 65 feet high from surface of ground to top of base of brick shaft; 30 feet 10 inches square at base course; 30 feet square above base, and 27 feet 9 inches under moulding of top. Body of pedestal of neatly-covered rubble work of the strongest kind, the stone chiefly from Hailes Quarry of the best rock. The cope mouldings and base of brick, shaft of Craigleith. Within the pedestal and rising 20 feet above it, is an inner chimney or brick shaft standing quite detached, having a space from 18 inches to 2 feet clear in every part; but this space covered over at the top to keep out soot deposit, but yet left free of the outer pedestal and chimney. The inner chimney is 90 feet high, 13 feet diameter inside, carried up at four different thick-

* In the very interesting work lately published by Mr Edwin Clark, on the Britannia Bridge, and containing many valuable and curious results, all deserving attention, on the strength of materials, some experiments are described on the compression of brick and stone, in large specimens, and where the pressure was applied, not by lever or hydraulic power, but by the direct accumulation of masses of material heaped up above the specimens till they were crushed. The bricks, however, he says, were soft, and did not bear above 30 or 40 tons, but some of the limestone bore upwards of 500 tons.

nesses, beginning at $3\frac{1}{2}$ bricks thick, and ending at 2 bricks, including a lining of fire-brick, carried up the whole way at two thicknesses—20 feet at 10 inches thick, and 70 feet at 5 inches. The brick-work of the best well-burnt circular stock brick, with a course of headers in reeled order for every four courses of stretchers. The main brick shaft is 264 feet high above the stone pedestal; making, with the pedestal, 65 feet, and foundation 12 feet 6 inches—in all 341 feet 6 inches. The shaft is 26 feet 3 inches diameter at bottom externally, tapers to 13 feet 10 inches at the height of 243 feet, at the first belt under coping 11 feet 10 inches below the top. The shaft is carried up at five different thicknesses, beginning at 35 inches or $3\frac{1}{2}$ bricks, for 35 feet up, and ending with 15 inches, or $1\frac{1}{2}$ brick for 58 feet at the top, all built with hard circular composition brick, referred to in the experiments on the strength of bricks. Brick-work put together in the strongest manner with headers, as already described, and best band all laid in the best lime from Burdiehouse, with sharp sand, sifted and made up in the mill. The beds are kept as thin as possible, and neatly pointed in with the edge of the trowel. All the vertical joints inside of wall, grouted up with thin lime. As a farther security, the shaft is bound with six malleable iron hoops, at intervals of 35 feet up, built into the brick-work, one brick on bed from the outside, and kept $\frac{1}{2}$ inch clear all round off the outside lining of brick-work, so as to allow the hoops to expand with heat without injury to the work. They are all three inches broad; the under three 1 inch thick, the upper $\frac{3}{4}$ inch each, made in three lengths, clamped together and made fast with three $\frac{7}{8}$-inch or $\frac{3}{4}$-inch rivets on each side. The projecting cope at the top is of cast-iron, 19 feet 6 inches diameter over all, and in sixteen pieces about $\frac{7}{8}$-inch thick, screwed together with bolts through the flanges. The cope being all fitted and bound together in a mass on the top of the stalk, the brick-work was continued up, and finished with a cope, or plate of cast-iron, composed of eight pieces $\frac{3}{4}$-inch thick, and about $2\frac{1}{2}$ feet broad, with a round belt going 9 inches down on the brick-work, and forming a strong hoop round it. The chimney is furnished with an endless chain going up the inside of the main shaft, giving the means of ascending at any time to the top. The electric conductor stands 6 feet above the top-plate, $\frac{5}{8}$-inch round copper, made fast to stone and brick-work with $7\frac{7}{8}$-inch copper holdfasts let 4 inches into the masonry or brick-work, with a head on the inside and an eye on the outside to receive the rod as it was carried up. By these holdfasts an ascent can easily be made to the top by a small tackle suspended to the holdfasts. The conductor is metallically connected to all the iron-work on the stalk—the plate on the top, projecting cope, malleable iron hoops, bolts on the top of stone pedestal, and also the ascending chain. The rod descends into a well about 10 feet from the foundation, and is immersed about 8 feet deep in water, and the end turned up 2 feet in a horizontal direction, and flattened.

3. The third paper of the evening was, "Formulæ for constructing Mr Thomas Stevenson's 'Totally Reflecting Hemispherical Mirror.'" By William Swan, Esq., F.R.S.E. and F.R.S.S.A.

Part of Mr Thomas Stevenson's holophotal lighthouse apparatus consists of a hemispherical reflector with the flame of the lamp in its centre, and therefore intended to reflect all the rays back to the radiant point. If this reflector were formed of metal, a large portion of the light would be lost by absorption ; and Mr Stevenson conceived the ingenious idea of substituting for a metallic mirror a series of glass prisms, by which the light, after being twice totally reflected, might be returned back to the flame. The object of this communication is to give the result of the author's investigation of formulæ for the construction of these prisms. The totally reflecting mirror consists of a central conoid surrounded by a series of zones all generated by the revolution of equal and similar curvilineal triangles about a horizontal axis passing through the flame. The sides of these figures next the flame are equal arcs of circles, forming together a semicircle with the flame in its centre ; and the other sides of the figures are portions of equal parabolas, each pair having the same axis, but the vertices turned in opposite directions, and having their common focus in the flame. As it is impossible to grind and polish parabolic surfaces in glass, it becomes necessary to substitute arcs of circles for the parabolas; and the author has investigated two different formulæ for finding their radii and centres of curvature. One is calculated on the supposition that the extreme rays falling on each reflecting side of the prism are accurately reflected ; in the other, which is an approximate formula, the osculating circle of the parabola is found, and an extremely simple expression is obtained for the radius and co-ordinates of the centre of curvature. The author stated that the latter formula was sufficiently accurate for the cases most likely to occur in practice. In an apparatus intended for a light of the first order, illuminated with a flame 3·6 inches in diameter, if the internal radius of the mirror were 24 inches, and the instrument were constructed of flint glass of the ordinary refractive power, it would be necessary to have at least 11 zones and a central conoid ; and if the approximate formula were used, the final deviation of the rays when reflected back to the flame would be about ·16 inch. The number of zones required in any case to ensure the total reflection of all the rays, depend jointly on the radius of the mirror, the radius of the flame, and the refractive power of the glass, and may be formed by a simple formula. The number of zones required for the total reflection of all the rays diminishes as the index of refraction of the glass increases ; and hence flint glass will be more suitable than plate glass for the construction of the totally reflecting mirror.

Thanks voted.

The following Donations were laid on the table, viz. :—

1. On Resin and Water Gas. By Andrew Fyfe, M.D., Professor of Chemistry, King's College, Aberdeen. (1850.) Presented by the author. (3326.)

2. A Letter to the Right Hon. Lord Brougham and Vaux, containing Proposal for a Scientific Exploration of Egypt and Ethiopia. By John James Wild, civil-engineer of Zurich. (London, 1850.) Presented by the author. (3327.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

The following Candidates were balloted for, and elected as Ordinary Fellows, viz. :—

1. John Hewat, Edinburgh.
2. John Walker, M.D., London.

9*th December* 1850.—Thomas Grainger, Esq., President, in the Chair. The following Communications were made :—

1. Description, with Drawing and sections, of Steam-Engine with Oscillating Cylinder, the motion of which works the Steam Valves. By Mr William Proctor, tinsmith, Forfar.

The objects of this invention have been an improved mode of introducing the steam to the cylinder, and of withdrawing it ; also to simplify the process of reversing the engine. For the first of these objects, the trunnions of the cylinder, and the bearings in which they vibrate, contain the steam-pots, acting in a similar manner to the common short slide valve, but vibrating in a circular arc. For the second of these objects, by a peculiar arrangement of the steam-pipes, combined with the above-described valves, the process of reversing is effected by simply turning a stop-cock, through which the steam passes from the boiler. When the lever of this stop-cock is placed to the right, the motion is forward ; if turned to the left, it is back ; and if placed intermediate, it is a stop. By the combination of these parts, the exhaust steam from the cylinder is also discharged through the same stop-cock.

2. An Abstract of a portion of Mr Paxton's paper, descriptive of the Great Exhibition Building, was read by the Secretary.

3. Description of the Drainage of Haarlem Meer (an extensive inland lake in Holland) by means of Steam Power ; with some account of other Engineering Works therewith connected. By Thomas Grainger, Esq., F.R.S.E., Memb. Inst. C.E., Pres. R.S.S.A.

In this paper the President gave a particular account of this gigantic work of Dutch engineering, which has been going on for several years past ; he also made observations on other works connected with it, and gave a general view of the nature of these low countries which form the great Delta of the Rhine, the Scheldt, and other rivers. These countries are remarkable in many ways, but in none more than in their physical and geographical features, and in the magnificent works of engineering connected therewith, which have been undertaken and carried on with success through a course of ages by this persevering people, chiefly in maintaining their territories from the inroads of the sea and rivers, from whose dominion they were originally rescued, and, without continual and persevering efforts, would be again submerged. The subject is highly interesting and important, and was ably treated by Mr Grainger, and much pains appear to have been taken by him, both in visiting the works and collecting the valuable materials of the exposition. Of the gigantic machinery employed, with some additional particulars regarding the subsidiary works and the progress of the drainage, he promised to give an account in a paper to be read at a subsequent meeting of the Society. In respect of the inundations and uncertain tenure of the country, Mr

Grainger noticed several instances of extensive inundation, and one of very ancient date, in the Zuder Zee, where 80,000 inhabitants were involved in the general destruction. The Lake of Haarlem was also a fruitful source of danger to the surrounding districts, having increased in size from about 15,000 acres in 1531, to nearly 45,000 acres in 1840: and frequently, during floods and gales of wind, submerging the country to a great extent, and doing immense damage. It was, therefore, of the utmost importance to put a stop to its ravages, to effect which, the bold measure of pumping it dry was proposed so early as 1643. Although the Dutch, before this time, had reclaimed many lakes, this was by far the most extensive project of the kind that had been entertained; and the idea seems to have been regarded by them with their characteristic prudence and caution; for no less than fourteen schemes were planned, at different periods, down to 1836, before any effective steps were taken to carry out the work. In this year, extensive inundations of the country, even to Amsterdam and Leyden, having been caused by the lake, the subject was forced on the attention of the Government, who soon after passed a law, authorising a commission to report on the best means to be adopted, and to raise the necessary funds. The difficulty of effecting the object in view was much increased by the peculiar character of the lake, which was considerably below the level of the sea. The work was commenced in 1840, by the construction of a large canal, with dikes surrounding the whole area to be drained. The objects of this canal were threefold—to intercept the drainage from lands on a high level; to carry off the water pumped up from the lake; and to form a navigation to compensate for that previously afforded by the lake itself. The discharge of the water into the sea was provided for by various means, which were described. Hitherto the drainage of such lakes had been effected by the application of numerous windmills; but here the powerful agency of steam was introduced, in a manner as novel as it has proved efficient. Three gigantic engines, of 350 horse-power each, raise the water from the lake into the canal, streaming out the enormous quantity of 189 tons of water at each stroke of the pumps. Owing to many unforeseen difficulties, the pumping was not commenced until May 1848, when one engine only had been erected. The machine realising all the expectation that had been formed of its efficiency, other two engines were afterwards constructed, on the same principle; and, since April 1849, the pumping has been going on with three engines, subject, however, to many interruptions, not only incident to the usual casualties to engines, but incident to the peculiar nature of the country. In October last the lake had been lowered about 8 feet, and as the average depth of the lake is about 13 feet, nearly 4-10ths of the pumping remains to be done. This progress may appear to be slow; but when we consider that every vertical inch by which the lake is lowered involves the pumping of no less a quantity than considerably upwards of 4,000,000 tons of water—and as Mr Grainger estimated that about 70 inches of rain had fallen during the progress of the work, thus greatly increasing the quantity to be raised—it must appear to be a very great performance indeed. Sufficient progress had, however, been made to establish, beyond a doubt, the ultimate success of these gigantic operations, which Mr Grainger expected would be completed in the summer of 1852, at a cost of about

£700,000, which would be reimbursed by the sale of the reclaimed lands, and by the proceeds of a land-tax which is levied throughout Holland.

The warmest thanks of the Society were voted and given to Mr Grainger from the chair, for this communication.

The following Donations were laid on the table, viz. :—

1. Theory of Heat and the Vital Principle. By Arthur Trevelyan, Esq. (Edin. 1850.) Presented by the Author. (3329.)

2. The Method of using the apparatus for Exhibiting Vibrations caused by Heat. (1829.) A Description of a Chemical Vapour Lamp Furnace. (1834.) And an Account of the Experiment with Chlorine Gas. (1833.) By Arthur Trevelyan, Esq. (Edin. 1850.) Presented by the Author. (3330.)

Thanks voted to the Donor.

In terms of Law XX., the Treasurer's books were laid on the table, and a Committee was appointed to audit the same, and to report thereon, and generally on the state of the Funds of the Society.

PRIVATE BUSINESS.

The following Candidates were balloted for, and elected Ordinary Fellows, viz. :—

1. John G. Winton, engineer, Newhaven.
2. James MacGilvray, Royal Artillery, Woolwich Barracks.
3. Thomas Oak Mitchell, M.D., Greenwich.

Professor Donaldson kindly offered to exhibit to as many of the Fellows as his class-room could conveniently accommodate, some of the machinery and apparatus he makes use of in his class for the Theory of Music, in which they may feel an interest, but which could not be transported to the Society's Hall; and to give an exposition thereof. This kind offer was accepted by the Society, and their thanks tendered to the Professor.

Extra Meeting, 23d December 1850.—Professor Donaldson gave an Exposition of some of the Physical Principles of Harmony, at his Class-Room in the College, on Monday Evening. Thomas Grainger, Esq., President, in the Chair.

This exposition was given in the clearest manner, with those interesting illustrations which the beautiful apparatus constructed by Professor Donaldson for the illustration of this branch of his subject is so well calculated to afford; and by means of which he proved that the strictly *mathematical divisions* into which a vibrating string spontaneously arranges itself gave out clear ringing harmonic sounds, producing the musical scale. He proved also, that by giving increased tension to the string by means of weights attached to one end, the harmonic notes which had been produced at certain points of the string could also be produced by *proportional weights* :—For example, if we wish to produce the *octave above* the note given by the string having one stone weight appended—which we know to be in the relation of 2 to 1—we square the number 2, which gives us 4; and we find that by stretching the string by means of 4 stones weight we have the exact octave above the original note; and so on in regard to the other divisions of the string. The whole of the exposition was extremely interesting; and whether it be viewed as a science, or as a branch of Fine Arts, it appeared very evident that, on many accounts, much practical benefit would be derived if the study of the *theory* of music were more generally adopted as a branch of liberal education.

At the close of the exposition, the President proposed a vote of thanks to the Professor for his able and interesting exposition, much of which, from its treating of the vibrations of strings or tension rods, was calculated to be of great service in civil engineering, especially as regards girder and suspension bridges. The vote was passed unanimously, and the thanks of the meeting were given to Professor Donaldson from the chair. The Professor stated, that as the class-room was limited in accommodation, the exposition would be repeated on a future evening, of which notice would be given to those members who had not received billets upon that occasion.

13*th January* 1851.—George Buchanan, Esq., and afterwards Thomas Grainger, Esq., President, in the Chair. The following Communications were made :—

1. (Part II.) Description of the Drainage of Haarlem Meer (an extensive inland lake in Holland), by means of steam-power; with some account of other Engineering Works therewith connected. By Thomas Grainger, Esq., F.R.S.E., Mem. Inst. C.E., Pres. R.S.S.A.

Mr Grainger, before proceeding with the topics which were more immediately to form the subject of his consideration that evening, rapidly recapitulated the principal points of information, relative to this interesting subject, which he had laid before the Society at their previous meeting. He recalled to their recollection what he had stated in reference to the peculiar physical character of Holland—the gigantic embankments constructed to protect that kingdom from the encroachments of the sea, or inundation by the inland waters—the net-work of canals with which the country was covered, some of them works of great importance, and presenting many peculiarities in their construction—and the immense extent of land that had been reclaimed by the drainage of inland lakes, many of them laid dry at a very early period, the success of which operations had led to proposals being made for the drainage of Haarlem Meer so long ago as 1617. Mr Grainger then adverted to the state of this lake in 1531, at which time it consisted of four sheets of water, with an area of 15,000 acres, or about one-third of that to which it ultimately reached before the drainage operations commenced. In 1647 these were united—the lake still continuing to increase in extent, principally by the action of the wind and water on its soft banks, frequently breaking through the barriers raised to resist its encroachments, and causing immense damage by overflowing the surrounding country. It was thus an object of great importance to devise such measures as would effectually remove the cause of so much danger to the lower parts of North Holland; and Mr Grainger stated, that from the first proposal in 1617, no fewer than fourteen different projects had been promulgated. But either deterred by the magnitude of the operations, or prevented by the difficulty of raising the necessary funds, it was not until 1837 that the Dutch Government were in a measure forced to grapple with the subject, by the lake in the previous year overflowing all the country to Leyden and Amsterdam, and even threatening the district towards Utrecht. The works undertaken for effecting this object which were fully described at the previous meeting, were then shortly alluded to. They consisted principally of a great canal about 33 miles long, 131 feet broad at the surface, and 10 feet deep, which surrounds the whole area to be drained. This canal has been constructed for the threefold purpose of intercepting the drainage from the adjoining lands; forming a navigation to compensate for that previously afforded by the lake itself; and for conveying the water pumped up from the lake to the points of discharge at Katwyk, on the North Sea, and at Spaarndam, and half-way on the Ye. In forming a correct estimate of the arduous nature of the work now in progress, it is of importance to bear in mind that the surface of the lake, when the drainage commenced, was upwards of $2\frac{1}{2}$ feet *below* the medium level of the sea at Amsterdam, so that the whole of the immense body of water contained in the lake must be raised into the canal by mechanical means, and in certain circumstances it must be elevated to a still higher level before it can flow by its own gravity into the sea. The first of these operations is performed by three powerful steam-engines erected at the side of the lake, which pump the water from it into the canal at the rate of 189 tons per stroke, and the latter by a steam-engine at Spaarndam, which scoops up the water from the canal into the sea by means of a series of water-wheels, with float-boards or scoops fixed upon them. In 1840 three of the Government Commissioners were sent to England to make inquiries relative to the best plan to be adopted for the steam-engines, and to inspect the principal ones erected in this country for pumping operations. Various plans were suggested, but it was ultimately resolved to employ Messrs Gibbs and Deans of London, to furnish the necessary plans for one engine, which would, when erected, afford an opportunity of effecting such improvements on the other two as were suggested by experience of its working. This engine, which has been named the "Leighwater," is above 350 horse-power, and has two cylinders, placed one within the other, united to the same bottom plate, but the inner one not attached to the cover at the top, a space of $1\frac{1}{2}$ inch being left all round; the inner cylinder is $84\frac{1}{4}$ inches diameter, the outer 144 1-5th inches. This arrangement of cylinders renders it necessary to have an annular piston to the outer one. Both pistons have a stroke of 10 feet, and are attached by five piston-rods to one great cross-head, formed like a box, and loaded with cast-iron to assist the down stroke of the pistons. The pumps worked by this engine are eleven in number, 63 inches in diameter, and placed at the ends of cast-iron balance beams, which radiate from, and are arranged round the cylinders, so as to work in equilibrium, and to admit of any number of pumps, from two to eleven, being worked simultaneously. The pump buckets are of a simple and novel description, and are constructed so as to descend in the pump with their own weight with the least possible shock—great facility being also given to pass a large quantity of water, and to prevent the accumulation of mud about them. To allow time for filling the pumps and closing the valves, provision is made for sustaining the deadweight of the cross-head and pistons, for a second or two, by a very simple and beautiful hydraulic apparatus. The steam is worked expansively, and is admitted first under the inner piston, where it is cut off in proportion to the height the water has to be raised, and the quantity of deadweight with which the cross-head is loaded. This expanded steam is then passed from the under side of the inner piston to the upper side of both pistons, where it again expands, making the down stroke of the piston, and elevating the pump buckets with their water load of 63 tons. This engine having been subjected to many severe trials, and having proved remarkably efficient, the other two engines were constructed on a similar model; but the number of pumps was reduced from eleven to eight, and their diameter increased from 63 to 73 inches. There were also such other alterations made as were suggested by experience; but which it is needless to enumerate here. These three engines are remarkably simple in their construction, and admirably adapted for raising an immense quantity of water to the limited height from the lake into the canal. The engine erected at Spaarndam for raising the water from the canal into the sea is about 180 horse-power, and has a cylinder of 60 inches diameter placed horizontally, with a stroke of 10 feet; the piston is directly connected with a cranked shaft, on which two massive fly-wheels are keyed, and on which ten water-wheels of a total breadth of 72 feet are also fixed, five on each side of the engine, provision being made for disconnecting any number of wheels, as may be required by the height the water has to be raised. This engine, making eight strokes per minute, raises 1500 tons of water one foot high. These four powerful engines are the mechanical means employed for draining this great lake, and by their united labours it is being lowered at the rate of about 5 inches per month. During the months of November and December last, it appears from the official returns that no progress has been made, in consequence of various unforeseen casualties connected with the engines, and also from the quantity of rain that had fallen during these months. When the lake is thoroughly drained, which may be about the summer of 1852, it is proposed to construct a series of canals and ditches by which the internal communication and the drainage are to be maintained—the latter, of course, by the periodical use of the steam-engines. It is expected that the land when drained will be sold at about £7, 12s. per imperial acre; and as there are 44,520 acres to dispose of, the sale will

realise the sum of	£337,500	0	0
But in addition, a land-tax of 7s. 4d. per acre will be payable by the purchasers, representing, at 4 per cent. interest, a capital of . . .	375,000	0	0
	£712,500	0	0
The estimated cost of the work when completed is	687,500	0	0
	£25,000	0	0

Leaving a small balance which will, in all probability, be absorbed by contingencies. The annual expense of maintaining the works and pumping has been estimated at about £5500, which will be borne partly by the purchasers of the land, and partly by the Waterstaat of the Rhineland: the former will pay for pumping the drainage into the canal, and all the expense connected with the engines; while the discharge of the water from the canal into the sea will fall upon the latter, and will cost them a much less expense than that previously incurred by them for protecting the shores of the lake. In a commercial point of view, the undertaking may be regarded as hardly remunerative; but it must not be lost sight of, that a dangerous internal sea will have been got rid of, preventing the recurrence of great periodical damage, if not the entire destruction, of extensive districts, and much valuable property; and that upwards of 44,000 acres—an area nearly equal in extent to the county of Kinross—will have been added to the productive soil of the kingdom. Mr Grainger then shortly described the extensive works executed at Katwyk in 1804–7, for protecting the country from inundations from the Old Rhine, and the alterations which had been rendered necessary upon them, in consequence of the selection of Katwyk as one of the points of discharge for the drainage of Haarlem Meer.

After the conclusion of his highly interesting paper, and remarks upon it by various members, the thanks of the Society were accorded to Mr Grainger for his communication; which it was resolved to print in the Society's Transactions.

2. Suggestions for a simple and rapid mode of Cutting a Navigable Channel through Bars and Sand-Banks in Rivers; especially adapted to the Improvement of the Navigation of the Euphrates and other Oriental Rivers. By James Stark, M.D., F.R.S.E., F.R.S.S.A. (3340.)

After detailing the circumstances which led him to direct his attention to the subject, the author stated that it occurred to him that if the principle which the salmon employs for hollowing out its spawn bed were adapted to machinery, a navigable channel might be rapidly and cheaply cut through bars and sand-banks in rivers. He showed that the salmon effects its purpose by lying close over the gravel banks, and sweeping its tail rapidly from right to left, when the water rushing into the vacuum caused by the sweep of the tail strikes the gravel with force, and rapidly scoopes it out. To test the practicability of a mechanism similar in principle answering the purpose proposed, he made a few experiments in the shallows of the Clyde with a flat board, when he found that by giving it a fanning motion over the gravel or sand bank he could cut a trench through it with great rapidity. The author, therefore, proposed that a hinged keel from 18 to 24 inches broad, and from 8 to 12 feet, or more, long, should be fitted to a broad and flat-bottomed steam-boat; and this keel should be attached by hinges allowing of free lateral motion, to strong iron pillars passing through the whole depth of the boat, and so constructed that they could either raise the keel close to the boat, or allow it to be lowered 10 or 12 feet below it. A strong semi-circular bar of iron was to be attached by its centre to the middle of the keel, close to its lower margin, with rings at its extremities for the attachment of chains in connection with the working gear of the engine. When these chains were alternately elevated and depressed, the lower margin of the hinged keel passed through the arc of a circle, and produced a powerful fanning motion, similar to the sweep of the salmon's tail, and caused the agitated waters to hollow out a deep furrow or channel. As the boat would be allowed to drop down with the current, over the bank, a broad and deep channel would be at once cut through it, and by going over it twice or oftener, lowering the keel further each time, but always so as to keep clear of the gravel or sand, a navigable channel could be cut of any required depth and breadth. He thought that the additional current thereby produced would keep clear, and even both widen and deepen the channel when once cut. The author shewed that the same principle and mechanism would be found of immense utility in clearing out and in deepening the channels of rivers, harbours, bars at the mouths of rivers, and all places where a current of water flowed; and he expressed a confident hope, that were engineers to apply themselves to the full development of the plan which he suggested, it would speedily supersede the present slow, imperfect, and costly plan of deepening by the dredging machine.

The paper was referred to a Committee.

3. Description of a Plan of a Self-Acting Safety-Valve for Life-Boats. By John G. Winton, Esq., F.R.S.S.A., Engineer, Cherrybank, Newhaven. (3341.)

In drawing the attention of the Society to this small contrivance, the inventor referred to the late melancholy accidents that have happened by the insufficiency of the common wooden plug. The plan he proposes is as follows:—The rings to which the hoisting blocks are attached, carries a rod, working through an eye fastened to a convenient part of the boat, to the end of which is fixed the valve covering the hole left in the bottom of the boat; the rod likewise carries a spring, so that when the boat is suspended the spring is compressed, and the valve is lifted from the face, but on lowering it into the water, it regains its elasticity, and shuts the valve. The plan is such that any of the seamen can refit it, should it get out of order.

Referred to a Committee.

The following Donations were laid on the table:—

1. Drainage of Land, a Contribution to Morton's Cyclopedia of Agriculture. By John Girdwood, Esq., F.R.S.S.A., Chirk, North Wales, Assistant-Commissioner under the Drainage Acts. (3336.)

2. Proceedings of the Philosophical Society of Glasgow, 1849–50, Vol. III., No. II. Presented by the Society. (3338.)

Thanks were voted to the Donors.

PRIVATE BUSINESS.

The following Candidates were balloted for, and elected as Ordinary Fellows, viz.:—

1. William A. Parker, General Register House.
2. Alex. H. Lee, civil-engineer, College.
3. William Archer, solicitor, Lincoln's Inn, London.
4. James Duncan, M.D., Heriot Row.
5. Robert Kirkwood, civil-engineer, North Bridge.
6. John Bryden, bell-hanger, George Street.

The Report of the Auditing Committee on the Treasurer's books, and on the state of the Funds of the Society, was read and approved of.

27th January 1851.—Thomas Grainger, Esq., President, in the Chair. The following Communications were made:—

1. Description of the Iron Roof over the Railway Station, Lime Street, Liverpool. By Richard Turner, Esq., engineer, Hammersmith Iron Works, Dublin. (3347.)

The extreme length of the area roofed over is 374 feet, and the breadth 153 feet 6 inches. The roof consists of a series of segmental principals, or girders, fixed at intervals of 21 feet 6 inches, from centre to centre; these are supported, on one side, upon the walls of the offices, as far as they extend; and from thence to the viaduct, a distance of 60 feet 4 inches, upon a box beam of wrought-iron; whilst, on the other side, they rest on cast-iron columns. The principals are trussed vertically, by a series of radiating struts, which are made to act upon them by straining the tie-rods and diagonal braces; they are trussed laterally by purlins, placed over the radiating struts, and intermediately between them; as well as by diagonal bracing, extending from the bottom of the radiating struts to the top of the corresponding struts, in the adjoining principal. These diagonal braces are connected with linking plates, by a bar of the same scantling, and also with the purlins already referred to. The curved ribs are thus firmly drawn together and attached to one another, and a rigid framework is formed upon which the covering of corrugated iron and glass is laid. Each principal, or girder, is composed of a wrought-iron deck-beam, 9 inches in depth, with a plate 10 inches wide, and $\frac{1}{4}$ of an inch thick, riveted on the top. The upper flange of the deck-beam is $4\frac{1}{2}$ inches wide, and $\frac{1}{2}$ inch thick; the lower flange is 3 inches wide, and 1 inch thick; the web is about 7-8ths of an inch thick. This curved rib is formed of seven pieces, connected with each other at the points where the radiating struts are attached, by means of plates riveted on both sides; these plates are 6 feet in length, 7 inches broad, and 7-16ths of an inch thick. The beam is also strengthened at the haunches, for a distance of 27 feet from the springing, by plates 7 inches broad, and 7-8ths of an inch thick, fastened together by rivets. There are six radiating struts in each rib, varying in length from 6 feet to 12 feet, the lengths increasing, of course, from the springings towards the centre. They are similar in section to the principals, but are only 7 inches in depth, being attached to them and to the tie-rods, by means of wrought-iron linking plates. From this attachment the top of the strut is made to touch the underside of the principal; it is in this position clasped by the linking plates, and there secured by a bolt $1\frac{1}{4}$ inch in diameter. The tie-rods in each rib are composed of three lines of rods, between the two extreme radiating struts, and from these struts to the extremities of the principals, they are in two lines; the sectional area is, however, in each case the same, being equal to $6\frac{1}{2}$ square inches. The ends of the tie-rods, which are prepared with eyes to receive the bolts, are placed side by side between the linking plates attached to the struts, and a bolt is then passed through them; it will, therefore, be evident, that if any elongation or contraction takes place in the tie-rods, the struts are necessarily acted upon. The diagonal braces extend from the bottom of each strut to the top of the one next towards the springing; they hold the struts tight up against the principal, and at the same time assist the tie-rods in their duty. These braces are formed of round iron, $1\frac{3}{8}$ inch in diameter, secured at the top by a bolt passing through the linking plate, and at the bottom by wedges, instead of bolts, so as to afford the opportunity of tightening them up, should it be requisite. Each compartment of the principal is thus separately trussed and tied, and the whole is made fast to the extremities, by passing a stirrup iron, or strap, round the back of the metal chair, in which each end of the girder rests, and to which it is bolted at the side; the jaws of this stirrup iron are attached to the extremities of the tie-rods by wedges. The ends of the principals are each fixed in a chair of cast-iron, resting on one side upon a metal pillar, and on the other upon the wall of the offices, or upon the box beam; those upon the pillars are cast upon the upper cap, and those upon the wall and upon the box girder rest upon two rollers, which have the power of traversing a space of 3 inches, upon a metal plate, so as to admit of any expansion, or contraction of the rib, though, up to the present time, no motion has been noticed. The purlins are each formed by a combination of three T irons, the centre T iron running straight from principal to principal, and those at the sides branching off at 5 feet from each end, so that they strut the girder in three points. The purlins are secured to the deck beam by L (or angle) plates, fixed on both sides, one limb being fixed to the blade of the purlin, and the other to the deck beam. In addition to the lateral trussing, which the ribs receive from these purlins, diagonal braces are fixed between each two corresponding struts, connected at the top with the purlins, and at the bottom with linking plates, by bars of their own scantling: thus the ribs are all braced and secured to one another, and a firm rigid mass of framing is formed to sustain the covering. The roof, as was before stated, is supported, on one side, partly by the offices and partly by a wrought-iron box beam, which was constructed by Mr Wm. Fairbairn of Manchester. It is 63 feet 4 inches in length, 3 feet 2 inches in depth at the ends, and 2 feet 6 inches in depth in the centre, being arched on the underside to the extent of 8 inches. The upper chamber is 20 inches wide by 8 inches deep; and the body is $13\frac{3}{8}$ inches wide, by 1 foot 10 inches in depth; the bottom, which was $19\frac{3}{8}$ inches in width, was formed of two rows of plates 8-16ths of an inch in thickness in the middle, and 6-16ths of an inch at each end; the thickness of all the other plates was 5-16ths of an inch. On the opposite side, the roof is supported on seventeen cast-iron columns; one under each rib, at intervals of 21 feet 6 inches apart, from centre to centre, and securely fastened into stones five tons in weight, about 3 feet below the base. These columns are of the Roman Doric order, each averaging 19 feet in height from the base to the capital, and 4 feet 3 inches from the capital to the metal chair, in which the end of the principal rests; this latter portion forms the abutment, or attachment piece, for the intermediate cast-iron arches, with ornamental spandrils. The gutters are of cast-iron, 1 foot 8 inches wide, resting upon the columns and the intermediate arches; the upper part of the gutter is splayed to the rake of the roof, and to this the corrugated sheeting is fixed by galvanised bolts, 5 inches apart. The rain water is carried off on one side by the columns, and on the other by pipes placed against the face of the wall. The roof is covered with galvanised corrugated wrought-iron, and with rough plate-glass. The corrugated iron is No. 16 wire gauge, in sheets averaging 7 feet 6 inches in length, by 2 feet 8 inches broad, which are fastened together with galvanised rivets and washers. The glass is 3-8ths of an inch thick, in plates 12 feet 4 inches long, by 3 feet 6 inches wide; these plates are bedded upon iron sash bars, at the sides, and rest upon Z iron at the ends, the upper flange of which receives the glass, and the lower one the corrugated sheeting. This connection is made tight by lead flushing, which is turned under the glass, and over the corrugated sheeting. The roof strikes the viaduct and the façade at Lime Street obliquely, forming obtuse angles with the line of the offices. The general construction of the roof, however, is not changed at these points, but the purlins and sheeting are in each case carried on, until they meet the gable faces, where they are secured. The gable at the viaduct will be an iron construction, designed by Mr Cunningham of Liverpool; that at the other end is formed by the façade in Lime Street. The total cost of this roof was about £15,000, and the time occupied in its erection was about ten months.

On the motion of Professor More the thanks of the Society were voted to Mr Turner, and given to him from the chair.

2. Mr Turner also exhibited his proposed Models of the Great Exhibition Hall, and Drawings of the Conservatory at Kew Gardens, erected by him. (3348.)

3. Description of an Improved Self-Acting Apparatus for Disconnecting the Carriages of a Railway Train from the Tender upon the Engine leaving the Rails. By Thomas C. Gregory, Esq., F.R.S.S.A., C.E. (3349.)

As stated by the author, the apparatus consists of a lever running below the centre of the engine and tender, and of a box, containing a spring, fixed in the back board of the tender by means of a strong iron bar. There is a strong iron rim on the top of the box, having an opening to allow the carriage hook, when the apparatus is discharged, to fall out; and there is also a stud on the side, with a hole in it to receive the end of the lever. The fore part of the lever is hung to the front board of the engine, and the fulcrum is at the front of the tender. There is a junction in the lever at the fire-box to allow of the engine and tender being separated. In order to charge the instrument, the box must be turned from the position, wherein the spring is inactive, until the stud on the side is brought under the end of the lever. It is then kept in position by means of the lever, and the junction of the engine and tender is effected. The carriage chain is then hooked into the rim of the box. As long as the front wheels of the engine are on the rails the level of the fore part of the lever is unchanged, but whenever they leave the rails the end falls, and the lever turning on the fulcrum, the back end consequently rises out of the stud and releases the box. The spring recoils, and the box returning to its former position, with the opening in the rim to the carriages, the hook falls out. As further stated, the principal use of the intervention of the box is to throw the weight of the train on the buffer-board, and not on the lever, as no lever cuold stand any such strain. The delicacy of the instrument can be reduced to any amount by lengthening the hook at the end of the lever. The author finally entered into an investigation to shew the security of the arrangement from accidental disengagement.

Referred to a Committee.

The following Donation was laid on the table, viz. :—

1. Turning and Mechanical Manipulation. By the late Charles Holtzapffel, Assoc. Inst. C.E., Hon. Memb. R.S.S.A., &c., &c., Vol. III. (London 1850.) Presented by his widow, Mrs Holtzapffel. (3342.)

Thanks voted.

PRIVATE BUSINESS.

The following Candidate was balloted for, and elected as an Ordinary Fellow, viz. :—

John Middleton, M.D., E. & L., F.R.C.S.E.

10*th February* 1851.—Thomas Grainger, Esq., President, in the Chair. The following Communications were made :—

1. On Colliery Engineering in Scotland. By William Alexander, Esq., mining-engineer, 24 St Vincent Place, Glasgow.

In this paper the author gave a general idea of searching for, proving, and sinking to the coal; different methods for securing pits in sinking through the alluvial cover, and overcoming the peculiarities of certain coal fields. Here the author described an operation at present going on near Glasgow, viz., sinking a shaft through 22 fathoms of quicksand, "highly charged with water," by means of wooden tubbing 12 feet in diameter, formed of three-inch planks, jointed like cooper-work, firmly bound by means of iron girders on both sides, and forced down by four hydraulic rams. At a distance of 40 feet down, the piles and framing to which the rams were fixed had to be loaded with 80 tons; this has since been found insufficient, and it is contemplated to put another cylinder of less dimensions within the present one. The author went on to describe the Cornish method, &c., of raising water from mines, showing the advantages of the forcing method in certain cases over the lifting one; arrangements for ventilation, in which he discussed the advantages to be derived from a small upcast in general, over one of greater area than the downcast; preliminaries after the sinking is completed, and before the general working of coal commences; general methods of coal working at present pursued; improved pithead arrangements, and introduction of cages and conductors in shafts. He exhibited detailed drawings of sinkings at different stages; pumping on the forcing and lifting principle; mechanical arrangements for lowering the coal from one seam to another; four methods of working coal; plans of cages; the winding machinery and tipping-frame, by which the coals are emptied from the hutches upon a screen, down which they roll into the railway waggons;—the whole being meant to show the variety of operations subsequent to the breaking of ground, and before the coal can be dispatched from the pithead, by railway or otherwise.

Thanks voted, which were given from the Chair.

2. On the Improvements on the River Clyde during the past hundred years. (Part I.) Illustrated by maps, plans, and diagrams. By William Campbell, Esq., F.R.S.S.A., C.E., 11 Scotland Street, Edinburgh. (3351.)

The author stated that the progress of improvement on the river Clyde during the past hundred years has been, from a state of nature, spreading over a wide bed, full of shoals, to a highly improved condition, forming a valuable inland navigation, and one of the greatest works of its kind. The rapidity of the improvement since the commencement of the present century rendered the whole the more remarkable, as the forest of masts at the Broomielaw had accumulated before our own eyes. Since 1751, the trustees had got about fifty reports on the depths and the improvements proposed on the river. It was chiefly from them, and historical and statistical information, joined to his own knowledge of the works, that Mr Campbell was enabled to lay before the Society a statement of what has been done on this important national undertaking. The whole was indicated on large maps and drawings. A diagram shewed, rising above a datum line, the revenues of the trust, and the customs, doubling and trebling in the different years. Under the datum line the depths of the river each ten years, as also the tonnage, rapidly increasing as the depths allow the larger-sized vessels to ascend to the Broomielaw. In a general view the river was then traced, from its source in the south of Lanarkshire—in the same hills, above Moffat, in which also rise the Annan and the Tweed, 2500 feet above the level of the sea, through its north-westerly course of 70 miles to Dumbarton and the Frith of Clyde, thence 30 miles to the little Cumbrae Island, on which is the first light maintained by the Clyde ports. At its rocky bed at Bothwell (eight miles above Glasgow) the river has fallen to near the level of the sea, and from Glasgow downwards there is only a fall of one foot, &c. The subject of deepening the river above Glasgow was then considered, as to the probable effect of such a reservoir in heightening the tide in the Broomielaw harbour, and probably lengthening the time of clear high-water there. Tradition tells us that the Clyde had changed its course at various places. It now winds round a haugh in Glasgow Green, through which it anciently ran when its velocity was greater. It had left Renfrew, where ships were formerly built; and, still holding to the north, had, in confluence with the river Cart, formed Newshot Isle, where the South Channel, once 100 acres, is fast disappearing. These changes most affected Rutherglen, which was the shipping port, when at Glasgow there was but a landing shore, and the fishing-boats harboured in burn mouths, ascending the Molendinar Burn to near the Gallowgate; but the erection of Jamaica Street Bridge, under the Trustees' first Act, and its weir stopped these small channels above. From 1782 to 1831, the river had often risen 18 to 20 feet. The spate of the former date having stood 19 inches higher above the bridges than below, the inhabitants thought the improvements were damming up the waters, but now they get freely down the river. In the paper were next described the soft bottom, and the velocity and discharge of the river, and its alluvion. The ancient state of the navigation was then traced from the year 560, and the charters to Glasgow and Dumbarton, under which exemptions are claimed to the present day. In

1556, the quantities of rubbish thrown into the river at Glasgow had impeded the channel, and Dumbarton, Renfrew, and Glasgow, agreed to deepen at the Fords. Mr Campbell then gave a verbal description of the places on the firth and the coast of Ayrshire, where the Glasgow merchants formerly brought their ships, and stated that (in 1653) two hundred years ago, the magistrates of Glasgow intended to build docks at Dumbarton, but this was not allowed, lest the influx of traders should raise the price of provisions on the inhabitants—the carriage on the bad roads then being a difficult matter. At Troon the same objection was made. In 1662, 22 acres of land was bought, and Port-Glasgow commenced; then the Broomielaw quay was built, and in 1710 the first harbour at Greenock was finished. In 1762 the first graving dock in Scotland was built at Port-Glasgow, under the direction of the afterwards celebrated James Watt. The docks fell out of repair in 1837; and as large vessels could then ascend the river, no more capital has been laid out on them. The water in the river was guided by dikes to deepen the channel; and in 1824 steam dredging machines were applied. (Mr Campbell then described copies of drawings which had been prepared by him for the construction of No. 5 Dredger.) Dumbuck Ford, 12 miles below Glasgow, was the first point deepened, having had only 2 feet low water over it. The Romans fortified Dunglass to command this pass of the river.

> "When Rome no more could in her camps confide,
> She reared her forts between the Forth and Clyde."

The lines for widening the channel were then described. It would have been a hopeless task to commence on the original shallows with such wide lines for the river dikes as are now required to give water way to the traffic which the deepening has created. The Clyde was the cradle of the steam-engine—the nursery of steam navigation in Europe; and nowhere has it worked greater changes. When vessels trusted to the winds they came slowly through this inland navigation. It is the tug steamboat that makes Glasgow indeed a sea-port. In 1824, when the dikes had formed a good channel, the river was compared to a canal; but the Clyde still drained 1200 square miles, and had important functions to perform. Standing on the towing path, the setting sun glittering on the waters, you see gliding past you the tall heavy laden ship "tugged" against wind or tide. Then up comes another "tug-steamer," with some dozen Highland boats in its wake, all sure to be in time for their markets. And ever and anon the sharp "river steamer" shoots through the busy scene, its decks covered with gay, happy faces. To complete the glance at the noble river, see the English and Irish steamers (with their great paddle wheels, going perhaps half steam), and the Highland steamer ploughing its way along. There is also the old luggage steam-boats and the rafters coming slowly along. Majestic operations must continue to go on upon the river these fifty years to come, as the wants of the third city of the empire are yet far from being supplied. The entrance to the river, indeed, from Greenock Bank up to Dumbarton, still requires the greatest engineering skill to preserve a deep water channel among the many banks, as the lower parts are always in danger from the currents being affected by any alterations above. The accumulations on Port-Glasgow and other banks had to be cut through, 420,000 cubic yards of stuff being lifted, &c. The subject of maintenance was then considered, amounting to £8000 per annum. The silt in the harbour alone is 80,000 cubic yards annually. About one million sterling had been drawn in all, and one and a half million expended. But in reviewing what has been effected, we must keep in view not only the cost of *securing*, but also the outlay and perseverance by which the whole has been *maintained*. The paper concluded with the quantities of stuff lifted, and the nature and cost of other works on the river,—the subject of the harbour, the tides, &c., being reserved for another evening.

Thanks voted and given from the Chair.

PRIVATE BUSINESS.

The following Candidates were balloted for, and elected Ordinary Fellows, viz. :—

1. Robert Smith, engineer, Governor City Workhouse, Edinburgh.
2. Robert Milne, civil-engineer and land-surveyor, Aberdeen.
3. James Cormack, smith and ironmonger, Edinburgh.

24th February 1851.—Thomas Grainger, Esq., President, in the Chair. The following Communications were made :—

1. Description of the Lugar Viaduct, erected from the design of John Miller, Esq., C.E., on the Glasgow and South-Western Railway. By John Cameron, Esq., C.E., 132 George Street, Edinburgh. (3354.)

Drawings in Illustration were exhibited and presented to the Society by Mr Cameron.

The Lugar Viaduct carries the line of the Glasgow and South-Western Railway across the valley of the Lugar, near the village of Old Cumnock, in Ayrshire, and is situated about fifty miles from the terminus at Glasgow. It consists of fourteen semicircular arches, nine of which are 50 feet spans, and five are 30 feet spans; three 30 feet spans terminate the viaduct at the north end, and two at the south end. The large arches are separated from the small ones by abutments 16 feet 6 inches thick. The greatest height of the viaduct is at the water pier, where it is 161 feet 6 inches from the foundations to the top of the parapet. The average height, including the parapet, is 94 feet 6 inches. The total length is 752 feet. The viaduct is built level throughout. The ground on which the viaduct is built consists of beds of limestone and coal; the coal being mostly worked out. This gave rise to some difficulty in the founding of some of the piers. Shafts were sunk to find the exact position and condition in which they were. It was found that the waste was about 2 feet thick, and as there existed two or three beds of limestone between the coal workings and the surface of the ground, it was decided that the coal workings should be filled up. The coal workings were cleared of all refuse and soft material, and built up with dry stone packing for a considerable distance under the piers; and the complete success of the operation was proved by the absence of all appearance of sinking in any of those piers which were founded in this manner. The piers are all what are termed hollow piers; those of the large arches are 7 feet thick at the springing, and those of the small arches are 5 feet.

The large piers are bonded across horizontally every 15 feet in height, with a view of counteracting any tendency which such tall and slender piers might have to twist—at the same time acting as intermediate covers to the piers during their execution. The water pier is built up solid for 11 feet above its foundations. The abutments of the small arches, which have also to receive the pressure of the embankments at each end of the viaduct, are 23 feet thick at the springing of the arches, and are hollow in the same manner as the piers. All the abutments and piers have a batter of 1 inch in 5 feet on the faces. The insides of the piers have a batter of 1 inch in 10 feet. The voussoirs of the large arches are of droved ashlar, 2 feet deep, no stone being more than 3 feet 6 inches, or less than 2 feet 3 inches long. The small arches are 1 foot 6 inches deep in the voussoirs of the same description as those in the large arches. The solid spandrils of the large arches are carried up 15 feet above the springing. The outer spandrils are 3 feet, and the inner spandrils are each 2 feet thick. The viaduct is puddled throughout with a layer of clay puddle, 9 inches thick; and above the puddle a layer of sand is laid, 9 inches thick. The piers and abutments were built to the height of 20 feet above the ground with derrick cranes; above that level a service road was used. During the whole time that the work was executing there was only one fatal accident. The work does the utmost credit to the contractor, Mr James M'Naughton. This noble specimen of railway architecture contains the immense quantity of 500,000 cubic feet of masonry, the weight of which is about 33,500 tons. The total cost has been about £30,000; the expense of the centring alone being £4500.

Thanks voted on the motion of George Buchanan, Esq., C.E., and given from the Chair to Mr Miller for the design, and to Mr Cameron for the description of it.

2. Description of an improved Safety-Valve Apparatus for Steam-Boilers. By Mr James Neil, Newfield Lane, Paisley Road, Glasgow. (3345.)

Three Illustrative Drawings were exhibited.

The author proved that this is intended for an adjunct safety-valve, and is of that description termed double beat, or balance valve. The steam exerts an equal pressure upon the face of the upper and the back of the lower valve lid, the area being equal; consequently, as regards steam pressure, the valve is in equilibrio, and kept shut merely by the weight of spindle and appendages; but in the event of the steam exceeding, by so many pounds per square inch, the pressure at which the common safety-valve ought to open and discharge overplus steam, a small piston-valve is arranged so as to open and give passage for the steam into a separate chamber, which acting upon the lower valve face, destroys the equilibrium, opens the valve, and allows the steam from the boiler to escape into the atmosphere. Should the piston-valve not open in proper time, and the steam pressure still increase, a column of mercury is discharged into a cup, and the steam rushes through a tube into the separate chamber, and acting upon the lower valve face, gives egress to the steam as before described. The communication also embraces an apparatus, to be connected and worked with the common safety-valve, for the purpose of aiding the escape of steam when blowing off.

Referred to a Committee.

3. A Cheap and Simple Telegraph, or System of Sea-Signals, which, by means of White, Red, Blue, and Yellow Colours, indicates the letters of the Alphabet, Numbers, and the Points of the Compass. By Mr Henry Dempster. (3346.)

Illustrations were given.

The author stated, that the chief improvement in this telegraph is the keeping one of the cardinal colours as a centre until the other three work six different changes, each cardinal colour symbolically distinguishing seven different numbers, characters, or letters. For example:—The white cardinal flag appearing alone represents 1, or A; the white cardinal as a centre, with red up and blue down, represents 2, or B; white centre, blue up red down, 3, or C; white centre, red up yellow down, 4, or D; white centre, yellow up red down, 5, or E; white centre, blue up yellow down, 6, or F; white centre, yellow up blue down, 7, or G. By the same law of distinguishing as has been shewn with the white cardinal—the red cardinal being transposed to the centre, represents seven more numbers, characters, or letters; the blue cardinal seven more; and the yellow cardinal another seven. This new principle of changing colours admits of a variety of description of signals being used to express the characters of the alphabet, providing they substitute the four colours, white, red, blue, yellow. Coloured balls or buckets by day, or lanterns at night, will answer the purpose.

Thanks given from the Chair.

4. Description of an Improved Prussiate of Potash Retort. By Mr W. R. Douglas, engineer to Messrs Millar and Arthur, Scottish Colour Works, Leith. (3356.)

A Model and Drawings were exhibited.

The great defect under the present construction of the retort in general use arises from the difficulty in effecting an incorporation between the animal matter and the potash, resulting from the necessity of putting in the potash before the animal matter is introduced into the retort. The animal matter is thus exposed to the action of the fire; in consequence of which, the manufacturer suffers material loss before the incorporation can possibly be effected. In order to obviate this, a feed-tube, six inches in diameter, is cast on the outside of the retort, the upper end of which is on a level with the top of the retort, the lower end of the feed-pipe being introduced at the lower extremity of the retort, and within two inches of the bottom, by which the animal matter is introduced, and (by means of a feed-rod) forced down to the bottom of the retort, where, by the motion of the scraper, the animal matter becomes thoroughly incorporated with the potash before any loss can be sustained.

Referred to a Committee.

A Report by the Committee on Dr Stark's suggestions for a simple and rapid mode of cutting a Navigable Channel through Bars and Sand-Banks—Mr D. Stevenson, Convener—was read and approved of.

PRIVATE BUSINESS.

The following Candidates were balloted for, and elected Ordinary Fellows:—

1. Rev. Hugh Nicolson, London.
2. George Cunningham, C.E., Edinburgh.
3. Richard Turner, engineer, Dublin.
4. William Alexander, mining-engineer, Glasgow.
5. James Rogers, ironmonger, Edinburgh.

10*th March* 1851.—Thomas Grainger, Esq., President, in the Chair. The following Communications were made:—

1. On the Improvements on the River Clyde during the past Hundred Years. (Part II.) By William Campbell, Esq., C.E. (3351.)

Illustrated by Maps and Plans.

In the former part of this paper the progress of improvement was described in so far as it refers to the navigation of the river. The author now proceeded with what related to the harbour. The object of the first powers applied for by the magistrates of Glasgow was to get coasters of 30 or 40 tons up to their quay at the Broomielaw, and little beyond this had been done till the beginning of this century, when, in 1806, a vessel of 120 tons, drawing 8½ feet water, reached the Broomielaw. The trustees, in their bill of 1809, took power to purchase the original quay and dues from the city. The quay was immediately lengthened in stone to one-third of a mile below the bridge; within twenty years it was extended in timber, and a low timber wharf erected opposite it; but it was not till 1834, when the idea of erecting any docks or basins in the bed of the river seems to have been abandoned, that the cheaper and more spacious plan of widening out the river was finally determined on, and the bold line of the present south quays commenced, which by 1838 extended down to Springfield. The harbour is now about 400 feet wide, with a waterway equal to that of the bridges, and a fairway up the middle between the tiers of the vessels, sufficient for the canting of ships and the constant passing of the river steamers, which for the last ten years have sailed from timber wharfs erected for them at the top of the harbour. Mr Campbell then described large drawings of these and other works in the harbour. The works in progress will extend the line of quays about one mile along each side of the harbour. As these will soon be all filled up by the rapidly increasing trade, the wet docks at Stobcross will be commenced, for which the trustees got powers in 1846. A place will surely then be found for dry docks. The author exhibited to the meeting designs for a graving dock prepared by him in 1844 for a company which did not go on, as the trustees then contemplated going to Parliament themselves, and he recommended that one should first be built with a gate only 35 feet wide, but with great depth of water on the sill, so that large vessels would require to remove their stores, and small vessels might readily enter for the repair of any slight damage. The next dock to be built to have a 65 feet gate, and to be 600 or 700 feet long, if possible, so that a second large steamer could enter though one were already there undergoing repair. This dock need not be so deep as the other, and would be easily emptied. Shipbuilding yards and slips have been rapidly disappearing from Glasgow harbour. Warning should be taken from Liverpool, which, in extending the docks along the Mersey, has ruined the shipbuilding trade there, and sent parties to seek their engines elsewhere. The progress of steam navigation in the Clyde was then traced up to the "City of Glasgow" steam-ship, which, last year, sailed direct from Glasgow to and from New York. The largest steamers have been built on the Clyde, and that river is waiting for a lion's share of the Australian liners, which are all that are now wanting for the circumnavigation of the globe by means of steam-power. The author stated that he had now laid before the Society as complete an account of the Clyde as his time and resources allowed—he had found it necessary to trace the matter from the earliest period, to shew that, though some improvements were begun in the middle of last century, yet the great and extended improvements were the work of this century; and concomitant with these, the rapid advancement of the city of Glasgow itself, not the least important in the march of improvement. On the conclusion of the reading of the paper it was moved by James Jardine, Esq., civil engineer, and unanimously approved of, that it be printed in the Transactions, and that the thanks of the Society be given to Mr Campbell, which were accordingly given from the Chair. The President stated that, so far as he was aware, though a great deal had been suggested and written about these works, this was the first complete and connected account of the River Clyde improvements, and would be one of several valuable papers in the Society's Transactions for the session.

2. Account of the Proceedings and Operations of the Commissioners appointed for the Improvement of the Navigation of the River Shannon. By Lieutenant-Colonel H. Jones, R.E. (3358.)

Illustrated by Drawings.

For a long series of years the neglected state of the River Shannon had attracted the attention of many eminent men: mention is made of it in Lord Bacon's Works; Oliver Cromwell noticed it; and Lord Stafford had plans prepared for its improvement. In the reign of George the First, the attention of the Parliament of Ireland was directed to the necessity and advantage of making some provision for the improvement of the great rivers in Ireland, and more especially the Shannon, for purposes of inland navigation. An Act was passed in the second year of George the First, when the Justices of Peace and members of Parliament of the several counties bordering the Shannon were created undertakers for the purpose of improving the navigation. The Act commenced by declaring the Shannon a public navigable river from Carrick Dumrusk to the sea. However much was required to make it navigable, little was done for nearly half a century. Several changes took place in the direction; and in the 40th year of George the Third, the Shannon, with other rivers, was placed under the control and management of the Directors General of Inland Navigation. During this period the Grand and Royal Canals, connecting the Shannon with Dublin, were formed; the Directors of the Grand Canal, by arrangements with Government, got the Middle Shannon into their hands, under certain conditions as to the improvement of the navigation. The Limerick Navigation Company obtained possession from Limerick to Killaloe, and the Royal Canal Company from Lanesborough to Lough Allen, so that the entire length of the river was divided between three distinct companies, having special interests, and without any controlling power over the whole; any works that had been executed from the passing of the Act, until in George First's reign, about 1721, until in 1830, were generally side cuts or lateral canals, to avoid the shoals in the beds, or impediments in the river remaining intact. During the long period above referred to, there being no controlling powers, every person who felt he possessed right or might had drawn eel weirs across the river; the great increase in the number of them at last formed such obstructions to the free discharge of the waters, that thousands of acres of fine meadow land were usually six months covered with water every winter. Such was the state of things in 1831, when the subject of the improvement of the river was taken in hand by Government, who appointed three Commissioners to report upon the then state of the river, and what they would recommend to be done to render it navigable; and to accompany their report with plans and estimates. These reports, &c. were laid before Parliament, and referred to a select committee, who recommended that a commission should be appointed to examine into the details of those plans and estimates, and to report the amount of compensation that would be necessary for such lands, houses, mills, and weirs that would be required for carrying out the plans as proposed by Thomas Rhodes, Esq., C.E. This commission was composed of two military engineers and two civil engineers, to whom was joined Mr Rhodes, making, in all, five members. The Commissioners approved of the principles laid down by Mr Rhodes for improving the navigation, combined with the draining of the callows; but in the interval between the completion of Mr Rhodes' survey and the issuing of the new commission, the Inland Steam Navigation Company had launched upon Lough Derg steamers of great length, which rendered it necessary to increase the size of the lochs and the navigable channels generally; and further, in one or two cases, made some alterations in the details of the plans, considering it to be their duty to make their reports and plans as perfect as possible—not alone as regarded the then existing state of things, but prospectively, as to the general improvement taking place in the country, from which a great increase of traffic might be expected; these alterations from Mr Rhodes' plans naturally caused a greatly increased estimate. There was also another important item which very much surpassed in amount the sum put down by him, which was the amount to be paid for compensation which it was not possible for him, in the progress of his survey, to ascertain with any degree of accuracy; it required the powers with which the Commissioners were vested to attain to anything like an approximation of the fair value to be paid. Mr Rhodes' estimates, including compensation, £153,163, 2s. 10d.; Commissioners' estimates, £584,805, 17s. 9½d. The amount of sums claimed as compensation was upwards of £600,000, and the sum awarded was £74,054, 2s. 0½d., which was considered fair and even liberal. The preparation of the details and calculations for the awards was a very long and tedious operation. The Commissioners were fully rewarded for their trouble by the satisfaction displayed by all interested, and even the counties who occasionally complained, not against the proportion, but declared that they ought not to have been called to contribute in any way, overlooking the fact that by the improved communications across the river, as well as the increased facilities for sending their produce to market, or for shipment, the benefits would not be otherwise than very generally extended, and to define the limits would not be otherwise than arbitrary. The sums to be paid by the counties assessed was one-half the actual expenditure, to be repaid by twelve half-yearly instalments—the whole sum required for the improvement of the river being advanced, in the first instance, from the Consolidated Fund. The nature of the Shannon had presented formidable impediments to its navigation, owing to its width of channel—expanding in many parts into considerable lakes. For instance, Lough Derg, 23 miles long; Lough Ree, 17 miles long; and Lough Allen, 10 miles; with others 2 and 3 miles in length. The Shannon, from the sea below Limerick to Lough Allen, in the county of Leitrim, is about 200 miles; the tidal part extends a short distance above the city of Limerick, 60 miles from the sea; at Limerick the tide rises about 18 feet. The difference of level from high water spring tides at Limerick to summer water at Lough Derg, a distance of 15 miles, is 97 feet; the navigation being partly still water by canal and partly by river, being 11 lochs of different lifts. From Lough Derg to Lough Ree, a distance of 36 miles, there is a difference of level of 13 feet 10 inches; from Lough Ree to Loch Allen, the distance is 46 miles, and a difference of level 41 feet, making a total rise from Limerick to Lough Allen of 151; there were 21 bridges across the river of various waterways and breadth of roadways; the arches of many blocked up by mills, which had been erected upon them to benefit by the fall of water—the bridges generally being built upon shoals, or the edges of eskars, which in many parts cross the country and Shannon, as at Banagher, Shannon Bridge, Athlone. Nine bridges were taken down and rebuilt; others underpinned. The Commissioners in the tidal way proposed to give those proprietors the benefit of the act who wished to have piers or quays erected on their property, and who notified to the Commissioners their willingness to contribute towards the expense of the works—the proportion so to be paid by them was fixed by the Commissioners. The Commissioners for improving the port of Limerick objected to the Commissioners entering upon their domain, and protesting strongly against any interference, the latter commenced immediately above the Port to effect the improvements; the principles on which they acted were to build good substantial weirs across the river, at the great falls, for preserving the level, and to keep the water at or near one uniform defined height over the lock sills, so that the water not required for lockage might pass over the weirs. From Killaloe to Lough Allen the river was divided into the following levels:—The great regulating weir at Killaloe, 1160 feet long, acted up to Meelick, a distance of 32 miles; the weir at Meelick, 1100 feet long, acted up to Athlone; the weir at Athlone, 720 feet long, to Tarmonbarry, a distance of 26 miles; Tarmonbarry weir, 520 feet long, to Rooskey, a distance of 8 miles; Rooskey, 744 feet long, to Jamestown, a distance of 10 miles; and Jamestown, 700 feet, to the lock at Battle Bridge, a distance of 12 miles, thus forming a perfect navigation for steam-vessels, with only six locks. The dimensions of the locks were regulated by the larger class steamers which were used by the City of Dublin Steam Company on Lough Derg, but which experience proved to be far too long for river navigation. The dimensions of the locks between Killaloe and Tarmonbarry are 170 feet in length and 40 feet breadth of chamber; from Tarmonbarry to Leitrim and Boyle the locks are 110 feet in length and 30 feet in breadth. The bridges were built of good limestone, which is found in the central district of Ireland, of excellent quality and large scantling; for instance, in the Bridge of Banagher, there are ashlers of 10 and 12 tons each. It was intended to have removed the shoals by dredging, and for which purpose two fine vessels were built, with excellent 12-horse power engines, and a complete set of barges, a certain number being what are known as "Hopper-Barges." The shoals and the bed of the river generally, proved to be composed of strong calcareous gravel and clay, intermixed with large boulders firmly imbedded in the gravel, some measuring as much as 5 and 6 tons, and which were likely to tear vessels and engines to pieces; it therefore was found best to enclose the shoals with stanks, pump the enclosed space dry, and excavate. In the low state of the river this was found to be an excellent arrangement, but when the floods came down, in many cases the stanks burst, and great loss was experienced by the contractors; in some cases it was found necessary to employ powerful machines and pumps to keep the water under. For instance, at Clerhaun there were three steam engines, of six, eight and twelve horse power, working eleven pumps, and discharging 2797 imperial gallons per minute. From the description before given of the nature of the bed of the river, it may easily be understood the difficulties that were experienced in driving piles for the coffer dams; when they struck upon one of the boulders, they were either shivered to pieces, or it proved a weak place, and great leakage ensued. In the year 1844 there was a daily average of 2040 men employed, 668,636 cubic yards removed by excavation and dredging; and 13,896 lineal yards of stanks formed, being equal to nearly eight statute miles. Eighty-six pumps were employed, fourteen steam engines, and three water wheels. These details will enable the professional man to form some idea of the nature of the operations. The Commissioners were restricted to an expenditure of £100,000 per annum, but were never able to expend that amount. The necessity of working up the river confined their operations to the completions of the great regulating weirs on the lower portions of the river, before ascending to the upper reaches. Time did not permit the author to enter into the engineering details; but, before closing, he stated that there is now good navigation for steam vessels from Killaloe to Leitrim and Boyle, there being at all times 6 feet water on the lock sills.

PRIVATE BUSINESS.

The following Candidate was balloted for, and elected an Ordinary Fellow, viz :—

George Simpson, civil and mining engineer, Glasgow.

24*th March* 1851.—Thomas Grainger, Esq., President, in the Chair. The following Communications were made :—

1. On a Method of preventing Water-Pipes from Bursting during Frost. By Mr Alexander Macpherson, plumber, Leith. (3355.) Illustrated by Drawings.

The author gave a full description of the means at present adopted to prevent this highly destructive occurrence to property—such as exterior coverings of straw, ropeyarn, charcoal, &c., to the pipes in exposed situations; and also the method of allowing the water to circulate through the pipes by means of partially opening the cock at the sink;—all of which were shewn to be practically useless, and especially the latter mode, as being quite opposed to the scientific theories of cold. The only effectual means of preserving water pipes from the action of frost is to keep them empty at low temperatures, as effected by the present plan of having two cocks on the supply pipe, by the one to shut off the water, and by the other to empty the pipes,—or by the simpler mode adopted in New York, of a three-way cock applied in the same manner. It is difficult to apply this method of prevention, when there are very sudden changes of temperature, inducing a degree of cold sufficient to freeze the water contained in the pipes, and consequently bursting them in a single night. A variety of chemical liquids more easily affected by frost, was offered as a means of prevention, if applied in the manner subsequently proposed; and reference was made to Sir David Brewster's suggested application of the expansion of metallic rods, as in the case of the pyrometer. But the best possible means were shewn to be a small body of water confined in a tube of superior conducting power to that of the lead pipes, in connection with a double-action valve of a peculiar construction, the expansion of which water, in its crystallization (about one-ninth of its bulk), is employed to elevate a piston and shut off the water, at the same time emptying the pipes. The peculiar fitness of this principle is well shewn, on an increase of temperature, in the liquefaction of this body of water previous to that contained in the lead pipes—thus offering no obstruction to the free supply of the cisterns.

Referred to a Committee.

2. Description of a Railway Signal constructed on a new principle. By Mr John Steven, North British Railway. (3352.)

A Working Model was exhibited.

The author stated that this signal was intended to be useful in the prevention of accidents, by shewing the precise time at which a train has passed the point where it is erected. The necessity which exists for a self-acting signal, which shall answer the purpose above indicated, and whose accuracy may be relied upon, has long been felt. Had such signals been in operation on the various lines of railway throughout the kingdom, many of those accidents which have unfortunately resulted in a considerable loss of life might, humanly speaking, have been prevented. As a case in point, reference might be made to the accident which occurred at the Cowlairs station of the Edinburgh and Glasgow Railway in the month of August last. The construction of the signal (a model of which was exhibited) is very simple. The flange of the engine wheel passes over a slightly inclined double lever placed on the inside of the rail. This being depressed, presses down the end of another lever. By the depression of these levers a perpendicular rod is raised, upon the under end of which is fixed a toothed rack wrought by a pinion. The weight of an index plate, placed on the top of the perpendicular rod, causes it to descend slowly and regularly, the motion being regulated by a series of wheels, and capable of being made to extend over a period of ten or fifteen minutes, as may be found necessary. The lever, by means of a weight, is immediately raised to its usual place, after the passing of the train, so as to be ready for giving a fresh signal when the next train comes up. The space through which the rod has descended, and consequently the amount of time which has elapsed since the passage of a train, is indicated by a red index plate, which is wholly concealed in a white case when the machine is in a state of rest. For a more detailed description of the signal, reference is made to the larger document read before the Society.

Referred to a Committee.

3. Description of a method of Printing Letter-Press in Two or more Colours, securing perfect Register. By Mr William Mackenzie, printer and stereotype founder, Glasgow. (3357.)

Forms of Type and printed Specimens were exhibited.

The author stated that, in jobbing, the lines or words to be printed in colour are raised by placing either a strip of pica reglet, or a row of pica quadrats below the types. The black (or greatest surface, of whatever colour) is printed first, in the usual manner, and when faint lines are wanted in colour, high brass must be substituted for leads originally composed in the form. In printing fine book-work, such as the Book of Common Prayer, a small fount, cast a pica taller than the usual type height, is necessary for correctness and expedition. The black is printed first, in the usual manner. The red is printed by taking out the blanks left in the black form, and inserting the words or letters to be printed in red composed with the tall types. The platten of the press must be raised and lowered to adapt itself to the two heights of type, either by placing glazed pressing boards between the drawer and the tympan, or by putting an iron washer of a pica thickness below the piston, when printing the black, and taking it out when printing the red.

Referred to a Committee.

PRIVATE BUSINESS.

The following Candidates were balloted for, and elected Ordinary Fellows, viz. :—

1. John Trafalgar Black, Surrey.
2. Charles Dawson, London.

14*th April* 1851.—Thomas Grainger, Esq., President, in the Chair. The following Communications were made :—

1. Oral remarks on the Modes of ascertaining the Illuminating Power of Coal Gas. By Andrew Fyfe, M.D., Professor of Chemistry, King's College, Aberdeen. With tabular views of the results of his experiments. (3362.)

Dr Fyfe first drew the attention of the Society to the results of his experiments brought before it some time ago, in which he stated the value of the English caking, the English parrot, and the Scottish parrot coals for the manufacture of gas. He also again alluded to the Bunsen photometer, by which the illuminating power of gases is now ascertained with more accuracy than by former methods. Since its introduction he had tried numerous coals, with the view of fixing their comparative value for the manufacture of gas and of iron—comparing the light afforded by their gases, with that afforded by candles. With the view of finding a standard of comparison, he had been induced to make trial of various kinds of wax and spermaceti candles. These he found consumed different quantities at different times, depending chiefly on the size of the wick and other circumstances; and of course they afforded more or less light according, in a great measure, to the consumpt—the light for equal consumpts varied from 1 to 1·3. Instead, therefore, of fixing on any particular candle as a standard, he thought it would be better to assume as a standard, the light afforded by the combustion of 100 grains of wax or spermaceti in a given time. Dr Fyfe next alluded to the mode of ascertaining the illuminating powers of gases, many of which modes, though still practised, are very defective. He gave the results of numerous trials in which the Bunsen photometer was used, and in which one gas was contrasted with another—the gases being burned in different ways. In these he found that by one mode of proceeding one gas was far superior to the other; while, by another mode of proceeding, but on the same principle, it was inferior to it. These contradictory results depended chiefly on the imperfect combustion of the gas. The only satisfactory method of operating is to burn the gas in various ways, and to contrast the light afforded with the candle which by previous trials has been found to burn steadily. The average of the best trials may then be taken as the result. Adopting this method, Dr Fyfe had made repeated trials on the coals from different districts, all of which had confirmed what he had formerly asserted, viz., the great superiority of the Scottish parrot coals, even though English caking and English parrot coals better than those on which he had formerly experimented had been brought into the market. Considering the value of best English caking coal—that commonly called Pelton—as 1, that of the Wigan coal he found was about 1·2, that of Newcastle parrot 1·4, of the average of Lesmahagow 2·3, of Boghead 3·6. This last coal is very peculiar, not only as to the superiority of its gas, but also as to the quantity which it affords—a ton yielding nearly 15,000 cubic feet. It has, however, one disadvantage—its coke is almost valueless as fuel, from the large quantity of ash which it contains.

Thanks were moved by Professor More and given to Dr Fyfe from the Chair.

2. On Iron, and certain Compounds and Alloys of Iron. By J. D. Morries Stirling, Esq. (3363.)

Specimens were exhibited.

The author gave a short description of the various kinds of cast iron, and a statement respecting their strengths, and the uses to which they are more especially adapted, pointing out the discrepancies which exist between chemists as to the quantity of carbon contained in each sort. The author's experience led him to believe that the quantities of carbon were different in the different Nos.—greater in No. 1, less in Nos. 2, 3, and 4. Slow cooling of large masses of iron renders them softer. In making the mixtures of wrought and cast iron, different proportions of wrought iron are used; for soft iron containing much carbon (or No. 1), more malleable iron, and for harder iron, less;—Welch, Scotch, and Staffordshire iron differing much from each other—the Scotch being the softest, the Welch the hardest. By properly proportioning the addition of malleable iron, the strength of cast iron is nearly doubled, both transversely and tensilely. By melting this mixture of wrought and cast iron, and then puddling the mixture, a very superior kind of wrought-iron is obtained, and the process of refining is avoided. By the addition of *calamine* or zinc to common iron, without the admixture of wrought iron, a very superior malleable iron is produced, equal in appearance, when twice rolled, to iron that has been thrice rolled, and very much stronger, or as 28 to 24½. The increased strength in the mixture of wrought and cast iron, called toughened cast iron, renders it peculiarly adapted for wheels, pinions, &c., and for girders, columns, and other architectural uses. Several Government works are constructed with it—as the Chelsea, the Windsor, and the Yarmouth bridges; also, at various iron-works, all rolls, pinions, and cog-wheels are made of it. The wrought iron made either from the toughened cast, or by the admixture of calamine, is particularly useful for tension rods, chain cables, &c. The addition of antimony and some other metals to wrought iron in the puddling furnace, gives a hard and crystalline iron, nearly allied to steel in some of its properties, and adapted, from its hardness and crystalline character, to form the upper part of railway rails, and the outer surface of wheels. When thus united to the iron containing zinc, the best sort of rail results, combining strength, stiffness, and hardness, with anti-laminating properties, and being also cheaper than any other kind of hardened rail or *tire*. Compounds of copper, iron, and zinc, are found to be much closer in texture, and stronger than similar compounds of copper and zinc (the proportion of iron not usually exceeding 1½ per cent.), and can be advantageously used as substitutes for gun-metal, under all circumstances;—for great guns, screws, propellers, mill brasses, and railway bearings. Small additions of tin and other metals alter the character of these compounds, and render them extremely manageable as regards hardness and stiffness. The advantages which these compounds possess over gun-metal, are cheapness and increased strength, being about one-fourth cheaper, and one-half stronger, and wearing much longer under friction. On many railways, the alloys of zinc, iron, copper, tin, &c., have superseded gun-metal for carriage bearings. An alloy equal in tone to bell-metal, cheaper, and at the same time stronger, is made from the alloy of copper, zinc, and iron, a certain proportion of tin being added. The addition of iron seems, under most, if not all circumstances, to alter the texture of metallic alloys, rendering it closer, and the alloys, therefore, more susceptible of a high polish, and less liable to corrosion. Other alloys of iron were exhibited, some shewing extreme closeness of texture, others possessing very great hardness, and suitable for tools, cutting instruments, &c., others possessing a high degree of sonorousness. A bell was exhibited, of fine tone; its advantages being cheapness (less than half the price of common bell-metal) and superiority of tone. Other alloys of iron, copper, zinc, manganese, and nickel were exhibited, some bearing a near resemblance to gold, others to silver; the latter being now most extensively made in Birmingham, and gradually superseding German silver, or, at least, being largely used instead of that alloy, which it surpasses in lustre, closeness of texture, and freedom from tarnish. A malleable bell was also shewn, the tone of which was equal, if not superior, to that of a common bell of the same size: a specimen of this sort of metal was shewn crushed almost flat. The author recommended its use for ship and lighthouse bells, &c. On the motion of James Mackenzie, Esq., the thanks of the Society were voted to Mr Morries Stirling, and given to him from the Chair.

3. On Improvements in Scouring and removing Obstructions in Dry Harbours. By Alexander Swan, Esq., Kinghorn. (3361.)

Illustrative Drawings were exhibited.

The author stated that the invention related to the practice of letting off the water from basins, at present in use, for scouring and removing obstructions at harbours, but, from the imperfect mode of using the water, it is generally inoperative. The proposed plan is to convey the water from the basins with pipes, having sluices at convenient places, whereby it can be directed with all its force and quantity against the sand-banks or other obstructions, and complete control over the water will be maintained. Most harbours in the vicinity of a sandy beach are obstructed with a deposit of sand after particular winds: of these, the harbours of Pettycur and Leven were mentioned, where the plan could be advantageously applied for the removal of sand banks, and otherwise improving and deepening the harbours, at a comparatively small outlay of capital. Likewise Leith, where there are docks with a high rise and fall of the tide. A great depth of water to the entrance is desirable. After the dredging machine has removed the solid ground, this method could be applied in maintaining the depth of water, by sweeping away any new and light deposit from the upper harbour.

The Report of Committee on Mr W. R. Douglas' Prussiate of Potass Retort was read and approved. (3356.)

PRIVATE BUSINESS.

The following Candidates were balloted for, and elected Ordinary Fellows:—

1. John T. Gordon, F.R.S.E., Sheriff of Mid-Lothian.
2. John Dawson, distiller, Greenpark, Linlithgow.
3. John Sawers, Provost of Stirling.
4. David Gray, M.D., F.R.S.E., Professor of Natural Philosophy, Marischal College and University, Aberdeen.
5. Henry Craigie, W.S., Falcon Hall.

A list of subjects for Prizes to be offered for Session 1851–52, prepared by the Council, was read and approved of.

A motion by A. K. Johnston, Esq., "That the Society shall present a petition to the House of Commons, and a memorial to the Treasury, relative to the vigorous prosecution of the Ordnance Survey of Scotland; and that the map may be published, not on the proposed scale of 6 inches to the mile, but on such a reduced scale as will be generally useful," was unanimously adopted. The petition was read in draft, and approved, and ordered to be signed by the President, and to be presented by Charles Cowan, Esq., M.P. The draft of a memorial to the Lords of the Treasury was also approved.

28*th April* 1851.—Thomas Grainger, Esq., President, in the Chair. The following Communications were made:—

1. Description of an Incline Plane for conveying boats from one level to another on the Monkland Canal, at Blackhill, near Glasgow, constructed in 1850. By James Leslie, Esq., civil-engineer, Edinburgh. (3360.)

A Working Model and Drawings were exhibited.

The incline plane is for the purpose of taking up empty boats from one level of the canal to another, the vertical height being 96 feet. The object is to save time and water. There are two sets of locks on the canal, each consisting of four double locks, making eight lifts of 12 feet. These locks are generally fit to pass all the trade, viz., about 70 boats each way daily, when there is plenty of water; but for the last two years, owing to the dry weather, and to the increase in the trade, the canal has been shut for several weeks from want of water. It was at one time proposed to pump up water from the lower reach for the purpose of locking; but as it would have been necessary to pump up 350 tons of water 96 feet for every boat that ascended or descended, it was ultimately resolved by the Forth and Clyde Canal Company, to whom the Monkland now belongs, to adopt, with modifications, a plan of the inclined plane which had been submitted to the Monkland Canal Company in 1839. The trade is mostly in minerals, and is almost entirely downwards, the boats generally returning empty. The rate of inclination of the plane is 1 in 10, and the height being, as before stated, 96 feet, the length of the carriage 70 feet, and a farther length of 10 feet being allowed for the varying levels of the water, the total length of the rails is 1040 feet. There are two lines of railway, so that while one carriage is ascending the other is descending. The boats are taken up afloat in a wrought-iron water-tight caisson, set on a carriage having ten pair of wheels, and having the after end raised much higher above the wheels than the fore end, so as to be quite level. The caissons have a lifting sluice at each end, and the section is almost exactly that of the boats, so as to require the least possible quantity of water. They are 70 feet long, viz., the extreme length of the boats, 13 feet 4 inches wide, and 2 feet 9 inches deep. One caisson is run down into the water of the lower reach, the lower sluice opened, a boat floated in, and the sluice again shut, so as to confine the water. By means of wire ropes, 2 inches diameter, working on two drums 16 feet diameter, on separate shafts, so as to move in opposite ways, and driven by two coupled steam-engines of 25 horse-power each, the one caisson with the boat is hauled up, while the other is descending with a load of water, so as to be just the same weight as the other. For the sake of safety, there is a ratchet alongside of each rail; and in the case of the ascending carriage there are palls which drop into the ratchet teeth, so as to prevent a descent. In the case of the descending carriage, the palls cannot work into the ratchet, but a large carriage-spring under the caisson, to which the rope is attached, by its opening out whenever the tension is taken off, allows the palls to drop should anything go wrong with the rope. When the caisson is at the top of the inclined plane, it is pressed hard to the face of the gates of the upper reach by means of an hydraulic press, so as to make a water-tight joint, the gates are opened, the boat floated out into the upper reach, during which time another boat is being admitted below. The whole time occupied is about ten minutes, viz., two minutes to enter, six to ascend, and two to be taken out of the caisson; but as the entering and leaving are simultaneous, there is a boat passed up every eight minutes. The time to ascend the set of locks is from one half to three quarters of an hour. The weight of the empty boat, caisson and carriage, is from seventy to eighty tons. Empty boats when they do ascend, which, however, is rare, may be sent down the incline. The greatest number that have been passed in a day hitherto is 48 up and two down, more could have been passed, but that was the whole number that had come during working hours. The incline was constructed in 1850, and was ready for work last autumn, but owing to the breaking of one of the spur wheels, only one line of rails was worked. The wheel has been replaced and other improvements effected, and the machinery now works most satisfactorily.

On the motion of George Buchanan, Esq., the thanks of the Society were voted to Mr Leslie for this interesting and valuable communication; which were given to him from the Chair.

Referred to a Committee.

2. A short account of the Progress of the Drainage of Haarlem Meer during the months of January, February, and March 1851. By Thomas Grainger, Esq., President. (3366.)

The President stated that it might be interesting to the Society to be informed of the progress made in this great undertaking since he had the pleasure of bringing the subject under their notice in December last. At that period the lake had been lowered 7 feet 3 inches below the original level when enclosed. During the month of January, owing to an accident which happened to the "Cruquius" engine, and also from the "Lynden" being under repair, the surface of the lake rose rather more than 1½ inch. In February, although the "Lynden" engine had been repaired, yet, from the state of the weather, and also of the levels of the water in the surrounding canal, preventing the two engines from being fully worked, the lake was lowered only about 2 inches. By the middle of March, with two engines only at work, the lake was lowered 6·29 inches below what it was at the beginning of the month; but, owing to the heavy rains which prevailed at the end of the month, this was reduced to 2·35 inches on the 31st. At that date the level had been reduced 7 feet 5·35 inches below the level at the time when the lake was enclosed. To give some idea of the actual amount of work involved in obtaining even the comparatively small diminution in depth which has taken place during these last three months—the President assumed that the same quantity of rain had fallen in Holland as in this neighbourhood—an estimate which will not be far from the truth, as he finds, on an average of years, that the total rain-fall is very nearly the same. The quantity of rain during January, February, and March, from a rain-gauge kept by himself, was 7·67 inches, which being added to the depth which the lake has been lowered, makes a total depth of water pumped out of 10·02 inches; and as there are about 4,113,187 tons of water in each vertical inch, we have a total quantity of 41,214,133 tons of water, which have been actually pumped up to obtain a diminution of 2·35 inches in the depth. Notwithstanding that these results are not so favourable as could have been wished, yet it may be confidently expected that, during this year, very great progress will be made—as the area of the lake now begins to diminish rapidly—and the President said he did not see any reason to change the opinion formerly expressed by him, that the works would be wholly completed in the autumn of 1852.

Thanks voted.

3. Drawings of the Goltzschthal and Elsterthal Railway Viaducts, near Leipsic. Communicated by the President. (3367.)

These two large viaducts are now constructing on the frontiers of Saxony. They form part of the works of the "Saxon and Bavarian State Railway," which is now open from Leipsic to Hof, with the exception of the portion between Reichenbach and Plauen, being the parts of the line on which these great works are being erected. These viaducts are situated in a district richly abounding in silver, lead, tin, iron, and coal. One of these viaducts is over the "Goltzsch," the other over the "Elster." The Goltzsch Valley Viaduct, which is the larger of the two, is 634 yards, or rather more than one-third of a mile, in length, and is 258 feet in height, being 73 feet higher than the Ballochmyle Viaduct, and 78 feet higher than our Scott Monument. The principal feature is the two centre arches placed one above the other. The span of these arches is 50 Dresden ells, equal to about 93 feet of our measure. The other parts consist of four tiers of arches, the lowest containing ten arches, the span of which, with the exception of those next the centre arches, which are only 22 feet span, is 35 feet. The second tier consists of 16 arches of 37 feet span; the third tier of 23 arches of 39 feet span; the fourth or upper tier of 29 arches of 44 feet span. There are extensive and massive wingwalls at each end; and at one end, and adjoining the wingwalls, four of the arches have piers 61 feet high. There are thus, besides three small arches, no fewer than 80 arches in the structure. The thickness of the piers of the small arches is—1st tier, 22 feet; 2d tier, 18 feet; 3d tier, 15 feet; 4th tier 11 feet. The breadth of the piers diminishes with each tier of arches, the base being 74 feet, lessening to the roadway, which appears about 27 feet, which is sufficient for two lines of rails. The piers of the first tier and the arching of the upper tier consist of dressed stone or ashler work; also the impost course, the parapet, and some of the base courses. The abutments and arch of the upper great arch is also of ashler work; the other parts of the structure are of brick work, with the exception of the wingwalls and the under part of some of the piers near the extremity, which are rubble stone work. The Elster Valley Viaduct is 297 yards long, the height at the centre being 225 feet. A pretty correct notion of the altitude may be obtained by reference to the Dean Bridge, which is only one-half of this height, which is 60 feet more than Melville's monument. The design of this viaduct differs materially from that just described, and is lighter and much more elegant. There are only two tiers of arches, two in the under and six in the upper tier, of a span of 50 Dresden ells, or 93 feet, besides eight small arches in the two centre piers of 18 feet span. This viaduct, like the other, consists chiefly of brick work—the corresponding parts are of stone work. With reference to the transverse section, it will be seen that the piers of the upper tier of arches are of a considerably less breadth than those of the under tier. Not having had an opportunity of making a personal inspection of these works, or of examining the material of which they are constructed, the author did not feel justified in entering into a comparison of them with similar works in this country. But on a very cursory examination of the drawing of the large viaduct, it would be seen that a much greater mass of material has been used than would have been considered necessary with us. The same observation does not, however, apply in the same extent to the smaller viaduct. It appears from a drawing in perspective, representing a considerable portion of the centring of the two upper tiers of arching of the large viaduct, that the centring for the whole of the two upper tiers of arches—that is, one set of centres for each arch had been provided—in which, together with the scaffolding, an *enormous* quantity of timber must have been employed. With us, the usual mode is to construct three or four sets of centres, and remove these as the arches are completed, to be used for the others, so that one is carried forward as required. With us, two *travelling cranes* are used; while in the case under consideration there seems to be a crane fixed over each pier. It is believed these works have been in hands for several years, and are now nearly completed.

Thanks voted.

4. Description and Drawing of a Portable Raft, to be used at sea in case of shipwreck; and of an Aquatic Life-Preserver, to be used at sea in case of boats swamping. By Mr Alexander M'Coll, teacher, Auchtermuchty. (3335 and 3337.)

A Model of the Raft was exhibited.

The portable raft is a square double framing of timber, easily put together, and having 30 air vessels of zinc coated with gutta percha, each containing a cubic foot of air fixed between the frames, having a buoyancy of 6000lb., which would support 40 persons, and have room for 800 lb. of stores. Smaller rafts could be made for smaller coasting vessels.

The aquatic life-preserver is a smaller apparatus, consisting of two light shafts of twisted osier, 12 feet long, and 20 inches apart, supported by zinc air vessels, such as are used in the portable raft. Its use would be to throw overboard from the ship in the event of a boat swamping, by clinging to which 20 people might be saved.

5. Description and Drawing of a Double-Acting Churn. By Mr Philip Hunter, cooper, 6 Sibbald Place, Edinburgh.

This churn is so constructed as to possess two motions, a vertical and a rotatory. The former is accomplished by the churn being placed on pivots at its centre, and a rod extending from the breakers inside to the machinery which puts the churn in motion. This rod, by means of a crank on one of the wheels, is caused to move up and down along a rack by the revolution of the wheels, which put the breakers inside of the churn in motion. By this simple provision the churn itself is made to move in a vertical direction. The rotatory motion is performed by breakers inside the churn. It has, however, this peculiarity, that in consequence of the rod moving on the rack the breakers do not move uniformly in one direction, but their revolutions, while the rod moves upwards, are in one direction, but are reversed while the rod moves downwards. This is designed to prevent the milk from assuming a regular and uniform motion in one direction. The machinery is exceedingly simple, and can be put in motion by the hand, by weights, water,

&c. The churn can be removed from the machinery (which is enclosed in a box to preserve it) at pleasure; and by removing the rod from the churn the breakers can be taken out and cleaned when necessary.

The Report of Committee on Mr Mackenzie's Printing in Colours, Mr D. Wilson, Convener, was read and approved of.

PRIVATE BUSINESS.

The following Candidates were elected Ordinary Fellows, viz.:—

1. John Tennant of St Rollox, Glasgow.
2. Charles Tennant of St Rollox, Glasgow.
3. Robert Johnston, accountant, Edinburgh.
4. William John Lawson, manager, Argus Life Company, London.

The Secretary read a letter from the Treasury, intimating that the Society's memorial relative to the Ordnance Survey had been laid before their Lordships.

The Society then adjourned till June.

23d June 1851.—Thomas Grainger, Esq., President, in the Chair.

M. Foucault's Pendulum Experiment.—A numerous company assembled in the Music Hall, to witness the demonstration of the axial rotation of the earth by the Pendulum Experiment, which was conducted by Dr G. Lees, at the request of the President and Council of the Society. Cards of invitation were issued by the Society to about 1300 persons, of which 400 were to members of public bodies, and 400 to the Fellows of the Society. A considerable proportion of the assemblage consisted of ladies, and the great majority of the parties invited availed themselves of the privilege. The hall was fitted up with raised platforms on each side, to enable the spectators to witness the progress of the experiment, which was made on a much larger scale than any of Dr Lees' former expositions, the pendulum being suspended from the height of fifty feet, and made to swing on a plane of fifteen feet.

Dr Lees, after a number of preliminary experiments illustrative of the theory of the earth's rotation, and of pendular motion, proceeded to the great experiment, and, having set the pendulum in motion by burning the slight cord which withheld it, and thus caused it to describe a line perfectly straight and free from the elliptical motion, so apt to mar the experiment, the pendulum traversed a white cord in a meridian line with great exactness; and very soon, to those in a favourable position, the deflection became very palpable. After being allowed to deflect for about three degrees, it was in like manner caused to oscillate from east to west, and again the result was equally decisive, thus confuting the idea, which Dr Lees stated had been taken up by many, that the pendulum would not exhibit any deflection unless made to oscillate in a meridian line. The apparatus was of a most elegant and admirably devised description, and the whole exposition was of a most lucid and satisfactory character. The exact and unwavering motion of the pendulum could not be exceeded.

Lord Murray moved the thanks of the meeting to Dr Lees for his able and interesting exposition, which was seconded by Mr G. Buchanan.

Lord Fullerton, seconded by Dr Cunningham, then moved a vote of thanks to the President and Council of the Society for affording to so many of the public an opportunity of seeing the experiment.

Professor More, seconded by Sheriff Cay, moved the thanks of the Society and of the meeting to the Directors of the Assembly Rooms for granting the use of the Music Hall for the purpose of this exposition.

The motions were warmly carried, as also a vote of thanks to Mr Grainger for presiding.

A considerable number of the company remained after the proceedings were concluded to witness the progress of the pendulum's deflection, and which eventually amounted to eight degrees.

30*th June* 1851.—Thomas Grainger, Esq., President, in the Chair. The following Communications were made :—

1. On the Substitution of Cast Iron for Wooden Sleepers. By R. W. Kennard, Esq. of Thames Street, London. Communicated by the President.

With Illustrative Drawings. (3376.)

Thanks voted.

2. Description of a method of Widening the North Bridge of Edinburgh. By Mr Robert Leslie, 26 Hill Street.

A Model on a Scale of 8 feet to 1 inch was exhibited. (3359.)

Thanks voted.

3. Description and Drawing of a Self-Acting Marine Pump. By Mr Daniel Erskine, 58 Clerk Street, Edinburgh.

A Working Model was exhibited. (3382.)

Referred to a Committee.

4. Miss Miller (Dalswinton) exhibited the Original Model of a Twin Vessel, to be propelled by five Paddle Wheels worked by Capstans,—invented and made under the inspection of the late Patrick Miller, Esq. of Dalswinton ;—and a short Account of it, and of a Vessel constructed from it, was read. (3369.)

Thanks voted.

5. On a Method of obtaining a Communication betwixt a Stranded Ship and the Shore. By Mr Alexander M'Coll, teacher, Auchtermuchty. (3343.)

Thanks voted.

6. Read Letter from Sir William Keith Murray, Bart. of Ravelston, inviting the Fellows to witness his Optical Experiments for ten days, at 116 George Street, from Ten to Twelve, when the sun shines.

The Thanks of the Society were voted to Sir William for his kindness.

The following Reports were read and approved of, viz. :—

1. On Mr Swan's Suggestions for Scouring Dry Harbours. Mr D. Stevenson, Convener. (3361.)

2. On Mr Procter's Oscillating Cylinder Steam-Engine. Mr Slight, Convener. (3334.)

3. On Mr Winton's Self-Acting Valve for Life-Boats. Mr Slight, Convener. (3341.)

4. On Mr Gregory's mode of disconnecting Train from Tender. Mr Slight, Convener. (3349.)

5. On Mr Neil's improved Safety-Valve Apparatus. Mr Paterson, Convener. (3345.)

6. On Mr Steven's Railway Signal. Mr Paterson, Convr. (3352.)

7. On Mr Leslie's Inclined Plane on Monkland Canal. Mr Buchanan, Convener. (3360.)

8. On Mr M'Coll's Portable Raft and Aquatic Life-Preserver. Mr Paterson, Convener. (3335 and 3337.)

9. On Mr Hunter's Double-Acting Churn. Mr Slight, Convener. (3365.)

The following Donations were laid on the Table :—

1. Report of the Commissioners appointed to inquire into the application of Iron in Railway Structures; with numerous Plates. (1849.) Presented by Charles Cowan, Esq., M.P. (3370.)

2. Report on the Ventilation of Mines and Collieries, by John Phillips, Esq., 1849; and by J. Kenyon Blackwell, Esq., 1850. (London, 1850.) Presented by the Same. (3371.)

3. Return to the House of Commons on—
 (1.) Harbours of Refuge, 1851.
 (2.) Hydrographic Department Admiralty, 1848.
 (4.) Iron Steam-Ships, 1851.
 (4.) Blackwater River, 1850.
 (5.) Monumenta Historica Britannica, 1850.
Presented by the Same. (3372—1–5.)

4. The History of Banking, with an Account of the Origin and Progress of the Banks of England, Ireland, and Scotland. By William John Lawson, Esq., Manager of the Argus Life Office, 14 Pall Mall, London. (London 1850.) Presented by the Author. (3373.)

5. An Experimental Enquiry into the strength of Wrought Iron Plates and their Rivetted Joints, as applied to Ship-Building and Vessels exposed to severe strains. By William Fairbairn, Esq., Manchester. (London 1850.) Presented by the Author. (3374.)

6. Plan and Description of the Original Electro-Magnetic Telegraph, with prefatory note to the Royal Commissioners of the Great Exhibition 1851, and relative documents. By William Alexander, Esq., W.S., F.R.S.E. (London 1851.) Presented by the Author. (3375.)

7. Transactions of the Institution of Civil Engineers, London, vols. I. and II. Presented by the Institution. (3377—1, 2.)

8. Minutes of Proceedings of the Institution of Civil Engineers, London. Vols. I. to VI. inclusive, and vol. VII., to page 208,—vol. VIII. to page 64,—and vol. IX., to page 232. (1844 to 1850.) Presented by the Same. (3378—1–9.)

9. Catalogue of the Library of the Institution of Civil Engineers,

London, corrected to December 31, 1850.—List of the Members of the Institution, December 1850. Presented by the Institution. (3379—1,2.)

10. Suggestions to Astronomers for the Observation of the Total Eclipse of the Sun, on 28th July 1851. Drawn up a by Committee of the British Association. Presented by Professor Forbes, Sec. R.S.E., &c. (3380.)

11. The Transactions of the Institution of Civil Engineers of Ireland. Vols. II. and III. (Dublin, 1848 and 1849.) Presented by the Institution. (3381—1, 2.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved of.

II. The following Candidates were elected Ordinary Fellows, viz. :—

1. James Newell Gordon, The Priory, Islington, London.
2. John Willet, civil engineer, Aberdeen Railway.

III. The Society appointed the Prize Committee to award the Prizes for Session 1850–51, viz. :—

Richard Whytock, Esq., *V. P.*
Alexander Rose, Esq.,. *V. P.*
James Slight, Esq.
David Stevenson, Esq.
Dr Lees.
James Dalmahoy, Esq.
Daniel Wilson, Esq.
Alexander Ramsay, Esq.
William Paterson, Esq.
Benjamin H. Blyth, Esq.
Patrick Wilson, Esq.
David Cousin, Esq.
James Tod, Secretary, Convener, *ex-officio*.

IV. The President closed the Session with a short address.

The Society then adjourned till November.

APPENDIX (B).

LIST OF PRIZES FOR SESSION 1851–52.

The ROYAL SCOTTISH SOCIETY of ARTS proposes to award Prizes of different values (none to exceed Thirty Sovereigns), in Gold or Silver Medals, Silver Plate, or Money, for approved Communications primarily submitted to the Society, relative to Inventions, Discoveries, and Improvements in the *Mechanical* and *Chemical* Arts in general, and also to means by which the *Natural Productions* of the Country may be made more available; and, in particular, to—

I. Inventions, Discoveries, or Improvements in the Useful Arts, including the *Mechanical* and *Chemical;* and in the Mechanical Branch of the *Fine Arts;* such as, but not limited to, the following, viz.:—

1. *Mechanical Arts.*

1. Improvements in Sewerage,—in Economical Appliances for increasing the Sanitary Condition of Cities and Towns,—in Methods of Warming and Ventilating Public Edifices, Private Dwellings, &c.,—in Ventilation of Mines,—of constructing Economical and Salubrious Dwellings for the Working-Classes,—of Filtering Water in large quantities,—of Extinguishing Fires,—of applying Glass to new and useful purposes, &c. &c.

2. Inventions or Improvements in preserving Timber and Metals in Marine Works,—in Locomotive, Stationary, and Marine Engines,—in Light-House Apparatus,—in Railways and Railway Plant and Signals,—in Tools, Implements, and Apparatus for the various Trades,—in Rifle Guns,—in Grates,—in Gilding and Lacquering Brass,—in Cements and Mortars,—in Machines for Planing Wood,—in Window Sash-Lines,—in Printing Ma-

chines,—in Printing Cases,—in the Composition of Printers' Rollers,—in Cranes for raising heavy bodies,—in the Machinery for Collieries and other Mines,—in Machines for Cutting or Folding Paper,—in Microscopic Apparatus,—in Gold and Steel Pens, &c. &c.

2. *Chemical Arts.*

IMPROVEMENTS in Dyes and Paints—in rendering Glass hard and difficult of fusion for Chemical purposes,—in Writing Inks,—in the Manufacture of thin sheets of Gutta Percha, of equal strength in all directions for Surgical purposes, &c.,—in Oil for fine Machinery, Clocks, and Watches,—in Apparatus for Fermentation, &c. &c.

3. *Relative to the Fine Arts.*

IMPROVEMENTS in the form of Articles in Procelain, Common Clay, or Metal,—in Fire Clay Articles for Architectural purposes,—in Glass Staining,—in Engraving on Stone,—in Daguerreotype, Talbotype, or other Photographic processes,—in Electrotype processes,—in Dye-sinking,—in methods of illustrating Books to be printed with the Letter-Press,—in Ornamental Metallic Casting,—in Designs and adaptation of new Materials for Sepulchral Monuments,—in Mosaic and Inlaid Stone Work, &c. &c.

II. EXPERIMENTS applicable to the Useful Arts.

III. COMMUNICATIONS of Processes in the Useful Arts practised in this or other Countries, but not generally known. (Subjects of *Foreign* Patents are not excluded.)

IV. PRACTICAL DETAILS of Public or other Undertakings of National importance, already executed, but not previously published;—or valuable suggestions for originating such undertakings.

The SOCIETY also proposes to award the KEITH PRIZE, value Thirty Sovereigns,

For some important " Invention, Improvement, or Discovery, in the Useful Arts, which shall be primarily submitted to the Society," during the Session.

GENERAL OBSERVATIONS.

Communications lodged *in competition for Prizes*, shall not have been Patented in the United Kingdom or Colonies, nor have been previously Published, or read before any other Society.

The Descriptions of the various inventions, &c., must be *full* and *distinct*;—be written on *Foolscap* paper, leaving margins at least one inch broad, on *both sides of the writing on every page*, so as to allow of their being bound up in volumes; and, when necessary, be accompanied by *Specimens*, *Drawings*, or *Models*. All drawings to be on *Imperial* Drawing Paper, unless a larger sheet be requisite. The Drawings to be in *bold* lines, not less than an eighth of an inch thick, or *strongly coloured*, so as to be easily seen at about the distance of thirty feet when hung up in the Hall of Meeting, and the Letters or Figures of Reference to be at least 1½ inch long. When necessary, smaller and more minutely detailed Drawings should accompany the larger ones, for the use of the Committees, having the same letters or figures of reference.

The Society shall be at liberty to publish in their Transactions copies or abstracts of all Papers submitted to them. All Models, Drawings, &c., for which Prizes shall be given, to be held to be the property of the Society; the Value of the Model, &c., being separately allowed for.

Communications, Models, &c., are to be addressed to James Tod, Esq., the Secretary, 55 Great King Street, Edinburgh, Postage or Carriage paid; and they are expected to be lodged *on or before* 1*st October* 1851, in order to ensure their being read and reported on during the Session, the ordinary Meetings of which end in April 1852; but *those which cannot be lodged earlier*, will be received up to 1st April 1852; those lodged after that date may not be read or reported on till the following Session.

By order of the Society,

James Tod, *Secretary*.

Edinburgh, 14*th April* 1851.

APPENDIX (C).

REPORT

OF

THE COMMITTEE

APPOINTED BY

THE ROYAL SCOTTISH SOCIETY OF ARTS

TO AWARD PRIZES FOR COMMUNICATIONS READ AND EXHIBITED DURING SESSION 1850-51.

Your COMMITTEE having met and carefully considered the various Communications laid before the Society during Session 1850-51, beg leave to report that they have awarded the following Prizes :—

1. To JAMES LESLIE, Esq., F.R.S.S.A., Civil Engineer, Edinburgh,—for his " Description, with Working Model and Drawings, of an Inclined Plane for conveying Boats from one level to another on the Monkland Canal, at Blackhill, near Glasgow, constructed from his design in 1850." Read and exhibited, 28th April 1851; and printed in the Transactions. (3360)

The Society's Silver Medal, and Plate, value Fifteen Sovereigns.

2. To THOMAS C. GREGORY, Esq., F.R.S.S.A., Civil Engineer, Edinburgh,—for his " Description and Drawings of an Im-

proved Self-acting Apparatus for Disconnecting the Carriages of a Railway Train from the Tender, upon the Engine leaving the Rails." Read and exhibited, 27th January 1851; and printed in the Transactions. (3349)

The Society's Silver Medal, and Plate, value Ten Sovereigns.

3. To Mr William R. Douglas, Millwright and Engineer, Leith,—for his "Description and Model of an Improved Retort for the Manufacture of Prussiate of Potash." Read and exhibited, 24th February 1851. (3356)

The Society's Silver Medal, value Five Sovereigns.

4. To Mr John Steven, St Leonard's Station, North British Railway, Edinburgh,—for his "Description, with Working Model, of a Railway Signal, constructed on a new principle; and intended to be useful in the prevention of Accidents, by shewing the precise time at which a previous Train had passed the point where it is erected." Read and exhibited, 24th March 1851. (3352)

The Society's Silver Medal, value Three Sovereigns.

5. To Mr William Procter, Tinsmith, Forfar,—for his "Description, with a Working Model and Drawings, of an Oscillating Steam-Engine," capable of being easily reversed. Read and exhibited, 9th December 1850. (3334)

The Society's Silver Medal, value Three Sovereigns.

Note.—The Prize is given for his Stop-Cock and mode of Reversing, and is recommended by the Committee only for Steam-Engines of Ten Horse power, and under.

6. To William Swan, Esq., F.R.S.E., F.R.S.S.A., Teacher of Mathematics, Edinburgh,—for his "Formulæ for constructing Mr Thomas Stevenson's Totally Reflecting Hemispherical Mirrors." Read 25th November 1850; and printed in the Transactions. (3333)

The Society's Silver Medal.

The Committee recommend, that while the *Thanks* of the Society are justly due to all those gentlemen who have sent Communications, the *Special Thanks* of the Society be given to the following gentlemen, viz. :—

1. To Thomas Grainger, Esq., F.R.S.E., Memb. Inst. C.E., Pres. R.S.S.A.—for his "Description with Drawings of the Drainage of Haarlem Meer by means of Steam Power, with some account of other Engineering Works therewith connected." With Illustrative Model of the System of Pumps. Read and exhibited, 9th December 1850, 13th January and 28th April 1851 ; and printed in the Transactions. (3339 and 3366)

2. To Lieut.-Colonel H. Jones, R.E.—for his oral "Account of the proceedings and operations of the Commissioners appointed for the Improvement of the Navigation of the River Shannon." Given on 10th March 1851. (3358)

3. To Andrew Fyfe, M.D., F.R.S.E., F.R.S.S.A., Professor of Chemistry, King's College, Aberdeen—for his oral "Remarks on the modes of ascertaining the Illuminating Power of Coal-Gas, with Tabular Views of the results of his Experiments." Given on 14th April 1851. (3362)

4. To George Buchanan, Esq., F.R.S.E., F.R.S.S.A., Civil Engineer, Edinburgh—for his "Account of the Great Chimney of the Edinburgh Gas-Works, with observations on the principles of its strength and stability." Read, 11th and 25th November 1850. (3331)

5. To M. Taylor, Esq., Engineer for the Edinburgh Gas-Works —for his "Detailed Description with Drawings of the Great Chimney of the Edinburgh Gas-Works." Read and exhibited, 25th November 1850. (3332)

6. To WILLIAM ALEXANDER, Esq., F.R.S.S.A., Mining Engineer, Glasgow—for his Paper "On Colliery Engineering in Scotland;" with Illustrative Drawings. Read and exhibited, 10th February 1851. (3350)

7. To WILLIAM CAMPBELL, Esq., F.R.S.S.A., Civil Engineer, Edinburgh—for his Paper "On the Improvements on the River Clyde during the past hundred years." Illustrated by Maps and Plans. Read and exhibited, 10th February and 10th March 1851; and printed in the Transactions. (3351)

8. To JOHN CAMERON, Esq., Civil Engineer, Edinburgh—for his Description with Drawings "of the Lugar Valley Viaduct on the line of the Glasgow and South Western Railway, erected from the design of John Miller, Esq., C.E. Read and exhibited, 24th February 1851; and printed in the Transactions. (3354)

Your Committee recommend that Mr KENNARD's Paper on Cast-Iron Sleepers should be remitted to a Committee to Report upon it, and that the Paper and Report should be brought up to next Prize Committee.

The Committee have further granted, for the purchase of Models, Drawings, &c., illustrative of Papers read during the Session, the sum of Seventeen Pounds.

All which is humbly reported by

JAMES TOD, *Sec.*, *Convener ex officio.*

EDINBURGH, 21*st Oct.* 1851.

APPENDIX (D).

NOTICE REGARDING THE PUBLICATION OF THE TRANSACTIONS OF THE SOCIETY.

THE COUNCIL have for some time had under consideration the propriety of publishing the Transactions of the Society in a more satisfactory way than heretofore, with a view to giving regular and general publicity to the many important papers read at the Meetings. The publication has hitherto been dependent upon an arrangement with the editor, printers, and publishers of the Edinburgh New Philosophical Journal, by which select papers were first printed in that Journal, and the types being kept up, were subsequently collected, put together in a separate form, and distributed as the Transactions of the Society. Many very valuable papers were offered to the editor of the Journal, which could not consistently with his arrangements be printed at all, and others not till after a considerable delay, and much troublesome correspondence and inconvenience of various sorts were thus occasioned.

The Council conceive that the Transactions of the Society are now of sufficient importance to justify an independent publication; and they are of opinion that such a publication would redound to the credit of the Society. They have, therefore, made minute inquiry, and finding that, at an inconsiderable increase of expense, this object might be accomplished, have resolved to submit the following plan for the approval of the Society :—

1. The Transactions shall be printed in octavo, as at present, once a-year.

2. Seven hundred and fifty copies shall be printed ; a copy being sent to each Member in Edinburgh, and to such Members residing elsewhere, as shall give directions for that purpose, furnishing the printers, Messrs Neill & Co., with a note of the addresses of friends in Edinburgh with whom they may be left. A certain number of the extra copies shall be placed in the hands of the publishers, Messrs A. & C. Black, booksellers, Edinburgh, for sale ; and the remainder partly presented to such Societies as are in use to present their Transactions to this Society, or as may be expected to do so, and partly retained for the purpose of making up defective sets at the publication price.

3. A Committee of the Council, to be called the Committee on Publication, shall be appointed to superintend the selection of the papers to be embodied in the Transactions, and generally to assist the editor, who shall be convener of such Committee.

4. No paper shall be printed without the sanction of such Committee, who shall have power to confer with the authors of papers, with a view to their condensation, correction, and adjustment for publication, necessity for plates or woodcuts, &c. ; and to take the aid of any Member or Members of the Society who may happen to be peculiarly conversant with the particular subjects to which papers refer.

5. It shall be in the power of special Committees to whom papers are referred at the Meetings of the Society, to recommend such papers, when of importance, to the consideration of the Publication Committee, with a view to their being printed, besides indicating whether, in their opinion, Prizes should be awarded, or other favourable notice of such papers should be given ;—it being understood that the final determination as to the *publication* shall rest entirely with the Committee on Publication.

6. The Committee on Publication shall meet from time to time during the Session, so that the preparation and printing of the papers may be in progress, and the volume of Transactions be, as far as possble, advanced at its termination.

7. So soon as the publication of any paper has been determined upon, it shall be announced to the author, and the paper transmitted (if possible) to him; and he shall be required, if necessary, to transcribe it in a fair legible hand, and to arrange, compare, and correct it carefully for the press, before it is sent to the editor for his revision.

8. After the paper is in types, *one* proof and *one* revise only shall be allowed to the authors for revisal at the Society's expense. All extra proofs and revises must be paid for by the authors themselves.

9. Where plates or woodcuts are necessary, the authors will be required to furnish the drawings, *reduced to a scale* suitable to the size of the work; the dimensions of the plates being 7 by 4 inches for a common octavo plate, and 7 by 10 or 12 inches for a quarto or folding plate. Woodcuts not to exceed the width of the page, being 4 inches.

10. It shall be competent to the Publication Committee to permit the authors of papers printed in the Transactions to have a limited number of such papers separately thrown off for their private use, on paying the expense of paper, press-work, stitching, &c.

EDINBURGH, 8*th December* 1851.

ROYAL

President,

Vice-Presi

Secretary,

Treasurer,

WILLIAM PAT

Professor MOR

JO. CLERK MA

THO. STEVENS

JOHN CAY, ES

GEORGE LEES

APPENDIX (E).

LIST

OF THE

OFFICE-BEARERS AND FELLOWS

OF THE

ROYAL SCOTTISH SOCIETY OF ARTS.

AS AT 1st NOVEMBER 1851.

THE QUEEN, PATRONESS.

OFFICE-BEARERS FOR SESSION 1850-51.

President,	Thomas Grainger, Esq., F.R.S.E., Memb. Inst. C.E.
Vice-Presidents,	Richard Whytock, Esq. Alexander Rose, Esq.
Secretary,	James Tod, Esq., F.R.S.E., W.S., 55 Great King Street.
Treasurer,	John Scott Moncrieff, Esq., Acct., 15 India Street.

Ordinary Councillors.

*William Paterson, Esq., C.E.
*Professor More, F.R.S.E.
*Jo. Clerk Maxwell, Esq., F.R.S.E.
*Tho. Stevenson, Esq., F.R.S.E., C.E.
John Cay, Esq., F.R.S.E.
George Lees, LL.D.
David Rhind, Esq., F.R.S.E.
Daniel Wilson, Esq., F.S.A. Scot.
Patrick Wilson, Esq.
Douglas Maclagan, M.D., F.R.S.E.
Rev. Prof. Kelland, F.R.SS. L. & E.
James Dalmahoy, Esq., F.R.S.E.

Editor of Transactions,	George Wilson, M.D., F.R.S.E.
Curator of Museum,	Mr Alexander Jamieson.
Medallist,	Mr Alexander Kirkwood.
Officer and Collector,	Mr Hugh Johnston.

(The four Ordinary Councillors marked * retire by rotation.)

LIST OF THE ORDINARY FELLOWS

AS AT 1ST NOVEMBER 1851.

1822. ABERCORN, The Most Noble the Marquis of, K.G.
„ ABERDEEN, The Right Hon. the Earl of, K.T.
„ Abercromby, Sir Robert, of Birkenbog, F.R.S.E.
„ Adinston, Thomas, of Carcant.
„ Alison, W. P., M.D., F.R.S.E.
„ Adie, Alexander, F.R.S.E.
1826. Aytoun, Robert, W.S.
1837. Aikman, George, engraver.
„ Alves, H. S.
„ Alexander, William, F.R.S.E., W.S.
1838. Anderson, Charles J.
„ Adie, John, optician, F.R.S.E.
1841. Anderson, Charles W., merchant.
1843. Anderson, John, Pratis, Fife.
1846. Ainslie, P. B., Chertsey, London.
„ Alexander, James, wine-merchant.
„ Ainslie, Daniel (late Calcutta).
1847. Abbott, Francis, Sec. G. P. O.
1850. Anderson, Thomas, M.D., F.R.S.E., Leith.
„ Adie, Alex. J., F.R.S.E., C.E., Linlithgow.
1851. Archer, William, solicitor, London.
„ Alexander, Wm., M.E., Glasgow.

1822. BUCCLEUCH and QUEENSBERRY, His Grace the Duke of, K.G., A.M., F.R.SS. L. & E.
„ Brewster, Prin. Sir David, K.H., D.C.L., F.R.SS. L. & E.
„ Bald, Robert, F.R.S.E., Alloa.
1826. Brisbane, Sir Thomas Macdougall, Bart., G.C.B., President R.S.E.
1830. Bonar, William, F.R.S.E.
„ Brown, Robert, junior, architect.
1832. Black, Alexander, surveyor of buildings.
1833. Buchanan, George, F.R.S.E., C.E.
„ Bryce, David, architect.
1835. Borthwick, James, manager N. B. Insurance Company.
„ Berkely, Frederick Hewett, Chester.
1835. Burn, William, F.R.S.E., architect.
1836. Bryson, Alexander, watchmaker.
„ Ballantyne, James, of Holylee.
1837. Bell, John Beatson, W.S.
1838. Beattie, Alexander, smith.
„ Bruce, O. Tyndall, of Falkland, F.R.S.E.
„ Blanshard, Lieut.-Col. Thomas, Roy. Eng.
1839. Brown, Thomas, architect.
1840. Brown, James, accountant.
„ Berwick, David.
1841. Baird, Douglas, iron-master, Gartsherrie.
1844. Bell, J. A., architect.
„ Baillie, William R., W.S.
1845. Bowie, William.
1846. Buist, George, LL.D., Bombay.
„ Beattie, George, builder.
„ Bryson, James, engineer, Dunfermline.
1847. Bernard, Thomas, brewer.
„ Buchanan, William Miller, M.D.
1848. Brebner, Allan, engineer, Burntisland.
1849. Bouch, Thomas, C.E.
„ Burn, Robert, engineer.
1850. Black, Rev. Archibald P., A.M., London.
„ Blyth, Benjamin Hall, engineer.
„ Bell, Alex. Melville, Prof. of Elocution.
„ Balfour, Robert, secretary City of Glasgow Insurance Company.
„ Bruce, George Cadell, C.E.
„ Bryden, Adam, bell-hanger.
1851. Bryden, John, bell-hanger.
„ Black, John Trafalgar, Surrey.

1822. Clerk, Sir George, Bart., M.P., F.R.S.E.
„ Campbell, Walter, of Islay, M.P., F.R.S.E.
„ Cadell, W. A., of Banton, F.R.S.E.
„ Cunningham, Charles, W.S.
1827. Chalmers, Charles.
„ Crawfurd, William, of Cartsburn.
1832. Craig, Sir William Gibson, of Riccarton, M.P., F.R.S.E.
1834. Campbell, Alexander, brewer.
1835. Crichton, Alex., lithographic-printer.

1836. Cowan, Charles, M.P., Penicuik.
1837. Cowan, Alexander, paper-maker.
„ Cooper, Wm., glass-manufac., Canada.
1838. Caldwell, Robert, builder.
1840. Christie, Robert, accountant.
„ Crosbie, George.
„ Cormack, David, S.S.C.
„ Carstairs, Drysdale, Liverpool.
1841. Cowan, James G., merchant, Leith.
„ Cowan, James, M.D., surgeon R.N.
„ Cameron, Captain Charles.
1842. Cushnie, William, Malta Green.
1845. Cay, John, F.R.S.E., advocate.
1846. Callender, J. A., C.E., Southampton.
1847. Campbell, John Archibald, F.R.S.E.
„ Cousin, David, architect.
1848. Craig, Rev. John, Cupar-Fife.
1849. Clark, Thomas, M.D., Whitburn.
1850. Campbell, William, C.E.
„ Carstairs, James L., C.E., Berwick.
„ Calvert, Frederick B., A.M.
1851. Cormack, James, ironmonger.
„ Cunningham, George, C.E.
„ Craigie, Henry, W.S., Falcon Hall, Morningside.

1822. Davidson, Robert, of Ravelrig.
„ Dunlop, Arch., F.R.S.E., London.
1838. Dunlop, Andrew, W.S.
1840. Dun, Andrew, W.S.
1841. Davidson, Charles F., W.S.
1843. Dove, James, engine-maker.
1844. Dickson, James Jobson, accountant.
„ Dunn, Thomas, optician.
1846. Donaldson, J., advocate, Prof. of Theory of Music.
1847. Dalmahoy, Jas., F.R.S.E., late H.E.I.C.S.
„ Dymock, James R., merchant.
1848. Duff, Rev. Henry, South Leith.
1849. Drury, Rev. Robert, Surrey.
1850. Davidson, Samuel D., Leith Eng. Works.
„ Dickson, John, junior, gunmaker.
1851. Duncan, James, M.D.
„ Dawson, Charles, London.
„ Dawson, John, distiller, Linlithgow.

1828. Ellis, Adam Gib, M.W.S., W.S.
1839. Ellis, Thomas, upholsterer.
1843. Erskine, Daniel, Musselburgh.

1822. Forbes, George, F.R.S.E.
„ Fyfe, Prof. A., M.D., F.R.S.E., Aberdeen.
1828. Fraser, Robert.
1832. Forbes, Prof. J. D., F.R.SS. L. & E.
1838. Fergusson, Lieut.-Col., H.E.I.C.S.
1840. Fleming, Alexander, W.S.
„ Forrester, John, W.S.
1843. Falkner, James P., solicitor.
1844. Foulis, Sir Wm. Liston, Bart., Hermiston.
1847. Ford, John, glass-manufacturer.
1847. Fullarton, John A., publisher.
1848. Fairbairn, J., House-Gov. Heriot's Hosp.
1849. Fraser, J. S., engineer Gt. Western Rail.
1850. Ferguson, William B., C.E., Aberdeen.
„ Falshaw, James, C.E., Perth.
„ Fraser, John, actuary and manager Life Association of Scotland.
„ Fraser, Alexander, printer.

1822. Gordon, Rev. Robert, D.D., F.R.S.E.
„ Graham, Humphrey, W.S.
1828. Grainger, T., F.R.S.E., Memb. Inst. C.E.
1829. Græme, James, W.S., yr. of Garvoch.
1832. Gray, James, ironmonger.
1835. Groat, A. G., of Newhall, advocate.
1836. Greig, Thomas.
1842. Gillespie, John, W.S.
1844. Girdwood, John, North Wales.
„ Gregory, Prof. William, M.D., F.R.S.E.
1848. Gray, Rev. Thomas, A.M., Kirkurd.
„ Gardner, James.
1850. Glennie, George, C.E., Melrose.
„ Gowans, James, builder.
„ Gregory, Thomas Currie, C.E.
„ Gordon, James, jun., W.S.
1851. Gordon, John T., F.R.S.E., Sheriff of Mid-Lothian.
„ Gray, David, M.A., F.R.S.E., Prof. of Nat. Phil. Marischal Coll., Aberdeen.
„ Gordon, James Newell, London.

1822. Hamilton and Brandon, His Grace the Duke of, K.G.
1829. Horne, Archibald, accountant.
1833. Hamilton, Alex., LL.B., F.R.S.E., W.S.
1834. Hamilton, John, W.S.
„ Horsburgh, Robert, Tongue House.
1835. Hay, James, merchant, Leith.
1836. Haldane, James, brassfounder.
„ Hepburn, J. Stewart, of Colquhalzie.
1837. Hopkirk, J. G., LL.B., W.S.
1838. Hunter, Richard, Bengal Civil Service.
„ Henderson, Eagle.
1839. Hill, Laurence, jun., C.E., Glasgow.
„ Hill, Henry David, W.S.
1840. Harvey, George, R.S.A., histor. painter.
1841. Hope, David T., C.E., Liverpool.
„ Hughes, John, printer.
1843. Howden, James, watchmaker.
„ Henry, Jardine, writer.
1845. Hay, David Ramsay, F.R.S.E.
1850. Hill, James L., W.S.
„ Hawkins, John, H.E.I.C.S.
„ Henderson, John, C.E., Leeds.
„ Hewat, John, merchant.

1822. Jardine, James, F.R.S.E., C.E.
1840. Johnston, Alex. K., F.R.S.E., geographer to the Queen.
1848. Jefferiss, Robert R., M.D., Dalkeith.

1850. Jardine, William Alexander, C.E.
,, Jopp, Charles, C.E.
,, Johnstone, William, C.E., Glasgow.
1851. Johnston, Robert, accountant.

1822. Keith, James, M.D., F.R.S.E.
1836. Kirkwood, Alexander, die-cutter.
1839. Kennedy, William, W.S.
1842. Kronheim, Jos. M., ornamental designer.
1843. Kemp, Alex., lecturer on chemistry.
1844. Kinloch, Alex. J., M.D., Aberdeen.
1845. Kennedy, John, jun., W.S.
1848. Kirkwood, James, goldsmith.
1850. Kelland, Rev. Philip, F.R.SS. L. & E., Professor of Mathematics.
1851. Kirkwood, Robert, C.E.

1822. L'Amy, James, F.R.S.E., advocate.
1834. Lawrie, William A., W.S.
1836. Lees, George, LL.D.
,, Lawson, Charles, seedsman.
1838. Lorimer, George, builder.
1840. Leburn, Thomas, S.S.C.
1842. Leith, Samuel, lithographer.
1844. Leslie, John, cupper.
1845. Lancefield, Alfred, surveyor.
1848. Laurie, Rev. Joseph, D.D., H.E.I.C.S.
1850. Leslie, James, C.E.
,, Lees, Henry, secretary E. P. & D. R.
,, Lessels, John, architect.
1851. Lee, Alexander H., C.E.
,, Lawson, W. J., manager Argus Life Co., London.

1822. Maconochie, Alexander, FR.S.E.
,, More, John S., Professor, F.R.S.E.
,, Murray, Hon. Lord, F.R.S.E.
1826. Maxwell, John Clerk, F.R.S.E., Glenlair.
1829 Miller, John, C.E.
1831. Macdonald, William, of Powderhall.
1834. Murray, W., of Henderland, F.R.S.E.
1835. Marjoribanks, Gilbert, Australia.
,, Mould, J. B., engraver.
1836. Milne, James, brassfounder.
,, Mackay, James, goldsmith.
1838. Macgibbon, Charles, builder.
,, Morton, Hugh, engineer.
,, Maclagan, David, M.D., F.R.S.E.
,, Moncrieff, John Scott, accountant.
,, Mackenzie, James, W.S.
,, Murdoch, J. B., of Gartincaber, F.R.S.E.
1839. Macbrair, D. J., S.S.C.
,, Maclagan, D., M.D., F.R.C.S., F.R.S.E.
,, Menzies, T., ship-builder, Leith.
1840. Murray, James T., W.S.
1841. Maitland, John, accountant.
,, Marshall, J., of Curriehill, advocate.
,, Macpherson, Charles, printer.
1842. Mitchell, Edward, surgeon.
1843. Marshall, G.H., jeweller.
1843. Melville, John, W.S.
,, Murray, Sir W. K., Bart., of Ochtertyre.
1844. Mackie, D., rector Royal Academy, Tain.
1846. M'Dowall, John, engineer, Johnston.
,, Middleton, Captain J., Waltham Lodge.
,, Mortimer, Thomas E., gunmaker.
,, Miller, James, engineer.
1847. Middleton, James, Waltham Lodge.
,, Mackenzie, William M., surgeon, Kelso.
,, Macadam, John, chemist.
1848. Marshall, Rev. William, Leith.
,, Milne, John Kolbe, pocket-book maker.
,, Macfarlan, John F., druggist.
,, Mackenzie, Rev. Kenneth, Bo'ness.
,, Mitchell, Graham Alexander, Whitburn.
1849. M'Intosh, Charles, Dalkeith Park.
,, Mackie, J. W. R., surgeon, Cupar-Fife.
1850. Mackay, John M., chemist and druggist.
,, Melville, James M., W.S.
,, Martin, George, Glasgow.
,, Mitchell, James, contractor.
,, Macintosh, James A., wood-engraver.
,, Mackay, Charles, goldsmith.
,, Moffat, William L., architect.
,, Mein, Archd., M.D., surgeon and dentist.
,, Mitchell, John M., merchant, Leith.
,, MacGill, Rev. David, London.
,, Maclagan, David, manager Insurance Company of Scotland.
,, Marjoribanks, William, merchant.
,, Mackain, Daniel, C.E., Glasgow.
,, Marshall, William, accountant.
,, Miller, Colin M., M.D.
,, M'Leod, James B., teacher.
,, Macpherson, Alexander, plumber, Leith.
,, Macdonald, D., cotton-spinner, Aberdeen.
,, MacGillivray, J., Royal Artillery, Woolwich.
,, Mitchell, Thomas Oak, M.D., Greenwich.
1851. Middleton, J., M.D., licentiate R.C.S.E.
,, Milne, Robert, C.E. and land surveyor, Aberdeen.

1832. Nasmyth, James, jeweller.
1838. Nachot, Dr H. W., teacher of German.
1846. Newlands, James, architect, Liverpool.
1850. Newbigging, Patrick, M.D., F.R.C.S.E.
,, Nicholson, R., loco. sup., Burntisland.
,, Notman, David, builder.
,, Newbigging, Sir William, F.R.S.E.
1851. Nicolson, Rev. Hugh, London.

1848. Oliver, Robert S., hatter.
1849. Ogilvie, George Ramsay, advocate.
1850. Ogilvie, Archibald, merchant.

1822. Playfair, W. H., F.R.S.E., architect.
1833. Ponton, Mungo, F.R.S.E., W.S.
1840. Pearson, Charles, accountant.
1842. Pyper, Hamilton, advocate.

1842. Paterson, George, yr. of Castle Huntly.
1844. Paterson, John, Leith Docks.
„ Paterson, J., M.D., late 42d Regiment.
1846. Pattison, Thomas, M.D.
„ Paterson, W., resid. eng. E. P. & D. R.
1847. Purdie, Thomas, painter.
1848. Peddie, John D., architect.
1850. Pender, James B., paper-manufacturer.
1851. Parker, W. A., Register House.

1822. ROSEBERY, The Right Hon. the Earl of, K.T.
1829. Reid, David B., M.D., F.R.S.E., London.
1834. Ritchie, R., C.E., Assoc. Inst. C.E.
1835. Russell, J. S., M.A., F.R.SS. L. & E., Lond.
„ Ranken, Francis, glass-manufacturer.
1837. Ruthven, James, architeet.
1838. ROXBURGHE, His Grace JAMES H. R., Duke of, K.T.
1839. Russell, Thomas, ironmonger.
1840. Rose, Alexander, lecturer on geology.
1842. Rankine, W. J. Macquorn, F.R.S.E., C.E., Glasgow.
1843. Rhind, David, F.R.S.E., architect.
„ Roberts, W. A., M.D., dentist and surgeon.
1844. Robertson, James, M.E.
„ Ronaldson, John, writer.
1846. Robb, Charles, silversmith.
1848. Reid, Robert Little, painter.
1849. Robertson, Alex. D., merchant, Leith.
1850. Ramsay, Alex., manager Edin. Water Co.
„ Rae, William Fraser, brassfounder.
„ Richardson, Ralph, merchant.
„ Richardson, James, merchant.
„ Richardson, Robert, merchant.
„ Robson, Neil, C.E., Glasgow.
1851. Rogers, James, ironmonger.

1827. Swinton, George, F.R.S.E.
1828. Sang, Edward, C.E., Constantinople.
1832. Sclater, Robert, die-cutter.
„ STAIR, The Right Hon. the Earl of, K.T.
1833. Steele, Wilkinson, merchant.
1835. Steele, Patrick S., merchant.
1836. Slight, James, engineer.
1837. Smith, Jas., of Jordanhill, F.R.SS. L. & E.
1838. Stevenson, David, F.R.S.E., C.E.
„ Seeligmann, F. E., punch-cutter, London.
1839. Smith, David, F.R.S.E., W.S.
„ Spence, John.
1840. Sprot, Thomas, W.S.
„ Stevenson, Peter, philos. instrum. maker.
„ Smith, C. H. J., landscape-gardener.
1841. Steuart, Robert, of Carfin.
„ Simson, George, R.S.A., artist.
„ Steell, John, R.S.A., sculptor.
1842. Spence, Charles, S.S.C.
„ Smail, Will. Arch., of Overmains, R.N.
1843. Sanderson, James H., lapidary.
„ Stewart, Hope James, artist.
1843. Schenck, Frederick, lithographer.
„ Shanks, Thomas, engineer, Johnston.
„ Sligo, John, of Carmyle.
1846. Stuart, Joseph Gordon, Markinch.
„ Swan, Wm., F.R.S.E., teacher of mathes.
„ Simpson, J. Y., M.D., F.R.S.E., Prof. of Midwifery.
„ Spence, James, W.S.
„ Sellar, William, M.D., F.R.C.P., F.R.S.E.
„ Sinclair, William J. J. A., of Freswick.
1847. Steuart, James, W.S.
„ Stevenson, Thomas, F.R.S.E., C.E.
„ Sclanders, Alexander, upholsterer.
1850. Smith, Alexander, C.E., Aberdeen.
„ Swan, Alex., manufacturer, Kirkcaldy.
„ Stewart, James W., C.E.
„ Stark, James, M.D., F.R.C.P., F.R.S.E.
„ Smith, George, architect.
„ Scrymgeour, Henry, upholsterer.
„ Sinclair, Alex., manager Shotts Foundry.
„ Spittal, Robert, M.D., F.R.C.P.
„ Scott, Archibald, architect.
„ Smith, Robert, builder.
„ Sibbald, Thomas, ironmonger.
„ Strachan, Robert, accountant.
„ Smith, George C., land-surveyor, Banff.
1851. Smith, Robert, engineer, governor City Workhouse.
„ Sawers, John, Provost of Stirling.

1822. TWEEDDALE, The Most Noble the Marquis of, K.T., F.R.S.E.
1826. Tod, James, F.R.S.E., W.S., Sec.
1830. Tod, Henry, W.S.
1836. Traill, Thomas Stewart, M.D., F.R.S.E., Professor of Medical Jurisprudence.
1838. Trotter, James, teacher.
1839. Thomson, William T., manager Standard Life Assurance Company.
1840. Trevelyan, Sir Walter C., Bart., F.R.S.E.
„ Turnbull, William, Royal Bank.
„ Thomson, Jas., F.R.S.E., M.R.I.A., C.E.
1842. Taylor, John, cabinetmaker.
1843. Trotter, Charles, upholsterer.
1846. Trevelyan, Arthur, Wallington, Morpeth.
„ Thornton, Robert, locomotive engineer North British Railway.
1850. Tennant, Thomas, founder and engineer, Dalkeith.
1851. Turner, Richard, engineer, Dublin.
„ Tennant, John, St Rollox, Glasgow.
„ Tennant, Charles, St Rollox, Glasgow.

1843. Veitch, John, baker.

1822. WEMYSS and MARCH, The Right Hon. the Earl of, F.R.S.E.
„ Whytock, Richard, merchant.
1836. Wright, Robert, architect.
1838. Wilkie, John, of Foulden.

1838. Wilson, Patrick, architect.
„ Wighton, Alexander G., jeweller.
1840. Wood, William, surgeon.
„ Watson, Henry George, accountant.
„ Wright, Peter, linen-merchant.
„ Walker, William, surgeon.
1843. Wilson, Robert, linen-manufacturer.
1844. Wyllie, Henry J., C.E.
„ Wightman, William, contractor.
1845. Wilson, G., M.D., lecturer on chemistry.
„ Wilson, Daniel, F.S.A. Scot.
1846. Whitelaw, James, watchmaker.
1846. Wilson, Hutton, W.S.
1848. Wood, Rev. James George, Aberdeen.
1850. Wright, George, jun., merchant, Leith.
„ Webster, Andrew, S.S.C.
„ Walker, John, M.D., London.
„ Winton, John G., engineer, Newhaven.
1851. Willet, John, C.E., Aberdeen Railway.

1847. Young, Archibald, cutler.
1848. Young, William D., ironmonger.
1850. Young, Rev. John, M.A., Haggs, Denny.

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HONORARY FELLOWS

AS AT 1st NOVEMBER 1851.

1822. Aikin, Arthur, F.L.S., F.G.S., London.
1828. Airy, G. B., astronomer royal, Greenwich.
1830. AUSTRIA, His Imperial Highness The Archduke JOHN of.
„ AUSTRIA, His Imperial Highness The Archduke Maximilian of.
„ Amici, Geo. Batt. astronomer to Grand Duke of Tuscany, Florence.
1832. Abraham, J. H., Sheffield.
1834. Arago, M., sec. perp. de l'Institut de France.
1841. ALBERT, Field Marshal H. R. H. Prince.

1822. Barlow, Peter, F.R.S.
„ Babbage, Sir Chas., K.H., F.R.SS. L. & E.
„ Betancourt, M., St Petersburg.
1829. Beaufort, Sir Francis, R.N., F.R.S., Admiralty.
„ Brown, Robert, F.R.SS. L. & E., Linnean Society, London.
1835. Beaufoy, Henry, F.R.S.
1846. Bain, Alex., Pat. of Elect. Mag. Telegraph and Clock.

1822. Christian, Professor, Paris.
1826. Colby, General, R.E. F.R.SS. L. & E.
1829. Children, J. G., F.R.S., British Museum.

1822. DUPIN, M. le Baron, F.R.S.E., Paris.
1829. Dollond, George, F.R.S., London.
1843. Dadian, Ohanes, Dir. of Powder Works, Turkey.
1844. DUNDONALD, Vice-Admiral, Right Hon. THOMAS, Earl of.
1846. Dumas, Professor H., memb. de l'Institut de France.

1822. EICHTHAL, Baron Von, Munich.
„ Ermann, M., Berlin.
1840. Encke, Professor, Berlin.
1848. EDHEM BEY, His Excellency, Minister of Pub. Inst. to the Viceroy of Egypt.

1822. Farey, John, junior, C.E., London.
1829. Faraday, Michael, F.R.SS. L. & E. London.
1830. Fuss, P. Z., perp. sec. Imp. Academy of Sciences, St Petersburg.
1840. Fairbairn, William, engineer, Manchester.

1829. Goring, Dr C. R., London.
1830. Gauss, Professor, Göttingen.
1840. Graham, W. A., London.
1846. Grove, W. R. M.A., F.R.S., London.

1822. Herschel, Sir J. F., Bart., K.H., F.R.SS. L. & E.
1829. Hamilton, Rev. Archdeacon, H. P., F.R.S., Trinity College, Dublin.
„ Hamilton, Professor, Sir Wm. R., F.R.S., astronomer royal, Dublin.

1829. Hancock, Dr, America.
1830. HUMBOLDT, Baron Alexander, F.R.S.E.
1832. Harcourt, The Rev. W. Vernon, York.
1840. Hodgkinson, Eaton, Prof. F.R.S., F.G.S., M.R.I.A., &c., University College, London.

1840. Jacobi, Professor, St Petersburg.

1831. Kupffer, Professor, St Petersburg.

1826. Lardner, Rev. Dionysius, LL.D., F.R.S.E.
„ Lyell, Sir Charles, F.G.S.
1846. LIEBIG, Baron Justus, Giessen.

1829. Mather, James, South Shields.
1830. Mitscherlich, Professor, F.R.S.E., Berlin.
1835. Morton, Thomas, Kilmarnock.
1840. Mallet, Robert, M.R.S.A., C.E., Dublin.
1846. Mulder, Dr G. T., Prof. of Chemistry, Utrecht.
1849. Maxton, John, super. eng. to Viceroy of Egypt.

1827. Oldham, John, C.E., Bank of England.

1827. Parry, Captain Sir Edward, R.N.
„ Powell, Rev. Baden, F.R.S., Savilian Professor of Geometry, Oxford.
1832. Phillips, Professor John, York.
1834. Payen, M., Memb. Soc. d'Encouragement pour l'Industrie Nationale, Paris.
1842. Poullet, M., Memb. de l'Academie des Sciences de l'Institut, Professor de Physique au Conservatoire des Arts et Metiers, Paris.
1843. Pasley, General Sir Charles W., C.B., R.E., F.R.S.

1828. ROSSE, Right Hon. The Earl of, Pres. Royal Society.

1829. Robinson, Rev. T. R., D.D., F.R.S. Observatory, Armagh.
„ Roget, Dr Peter Mark, Sec. R.S., London.
1830. Repsold, M., Hamburgh.
1840. Rennie, Sir John, C.E., London.
„ Roberts, Richard, engineer, Manchester.
1845. RUSSELL, Right Hon. Lord JOHN, M.P.

1827. Scoresby, Rev. Dr W., F.R.S.E.
1829. Sabine, Col. Edward, F.R.S., London.
„ Scrope, George Paulett, F.R.S.
1830. Sedgewick, Adam, M.A., F.R.S., Woodwardian Professor of Geology, Cambridge.
1840. Smith, F. P., London.
1842. SEGUIER, M. le Baron, Memb. Soc. d'Encouragement pour l'Industrie Nationale, Paris.
1843. Sang, Edward, C.E., Constantinople.
1846. Schoenbein, Professor C. F., Basle.
„ Steinheil, Professor, Munich.

1832. Taylor, Rev. William, F.R.S., London.
1842. THENARD, M. le Baron, Memb. Soc. d'Encouragement pour l'Industrie Nationale, Paris.

1830. Utzschneider, M., Benedictbaiern, Munich.

1840. Vignoles, Charles, M.I.C.E., F.R.A.S., M.R.I.A., C.E., London.

1828. Whewell, Rev. W., D.D., Master of Trinity College, Cambridge.
1837. Whitworth, Joseph, engineer, Manchester.
1840. Wilson, General, St Petersburg.
„ Walker, James, Pres. Inst. C.E., C.E., London.
„ Williams, C. W., Liverpool.

ASSOCIATES

AS AT 1st NOVEMBER 1851.

1826. Anderson, George, Inverness.
„ Adam Matthew, A.M., Parkhouse, Ayr.

1826. Brodie, Rev. James, Monimail.

1826. Carlisle, Alexander, Paisley.
1827. Colquhoun, Dr Hugh, Glasgow.
„ Clark, Thomas, Glasgow.

1826. Dunbar, Rev. William, D.D., Applegarth.
1829. Dodds, George, superintendent of Monkland, Kirkintilloch, and Ballochney Railway, Airdrie.
„ Dunlop, Mr, astronomer, Paramatta.

1846. Eiffe, John S., F.R.A.S., chronometer maker, London.

1826. Fleming, Rev. Prof., D.D., New College, Edinburgh.
1829. Forrest, Mr, gunsmith, Jedburgh.

1826. Haidinger, William, F.R.S.E., Vienna.
„ Hart, John, C.E., Glasgow.

1826. Joseph, Samuel, sculptor, London.
„ Jameson, Rev. A., St Mungo, Lockerby.
1828. Johnston, Professor James F. W., A.M., F.R.SS. L. & E., Durham.

1826. Lachlan, Captain, 17th Regiment.
1832. Leith, Samuel, lithographer, Edinburgh.

1826. Milne, Rev. Andrew, D.D., Dollar.
„ Maclaren, James, C.E.
„ Macvicar, Rev. John, Ceylon.
„ Murdoch, Mr, Huntly Lodge.
„ Murray, John, M.D., F.L.S., lecturer on chemistry, Edinburgh.
„ Memes, Rev. Dr, Hamilton.
1839. Milne, Captain Alexander, R.N.
1850. Mitchell, Rev. Graham, LL.D., Whitburn.

1826. Nasmyth, James, engineer, Patricroft, Manchester.
„ Nasmyth, George, engineer, London.

1831. Potter, Professor R., University College, London.
1832. Paterson, And., lathe-maker, Edinburgh.

1826. Smith, John, Darnick.

1846. Vulliamy, Benjamin S., F.R.A.S., &c., clockmaker to the Queen, London.

1829. Williamson, James, Melrose.

The following Ordinary Fellows, included in the foregoing List, are ordered to remain, till they return to Scotland, in the following

SUSPENSE LIST.

William Cooper, glass-manufacturer, late of Picardy Place, Edinburgh, and now in America.
Joseph M. Kronheim, ornamental designer, London.
Edward Sang, civil-engineer, Constantinople.
Lieut.-Col. Blanshard, R.E., Mauritius.
George Buist, LL.D., Bombay.
Mungo Ponton, F.R.S.E., 11 Lansdowne Place, Clifton.
P. B. Ainslie, Chertsey, England.
F. E. Seeligmann, punch-cutter, London.

APPENDIX (F.)

Proceedings of the Royal Scottish Society of Arts, Session 1851–2.

The Annual General Meeting of the Society was held in the Hall, 54 George Street, on Monday, 10th November 1851, —Thomas Grainger, Esq., F.R.S.E., President, in the Chair.

The following Communications were made :—

1. The President delivered the following address :—

Gentlemen,—I beg to express the gratification which I experience in again meeting you at the commencement of another (being the thirty-first) session of this Society, and I have also the pleasure again to congratulate you on the continued prosperity of the Society. The papers read during the last session were numerous, and many of them highly interesting and important, and such as would have been cordially received in any similar association in the kingdom. The papers for which premiums have been awarded, and a list of which will be read this evening, will shew the importance attached by the Council to the various subjects brought under our notice during the last session. I have also to congratulate you on the state of the Society's finances, which are in a more satisfactory condition than at any former period. They have been increased by the legacy of £200, bequeathed by the late Mr William Auld, under the title of the "Reid and Auld Bequest," and which has now been paid to the Society. The terms of this bequest are, that the annual interest is to be given in one, two, or three prizes, to masters or journeymen clock and watch makers, for the best model of anything new in that art or line of business; and if no model is invented in the course of any year, or one so trifling as to be unworthy of attention, then the produce of the bequest for that year to be paid by the Society in charity to such of the poor of the trade residing in and within ten miles of Edinburgh as the treasurer of the Society, in his discretion, shall select. While I have to congratulate the Society on a considerable increase of its members since the commencement of last session, we have to lament the decease of the following Ordinary Fellows :—The Right Hon. Lord Vis-count Melville, Sir Henry Jardine, Dr Patrick Neill, Mr J. H. Tasker, C E., Mr Grant S. Dalrymple, C.E., Henry Marshall, Esq., M.D., Mr William Grierson Yorston of Garroch, and Mr James Greig, W.S. Also of the following Honorary Members :—Mr M. Schumacher, astronomer, Altona ; Mr J. J. Audubon ; and Mr George Stephenson, C.E. The late Dr Neill was well known to you and to the citizens of Edinburgh generally. He attended pretty regularly the meetings of this Society, and during a long and useful life he devoted much of his time and attention to the promotion of the arts and other kindred objects. Botanical science was, however, his favourite pursuit, and to this he applied himself with much enthusiasm. Mr J. H. Tasker was a native of Greenock, and had been trained to the profession of a civil engineer under Mr Locke ; and, for his years, he had acquired a high reputation in his profession. He had but recently joined our Society, when his sudden decease caused the deepest grief among all who, like myself, had the pleasure of his acquaintance. I feel called on to make honourable mention of my late friend Dr Henry Marshall, who also took a deep interest in our proceedings, and frequently attended our meetings, and whose valuable researches connected with the statistics of the army are well known. He will unquestionably be regarded as the father and founder of Military Medical Statistics, and their varied application. The only other name to which I shall allude more particularly is that of Mr George Stephenson, the eminent civil engineer, whose death I neglected to notice at the opening of last session, who, by his great natural abilities, ingenuity, and application, raised himself from a very humble station in life to the highest eminence in his profession. His name was more generally connected with the construction of railways and locomotive engines. But having been in early life connected with the coal-mines in the north of England, he was then brought into notice by his researches on the subject of the safety-lamp for the use of miners, and contests with Sir Humphry Davy the merit of that most valuable invention. The all-absorbing subject of general interest during the vacation, as connected with the arts and manufactures, has been the Great Exhibition of the Works of Industry of All Nations. In adverting to the Exhibition at the opening of last session, I stated that by it the means of comparison in the different branches of the arts and manufactures would be afforded to " an extent which no age or country had as yet presented, and such as would prove of universal advantage in the relations of manufactures, commerce, and the social interests of society. It is believed that foreigners will contribute largely, and I hope that the articles sent from this side of the Tweed, and for the manufacture of which Scotland is celebrated, will bear a favourable comparison with any that may be exhibited." All these anticipations—sanguine as they may have appeared at the time—have been more than realised. This Exhibition will ever be regarded by all as highly honourable to our country, in the history of which the year 1851 will be ever memorable. From the manner in which this magnificent enterprise has been supported by foreigners of all parts of the world, and the satisfactory way in which the details were carried out, the result cannot fail to be highly gratifying to our countrymen generally, but more especially to His Royal Highness Prince Albert, by whom the design was first conceived, and under whose auspices it was brought to so favourable a close. I hope that all of you had an opportunity of inspecting it personally, and that some of you are prepared to favour the Society with papers on some of the more important articles exhibited. I avail myself of this opportunity—the last which I shall have as your President—to call your attention to a subject of the very highest importance, to the agricultural as well as to the manufacturing and commercial interests of the country. I refer to the cultivation and preparation of flax—the raw material of one of the staple manufactures of the United Kingdom. The subject is one which has recently engaged much attention in Ireland, and also to a considerable extent in England, but more especially in districts where the linen trade is extensively carried on; and although it has not been altogether overlooked in Scotland, it has not hitherto received the attention which, I think, its importance demands—the soil and climate of which are admitted to be admirably adapted to its cultivation. I cannot conceive any object which better deserves the consideration of such a Society as this than the collecting and diffusing of correct information regarding the cultivation and preparation of so important a material as flax, and I therefore take the liberty of earnestly pressing the subject on the attention of my successor in this chair, and of the members generally. Its importance to the agriculturist consists in its being (under proper management) much more remunerative than any cereal crop whatever; and it is by no means so exhaustive to the soil as is generally supposed. And even were it otherwise, the means of supplying artificial manures are now so various that the fertility of the soil can easily be restored. In an excellent letter recently addressed to the Prime Minister on the cultivation of flax in the Highlands, by Mr Alexander M'Ewan of Sunderland, in the island of Islay, he says:—"Impressed with the idea that the soil and climate of the Highlands and Islands of Scotland were admirably adapted to the growth of flax, I submitted in the early part of this year a proposal to two of my principal tenants to join with me in making an experiment on a large scale, for the double purpose of obtaining a remunerative crop, and of giving employment to the people. So far our success has been complete. We have now growing on the estate of Sunderland, in the island of Islay, 120 acres of flax, which, I believe, with very little exception, will scarcely be surpassed." "Almighty wisdom has ordained that each soil and climate has crops peculiarly adapted to it. The south of England may grow better wheat than the Highlands of Scotland; but I am satisfied the latter, from its humidity, will grow better flax than the former. The agricultural money value of an acre of well-cultivated flax is equal to that of wheat, but the commercial and manufacturing value of flax is infinitely greater. The subsequent process to which it may be subjected, the vast amount of labour it creates, and the enhanced value it may realise before it reaches the consumer, are especially important to a country seeking employment for its people. I am convinced the day is not far distant when a flax-growing farm will be accounted as valuable as a wheat-growing farm. The introduction of flax cultivation is not only a valuable crop, as suited to the soil and climate of the Highlands, but it is peculiarly adapted to the present state of the Highland population; it would at once absorb the whole unemployed labour of men, women, and children; it is not too much to anticipate that the splendid waterfalls would be made available for the erection of flax-spinning factories, and a new era would dawn on the Highlands; the great desideratum that has hitherto existed would be supplied; the combination of commercial and manufacturing enterprise with agricultural industry spreading plenty and contentment among our romantic glens and villages, and elevating the people in the social scale." In an admirable pamphlet recently published by Mr Robert Brown of Hamilton, and to which I beg to refer such of you as wish to obtain information on the subject, he states,—" The small tenants' possessions in the Highlands are, from locality, soil, climate, and facilities for manuring, admirably adapted for the cultivation of flax; and, considering the great abundance of labour to be had at a cheap rate, are possessed of capabilities for that purpose which, perhaps, no other part of the United Kingdom can present." These observations, it will be seen, are referable to the Highlands and Islands, but they apply with equal force to other parts of Scotland, the climate and soil of which are in many respects more suitable for cultivation of flax than those of many of the countries from whence we obtain our chief supplies. I might also enlarge on the importance of this subject to the agricultural labourer, but the only other testimony which I shall at present particularise is the following:—" The condition of the inhabitants of the village of Trimmingham," says Mr Warnes, "was a few years since most deplorable, and the amount of pauperism exceeded that of the adjoining parishes. Since the introduction of flax culture, this state of things has passed away. There is not a pauper in the parish; the poor-rates are nominal; there is not one able-bodied labourer, or any portion of his family, who may not obtain constant employment throughout the whole of the year, and the moral and social state of the village will bear comparison with most. If the growth of flax can produce results elsewhere similar to those which I have witnessed at Trimmingham, there can be no doubt that the sooner it is cultivated to a greater extent in this country, the sooner will the enormous burden of pauperism decrease, and happiness and contentment be more generally diffused among the large masses of our labouring population." It is much to be regretted that, instead of promoting and lending its fostering care to the cultivation of flax in Scotland, the present Government have resorted to the miserable *make-shift* of *expatriating* the people of the West Highlands. The voice of this Society and of the country ought to be loudly raised against a proceeding so unworthy of a great nation. It has been rather fashionable of late to charge the Highlanders with indolence and reluctance to labour; but, from my own observation and experience of them, and the testimony of others well qualified to judge, I consider them to be by no means wanting in industry whenever they have an opportunity of exerting it. Their present state of destitution is their misfortune, not their fault. The time is not long past when our army was recruited and our navy manned, to no inconsiderable extent, by our brave Highlanders; and the time may come—though I hope it is very distant—when similar supplies may be again required. I regard the *expatriation* of our Highland population as an act discreditable to the Government, and one which they may yet deeply regret. I agree with the poet who says—

> "Princes and lords may flourish or may fade,
> A breath can make them, as a breath *has made;*
> But a *bold peasantry*—a country's pride—
> When *once destroyed*—can never be supplied."

One of the last acts of the last session of Parliament was to authorise a loan by Government for the purpose of *draining* the population;—let the money be given in instructing and otherwise assisting the Highland population in the cultivation of flax, and I am satisfied that it will be attended with happy results. It may be thought that this subject might more properly engage the attention of our agricultural societies; but from the bearing which it has on an important branch of manufacture, I hope that my having noticed it here will not be considered much out of place. Its importance will be apparent when it is considered that our linen and other manufactures in which flax is employed are all but completely dependent upon foreign countries for their supply, and of the 100,000 tons now annually consumed, not more than one-fourth is produced in this country. The total value of the flax fibre imported for manufacturing into linen, sail-cloths, tarpaulings, rick-covers, sacking, and other materials, exceeds £5,000,000 annually; and there is no doubt, judging from the rapid progress of our linen manufactures, that if the supply of the raw material could be more readily obtained at home, the consumption would be increased to a still greater extent. The progress of the linen trade, in consequence of the great improvements which have been made in machinery, has, within the last twenty years, been almost unparalleled. The exports of linen have increased since that time from 50,000,000 to 105,000,000 of yards, and its declared value from £1,700,000 to upwards of £3,000,000. No attempt whatever has been made on the part of our agriculturists to meet this enormous and rapid increase in the demand for the raw material; and, as a consequence, the foreign producer has been reaping a golden harvest from the monopoly which he possesses. The imports of foreign flax have increased from 936,000 cwt. in 1831, to 1,800,300 cwt. in 1842. The value of the increased imports being not less than two millions and a half, nearly the whole of which is paid for by money sent of the country. We also import large quantities of hemp, which might, like flax, be easily and profitably grown at home. The value of the hemp annually imported is about £1,500,000. We have thus a demand existing for flax and hemp, and for the supply of which we are dependent upon foreign countries, as shewn in round numbers, by the following figures:—

Flax fibre . . .	£5,000,000
Seed for crushing . . .	1,800,000
Seed for sowing . . .	200,000
Oil-cake	600,000
Hemp	1,500,000
	£9,100,000

Hitherto my observations have been confined to the subject of flax, as used in linen and other manufactures exclusively; but we cannot shut our eyes to the enormous demand likely to arise from the recent discovery of a method by which flax may be adapted to cotton and woollen machinery.

A thousand tons of cotton are daily consumed in our cotton manufactures, and the result of recent experiments has been such as to shew that flax may be substituted for at least one-half of this amount. In order, therefore, to supply the new demand for a new material thus created, the produce of two thousand acres will be required for each day, and the whole of the flax grown in the United Kingdom does not amount to more than one-seventh of the supply required for Manchester alone. It is a duty imperative on the agriculturists of the country to endeavour to meet this enormous demand, and not to allow it to pass into the hands of foreign countries, which will undoubtedly be the case if they do not immediately exert themselves in this respect. But besides this, there will also be required an increased supply of flax available for the purpose of spinning in combination with wool upon the existing wool machinery. My friend, Mr Richard Whytock, has kindly sent me a specimen of cloth made from a mixed material of flax and cotton; also a sample of yarn, a mixture of flax, prepared as cotton, with wool; also a sample of flax prepared as cotton by Chevalier Clausen's patent. The three specimens are exhibited. I have probably treated this subject at too great length, but it is by no means exhausted; and its importance is such that I may resume it during the present session, if I cannot induce some member more conversant with its details to undertake it. In my last address I referred to the want of a Museum for models and drawings, as militating to a great extent against the further prosperity of the Society; and although the subject has engaged the attention of the Council, I regret that no satisfactory progress has been made in remedying the defect. It has, however, occurred to some of us that in no way could some such sum as £10,000 of the surplus funds of the Industrial Exhibition be better applied than in providing this accommodation, under arrangements to afford at hours convenient to workmen the freest access for inspection, and making copies. Permit me to renew my testimony to the value of the services of Mr Tod, our indefatigable secretary, and of Mr Scott Moncrieff, our treasurer, and of the members of Council, collectively and individually, and to you and the other members for your regular attendance here, and for the general support I have experienced since you did me the honour to elect me your President. On taking the chair on that occasion, I stated, with reference to the supply of papers, which I beg leave to repeat now—" That while I shall rejoice to find our senior fellows contributing papers from the rich and invaluable stores of their practical knowledge, it is to the junior members, more especially, that I look for those contributions to which I have alluded. I make this demand on them with every confidence of success, the more so when I consider that the preparation of such papers will not only tend very materially to improve their professional knowledge, but the consideration of them here will lead to intercourse with professional friends that may prove highly beneficial in their future career in life. While I cordially assent to the truth of the oft-repeated observation that 'Genius is that gift of God which learning cannot confer, and which no disadvantages of birth and education can obscure;' yet I know full well that many gentlemen who have distinguished themselves in mechanical and other pursuits for the advancement of the useful arts and manufactures,—who have enjoyed, and some of whom, I rejoice to say, do now enjoy, the fruits of their discoveries, and others a fair share of the fame and emoluments which attend on a successful professional career,—can trace to such contributions the germ of—or the first step in the ladder by which they attained—their present position in society. I am aware that the opinion is entertained by many that the ages of discovery are past and gone, and that there does not now exist the same scope for the exercise of mechanical skill and ingenuity as was enjoyed by our forefathers. This appears to me to be a mistaken view of the subject, and is, besides, most mischievous, from its tendency to damp the ardour of those who are engaged in mechanical and scientific inventions. Every one who knows anything of the history of the arts will readily admit that scientific mechanical skill can accomplish many things in the present day which even intelligent men of the past generation would have derided as chimerical. This ought to prove a great encouragement to the ingenious mechanic to persevere in his researches in whatever branch of science he may be engaged." The greatest of Britain's sons are of the people, and if they rise, they owe their elevation to the assiduous cultivation of their own minds, and the useful industry of their own hands. It has been said that

> " There's nothing of honour, or wisdom, or worth,
> But hard-fisted labour has been at its birth."

Permit me, in conclusion, to assure you, that though about to vacate this chair, it will give me the greatest pleasure to continue to take an interest in this Society, and be assured that I shall at all times be ready to promote its welfare. I hope also to be able occasionally to contribute a paper on some subject of general interest.

2. An Oral Communication on the Application of Wind to the Raising of Water, for the purposes of irrigation in the Colonies, was given by Professor C. Piazzi Smyth, F.R.S.E. The thanks of the Society were moved by Mr Buchanan, C.E., and given to Professor Smyth, from the chair.

The following Report of the Prize Committee, awarding the Prizes for Session 1850-51, was read, and the Prizes were delivered by the President to the successful candidates, viz. :—

Your Committee having met, and carefully considered the various Communications laid before the Society during Session 1850-51, beg leave to report that they have awarded the following Prizes :—

1. To James Leslie, Esq., F.R.S.S.A., civil engineer, Edinburgh—for his " Description, with working model and drawings, of an Inclined Plane for conveying Boats from one level to another on the Monkland Canal, at Blackhill, near Glasgow, constructed from his design in 1850." Read and exhibited 28th April 1851, and printed in the Transactions. The Society's Silver Medal, and Plate, value Fifteen Sovereigns.

2. To Thomas C. Gregory, Esq., F.R.S.S.A., civil engineer, Edinburgh—for his " Description and drawings of an Improved Self-acting Apparatus for disconnecting the Carriages of a Railway Train from the Tender, upon the Engine leaving the Rails." Read and exhibited 27th

January 1851; and printed in the Transactions. The Society's Silver Medal, and Plate, value Ten Sovereigns.

3. To Mr William R. Douglas, millwright and engineer, Leith—for his "Description and model of an Improved Retort, for the Manufacture of Prussiate of Potash." Read and exhibited 24th February 1851. The Society's Silver Medal, value Five Sovereigns.

4. To Mr John Steven, St Leonard's Station, North British Railway, Edinburgh—for his "Description, with working model, of a Railway Signal, constructed on a new principle, and intended to be useful in the prevention of Accidents, by shewing the precise time at which a previous train had passed the point where it is erected." Read and exhibited 24th March 1851. The Society's Silver Medal, value Three Sovereigns.

5. To Mr William Procter, tinsmith, Forfar—for his "Description, with a working model and drawings, of an Oscillating Steam-Engine," capable of being easily reversed. Read and exhibited 9th December 1850. The Society's Silver Medal, value Three Sovereigns. *Note.*—The Prize is given for the Stop-Cock and mode of Reversing, and is recommended by the Committee only for steam-engines of ten-horse power, and under.

6. To William Swan, Esq., F.R.S.E., F.R.S.S.A., teacher of mathematics, Edinburgh—for his "Formulæ for constructing Mr Thomas Stevenson's Totally Reflecting Hemispherical Mirrors." Read 25th November 1850; and printed in the Transactions. The Society's Silver Medal.

The Committee recommend, that while the thanks of the Society are justly due to all those gentlemen who have sent communications, the special thanks of the Society be given to the following gentlemen, viz.:—

1. To Thomas Grainger, Esq., F.R.S.E., Memb. Inst. C.E., Pres. R.S.S.A.—for his "Description, with drawings, of the Drainage of Haarlem Meer by means of Steam Power, with some account of other Engineering Works therewith connected." With illustrative model of the System of Pumps. Read and exhibited 9th December 1850, 13th January and 28th April 1851; and printed in the Transactions.

2. To Lieut.-Colonel H. Jones, R.E.—for his oral "Account of the Proceedings and Operations of the Commissioners appointed for the Improvement of the Navigation of the River Shannon." Given on 10th March 1851.

3. To Andrew Fyfe, M.D., F.R.S.E., F.R.S.S.A., Professor of Chemistry, King's College, Aberdeen—for his oral "Remarks on the Modes of ascertaining the Illuminating Power of Coal-Gas, with Tabular Views of the Results of his Experiments." Given on 14th April 1851.

4. To George Buchanan, Esq., F.R.S.E., F.R.S.S.A., civil engineer, Edinburgh—for his "Account of the Great Chimney of the Edinburgh Gas-Works, with observations on the principles of its strength and stability." Read 11th and 25th November 1850.

5. To M. Taylor, Esq., engineer for the Edinburgh Gas-Works—for his "Detailed Description, with Drawings, of the Great Chimney of the Edinburgh Gas-Works." Read and exhibited 5th November 1850.

6. To William Alexander, Esq., F.R.S.S.A., mining engineer, Glasgow—for his Paper "On Colliery Engineering in Scotland;" with illustrative Drawings. Read and exhibited 10th February 1851.

7. To William Campbell, Esq., F.R.S.S.A., civil engineer, Edinburgh—for his Paper "On the Improvements on the River Clyde during the past Hundred Years." Illustrated by Maps and Plans. Read and exhibited 10th February and 10th March 1851; and printed in the Transactions.

8. To John Cameron, Esq., civil engineer, Edinburgh—for his description, with drawings, of "The Lugar Valley Viaduct, on the line of the Glasgow and South-Western Railway, erected from the design of John Miller, Esq., C.E." Read and exhibited 24th February 1851; and printed in the Transactions.

Your Committee recommend that Mr Kennard's Paper on Cast-Iron Sleepers should be remitted to a Committee to report upon it, and that the Paper and Report should be brought up to next Prize Committee.

The Committee have further granted for the purchase of Models, Drawings, &c., illustrative of Papers read during the Session, the sum of Seventeen Pounds.

All which is humbly reported by

James Tod, *Sec., Convener ex officio.*

Edinburgh, 21st October 1851.

The Models, Drawings, &c., of Inventions, &c., for which Prizes, &c., have been awarded, were exhibited.

The Minutes of last Meeting were read and approved of, after which the following Candidates were elected Ordinary Fellows, viz.:—

1. James Duncan, M.A., Principal of the Diocesan School, Prospect Place, Southampton.
2. Henry Cadell, mining engineer, Dalkeith.
3. William Anderson, Professor of French, Andersonian University, Glasgow.
4. Sir A. Gibson-Maitland, Bart., of Cliftonhall.

In terms of Law XV., the Society elected its Office-Bearers for 1851-52, viz.:—

George Lees, LL.D., *President.*
William Paterson, Esq., C.E., } *Vice-Presidents.*
T. Stevenson, Esq., F.R.S.E., C.E., }
James Tod, Esq., F.R.S.E., W.S., 55 Great King Street, *Secretary.*
John Scott Moncrieff, Esq., Accountant, 15 India Street, *Treasurer.*

Ordinary Councillors.

John Cay, Esq., F.R.S.E.
David Rhind, Esq., F.R.S.E.
D. Wilson, LL.D., F.S.A. Scot.
Patrick Wilson, Esq.
Douglas Maclagan, M.D., F.R.S.E.
Rev. Prof. Kelland, F.R.SS. L.&E.
James Dalmahoy, Esq., F.R.S.E.
Thomas Grainger, Esq., F.R.S.E.
Richard Whytock, Esq.
Alexander Rose, Esq.
James Leslie, Esq.
Alex. K. Johnston, Esq., F.R.S.E.

George Wilson, M.D., F.R.S.E., *Editor of Transactions.*
Mr Alexander Jamieson, *Curator of Museum.*
Mr Alexander Kirkwood, *Medallist.*
Mr Hugh Johnston, *Officer and Collector.*

The Society then adjourned.

24*th November* 1851.—George Lees, LL.D., President, in the Chair. The following inaugural address was delivered by the President:—

In taking this chair, Gentlemen, to which I have been called,—more, I am aware, through your kindness than through any claims or merits of my own,—I would tender you, in the first place, my warmest acknowledgments for the honour you have conferred upon me. Though from the duties of an arduous profession I have been able to take a less active part in the business of this Society than I could have desired, yet I shall perhaps protect myself from blame on this score when I remind you, that, in another place I may have been in some measure instrumental in diffusing a taste for those very studies which, in their practical bearing, it is the professed object of this Society to encourage. In this way, then, while I would seek to shelter myself from everything like a charge of indifference as to the progress of the Arts, as manifested by my appearance, or rather my non-appearance, in this place, I would at the same time offer to this Society something in the form of an apology for those kind friends in the Council who were the first to think of me in connection with the high office in which I now stand as President of the Royal Scottish Society of Arts. Though I may be allowed to know something of the theory of those matters which come more generally before this Society in a practical form, I am yet, I fear greatly wanting in familiarity with those varied adaptations which mark so distinctively the progress of mechanical art in our day. And if in this point I feel misgivings as to my own capabilities to discharge aright the duties of this chair, these, I can assure you, I feel all the more that I am called upon to succeed a gentleman not only familiar with theory, but familiar also with the great practical bearings of theory upon the arts of social life. In Mr Grainger we have certainly had a most effective President, always at his post, always ready to take an active part in the general business of the meetings, and one who has been eminently successful, by his kindly tact, in infusing much fresh life and blood among the members of the Society. For my own sake, I could have desired that the transition from my predecessor to myself had been less rapid, or less marked than it must necessarily be; however, as it is the custom to alternate between a *professional man* and an *amateur*, in the latter capacity I venture to present myself before you; in this capacity I venture to proceed, believing that I may always reckon upon your kind indulgence and support in conducting the business which may come before us. There is yet, I regret to say, a sad want of mathematical and physical knowledge among working men generally. No doubt there are many bright exceptions; still, looking to the masses in our large towns, it may be safely said that all that has yet been done is but as a drop in the bucket in comparison of what would be required. Nor will it ever be better, we fear, until the Government of the country fairly takes the education of the people into its own hands. To our practical men, who are daily engaged in their various avocations, and who have thus the best opportunities of marking the deficiencies of our physical agency, we are especially to look for those improvements and inventions which are yet to distinguish the onward march of this great country. The laws of nature are not like those of men, which may be and are often broken. They suffer no violation; they neither bend nor break; they act constantly,—everywhere and always in the same manner. By adapting our arrangements to these we may succeed; by acting otherwise we shall most certainly fail. Suffice it here to say, that whether the mechanician deals with matter in the *solid*, the *liquid*, or the *æriform* state, he must accommodate his arrangements and adaptations to the laws of nature which govern matter in these states, else he will inevitably fail. Hence, on the one hand, the grievous waste of time, and mind, and means, leading to nothing but vexatious disappointment; and on the other, these beautiful triumphs of human skill, which have added so greatly to human power, and so immensely to human enjoyment. Not to weary you by instances, look, for example, to the sextant of Hadley, in which we have the light of a star so ingeniously reflected as to indicate the true position of a ship, tossing and tumbling it may be, in the midst of a storm. Look to the steam-engine in its various forms, and to its achievements in our day. Look to it with its ten thousand wheels in the factory, multiplying and extending our comforts, raising the standard of our physical enjoyments, and giving, as it were, a great lift to the whole moral fabric of society. Look to it in the noble vessel facing and fighting the winds and the waves. Look to it in the railroad, transporting us, in easy chairs, with the velocity of the tempest, to wherever our business or pleasure may lead. Look to the electric telegraph, now piercing the very ocean itself, and transmitting human thoughts, as it were, in a flash of lightning. Somehow our natural insensibilities are rendered more insensible by the familiarities of experience. These things are continually before our eyes; we seldom think of them in comparison with their importance; they are prodigious results; they are the results of the physical arts,—of these very arts which we seek in this Institution to encourage, to extend, and improve. There is something exceedingly interesting in tracing the history of the physical arts. Think of the distaff with its one thread; of the spinning-wheel with its two threads; and the spinning frame with its thousands of threads; of the common loom with its one shuttle, and of the power-loom with its hundreds of shuttles. Or, to take but one other example, look to the steam-engine in its origin as little else than a toy in the hands of a Greek. Mark its progress in the hands of Worcester, of Savary, of Newcomen, and others, and finally, in the hands of the illustrious Watt. See the toy becoming, by successive changes, additions, and improvements, that mighty engine which has made our happy country, our sea-girt island, at once the most powerful and the most prosperous in the world. What a little speck this little island, which we proudly call Great Britain, is, and yet how 'Britannia rules the waves."

> "Britannia needs no bulwarks,
> No towers along the steep;
> Her march is o'er the mountain wave,
> Her home is on the deep."

We hear a good deal, in these days, of the moral power of our country We have no doubt it is great. We cannot help thinking, however, that it is all the greater, and all the more likely to command respect, more especially in those quarters where its ameliorating influences are most needed, that it is well backed by physical power. We have no wish to see this called into exercise. Still, there can be no doubt that its existence is a terror to evil doers. Let us hope and trust that, more than ever, it will be a praise and protection to all that do well. In bringing these remarks to a close, I would take this opportunity of adverting to a point of no small importance in the progress of the arts. This, which was well put by my predecessor at our last meeting, has reference to the idea which some people entertain, that the arts are now so perfect,—so complete in all departments,—that there is now little or no room for farther improvement. Now, while we have no fear that any one likely to advance the arts, either by improvement or invention, could ever entertain such a notion, we would pronounce the idea itself to be utterly absurd. Perfect! Imperfection, alas, cleaves to all human achievements. They may differ in degree; but all fall infinitely short of perfection. The works of God are all perfect; they are consequently incapable of improvement. They exist now as they did at their first creation. The human frame, with its bones, its joints, its muscles, its arteries, its veins, and organs of sense, is not more perfect now than when God said "Let us make man in our own image." The eye is alike adapted to the nature of light, and performs the same functions now as when Adam first looked upon the glories of the material creation. And what a beautiful piece of mechanism we have in this wonderful organ. Is it directed to a landscape,—there it is on that little screen, in hill and dale, cottage and castle, roads and rivers, woods and wilds, with all their living, and moving, and breathing objects in faithful miniature. Is it directed to the heavens,—there in mimic grandeur is the grandeur,—the awful, the sublime, and mysterious grandeur of the sparkling conclave; its moon and planets, its suns and stars, and systems innumerable, twinkling in the boundless infinitudes of space. What a wonderful optical instrument this! How perfect its adaptation to the nature of light, and to the great ends it was intended to serve in revealing to man the wonders of the outer world! Birds, in like manner, build their nests now, and charm us with their melody now, as did those that first fluttered and sung among the groves of Paradise. The bee constructs her hexagonal cell as well, but not better now, than did the first bee that buzzed and sipped the honey from the summer flower. There is this great distinction, too, to be noticed,—that the more closely the works of nature are examined, the more their perfection appears; while, on the contrary, the more closely we examine those of man, the more their imperfections are disclosed. Let no such idea as this, then, which we have been endeavouring to combat, ever damp the ardour of the ingenious mechanic. There is room, plenty of room, for farther improvements and farther inventions; and in proportion as these are achieved, new wants and new desires will spring up, rendering new means and new appliances still necessary. We may go on towards perfection, but we shall never actually reach it. It is the limit we may continually approach year after year, and age after age; still, after these years and these ages have passed away, we shall be far from attaining it. It will be still distant. The means and methods which we employ, and of which we think so very highly, will then have become the *old means* and the *old methods* of a bygone period, in which the arts were but in their infancy. Let improvements, then, gentlemen, proceed; let the arts flourish; for in proportion as they do so, so will civilisation flourish, so will oppression cease, and the just liberties of man flourish; so, under God's blessing, will the gospel of peace flourish, until, as the great panacea for all human evils, it cover the whole earth as the waters cover the channel of the deep.

The thanks of the Society were awarded to the President for his excellent address; and the following communications were then made :—

1. Account of Observations on the Solar Eclipse of July 28, 1851, made at Sebastople. By Edward Sang, Esq., F.R.S.S.A., Professor of Civil and Mechanical Engineering, Constantinople. (3397.)

Mr Sang stated in his communication that he had not received the "Suggestions" to observers, which the Secretary had suggested to be sent to him by the Astronomer Royal, until it was too late to enable him, with all the aid he had graciously received from the Russian Minister at the Ottoman Porte, to reach Theodosia in the Crimea, which was within the line of totality. By the kindness of his Excellency Baron Titoff, the Russian brig of war, Perseus, was put at Mr Sang's service, but, as she was a sailing vessel, she was unable, from light winds, to do more than reach Sebastople, which, though near, was not within the line of totality. His chief observations were consequently made upon the "beads," and his preformed opinion was strengthened by this observation, that these appearances were due to irregularities on the moon's surface alone. The irregularities on the moon's edge were so great, not only in detail, arising from mountains and concavities, but in the general way also, from the orb of the moon not being of a circular form, that he conceives serious errors are constantly made in determining the longitude by occultations, because a few degrees change of place on the earth's surface would bring the observer either opposite to a protuberance or a concavity on the lunar surface, and, as a consequence of this, make the occultation of a star to appear to take place, perhaps 15″ before or after it appears to take place at another point a few degrees distant. The irregularity also leaves us uncertain what is the diameter of the moon, and consequently we have no determined base line from which to compute the altitudes on the moon's surface. The author suggested the importance of having photographic pictures of the moon at different times during her libration. From observations made by the author it would appear that the longitude of Constantinople, as laid down in our books and maps, is too small, as it ought to be 1h. 55m. 51s.; the latitude being 41° 3′ 6″; the longitude of the quarantine station at Sebastople was found to be 2h. 13m. 55s., and the latitude 44° 36′ 17″.

Thanks voted, and referred to a Committee. The special thanks of the Society were also voted to his Excellency Baron Titoff, and to the officers of the Perseus, for their kind attentions to Mr Sang in his scientific expedition.

2. Description of a Design for an Improved Anemometer or Wind-

Gauge. By William Cross Buchanan, Esq., C.E., Glasgow. With an Illustrative Drawing. (3398.)

The object of the author in this suggested improvement of the wind-gauge is to remove as far as possible friction from the working parts. He proposes that the weight of the *vane* and tube to which it is attached should be removed from the axis on which they turn by means of a float which bears up that weight, and that the axis be reduced to about a quarter of an inch in thickness, the under one working at the foot of the apparatus, and the upper one in a hole in the centre of strong iron supports, crossing each other at right angles, and allowing room for the vane to traverse without touching them, the axis to work loosely both above and below. The vessel containing the float to be placed betwixt the vane and the index apparatus, and filled with water or oil. The wind passing down the tube acts upon an inverted vessel in water, and this vessel carries a rod with a pencil, which marks the force of the wind on a cylinder carried round by clock-work. There is another cylinder which is moved by a connection with a wheel on the upright tube, which gives the direction of the wind; so that the time, force, and direction of the wind are given by the instrument.

Referred to a Committee.

The following Donations were laid on the table, viz. :—

1. Two Lectures on the Construction of Boilers, and on Boiler Explosions; and a Paper on the Consumption of Fuel, and Prevention of Smoke. By William Fairbairn, Esq., F.R.S., C.E. Presented by the Author. (3388.)

2. Report relative to the Works executed under authority of the Lords Commissioners of the Admiralty for the Improvement of the Navigation of the River Lune. By Messrs Stevenson, C.E. Presented by the Authors. (3391.)

3. Journal of the Geological Society of Dublin. Vol. V. Part 1. (1850–51.) Presented by the Society. (3393.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved of.

II. The following Candidate was elected an Ordinary Fellow, viz :—

William Forbes, Cromer Terrace, Dalston, London.

8*th December* 1851.—George Lees, LL.D., President, in the Chair. The following Communications were made :—

1. Description and Drawing of Public Baths and Wash-houses established at Hawick. By John Goodfellow, Buccleuch Street, Hawick. (3389.)

The commencement of the wash-houses, on the present plan, was in 1847, and with three compartments. In the spring of the year 1850 the author had twenty-four washing compartments in operation—each compartment holding three tubs, or seventy-two tubs in all. One of the tubs in each stall is made a boiler, with a lid; and, by having a steam pipe dipping into it, the supply of water—cold and hot—is without limit; as also is the steam for boiling the clothes. The charge for each washer is one penny per hour. In the course of the first year, from April 1850 to April 1851, upwards of 25,000 washers made use of the public wash-houses—a number equal to three times the entire population of the town of Hawick. The baths were erected in the autumn of 1850, and during the summer months, and in warm weather especially, are well patronised. In winter the demand for baths falls off, and, consequently, they are only open on Saturdays. The charges are a penny for warm shower-bath, and twopence for warm bath—second class; first class warm bath, sixpence; with use of clean towels in both. The baths are twelve in number, with shower-bath in each. To the boiler is attached a small steam-engine, which pumps water from a sunk well on the premises for the baths and wash-houses; while the steam, after doing this duty, is conducted away in covered pipes, and heats the water for the baths and washers, and also boils the clothes being washed. Similar establishments may be erected in every town in Scotland, where coals are moderate in price, and water to be had at no great depth below the surface—being thus independent of any water company or corporation.

Referred to a Committee.

2. Description and Drawing of a Self-acting Railway Signal. By Mr John G. Winton, Cherry Bank, North Leith. (3392.)

The object of a signal of this description is to shew to the engine-driver of a following train, the time when, or distance at which, a preceding train has passed along the line, so as to caution him in passing through a tunnel, rounding a curve, or any place that may be considered necessary. The time signal is effected by means of a cataract, with catches, palls, &c. (such as are in use for regulating the strokes of large pumping engines), wrought by the engine on passing, which also raises the signal board. The arrangement is such that the danger signal remains for five minutes, the caution for other five minutes, when it shews all clear. The distance signal, instead of having a cataract, has a wire rope connected to the palls, which passes along the line to a certain distance, where it is fixed to a lever, which the engine, on passing, depresses, and sets off the signal at one or more of the stages as may be considered best.

Referred to a Committee.

3. Suggestions for the Improved Manufacture of Sheet-Iron. By Mr John Waters, millwright and engine-builder, Macon. (3387.)

Mr Waters conceives that the following plan will accomplish the object, and he requests the Society to endeavour to get it tried, viz., to have a pair of rolls, say 26 inches in diameter, working horizontally one in front of the other, and set in a cast-iron frame as strong as is generally used in rolling iron. The rolls being perfectly true, let a groove be turned out of both ends of each roll, so that a plate can be fitted nicely to each roll. These plates will form a receiver on the top of the rolls, with a chance of allowing the waste or cinder to get away. Let the iron be run from an air furnace, at that stage of heat when the iron is properly melted, and in a fine liquid state, into the receiver on the top of the rolls; working downwards, a thin skin will be formed on each roll, which will vary in thickness according to the temperature of the rolls, and will weld together at their junction, which will form a continued length of sheet-iron without scale, and of the purest quality. The sheet can never exceed one 3-32ds of an inch in thickness. Let there also be a cast-iron pan underneath the rolls, two-thirds of their radius, covered with water, so that the rolls may be kept at a proper temperature by a constant stream of water being made to run into the pan.

Referred to a Committee.

4. Description of an Improved Jointed Artificial Leg for short Stumps. By Mr John Howell, Polyartist, 110 Rose Street, Edinburgh. (3402.)

The seat or top of the artificial leg is attached to the buttock, and plays outwards, to enable the wearer to sit on his breach by means of the hip joint. In the action of sitting down, a slip bolt is drawn, which enables the knee-joint to play, so that the lower part of the limb and foot take the natural position; and in rising up, the bolt by that action again enters the knee-joint, whereby the limb becomes rigid, and fit for supporting the body, and for walking. The full-sized limb has been made for a person of fourteen stone weight, and as worn, weighs only six-and-a-quarter pounds.

Referred to a Committee.

5. Model and Description of part of Edinburgh, betwixt North Bridge and the Castle Esplanade, and betwixt Princes Street and the High Street, according to the alterations suggested by Robert F. Gourlay, Esq., 90 Princes Street. (3403.)

Referred to a Committee.

The following Donations were laid on the Table, viz.:—

1. The Indian Journal of Arts, Sciences, and Manufactures. Parts 6 and 7. Presented by Alexander Hunter, M.D., Madras. (3394–1, 2.)

2. Four Specimens of Gums or Juice, resembling Gutta Percha, produced from—1st, Ficus indica; 2d, Ficus racemosa; 3d, Ficus religiosa; 4th, Milk Hedge. Presented by the Same. (3395–1, 2, 3, 4.)

3. The Premiums awarded for Session 1850–51, and Subjects for Premiums for Session 1851–52. By the Institution of Civil Engineers, London. Presented by the Institution. (3399.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved of.

II. The following Candidates were elected Ordinary Fellows, viz. :—

1. William Ross of Greenside.
2. George Alexander Drummond, builder, Henderson Row.
3. Major R. S. Seton, Madras Artillery.
4. Robert Stewart of Omoa, Lord Provost of Glasgow.
5. John Scott, M.D., F.R.C.P., Rutland Street.

III. The following, proposed by the Council, were elected Honorary Fellows, viz. :—

1. His Excellency Baron Titoff, Russian Minister at the Ottoman Porte.
2. M. Gevers d'Endegeest, Counsellor of State, Member of the States-General of Holland, President of the Commission for the Drainage of the Lake of Haarlem.
3. Sir William Cubitt, F.R.S., Pres. Inst. C.E.
4. Lieut.-Colonel Harry D. Jones, R.E., M.I.C.E., Chatham.
5. Robert Stephenson, Esq., M.P., F.R.S., V.P., Inst. C.E.
6. Isambard K. Brunel, Esq., F.R.S., V.P. Inst. C.E.

IV. In terms of Law XX., the Treasurer's Books were laid on the Table, and a Committee appointed to audit the same, and to report thereon, and generally on the state of the Funds of the Society.

V. Two Copies of Forms of Application were sent to the Fellows, to enable them to recommend Candidates for Admission.

The Society then adjourned.

A *pro re nata* Meeting of the Society was held on Monday, 22d December 1851. Dr Lees, President, in the Chair.

PRIVATE BUSINESS.

1. A Memorial from the President and Fellows of the Society to Her Majesty's Commissioners for distributing the Surplus Funds collected at the late Great Exhibition of the Works of Industry of all Nations, soliciting a share of these Surplus Funds to enable the Society the better to carry out the objects for which it was instituted and incorporated—prepared by a Committee on a remit from the Council—was read and approved of, and authority for signing, printing, and forwarding the same was given unanimously. On the motion of Mr Grainger, seconded by

Professor Kelland, the thanks of the Society were voted to Mr Cay, for his trouble in preparing the Memorial.

2. A Memorial from the President and Fellows to the Lords of the Treasury, on the subject of establishing a Museum of Economic Geology for Scotland, at Edinburgh, prepared by a Committee on a remit from the Council, was read and approved of, and authority for signing and transmitting the same was given unanimously, on the motion of Mr Stevenson, V.P., seconded by P. Wilson, Esq. The thanks of the Society were voted to Mr Cay, for framing the Memorial.

12*th January* 1852.—Dr Lees, President, in the Chair. The following Communications were made :—

1. On some new methods calculated to facilitate the application of Ancient Arts to the decoration of Sepulchral Monuments. By Daniel Wilson, LL.D.

Various Illustrations were exhibited. (3407.)

Dr Wilson commenced by calling attention to the want of taste, and the misapplication of heathen symbols, so frequent in our cemeteries, where, in Scotland especially, the Christian is seen to reject the Cross—the symbol of the Christian faith—for inverted torches, serpents, and globes, urns, sarcophagi, and the like obsolete or meaningless symbols. He then stated in detail various processes calculated to render the restoration of monumental brasses easy, by diminishing the cost of their production. In illustration of this portion of the paper, a selection of rubbings from ancient sepulchral brasses was exhibited. The next process adverted to was a modification of the encaustic tile, highly advantageous from its extreme durability, and its resistance to moisture. This also was illustrated both by ancient and modern specimens. The third process may be described as a modification of the ancient incised slab, combining with it some of the advantageous applications of colour peculiar to the former. In describing its advantages, Dr Wilson specially adverted to the unsuitableness of white marble for exposure to our variable climate; and expressed his conviction that some more durable substitute must be soon generally recognised as indispensable for the mural monuments of our public cemeteries.

Thanks voted, and referred to a Committee.

2. Description and Drawings of a Platometer; an instrument for measuring the area of figures drawn on paper. By Mr John Sang, Kirkcaldy.

The Instrument in various forms was exhibited. (3409.)

The usual method of discovering the area of a figure drawn on a plan, is to divide it into a number of triangles, to measure the base and altitude of each, and take the sum of their products. By a careful process of this kind, the area may be discovered with great accuracy; but as it is necessary to revise the calculations several times, both for the purpose of obviating faults in the arithmetical part of the work, and in order, by taking the average of a few independent measurements, to increase the probable accuracy of the result, this method of calculation, especially when the figure is irregular, entails a considerable amount of labour. The instrument invented by Mr Sang indicates the area of any figure, however irregular, on merely carrying the tracer round its boundary, and, besides the advantage of not injuring the drawing, it possesses that of speed and accuracy. A frame carries an axle, which has on it two rollers of equal size, and a cone. The sides of the frame are parallel to the edge of the cone, and are fitted to receive the circumference of friction rollers, which carry a light frame, terminating in the tracing point, to which the handle is attached by a universal joint. It also carries an index-wheel, which is pressed on the surface of the cone, and receives motion from it as the tracer is carried along the paper. It follows, from the construction of this instrument, that if the tracer be moved forward, it will cause the index to revolve, in proportion to the motion of the tracer multiplied by the distance of the edge of the index-wheel from the apex of the cone; and that the revolving motion of the index-wheel will be positive or negative, according as the tracer is carried backwards or forwards. Hence, if the tracer be carried completely round the outline of any figure, on arriving at the end of its journey, the index-wheel will shew the sum of the breadth of the figure at every point, multiplied by the increment of the distance of the points from the apex of the cone—that is to say, the area of the figure.

After some remarks by Mr Stevenson, V.P., to the effect that this instrument appears to be a most important and beautiful invention, it was referred to a Committee.

3. Description of a Galvanic Apparatus for Medical purposes. By Mr William Hart, Jedburgh.

The Apparatus was exhibited in action. (3386.)

This galvanic apparatus is designed for medical purposes, and contains an improved regulating index, moving on a circular scale, having seventeen gradations of power, but which might be increased to any extent, and which is considered exceedingly convenient and economical. The battery contains six platinised lead plates, and seven of zinc, all in one cell, which is made of lead and platinised, exposing a large surface of metal, and producing a large quantity of electricity without intensity. To put the machine into action, the plates must be let down to the bottom of the trough, which is to be previously half filled with a solution consisting of one part of sulphuric acid and nine parts of water. The two binding screws in front of the box fix the wires joined to the handles for receiving the shock. To stop the galvanic action, the plates are to be lifted to the upper part of the half-filled trough. The machine can be produced at a cheap rate, and kept up at very little expense; and is so simple that any person can use it.

Referred to a Committee.

The following Donations were laid on the Table, viz. :—

1. (1.) Plantain Fibre, Madras.
   (2.) Paper made from ditto.
   (3.) Another specimen of Plantain Fibre (Musa paradisaica.)
   (4.) Cord made from ditto.
   (5.) Aloe Fibre, Madras.
   (6.) Guava Wood, prepared for and used for Wood Engraving.
   Presented by Alex. Hunter, M.D., Madras. (3396, 1–6.)

2. Reports to the Health Committee of Liverpool, by the Borough Engineer, Inspector of Nuisances, and Medical Officer of Health, 1851. Presented by James Newlands, Esq., C.E., Borough Surveyor of Liverpool. (3400.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved of.

II. The following Candidates were elected Ordinary Fellows, viz.:—

1. Thomas Murray, LL.D., Sec. School of Arts, Arniston Place.
2. Robert Landale of Pitmedden, S.S.C., 33 Dublin Street.
3. Duncan M'Callum, C.E., 7 Torphichen Street.
4. James Johnston, C.E., Superintendent of River Tees Navigation, Stockton-on-Tees.
5. David Hunter, chemist, 24 Upper Gray Street.
6. Archibald Sutter, land-surveyor, 5 Rutland Place.
7. Jean B. Deflandre, teacher of French, 40 Great King Street.

III. The Report by the Auditing Committee on the Treasurer's Books, and on the Funds, was read and approved of. Mr Horne, Convener.

IV. The President granted discharge to the Treasurer, in terms of that Report.

V. The Fellows received a printed copy of "Notice by the Council regarding the Publication of the Transactions of the Society."

26*th January* 1852.—George Lees, LL.D., President, in the Chair. The following Communications were made:—

1. An oral exposition on the relative advantages of the English and American (aerial), and the Prussian (subterranean) Electric Telegraphs. By Dr George Wilson, F.R.S.E. (3415.)

Dr G. Wilson's object in this exposition was to bring under the Society's notice the relative advantages of the methods followed in England and America, on the one hand, and in Prussia on the other, on the insulation and protection of the wire, which forms the largest and most costly portion of the electric telegraph. After explaining in detail the mode of constructing and arranging the wire in this country and on the Continent, the author discussed the questions of the relative excellence of the insulation attained by the two systems, the degree to which each is exposed to disturbance by atmospheric and terrestrial electricity and magnetism, and the relative cost, sensibility, and durability of the aerial or suspended insulated wire, and the subterranean or buried one. The general conclusion come to was, that although our experience of the subterranean wire was much less than that of the suspended one, the introduction of gutta percha had furnished such facilities for insulating the buried wires, that it was not improbable they would supersede in England the present arrangement, as the principles involved in the subterranean telegraph were sanctioned by all our engineers.

2. Description and Drawing of a suggested Explosive Projectile for Artillery. By Mr George D. Howell, 23 Howe Street. (3404.)

The advantages to be obtained by this projectile were stated to be greater precision of aim, with accelerated speed, if used as a common shot; but if used as a shell, it not only combines the above qualities, but an increased explosive force, and may be fired from ordinary cannon. It requires no fuse, ignition being caused by collision with the object struck.

3. Description of a Safe Lock. By Mr John Whyte, Easdale. (3410.)

This may be considered as a modification of the ancient Egyptian lock. The main bolt has six or eight notches on each side, and there are as many spring bolts playing with these. Along the tops of these spring bolts, a slide works (which, in fact, is the key), which is cut on one of its edges in the form of waves, and when it is fully pushed home, these wave-lines are so formed as to press down the whole of the spring bolts to the level line, so as to free the main bolt, which then has liberty to open or shut. On the other hand, when the slide or key is withdrawn, the spring bolts instantly enter the notches in the main bolt, and prevent it from moving. The advantages are stated to be the difficulty of picking this lock, or of making a slide or key to fit it; for even the thickness of writing paper introduced betwixt the slide and the spring bolts will press some of them down into the notches of the main bolt, and prevent it from opening. Besides, the keyhole is very small in proportion to the size of the lock.

4. Description and Drawings of—(1.) An improved mode of giving the greatest effect to an Overshot Water-Wheel; (2.) An Inclined Plane for loading and unloading Carts and Waggons. By Mr Dixon Vallance, Greenshields, by Carnwath. (3411.)

There did not appear to be any thing particularly new in the arrangement in this water-wheel; but an interesting discussion followed, in which several of the members doubted Smeaton's doctrine of the wheel being most effective when the periphery moved at the rate of three feet per second. On the contrary, some of the members had practically produced more work after altering the wheel so as to move at the rate of six or seven feet per second; and several members stated that these higher velocities were coming more and more into use, and, in consequence, that the gearing was much more simple—nay, that, for some purposes, it was entirely done away—as for pumping. Some members considered that Smeaton had laid down his rule empirically, and without proper data. A gentleman present stated that he had practically found much benefit by making the water enter near the top of the wheel, and allowing it to impinge on the float-boards, so as to act by impulse, as well as by its weight—the wheel, in this case, moving from the water, and not against it, as it often does in overshot wheels; and that, to prevent the water from splashing over and not filling the buckets, he had erected a kind of shrouding at each side, from the top of the wheel to about one-eighth of its diameter downwards, which had the effect of restraining the overflow of the water, and bringing all of it into effective use. The inclined plane for loading and unloading carts and waggons has a windlass and rope attached so as to save manual labour.

5. By permission of the Society a letter from Mr Alexander Bryson was read, containing his suggestions as to the origin of the Fire which caused the loss of the steamer Amazon. (3426.)

Mr Bryson considered that the suddenness of the ignition, the total want of the premonitory symptoms of fire, such as smoke or smell, take away all force from the suggestion of Admiral Cochrane, that the fire originated in the tallow store. Had this been the case, smoke or smell would have been seen or felt by the many persons on watch, both on deck and in the engine-room. Mr Bryson suggested that the first cause of the fire was the intense heating of the machinery from friction (it having become in some parts red-hot); and, secondly, the sudden conversion of the tallow employed in cooling the working surfaces, into oil-gas. As this gas contains more olefiant gas than the carburetted hydrogen obtained from coal, being also more inflammable than the latter, and specifically lighter than common air, Mr Bryson supposes that this highly inflammable atmosphere occupied the entire under surface of the deck, where the overheated parts of the machinery are situate, and, from its being less easily detected by the sense of smell than coal-gas, no danger was apprehended. He therefore considered that the instantaneous ignition of this gas was the direct cause of the misfortune on board the Amazon.

6. Report of Committee on Mr Goodfellow's Public Baths and Washhouses at Hawick. Mr Wilson, Convener. Read and approved. (3389.)

The following Donations were laid on the Table, viz. :—

1. Transactions of the Architectural Institute of Scotland, First Session, 1850-51. Vol. I. (Edin. 1851.) Presented by the Institute. (3401.)
2. Letter to the President of the Medico-Chirurgical Society of Edinburgh on the recent Speeches of Professors Syme and Simpson. By William Henderson, M.D., Professor of General Pathology. (Edin. 1851.) Presented by the Author. (3405.)
3. Proceedings of the Philosophical Society of Glasgow, 1850-51. Vol. III., No. III. Presented by the Society. (3406.)
4. The Young Man's Guide against Infidelity. By the Rev. Graham Mitchell, LL.D., Minister of Whitburn. (Edin. 1848.) Presented by the Author. (3408.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved of.

II. The following Candidate was elected an Ordinary Fellow, viz :—

Wardlaw M'Farlane, chemist, 1 Darnaway Street.

9th February 1852.—George Lees, LL.D., President, in the Chair. The following Communications were made :—

1. On the theories of Galileo and Leibnitz touching the Strain and Strength of Material; on the position of the Neutral Axis in Beams, and their actual strength in reference to the resisting forces of Compression and Extension on opposite sides of this line. By George Lees, LL.D., President. (3427.)

In this paper Dr Lees, after adverting to the several ways in which a beam may be strained, proceeded to say that neither the theory of Galileo nor that of Leibnitz was consistent with the real condition of the material when under transverse strain, to which alone he now proposed to call the attention of the Society. It required but little reflection to see that when a beam is strained transversely its fibres are compressed on one side and stretched on the other, and that, therefore, there must be some *line* within the beam where the compression ends and the extension begins. Here the material will neither be compressed nor extended: this line takes, accordingly, the name of the *neutral axis*. Although the existence of this axis was long maintained, its real position was first approximatively determined by Barlow. From his experiments, it appeared that in wood, to which they referred, the neutral axis divides the depth of the beam, so that the square of its depth, reckoning through the area of tension, was equal to three times the square of its depth, reckoning through the area of compression. On this principle it easily followed that the position of the axis was ·6 and ·4 of the depth nearly. Dr Lees then said that the real position of the axis might be determined, provided we knew the tensile and compressive force of material. These being understood to be given, he then proceeded to the mathematical consideration of the question, deducing formulæ, not only for the position of the neutral axis, but also for the strength of beam of any given material.

Formulæ.

Let f = tensile resistance per square inch,
f' = compressive resistance,
δ = depth of the neutral axis, reckoning through the area of tension,
δ' = that through the area of compression,
d = whole depth of beam ;

Then, (1.) $$\delta = \frac{d}{1+\sqrt{\frac{f}{f'}}}$$

(2.) $$\delta' = \frac{d}{1+\sqrt{\frac{f'}{f}}}$$

If l = length of the beam projecting from a wall,
P = greatest load it can bear suspended from the end ;

Then (3.) $P = \frac{2b\delta^2 f}{3l}$ or $= \frac{3b\delta'^2 f'}{3l}$

Where b is the breadth of the section of the beam.

In applying these to cast-iron, which has a compressive strength of 49 tons per square inch, and a tensile strength of 9 tons, it appeared that the neutral axis was at ·7 of the depth, reckoning through the area of tension; and ·3 of the depth, through that of compression; that a beam of the same material, 12 inches deep, 8 inches thick, and 10 feet long, would bear a weight of 28 tons at its extremity, or taking its own weight into account, a weight of 26 tons.

After some interesting remarks by Mr Buchanan, C.E., and Mr Leslie, C.E., the thanks of the Society were voted to Dr Lees for this communication.

2. Description of a Cast-Iron Swing Bridge, constructed for Peterhead Harbour by Messrs Blaikie, Panmure Foundry, from designs by Messrs Stevenson, Civil Engineers. By J. Lawrenson Kerr, Esq., C.E., Edinburgh. (3429.)

The swing bridge erected in 1850, over the canal, which was cut through the isthmus separating the north and south harbours of Peterhead, is of cast-iron, and consists of two compartments or leaves. The span is 41 feet 6 inches; rise, 5 feet 6 inches; breadth over all, 20 feet 5 inches; and total length, 99 feet 6 inches. The depth of the exterior girders at the crown is 15½ inches, and of that of the interior 11½ inches. The weight of each leaf is 91½ tons, of which 13 tons are ballast. A man with one hand can easily work the gearing which causes the leaf to revolve; and, considering the great weight (91½ tons), it testifies the quality both of the design and execution. The work reflects great credit on the Messrs Blaikie, of the Panmure Foundry, who were the contractors. The advantages which have resulted from the communication between the two harbours were stated to be great, as vessels can now enter or leave either harbour in every state of the wind.

Referred to a Committee.

3. Report of Committee on Mr Gourlay's Model of his proposed Improvements of Edinburgh. Mr Leslie, Convener. Approved. (3403.)

4. Second Report of Committee on Mr James Smith's mode of constructing Wire Fences. Mr Clerk Maxwell, Convener. Approved. (3278.)

The following Donations were laid on the Table, viz.:—

1. The Architect and Civil Engineer's and Architect's Journal for 1851. Vol. XIV. (London, 1851.) Presented by William Laxton, Esq., Editor. (3412.)

2. The Practical Mechanics' Journal for 1851. Vol. IV. (Glasgow, 1851.) Presented by William Johnson, Esq., Editor. (3413.)

3. The Artizan for 1851. Vol. IX. (London, 1851.) Presented by W. Whytehead, Esq., Editor. (3414.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidates were elected Ordinary Fellows, viz. :—

1. David Langdale, mining-engineer, 6 Forth Street.
2. James Orrock, surgeon-dentist, 7 Abercromby Place.
3. William Hollis, Professor of Languages, 2 Marlborough Cottages, College Street, Chelsea.

The Fellows were informed that the Transactions, Vol. III. Part V., were now ready, and in the course of delivery.

23d February 1852.—Dr Lees, President, in the Chair. The following Communications were made :—

1. Memoranda in regard to the history of Steam as a power for propelling Ships, &c. ; and in particular as to the late Mr William Symington's connection with that subject. By Mr William Grosart, Falkirk. Communicated by Dr Daniel Wilson, F.S.A. Scot. (3416.)

Thanks voted to Mr Grosart, and to Dr Wilson and the Society of Antiquaries for exhibiting the pattern shaft of the "Charlotte Dundas."

2. Description and Drawing of an improved Instrument for drawing Ellipses. By Mr George H. Slight, engineer, Leith Walk. (3430.)

The instrument is somewhat similar to a pair of compasses, with the legs formed of round steel rods, on either of which a pencil fixed to a tube is fitted to slide and revolve freely. When the rod which carries the pencil is inclined to the paper or other surface to be drawn upon, and the pencil made to revolve, touching the paper throughout its course, it describes on it an oblique section of a cylinder, and therefore a correct ellipse; the obliquity of the section, or the length of the ellipse, varying with the inclination of the rod. The improvements consist in a method of moving the pencil nearer to or farther from the rod for different sizes of ellipses, so as to preserve its parallelism to the rod ; and in making both legs round and of different lengths, with the means of lengthening or shortening the longer leg, to facilitate its adaptation to longer or shorter ellipses.

Referred to a Committee.

3. Report of Committee on Mr W. C. Buchanan's Improved Anemometer or Wind-Gauge. Mr Buchanan, Convener. (3398.)

Read and approved of.

4. Report of Committee on Mr George D. Howell's Explosive Projectile for Artillery. Major Seton, Convener. (3404.)

Read and approved of.

5. Report of Committee on Mr John Sang's Platometer. Mr Grainger, Convener. (3409.)

Read and approved.

The following Donations were laid on the Table, viz. :—

1. The Constitution and Laws of the Institute of Actuaries of Great Britain and Ireland, List of Members, and Catalogue of Books. (London, July 1851. (3417–1.) Presented by the Institute.

2. The Assurance Magazine, No. VI. (London, January 1852.) Presented by the Same. (3417–2.)

3. Smithsonian Contributions to Knowledge. Vol. II. (Washington, 1851.) Presented by the Smithsonian Institution. (3418.)

4. Appendix I. to Vol. III. of the Smithsonian Contributions to Knowledge, containing an Ephemeris of the Planet Neptune for 1852. By Sears C. Walker, Esq. Presented by the Smithsonian Institution. (3419.)

5. Fourth Annual Report of the Board of Regents of the Smithsonian Institution for 1849. Presented by the Same.

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved of.

II. The followin gCandidates were elected Ordinary Fellows, viz :—

1. John Moffat, C.E., Ardrossan.
2. Andrew Crichton, LL.D., 33 St Bernard's Crescent.

8*th March* 1852.—Dr Lees, President, in the Chair.

The following Communications were made :—

1. A short account—in continuation of those formerly read before the Society—of the progress made in the Drainage of Haarlem Meer during the last year. By Thomas Grainger, Esq., C.E. (3435.)

This short paper, in continuation of Mr Grainger's description of the drainage of Haarlem Meer, in North Holland, was read by the Secretary. After describing the difficulties to be encountered in the prosecution of this great undertaking, from the size of the lake, and principally from the circumstance that its level, even at the surface, was considerably below that of the sea, so that the whole of the water had to be raised to such a height as would enable it to reach the sea by its own gravity, Mr Grainger alluded, in general terms, to the various works undertaken to effect the object in view, such as the canal, 33 miles long, 124 to 147 feet in width, and 10 feet in depth, with which the lake had been surrounded to convey the pumped-up water to the sea—to receive the drainage of the district—and to maintain the internal water communication previously afforded by the lake itself—and also to the three gigantic steam-engines, of 360 horse-power each, erected at different points of the lake, giving motion to 27 pumps, which raise 186 tons of water at each stroke. The canal and all the other preliminary works having been completed, the pumping was commenced in May 1848, from which date to 30th April 1851 the lake had been lowered 7 feet 3 inches, which was the state of matters when the subject was last brought before the Society. During the months of May, June, July, August, September, and October, very satisfactory progress was made, notwithstanding that a considerable quantity of rain fell in August and September; the level reached at the end of October being 9 feet 7·74 inches below the original surface, or at an average rate of 4·79 inches per month. In November a great quantity of rain and snow fell, raising the level about 4 inches, and in December the weather was still unfavourable, so that at the end of that month the level stood at 9 feet 5·58 inches below the original surface, or a total gain since 30th April of 2 feet 2·58 inches, or 3·32 inches per month. This progress may appear to be inconsiderable; but, when it is recollected that the lowering of the lake one inch involves the raising of upwards of four millions of tons of water, and allowing for the rain and snow falling during these eight months, that there could not have been less than 186 millions tons of water pumped up during that period, the performance will appear great indeed. To give a better idea of this, it was stated that 186 millions of tons is equal to a mass of solid rock one mile square and 100 feet high, allowing 15 cubic feet to a ton. The average progress has been less last year than what it was in the preceding one; but this is readily accounted for by the *increased lift* of the pumps, and by the difficulty of forming the channels which lead the water to them. At the commencement of these operations, the average depth of the lake was 13 feet 1·44 inches; and as 9 feet 5·58 inches have been pumped out, there only remained at the end of December last an average depth of 3 feet 7·86 inches. It is therefore trusted that the drainage will be completed, if not in the autumn of this year, at least in the summer of 1853. A paragraph has been going the round of the newspapers about disastrous accidents to the boilers, which will delay the completion of the works for two or three years. It was stated that there were no grounds for such rumours, as the official report for January, which Mr Grainger had received, mentioned that the boilers of only one of the engines (the Lynden) were out of repair, and that it was expected that these would be repaired by February; so that, by this time, it is hoped that the whole of the engines are again at work.

Thanks voted.

2. Description of a Chromatic Fac-simile Process, or Method of Colour-Printing from Wood Blocks and from Stone—invented by Messrs Leighton Brothers, 4 Red Lion Square, London. Communicated by Mr Robert Sandeman, architect, 9 Greenside Street, Edinburgh. (3437.)

In this paper Mr Sandeman gave a very clear and interesting account of the new and curious process of printing coloured drawings lately invented and brought into use by Messrs Leighton Brothers, lithographers, London, and which, from the surprising effects produced by it, was stated to form an important step in the art of colour printing. The term "Chromatic fac-similes" has been given to these prints or to the process, to distinguish it from the usual method of printing coloured drawings on stone, from which it was said to differ very essentially. In the ordinary process, the print is thrown off from the stone or other material in one dark ground, and then the colours put in over this, whereby the original impression, still shining through, gives a degree of hardness and want of the natural effect of a drawing, which it is extremely difficult, if not impracticable, to correct. In place of this, it was stated that Messrs Leighton, boldly throwing aside the guide of outline and engraving, proceed to print with colours alone, and, entirely from the first, producing their effects and delineations without the slightest mechanical appearance, on the same principle as they would copy a drawing with the brush, only printing the colours on the paper from the blocks, plates, or stones, instead of laying them in with the pencil.

This process, and the difficulties and great skill attending it, were illustrated in a striking manner by the exhibition of several prints, and particularly one, the figure of a lady, in all the different stages of colouring, in which fifteen or sixteen different stones or blocks were employed, to give each its peculiar colour and touch, till it attained at last all the appearance of a finished drawing. Various specimens, including views of scenery, and other objects, were exhibited.

It was stated that the process is applied both with lithographic stones,—with wooden blocks,—and with plates silvered on copper surfaces, an invention of Mr S. Leighton sen., but that the wood is found superior to the stone, on account of the many thousands of impressions that can be taken from it without being impaired by the waste of material; and that it is this immense number produced from the same series of blocks, that renders the process so practicable in point of economy. With so many different stones applied to one drawing, much attention, as may easily be conceived, is necessary to insure the impressions of the different stones falling all exactly the one upon the other. The slightest deviation would be fatal to the general effect. In this respect these prints appeared to be wonderfully free from any defect, owing to the exactness of what is called the " register."

The President, Dr Lees, expressed much satisfaction with what he had heard, and with the manner in which the subject had been brought forward and illustrated to the Society. After remarks from several members, the paper and drawings were referred to a Committee.

3. Description and Drawing of a Bootmaker's Plane. By Mr Louis Niman, bootmaker, Edinburgh. (3432.)

This newly-invented tool is for planing the edges of boots or shoes without having to use a knife, rasp, or any other sharp tool now used for that purpose. The inventor stated that this plane will save a great amount of labour, and prevent any accident which so frequently occurs by the unintentional cutting of the upper leather. Referred to a Committee.

4. Read and approved—Report of Committee on Mr John Howell's Artificial Limb for Short Stumps of the Thigh. Dr Douglas Maclagan, Convener. (3402.)

5. Read and approved—Report of Committee on Mr Hart's Galvanic Apparatus for Medical Purposes. Dr Douglas Maclagan, Convener. (3386.)

The following Donations were laid on the Table, viz. :—

1. A Practical Treatise on the Working and Ventilation of Coal Mines, with suggestions for improvements in Mining. By Mr John Hedley, colliery-viewer and mining agent, Wigan. Presented by the Author. (3383—B.)

2. Report to the Smithsonian Institution, on the History of the discovery of Neptune. By Benjamin Apthorp Gould jun., Esq. (Washington, 1850.) Presented by the Institution. (3421.)

3. Notice of Public Libraries in the United States of America. By Charles C. Jewett, Esq., Librarian of the Smithsonian Institution. (Washington, 1851.) Presented by the Institution. (3422.)

4. Annual Report to the House of Representatives by the Commissioner of Patents for 1848. (Washington, 1849.) Presented by the Smithsonian Institution. (3423.)

5. Reports (to the Senate of the United States of America) from the Secretary of the Treasury,—of Scientific Investigations in relation to Sugar and Hydrometers, made under the superintendence of Professor A. D. Bache, by Professor R. S. M'Culloch. (Washington, 1848.) Presented by the Smithsonian Institution. (3424.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved of.

II. The following Candidate was elected an Ordinary Fellow, viz. :—

John Barlow, assistant veterinary professor, 1 Pilrig Street.

III. On a recommendation by the Council, that the Editor of Transactions is allowed a fee of £10, 10s. for his trouble in connection with the Publication Committee, and the Editing of the Transactions,—superintending the preparation of Plates, &c., &c., to commence with the current Session 1852.

IV. The Printed Annual Abstract of the Funds, and of the Revenue and Expenditure of the Society, for Session 1850–51, was distributed.

22d March 1852.—Dr Lees, President, in the Chair. The following Communications were made :—

1. Notice of the recently-discovered Iron District of Cleveland, Yorkshire. With specimens of the large masses of Ironstone, now being quarried at Easton-Nab there. By William Campbell, Esq., civil engineer, Edinburgh. (3438.)

Mr Campbell, in illustration of this paper, presented some remarkable specimens of the ironstone which he had got in the north of England, while engaged in the improvements of the River Tees. The beds lie nearly level in this mountain of ironstone, varying in thickness from 12 to no less than 20 feet. The most remarkable feature is, that the ore is got by open quarrying; and it is estimated that ten millions of tons may yet be got with the same facility. Two smelting furnaces were in blast when Mr Campbell left the district, and more are in progress. There is no limestone or coal got in the district, though geologists consider that these may yet be reached. The operations were commenced in April 1851, and the traffic of ironstone, up the Stockton and Darlington Railway, has since averaged 200,000 tons per annum. Ironstone has been found in Northamptonshire; and, as the future supply of iron ore is at present attracting much attention, the paper concluded with a geological account of the district where this curious ironstone has been so unexpectedly found, which was illustrated by geological and other maps. Several members made remarks on this interesting subject—all agreeing with the author that it would revolutionise the iron trade. The Chairman requested Mr Campbell, as he has business in the district, to communicate to the Society the results of farther experience in the smelting process of this ore, and also an analysis of it, and more minute details of the geology of the Cleveland Hills, where this ore is found.

2. An Account of Experiments made on the Minie Rifle at Dalmahoy Moss, with remarks on its use as proposed in the Army. By Messrs J. Dickson and Son, gunmakers, Edinburgh. Communicated, along with some general views of the principles of this branch of Gunnery, by Geo. Buchanan, Esq., C.E., F.R.S.E. (3443.)

This paper was introduced with some observations and experiments by Mr Buchanan on the general subject of gunnery, which he observed, had engaged the attention of the most eminent philosophers and mathematicians of modern times, but the history of which, more than that of any other science, read to us the sober lesson of caution in scientific inquiries, and the necessity of combining with our researches a continual reference to practical experiments. It was in the year 1638, just about the period of the dawn of knowledge in Europe, that the illustrious Galileo proved, from the doctrine of falling bodies, then discovered by him, that every projectile must move in the curve of a parabola: a striking, and, no doubt, beautiful law of motion, and quite true in an unresisting medium, but totally inapplicable, as it turned out, in practice, from the neglect of one element, the resistance of the air, which in these days, though weighed for the first time in a balance by Galileo himself, was yet commonly considered, if material at all, far too thin and aerial to have any influence in comparison with the explosive force of gunpowder. Half a century after this, we find the celebrated Dr Halley—no doubt from imperfect experiments—still maintaining before the Royal Society the parabolic theory as a safe guide. Some allowance might be made in small shot, but the rule would hold, he says, in "shooting great and weighty bombs," as if "this impediment (the air's resistance) were absolutely removed." Practice and experience soon shewed the fallacy of this opinion, and the profound researches published shortly afterwards in the *Principia* of Newton, on bodies moving in resisting media, led to more correct notions. From the weight of the air, it was by these calculated that the resistance to a leaden bullet three-quarter inch diameter, and weight $1\frac{1}{3}$ oz., would not be less than 4 lb.,—an amount not to be overlooked, being fifty times the weight of the ball itself. This resistance is not surprising, when we consider the effects of a hurricane of wind, which never exceeds forty or fifty miles an hour, when the ball, as it issues from the piece, generates against itself something like a blast, exceeding a thousand miles an hour.

Still, the calculations of Newton, though true enough in slow motions, came far short of the reality, by not considering the extraordinary swiftness of the projectile; and it was not till the celebrated researches and practical experiments of Benjamin Robins, at Woolwich, confirmed by those of Hutton, that the true law of projectiles was developed and established on a sure basis. Robins shewed that the resistance on a three-quarter inch bullet, instead of 4 lb., exceeded 18 lb.,—being 120 times its weight. These discoveries changed the whole aspect of gunnery. The Galilean theory, with the initial velocity, now accurately determined, would have given a range of fifteen or sixteen miles, but actual practice had never exceeded two miles, or three miles at the utmost, in any case. But another unexpected and equally important discovery was made,—that the air not only retarded and circumscribed the range of the projectile, but created by its unequal resistance the most extraordinary deviations from the line of aim to the right or left, and this even to a still greater extent than the contraction of the range in the vertical plane. This is the true cause of the limited power and uncertain aim of ordinary musketry, in regard to which some careful experiments were made with percussion muskets at Chatham in 1846, which shew this effect in a striking light. At a range of 100 yards, the deviation from the mark amounted to 4 feet 8 inches; at 200 yards, it was 9 feet 9 inches; and at 300 yards, no less than 19 feet. Nor was this owing to any inaccuracy of aim. With the musket fixed on a stand, and pointed precisely on the object, still at 200 yards, not one ball in ten struck a target 11½ feet high and 6 feet wide. Hence it appears that, beyond 150 yards, the fire of a musket is quite uncertain; and at 500 yards the chance of striking any one man is so exceedingly small as to be next to impossible. These irregularities are ascribed partly to a rolling motion acquired by the ball in the smooth barrel, and partly to the unequal effect of the air's resistance on the different sides of the ball, whereby there arises a whirling motion, which Robins discovered in every ball, of a very irregular character, and causing a most devious in place of a direct course. To correct these evils, the idea was conceived, but by whom is unknown, of launching the ball from the piece with a determinate rotatory or whirling motion, communicated by means of a spiral groove cut within the smooth surface of the barrel. This constitutes the principle of the Rifle, by which the ball, instead of being allowed, as formerly, to whirl at random, receives a rotatory motion on an axis parallel to the line of fire, and by which its aberrations are confined within narrow limits. If the ball, for instance, makes only half a turn in a barrel 2½ feet long, it will make a whole rotation every 5 feet. Any deviation, therefore, in this little interval, instead of going on as formerly, extending and accumulating in proportion to the distance, is corrected, and the ball brought back to its true path. This principle, therefore, is extremely simple, and one more ingenious is scarcely to be found in the whole range of mechanical invention. It is difficult, not in the field, to exhibit the effect practically, but Mr Buchanan gave a striking illustration, by a simple experiment of dropping from the ceiling disks of thin wood or card, on the principle of the parachute. These, when dropped simply, deviated from the vertical line, and fell on the floor greatly to the right or left of the mark, in consequence of the disk being weighted on one side, whereby the air's resistance acting obliquely, turned the disks aside. The same disks, with the same lean to the side, being dropped with a whirling motion communicated by the fingers, fell right down on the centre of the mark. From the singular effects of this principle of rotation, it was suggested whether it might not have some part, on a great scale, in preserving the regularity of the earth's and planetary motions, where we see the the principle of rotation prevailing universally—ordained, no doubt, for other grand purposes, but still, possibly, contributing in this manner, in subordination with other laws, to that wonderful harmony which pervades the system. In regard to the rifle, the soundness of the principle has been tested and proved by the use and extension of this weapon all over the world. Hitherto its application in military practice has been limited, owing to the loss of time and careful adjustment required in loading the piece. But improvements have been long going on, particularly on the Continent; and the great object has been to introduce balls, such as have been long used in rifles, of an elongated or cylindro-conical shape, and small enough to pass easily, like the musket ball, down the barrel. This was tried many years ago by Delvigné in France, by dropping the balls into the chamber, and then enlarging them by blows from the ramrod so as to fill the grooves. Another plan, in the musket termed "Carabine à tige," was to form a hollow in the after-end of the long balls, and drop them on a small stem standing up through the breach, and this penetrating the hollow, and there acting as a wedge, enlarged the sides, and pressed them into the grooves. This plan was found liable to objections. But the last and greatest improvement appears to be that of Captain Minié, of the French service, by introducing a small iron cup to close the hollow in the after-end of the ball, and the explosion of the charge driving this cup into the hollow and compressing the included air, the effect is to expand the whole body of the ball, and press it effectually into the grooves of the rifle. From these improvements, and the great attention which has been paid to the subject on the Continent, particularly in France, Norway, and Prussia, and the remarkable accounts which have been given of the successful results in actual warfare, it appears as if the general introduction of this improved fire-arm is not far distant; and no doubt, for good or for evil, it seems destined to bring on important changes in military tactics, and the formation of armies. On these accounts, and from the general interest now excited, Mr Buchanan had requested Messrs Dickson, whose attention had been much turned to the subject, to give the Society an account of their views, and of their most interesting experiments at Dalmahoy.

The paper itself was then read by Mr Dickson, and excited much interest. After adverting to the efficient use of the rifle in the hands of a steady marksman, it gave an interesting account of the practice in Switzerland, where the rifle is used as a pastime as well as a truly national amusement—the landholders as well as the peasants mingling in the competition for the prizes; and by the spirit of emulation thus excited, the natives of this mountain range have attained a perfection exceeding that of any other country, and form a band of efficient men, ready, at a moment's notice, to turn out for the national defence. Rifle companies, in this country, would no doubt form a powerful auxiliary to the regular army. As to the best rifle for convenience and quick loading, there were many conflicting opinions. The subject had long engaged their attention, and they would give shortly the result of their experience. Since the days of Robins, all sorts and shapes of balls have been tried; and, indeed, as far as they know, out of the many now brought forward, few can be called new. The reported success of the Chasseurs de Vincennes in Africa and at the siege of Rome, and the accuracy of their shooting, has raised a spirit of deeper inquiry into the subject than formerly. The description and principle of the rifle they had just heard from Mr Buchanan. Oval balls had at one time many friends, and were chiefly used in India for buffalo shooting, but are now out of repute. (Specimens were shewn.) Four-grooved balls were also in great esteem —(specimens shewn)—both conical and spherical; they did not answer for long distances, owing to the increased friction in the barrel retarding their flight. Three-grooved balls—(of which patterns were exhibited) —had also their advocates a few years ago, but, after repeated trials, they were rejected on similar grounds. About twelve years ago, after long and repeated tests, Messrs Dickson had adopted the two-grooved rifle, and found, in regard to the degree of spiral, that a quarter turn in a barrel of 30 inches was preferable to any other, that being sufficient to give the rotatory motion, with the least possible friction, the ball only turning on its axis once in 7 yards. A full turn shoots as correctly at short distances, but at a long range varies much more. The conical ball has a decided advantage over all others, for correct shooting at a long range, and to the sportsman is quite invaluable; but as a projectile in active warfare, it is totally useless, the lobes or projections on the sides requiring correct fitting into the barrel, not attainable in the hurry of warfare, or under any excitement; and this has been borne out by the experience and bitter disappointment of our gallant Rifle Brigade in the hour of need. They would now advert to what had excited such a sensation, namely, the Minie Ball and Rifle Musket which was shewn, being one of those intended to be introduced into the service; there were also shewn drawings and models on a large scale of this and other forms of ball. The Minie ball has a hollow in the back part, which serves to throw the centre of gravity forward and assist the ball in its flight. Into this hollow is inserted an iron cup, which, on the ignition of the charge, is forced up into the hollow, causing the ball to swell out and fill the rifle grooves. For the purpose of general warfare, this rifle and ball are preferable to any now in use, chiefly from the great facility—equal to that of an ordinary musket—with which it can be loaded, and it was shewn how easily the ball on entering the muzzle could drop into its place in the chamber. Anxious to try its effects, and ascertain the truth of the many statements circulated about it, Messrs Dickson and Son procured this musket (one of those about to be introduced into the British army), and, through the kindness of the Earl of Morton, they got permission to use his grounds at Dalmahoy Moss, where they had, in presence of Colonel Montgomerie of the Artillery, and other competent judges, a fair trial of the Minie fire-arm, along with their two-grooved and other rifles. The target was 5 yards square, and the shooting at 900 and 1100 yards. The Minie rifle musket and Minie balls shot with surprising accuracy, the balls being carried well forward, and at the end of the shooting the target was fairly riddled. The ordinary two-grooved rifles shot as well, and with this advantage, that the balls went quicker to the object, taking, as near as could be calculated, $2\frac{1}{2}$ seconds for the 900 yards, while the Minie balls took from $3\frac{1}{2}$ to 5 seconds for the same distance. The result might be summed up thus :—The Minie rifle musket, as a weapon of general warfare, is a decided improvement on the old musket; still the Minie musket shewn to the meeting might be greatly improved to ensure its efficiency, as well as to render it a weapon easier to handle, without detracting from its powers; and if a body of men were picked out of each regiment, properly trained to its use, and practised at the long range, they would be a great acquisition to the regiment, besides being well fitted for the annoyance of artillery, and even cavalry, at a distance; and for guarding a pass or defile, powerful and effective auxiliaries. A great deal more might be said, but the Messrs Dickson feared they had already trespassed too long upon the valuable time of the Society. They would be happy to give any further explanations. A good deal having been said lately on the Prussian needle igniting musket, they shewed one of these, and explained its properties, and the serious defects to which it was liable.

The President, Dr Lees, after expressing much interest and satisfaction in the valuable communications he had heard, gave some additional observations and illustrations on the experiments of Robins, and the curious effect of the Minie ball.

The thanks of the Society were then voted to Mr Buchanan and Messrs Dickson and Son, for their communications; the latter being referred to a Committee.

The Report by the Committees on Mr George H. Slight's Instrument for describing Ellipses (3430), and on Mr Dixon Vallance's Water-Wheel and Inclined Plane (3411), were afterwards read and approved of.

The following Donations were laid on the Table, viz. :—

1. Coast Survey Charts of the United States of North America, 29 in number. Presented by the Smithsonian Institution. (3425, 1–29.)

2. Minutes of Evidence, Reports and Returns to the House of Commons, on Metropolis Water Bill,—Railways,—Harbours of Refuge,—Museum of Practical Geology and of Irish Industry,—English and Irish Geological Surveys,—Drainage of Ireland,—Destructive Distillation of Peat, &c., &c. Presented by Charles Cowan, Esq., M.P. (3431, 1–18.)

3. Transactions of the Architectural Institute of Scotland, Session 1851–52. Vol. II. Parts 1st and 2d. (Edinburgh, 1852.) Presented by the Institution. (3433, 1–2.)

4. The Illustrated Indian Journal of Arts. Part II., November 1851. Presented by Alexander Hunter, M.D., Madras. (3434.)

5. Six Papers read before the Institute of Actuaries, London, during 1850 and 1851. Presented by the Institute. (3436, 1–6.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

The Minutes of last Meeting were read and approved of. The Society adjourned to 12th April.

12*th April* 1852.—Dr Lees, President, in the Chair. The following Communications were made:—

1. Description and Drawing of a Bullet-Mould for Minie Rifle Balls. By Mr Thomas E. Mortimer, gunmaker, Edinburgh.

In this paper, Mr Mortimer brought under notice his improved mould for Minie bullets; after which he commented upon the Minie and other balls, shewing the advantage of the former, and their applicability to every description of rifling. He stated that, by casting the Minie ball with a certain shape of cavity, he found no occasion to use the iron capsules at all, because the ball expanded quite well without it, and shot as truly. The cavity in the lead was not made so deep. He also mentioned that it was quite a common thing to find that the iron capsule falls out of the ball after it is fired off, and frequently also turns half round in the cavity of the ball. Upon the whole, then, Mr Mortimer considered that the capsule may be advantageously dispensed with. Mr Mortimer illustrated his subject by a diagram, shewing various forms of bullets, and gave an account of several interesting experiments carried on by him during the last three months, at distances varying from 150 to 1000 yards—at which latter distance the target was struck with his improved Minie ball nine times out of ten consecutive shots.

2. Description of a Portable Apparatus for taking, developing, and fixing, Glass Photographic Pictures in the light, without any dark apartment. By Mr William M'Craw, 287 High Street, Edinburgh.

This apparatus consists of a collapsing camera, of a simple construction, with yellow glass baths standing vertically behind it, in which the picture is successively taken, developed, and fixed. There is also an elastic dark-coloured bag or cover, for transferring the calotype from the one bath to the other—the whole being mounted on a stand that folds up into the form of a walking-stick. The bath in which the picture is taken differs from the others in having a colourless glass in front, and the yellow glass behind being ground for obtaining the focus. Mr M'Craw stated to the meeting, that yellow light having no chemical effect on the sensitive preparations, pictures could be successfully developed in this way in the strongest light; and the advantages of this arrangement were, that a number of pictures could be taken successively and finished on the spot, while the whole apparatus does not exceed in bulk the most compact apparatus now in use for taking a single specimen.

3. The Patent Striking Electro-Magnetic Clock, invented by Mr Charles Shepherd of London, was described by Dr George Wilson, F.R.S.E. The Clock was exhibited in action, together with Illustrative Models, &c.

Dr Wilson commenced by stating that his attention had been directed to this clock, by the interest which it had excited in London, where it had been shewn to the sister Society of Arts, and a prominent place had been assigned it in the Great Exhibition. Professor Brande also had brought it before the notice of the Royal Institution of Great Britain, and Mr Charles V. Walker had it already in action at the Tonbridge Station of the South-Eastern Railway; whilst, with the Astronomer-Royal, Mr Airey's approval, it was being erected at the Greenwich Observatory, with a view to send time signals to Paris, and to places in our own island, situated on the telegraph lines. Mr Shepherd having kindly acceded to the request that he should send one of his clocks for exhibition to the Royal Scottish Society of Arts, and Mr Alexander Bryson having willingly taken charge of the clock-work, Dr Wilson undertook to describe the instrument. After a preliminary reference to previous electric clocks, especially Mr Bain's, which was characterised as simple and ingenious, but which, from the mode in which electricity was employed in it as a moving power, could not but vary in its rate, Dr Wilson proceeded to explain the peculiarities of Mr Shepherd's instrument, which aimed at being a perfect time-keeper. It involved three separate arrangements, namely, one apparatus to move the pendulum; a second to move the works and wheels; and a third to strike the hours. Each of those pieces of apparatus had a battery (or batteries) and electro-magnets for itself. The pendulum arrangement was independent of the other two, so that the pendulum moves though the wheels may be motionless. The wheels are controlled by the pendulum, though moved by their own battery. The bell-stroke is controlled by both the pendulum and the wheels, but is effected by an independent battery. The special peculiarity of Shepherd's clock may be said to lie in the fact, that the pendulum is neither directly moved by the wheels, as in ordinary clocks, nor communicates motion to the works, as in Mr Bain's electric clock. Mr Shepherd's pendulum may be quite detached from the rest of the clock, and a single pendulum will suffice for many clocks. The different parts of the clock were then referred to in detail; and, (1.) *Of the Pendulum.*—It is kept in motion by *four* forces, two of which act *directly*, viz., elasticity and gravity; and two *indirectly*, viz., electricity and magnetism. The action of the direct forces is as follows:—A bent spring let loose in one direction, throws the pendulum to one side, and the pendulum returns by its own gravity. While it is returning, the spring is rebent, and held back by a detent, or catch, which the pendulum itself raises when near the limit of the oscillation which gravity determines, so as to receive from the spring a second impulse to the opposite side. It will thus be understood that some arrangement must be provided for re-bending and holding back the spring till the pendulum again acquires an impulse from it. This re-bending of the impulse-spring is determined by an electro-magnet, to which a current of electricity is alternately allowed to pass and then cut off, as the pendulum moves to one side or the other. The pendulum is in permanent connection with one pole of a battery. A wire from the other pole is touched by the pendulum-rod as it moves to the one side, so that the current passes, and is separated from it, when it swings to the opposite side, so as to cut off the current. When the current is on, it throws the electro-magnet into action, so that it pulls down an armature or keeper, which, acting on a compound lever, locks back, or re-bends the impulse-spring, so that it is caught by the catch or detent. When the current is off, the electro-magnet becomes inactive, and a counterbalancing weight and spring raise the armature from the electro-magnet, so as to be ready to act again, and re-bend the spring when the current is restored. The electro-magnetic arrangement is thus solely employed to re-bend the spring, and it does not matter how much the electricity, or the magnetism which it induces, may vary in intensity, provided that it is sufficient to re-bend the spring, at every alternate oscillation. The release of the spring is effected by the direct mechanical contact of a small arm or point projecting from the pendulum-rod.—(2.) *Clock Arrangement.*—To move the clock-wheels, two pallets acting upon the teeth of the escape-wheel are fixed upon an axis, at right angles to which, are attached two or more permanent bar-magnets. Beneath each pole of the bar-magnets is placed an electro-magnet. A wire proceeding from a double battery coils round the electro-magnets from the top to the bottom on the one side, and from the bottom to the top on the other, so that when a current passes, the upper ends on the one side are north poles, and those on the other side south poles, and *vice versa*. Two batteries are employed to actuate the electro-magnets. A wire from the negative pole of the one battery, and another from the positive pole of the other battery, are soldered into one wire, which, after passing round the electro-magnets in the way just described, terminates in the pendulum. The *free positive* wire of the one battery terminates in a point of platina on the one side of the pendulum-rod, and the *free negative* wire of the other battery terminates in the same way on the opposite side of the rod; the arrangement being such, that when the pendulum hangs vertically, neither battery is in action, but when it swings to the one side it touches the free positive wire and lets the current from one battery pass, and when it swings to the other side it touches the end of the free negative wire, and lets the current of the other battery pass. In this way the poles of the electro-magnets are alternately reversed, the ends which were north poles when the one battery was in action, being south poles when the opposite battery transmits its current. The bar-magnets are thus alternately acted on in reverse directions by an attractive force at one end, and a repulsive force at the other, and by their oscillations work the pallets and move the wheels. The rate, however, at which the wheels are moved, is entirely determined by the pendulum which regulates the intervals at which the alternate opposite currents reach and actuate the electro-magnets.—(3.) *Striking Arrangement.*—This includes a special battery which actuates two electro-magnets, one of which drives the wheel which determines the number of strokes given to the hour-bell, whilst the other moves the hammer which effects the strokes. It is impossible, without diagrams, to describe the very ingenious apparatus employed for this purpose. It may be stated, however, that a lever pushed back by a pin on the minute-hand, is depressed once an hour by a pin on the seconds hand, which completes the circuit of a battery, and calls into action the hour-wheel and the bell-hammer. For the working of these the current must be alternately cut off and let on the electro-magnets—and this is effected by making a break in the circuit be filled up every alternate second by the ascent of a thin plate of metal, moved by one of the oscillating bar-magnets. The bell is thus struck every two seconds—the number of strokes being determined by the distance between notches on the circumference of the hour-wheel. The current flows so long as one end of a lever is out of a notch—when it falls into one the current is cut off, and the striking ceases. The lever is not again raised till another hour comes round.

The Society was highly gratified with Dr Wilson's luminous description of this interesting machine, and their satisfaction was expressed by the President from the chair, who, after making complimentary remarks, both in reference to the ingenuity displayed by Mr Shepherd, and to Dr Wilson's manner of describing a piece of mechanism so difficult to illustrate to a large audience, concluded by proposing a vote of thanks to Mr Shepherd for so kindly consenting to send the clock, with diagrams and models, to Edinburgh; and to Dr Wilson, for the trouble he had taken, and the success of his description; and also to Mr Alex. Bryson, for his care and trouble in setting up the clock, and putting it in working order; which vote was carried unanimously.

The Reports of Committees on Mr Kennard's Cast-Iron Sleepers for Railways—on Mr Kerr's description of Messrs Stevenson's Swing Bridge at Peterhead Harbour—and on Mr White's Safe-Lock—were read and approved. The Council also reported that they had invited Mr Macadam, Secretary to the Royal Society for Promoting the Growth of Flax in Ireland, to give a lecture before this Society in Edinburgh, on the subject of the culture and manufacture of flax, in the month of May or June, as may be most convenient for him, and that he had kindly consented to do so.

The following Donations were laid on the Table, viz:—

1. The Assurance Magazine, No. V. (Oct. 1851). Presented by the Institute of Actuaries, London. (3439.)

2. Minutes of the Proceedings of the Institution of Civil Engineers, 1850, Vol. IX., Part 2;—and Ditto for 1850–51, Vol. X., Part 1;—and List of Members as at 24th December 1851. Presented by the Institution. (3446—1, 2, 3.)

3. Dr D. B. Reid's Report on the Ventilation of the House of Commons, dated 16th March 1852. Presented by Dr Reid. (3448.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

1. The Minutes of last Meeting were read and approved.

2. A List of Prizes offered by the Society for Session 1852–53, prepared by the Council, was read and approved, and ordered to be printed and advertised.

26th April 1852.—Dr Lees, President, in the Chair. The following Communications were made:—

1. On the Manufacture of Red or Amorphous Phosphorus on the large scale at Birmingham, by Messrs John and Edmund Sturge; with an account of its application to the preparation of innoxious Lucifer-Matches. By Dr George Wilson, F.R.S.E.

Dr Wilson commenced by stating, that phosphorus had been manufactured in Europe for at least two centuries, but only on the small scale, and as an object of curiosity, till within the last twenty-five or thirty years, when the introduction of the lucifer-match led to a prodigious increase in the quantity of phosphorus manufactured, as it entered into the composition of almost all the varieties of instantaneous lights. In illustration of this it was mentioned, that a single English lucifer-match maker employed nearly five hundred persons, and manufactured more than two thousand millions of matches yearly. The simplest lucifer-match consists of a splinter of wood dipped into melted phosphorus, and then covered with gum or glue. More frequently phosphorus is associated with chlorate or nitrate of potass, and with sulphur or sulphuret of antimony. The employment of such materials necessarily renders the manufacture a very hazardous one, from the risk of fire, and in certain of the Continental states, the preparation of lucifer-matches has been absolutely prohibited. Another and quite unexpected hazard was soon found to attend their manufacture. The work-people were attacked by a very painful and often fatal disease of the jaw-bones, which became carious, occasioning in many cases death, in several loss of the upper or under jaw, or other severe mutilation and disfigurement, and always much suffering. The German surgeons, who have paid great attention to this distressing disease, refer it to the absorption of the vapour of phosphorus, given off chiefly during the drying of the matches, but likewise at other stages of the manufacture. Phosphorus, also, is well known to act as a poison when swallowed in the solid form, and as it occurs in this condition in lucifer-matches, fatal accidents have more than once occurred from children sucking them. The red or amorphous phosphorus is much less combustible than ordinary phosphorus, and not at all poisonous. To prepare the new substance, ordinary phsophorus is melted in a peculiarly constructed retort, and kept for some hours at a temperature of about 500° F. A very singular change is the result of this heating, during which the phosphorus combines with caloric, and renders it latent, but does not otherwise undergo any chemical alteration. The original phosphorus was a pale yellow or white transparent body, so combustible that it must be kept under cold water, and when brought into the air grows luminous even at the freezing point, and enters into full blaze at a temperature of about 150° F. By the prolonged heating it becomes a soft opaque mass, which is easily pulverised, and then forms an uncrystalline powder of a scarlet, crimson, purple-brown, or brown-black colour, so incombustible that it may be exposed in summer in the open air, and handled with impunity; nor does it grow luminous till it is about to enter into full combustion at the temperature of 482° F. It is, further, so harmless to living creatures, that more than a hundred grains have been given to dogs without doing them any injury. Although, in its free state, it is sparingly combustible, yet, when it is mixed with the ordinary ingredients of lucifer-matches, such as sulphur or sulphuret of antimony and chlorate of potass, it kindles readily. In proof of this, matches made with amorphous phosphorus were shewn to ignite as easily as those made with ordinary phosphorus; and it was stated that they would soon be manufactured on the large scale, and sold, it was believed, as cheaply as the common matches. Dr Wilson then stated, that he thought the community were indebted to the Messrs Sturge, for the attempt which they were now making to introduce the new phosphorus, which had the following advantages over the old :—1. It involved much less risk of destruction of life and property by fire; 2. It was more suitable for matches intended for warm climates; 3. It was not poisonous in the solid form, so that matches made with it would be comparatively harmless if sucked or chewed; 4. It gave off no vapour at ordinary temperatures, so that it could not occasion disease in the matchmakers. It therefore seemed alike the interest and the duty of the public to encourage, by purchasing them, the manufacture of lucifer-matches made with the new phosphorus. Dr Wilson added that, considering how large an amount of phosphorus entered into the composition of our bodies, and those of other animals, he thought it probable that the amorphous phosphorus would prove a valuable medicine; and he had already ascertained that it would be of great use to scientific chemists in preparing compounds—such, for example, as phosphorous acid, hydrobromic and hydriodic acids, and the like.

On the motion of Mr Grainger, the thanks of the Society were voted to Messrs Sturge for so kindly sending drawings of their retorts, and specimens of red or amorphous phosphorus; and to Dr Wilson for his excellent description of the processes, and his illustration of the same by experiments.

2. Account of the Bursting of Bilberry Reservoir. By James Leslie, Esq., civil engineer.

It appears from the report of Captain Moodie, R.E., who, on the part of Government, made the necessary inquiries into the cause of the bursting of this reservoir, and from the other evidence before the coroner's inquest, that the embankment was originally 96 feet in height above the centre of the valley, 340 feet in length, 16 feet broad at the top, with an inner slope of 3 to 1, and outer slope of 2 to 1, having a puddle-wall in the centre 16 feet thick at bottom, and 8 feet at top, and founded 9 feet below the natural surface, with an outlet sluice 67 feet below the top of the embankment, and placed at this level to supply Bilberry Mills, thus leaving about 25 feet of dead water in the reservoir. Embankments having such slopes and dimensions ought, if well constructed, and subject to no unfair play, to be beyond doubt secure. The valley in which the reservoir stood consists of beds of mill-stone grit alternating with shale, and seems to be of a very pervious nature. There was a considerable spring under the puddle, which had never been stopped or carried past, and on that account the puddle was not well put in, being more slush than puddle; there were also several leaks in the bottom, and when the water rose above 44 feet there was a very heavy one, as thick as a man's arm. The escape of water by these leaks was sufficient for the supply of the mills, and it was found unnecessary to draw the sluices after the water had attained the height of 30 feet in the reservoir. A circular shaft, 12 feet diameter, called a waste pit, placed in the inner face of the embankment, and about 60 feet from the top, brought up from the solid ground, with a tunnel leading from it through the embankment, was intended to carry off the waste water. A shuttle or sluice was likewise placed at the bottom of the shaft, with an open cut leading into it, for the ordinary discharge. This shaft, which is similar to the waste pipe of a common cistern, although it affords $37\frac{1}{2}$ feet of waste weir, is not much to be admired. Its area is reduced and divided into two by a gangway across it for access to the sluice, and it is thus liable to be stopped up, by trees, &c., being floated on to the top of it. Besides, the fall of a body of water from a height of 59 feet, might damage the bottom of the shaft and sluice. It does not appear, however, that this waste pit ever had been of any use, owing to the embankment having sunk 10 feet in the centre shortly after its completion, or 2 feet below the level of the waste pit—thus rendering it quite inoperative. Mr Leslie attributes the cause of bursting to the water overtopping the embankment, and running down the back slope in a great and constantly augmenting volume, carrying everything before it, when at length the puddle was left exposed, and eventually gave way. This supposition is borne out by the fact that the south end of the embankment —a portion of which is very much sunk—and where there were two large leaks, and the north end, where there was one leak, have both stood perfectly sound. The reservoir, as stated by Captain Moodie, had a drainage area of 1920 acres, and that he computes might yield, in the heavy fall of rain which occurred immediately before the bursting of the embankment, 500 cubic feet a second. This is a large quantity, and may be correct; but Mr Leslie never knew of more than half that amount run off a similar extent of surface in the same time in the neighbourhood of Edinburgh. The reservoir has been variously stated to cover from seven to eleven acres, and to contain from ten to eleven millions of cubic feet—so that, even had it been empty, it would not contain more than six hours of such a flood as that spoken of. The bursting of the reservoir has caused great fears of reservoir embankments in general, but it ought rather to give increased confidence in their stability, if properly constructed, and having sufficiently extensive waste weirs, so as to make sure that the water shall never rise to a height at all approaching to the top. The embankment which was leaky had slipped, and was not by any means in good repute, yet had stood much more than ever it had been calculated to do, in having been twice actually overtopped before it gave way.

On the motion of Professor More, the thanks of the Society were voted to Mr Leslie for his interesting paper and drawings, and the same were referred to a Committee.

3. Description of an Instrument by which the variation of the Magnetic Needle can be determined with a greater degree of accuracy than has been attainable in Field Surveying. By John Adie, Esq., F.R.S.E.

In this paper the author refers to the changes that are known to be going on in the angular amount of the variation of the magnetic needle, and alludes to the various instruments employed for its determination, shewing how insufficient for this purpose many of these are. The instrument described is a tube exactly the same as the telescope of the theodolite, provided with collars to rest in the Y's, in which tube the needle is placed, the tube having a glass diaphragm with minute divisions at each end. The diaphragms are viewed by powerful eye-pieces placed at opposite ends. At each observation the needle is reversed, thus having a perfect correction for errors arising from any want of straightness in the needle, and also for the magnetic axis not being in the same line as the centre of the needle. The telescope of the theodolite being then turned into the true meridian line, the difference between the readings of the magnetic meridian and the true is the magnetic variation. The author then shews the result of these observations; and, in conclusion, gives a table shewing the changes that have been going on since the beginning of the present century; and that the variation of the needle was found at present to be in Princes Street Gardens, 25° 28′ west.

4. Description of an Improved Break for Railway Carriages. By Mr James Boyd Thomson, Memb. Inst. Mech. Engineers, Edinburgh and Glasgow Railway Office, Glasgow.

This break consists of a cast-iron pulley-wheel, with a flange on both sides, keyed on to each axle; a strap of iron encircles the pulleys, one end of it being fixed to the framing of the carriage, immediately above the pulley-wheel, passes from thence round it, and fits it sufficiently easy to allow the pulley to revolve freely when the break is off; the other end of the strap is attached to a connecting rod, which passes under the framing of the carriage, above the pulleys, to a bell-crank worked by the ordinary break, lever, and spindle; the screw being a double or triple threaded one. When the break is to be put on, the lever handle is turned, which raises the crank, and draws forward the connecting rod to which the break straps are fixed, and thus tightens them upon the pulleys. The friction thus caused, stops or retards the revolution of the axles as may be required. From two to three turns of the break lever are sufficient to retard the motion of the wheels, and from four to five only are required to stop them. The author stated that this break removes the objections to the common break, which consists of blocks of wood applied to the tyres of the wheels, which are expensive to keep in an efficient condition, from their great tear and wear, besides their tendency to twist the axles. In wet weather also, they cannot be depended upon, as they do not bite the wheels. It requires also from fifteen to twenty turns of the break-handle to sledge or stop the wheels—a serious objection in cases of danger. The new break was stated to obviate these and other objections, and also does away the creaking and jarring sensation caused by the friction of the break-blocks of the common break upon the carriage wheels. The new breaks could be easily substituted for the old ones upon all carriages, as the present break, lever, spindle, &c., would be available. The pulley-wheel may be cast in two pieces, and keyed on to the axles.

5. Description of two Models of his Explosive Projectile for Artillery, on a safer principle than those formerly submitted by him. By Mr George D. Howell, 23 Home Street, Edinburgh.

The two models exhibited are of a *conical* form, hollow at base. The one is made to explode by a piston running down through the centre, acting on a percussion point, the piston not being inserted till the shell is being put into the gun. The other is made to explode by a spiral wire, having the one end fixed in the point of the cone, whilst on the other end of the spiral is fixed a ball covered with detonating powder, which strikes the side of the cup when the shell hits the object, and instantly explodes. Both missiles are constructed so as to be easily handled without risk of premature explosion.

6. Report of Committee on Mr Edward Sang's Observations on the Solar Eclipse of July 1851. Mr Swan, Convener. (3397.)

The following Donations were laid on the Table, viz.:—

1. Eleventh Annual Report and Transactions of the Royal Society for the Promotion and Improvement of the Growth of Flax in Ireland, for the year ending 31st October 1851. Presented by James Macadam junior, Esq., Secretary. (3450.)

2. Drawing, with relative Description, of a 30-ton Crane, erected at Dundee Harbour in 1839, from the design of James Leslie, Esq., C.E. (formerly read to the Institution of Civil Engineers, London). Presented by the Author. (3452.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. Copies of the List of Prizes, offered by the Society for Session 1852-53, were distributed.

III. In terms of Law XX., the Treasurer laid on the Table a List of such of the Ordinary Fellows as were then in arrear of their Annual Contributions.

The Society adjourned till June.

14*th June* 1852.—Dr Lees, President, in the Chair. The Chair having been taken by the Vice-President *pro tempore*, the following communications were made :—

1. A Pictorial Exposition of the origin and progress of the Britannia Tubular Bridge, with Models illustrating the mode of joining and rivetting the Plates. By George Lees, LL.D., President.

In this communication Dr Lees gave a concise yet comprehensive account of the various stages of progress of this vast undertaking, characterising it as beyond doubt by far the most gigantic construction ever achieved in this world's history. By means of a beautiful drawing, he proceeded to exhibit at one view the Menai Strait, the site of Telford's Suspension Bridge; the site chosen for the Tubular Bridge, where there was the now famous Britannia Rock in the middle of the stream; the first design of Mr Stephenson, the engineer, of two cast-iron arches; the substitution for these of the tube, in consequence of the objections of the Admiralty to those arches impeding the navigation; the building of the tubes on scaffolding at the side of the Strait; mode of joining and rivetting the plates; the floating of the tubes, 1800 tons in weight, on pontoons to their position between the piers; their subsequent elevation by the hydraulic press of 14,200 horse power; their junction in the piers by additional tubing; these forming two complete lines of tubing, each 1513 feet long; the system of rollers under the tubes to admit of their free expansion or contraction—all the prominent features in part of this the eighth wonder of the world. After a warm eulogium on the eminent engineering skill which has been displayed from first to last in this stupendous erection (for his interesting exposition of which he received the thanks of the Society), Dr Lees, as President, addressed the Society as follows:—"As this is the last opportunity, gentlemen, which we shall have of meeting together for the session, allow me to avail myself of my present position, in returning you my warmest thanks for your kindness to myself personally, and at the same time to acknowledge the great interest which you have taken in the general business of the session. There is a vast interest, gentlemen, attaching to those objects which this and similar societies seek to promote. For, whether we regard the physical arts as mere studies—as mere intellectual exercises I mean—or look upon them in their endless applications as they minister to the necessities, the conveniences, the comforts, the luxuries, and, I may add, the elegancies of social life, they are equally worthy of all acceptation. In comparing this with other nations, it is gratifying to say, and to be justified in saying, that in all the great applications of practical science, our country stands pre-eminently distinguished. Where, for example, did the steam-engine first draw breath? in that little insignificant-looking speck on the surface of the globe, known by the name of Great Britain. Where is the nativity of railroads?—in Great Britain. Where were human thoughts first carried on the wings of lightning?—in Great Britain. Where were railway trains first shot across the sea, like bullets from a cannon?—over the Britannia Rock in Great Britain. Where, in short, have all those mighty triumphs of mind over matter been achieved, which so distinguish the age in which we live above all the bygone ages of the world?—In France? in Germany? in America? No; the answer is the same—in Great Britain. We are far from denying to these and other countries their just and proper claims to distinction in this race of improvement; still, with all these allowances, there can be no doubt that the great progress of the age, in all that gives a lift to the whole human race, is due to Great Britain. In travelling by steam some time ago in France, I was more than gratified to find that, with the steamer herself, the French had had the good taste to import the native language of the steamer. The captain, for example, in giving orders to the engineer, did not call out in his own language, *arrêtez le bateau a vapeur;* he called out with energy, 'Stop her,' or 'back her,' as the case might be. I could not help recognizing in this an immense compliment to home; and certainly my heart did warm at the moment 'to mine ain countrie.' The celebrated Syracusan philosopher exclaimed in the pride of his science, 'Give me a place on which to rest my lever, and I will move the earth.' Gentlemen, what Archimedes could not achieve mechanically, we, it strikes me forcibly, are about to accomplish morally. There is a fulcrum now resting on this favoured island of the sea, there is a power, a combination, it may be, of moral and physical power—now in action upon the lever, there is a time coming when this power, by accumulation and concentration, will produce its effect—and what will that be? the stupendous effect of raising the nations now borne down by oppression and superstition, to a participation of those glorious rights and liberties which it is the birthright of a Briton to enjoy. The time of this most desirable consummation may be distant—there may be trials and failures, risings and fallings between, still it is approaching—the great lift will be accomplished. In the simple and beautiful language of our own illustrious Burns—

‘ Then let us pray that come it may,
As come it will for a’ that,
That man to man the world o’er
Shall brothers be for a’ that.’ ”

2. Description and two Drawings of a Design for a Table-Lamp in Silver or Brass in the Victorian Style, convertible into a Flower Stand. By Mr. Randall P. Dale, 5 Buccleuch Place, Edinburgh. (3445.)

3. Description and Drawing or Design for a Fountain. By Mr John Tod Alexander, Rustic Work Manufacturer, Dumfries. (3451.)

The following Reports of Committees were then read and approved of, viz.:—

4. Report on Mr Niman's Bootmaker's Plane. Mr Young, Convener. (3432.)

5. Report on Mr James B. Thomson's Break for Railway Carriages. Mr Paterson, Convener. (3444.)

6. Report on Mr Winton's Railway Signal. Mr Slight, Convener. (3392.)

7. Report on Mr Waters' Manufacture of Sheet-Iron. Mr Slight, Convener. (3387.)

8. Report on Mr John Sang's Platometer. Mr Grainger, Convener. (3409.)

9. Report on Leighton's Chromatic Facsimile Process. Mr Simson, Convener. (3437.)

10. Report on Mr Campbell's Paper on the Cleveland Ironstone. Mr Rose, Convener. (3438.)

11. Report on Dickson and Son's Paper on the Minie Rifle and Ball. Dr Lees, Convener. (3443.)

12. Report on Mortimer's Minie Bullet-Mould. Dr Lees, Convener. (3442.)

13. Report on M'Craw's Photographic Apparatus. Mr Cay, Convener. (3449.)

14. Report on Leslie's Account of Bursting of Bilberry Reservoir. Mr D. Stevenson, Convener. (3454.)

15. Report on Adie's Variation Instrument. Mr Buchanan, Convener. (3455.)

16. Report on G. D. Howell's Projectile for Artillery. Dr Lees, Convener. (3447.)

The following Donations were laid on the table, viz.:—

1. The Assurance Magazine, No. VII. (London, April 1852.) Presented by the Institute of Actuaries. (3453.)

2. Du Dessèchement du Lac de Harlem, par M. Gevers d'Endegeest, Conseiller d'Etat, Membre de la Seconde Chambre des Etats Généraux, President de la Commission pour le dessèchement du Lac de Harlem. Piece Justificative No. 1, comprenant Carte I., Le Rhinland et le Lac de

Harlem. Carte II., La Machine à Vapeur à Sparendam. Carte III., La Machine à Vapeur le Leeghwater pres du Kaag. Presented by M. Gevers d'Endegeest, Hon. Mem. R.S.S.A. (3456, 1–2.)

3. Astronomical Observations made at the Royal Observatory, Edinburgh, by the late Professor T. Henderson, reduced and edited by his Successor, C. Piazzi Smyth, Astronomer-Royal for Scotland; Vol. X., for 1844–5–6–7. Presented by the Royal Observatory. (3457.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

The following Candidate was elected an Ordinary Fellow:—

James Boyd Thomson, Memb. Inst. Mech. Engrs., Assistant Manager, Edinburgh and Glasgow Railway Company.

The Society appointed the Prize Committee to award the Prizes for Session 1851–2, viz.:—

Dr Lees, *President.*
Wm. Paterson, Esq., *V.P.*
Thos. Stevenson, Esq., *V.P.*
Thos. Grainger, Esq.
Geo. Buchanan, Esq.
James Slight, Esq.
John Cay, Esq.
Professor Kelland.
Dr Douglas Maclagan.
Patrick Wilson, Esq.
George Simson, Esq.
Alexander Rose, Esq.
James Tod, Secretary, Convener *ex officio.*

On the motion of Sheriff Cay, the thanks of the Society were unanimously voted to Dr Lees, President, for his conduct in the Chair of the Society.

APPENDIX (G.)

LIST OF PRIZES FOR SESSION 1852–53.

THE ROYAL SCOTTISH SOCIETY OF ARTS proposes to award Prizes of different values, none exceeding Thirty Sovereigns, in Gold or Silver Medals, Silver Plate, or Money, for approved Communications *primarily* submitted to the Society, relative to Inventions, Discoveries, and Improvements in the *Mechanical* and *Chemical* Arts in general, and also to means by which the *Natural Productions* of the Country may be made more available; and, in particular, to—

I. INVENTIONS, DISCOVERIES, or IMPROVEMENTS in the Useful Arts, including the *Mechanical* and *Chemical*; and in the Mechanical Branch of the *Fine Arts*; such as, but not limited to, the following viz.:—

1. *Mechanical Arts.*

1. IMPROVEMENTS in Sewerage,—in Economical Appliances for increasing the Sanitary Condition of Cities and Towns, in Methods of Warming and Ventilating Public Edifices, Private Dwellings, &c.,—of Ventilation of Mines,—of constructing Economical and Salubrious Dwellings for the Working-Classes,—of Filtering Water in large quantities,—of Extinguishing Fires,—of applying Glass to new and useful purposes, &c. &c.

2. INVENTIONS or IMPROVEMENTS in preserving Timber and Metals in Marine Works,—in Locomotive, Stationary, and Marine Engines,—in Lighthouse Apparatus,—in Railways and Railway Plant and Signals,—in Flax Machinery, and in the processes for preparing the Flax for manipulation,—in Steam Machinery, as applied to Agriculture,—in Tools, Implements, and Apparatus for the various Trades,—in Rifle Guns,—in Grates,—in Cements and Mortars,—Machines for Planing

Wood,—in Printing Machines,—in Printing Cases,—in the Composition of Printers' Rollers,—in Cranes for raising heavy bodies,—in the Machinery for Collieries and other Mines,—in Machines for Cutting, Dressing, and Boring Stone,—in Microscopic Apparatus,—in Steel or other Metallic Pens,—in new or improved Motive Power, Electric, Chemical, &c. &c.

2. *Chemical Arts.*

IMPROVEMENTS in Dyes and Paints,—in rendering Glass hard and difficult of fusion for Chemical purposes,—in Writing Inks,—in the Manufacture of thin sheets of Gutta Percha, of equal strength in all directions for Surgical purposes,—in substitutes for, or improvements upon, the process of Vulcanizing India Rubber, &c.,—in Oil for fine Machinery, Clocks, and Watches,—in Apparatus for Fermentation,—cheap processes for separating Nickel from its ores, &c. &c.

3. *Relative to the Fine Arts.*

IMPROVEMENTS in the form of Articles in Porcelain, Common Clay, or Metal,—in Fire-Clay Articles for Architectural purposes,—in Glass Staining,—in Engraving on Stone,—in Daguerreotype, Talbotype, or other Photographic processes, and their application to taking microscopic objects and machinery,—in Electrotype processes,—in Die-sinking,—in methods of illustrating Books to be printed with the Letter-Press,—in Ornamental Metallic Casting,—in Designs and adaptation of new Materials for Sepulchral Monuments,—in Mosaic and Inlaid Stone Work, &c. &c.

II. EXPERIMENTS applicable to the Useful Arts.

III. COMMUNICATIONS of Processes in the Useful Arts practised in this or other Countries, but not generally known.

IV. PRACTICAL DETAILS of Public or other Undertakings of National importance, already executed, but not previously published;—or valuable suggestions for originating such undertakings.

The SOCIETY also proposes to award the KEITH PRIZE, value Thirty Sovereigns,

For some important "Invention, Improvement, or Discovery, in the Useful Arts, which shall be primarily submitted to the Society" during the Session.

GENERAL OBSERVATIONS.

Communications lodged *in competition for Prizes*, shall not have been Patented, nor have been previously Published, nor read before any other Society.

The Descriptions of the various inventions, &c., must be *full* and *distinct*;—be legibly written on *Foolscap* paper, leaving margins at least one inch broad, on *both sides of the writing on every page*, so as to allow of their being bound up in volumes; and, when necessary, be accompanied by *Specimens, Drawings, or Models*. All Drawings to be on *Imperial* Drawing Paper, unless a larger sheet be requisite. The Drawings to be in *bold* lines, not less than an eighth of an inch thick, or *strongly coloured*, so as to be easily seen at about the distance of thirty feet when hung up in the Hall of Meeting, and the Letters or Figures of Reference to be at least 1½ inch long. When necessary, smaller and more minutely detailed Drawings should accompany the larger ones, for the use of the Committees, having the same letters or figures of reference.

The Society shall be at liberty to publish in their Transactions copies or abstracts of all Papers submitted to them. All Models, Drawings, &c., for which Prizes shall be given, to be held to be the property of the Society; the Value of the Model, &c., being separately allowed for.

Communications, Models, &c., are to be addressed to JAMES TOD, Esq., the SECRETARY, 55 Great King Street, Edinburgh, Postage or Carriage paid; and they are expected to be lodged *on or before 1st October* 1852, in order to ensure their being read and reported on during the Session, the ordinary Meetings of which end in April 1853; but *those which cannot be lodged earlier*, will be received up to 1st April 1853; those lodged after that date may not be read or reported on till the following Session.

By order of the Society.

JAMES TOD, *Secretary*.

EDINBURGH, 12*th April* 1853.

APPENDIX (H).

REPORT

OF

THE COMMITTEE

APPOINTED BY

THE ROYAL SCOTTISH SOCIETY OF ARTS

TO AWARD PRIZES FOR COMMUNICATIONS READ AND EXHIBITED DURING SESSION 1851–52.

Your COMMITTEE having met and carefully considered the various Communications laid before the Society during Session 1851–52, beg leave to report that they have awarded the following Prizes :—

1. To Mr JOHN SANG, Land-Surveyor, Kirkcaldy, for his "Description and Drawings of a Platometer; an instrument for measuring the area of figures drawn on paper." Read, and the Instrument in various forms exhibited, 12th January 1852. (3409.)

   The KEITH *Medal and Plate, value Thirty Sovereigns.*

   Note.—Your Committee have with great care investigated Mr SANG's claim to originality, and are perfectly satisfied on that head, although they are aware that instruments somewhat analogous in construction have been employed on the Continent. Your Committee have also taken pains to collect the opinions of some of those gentlemen who have had an opportunity of comparing Mr SANG's instrument with others, and their opinions coincide with those of your Committee.

2. To Mr John Adie, F.R.S.E., Optician, Edinburgh,—for his "Description of an Instrument by which the Variation of the Magnetic Needle can be determined with a greater degree of accuracy than has been attainable in Field Surveying." Read, and the Instrument exhibited, 26th April 1852. (3455.)

The Society's Silver Medal and Plate, value Ten Sovereigns.

3. To Mr John Howell, Polyartist, Edinburgh,—for his "Description of an Improved Jointed Artificial Leg for short Stumps of the Thigh." Read, and a Working Model exhibited, 8th December 1851. (3402.)

The Society's Silver Medal, value Three Sovereigns.

4. To Mr William M'Craw, 287 High Street, Edinburgh,—for his "Description of a Portable Apparatus for taking, developing, and fixing Glass Photographic Pictures in the light, without any Dark Apartment." Read, and the Apparatus, and Specimens of Pictures taken by it, exhibited, 12th April 1852. (3449.)

The Society's Silver Medal, value Three Sovereigns.

5. To Mr Louis Niman, Journeyman Bootmaker, St Vincent Street, Edinburgh,—for his "Description and Drawings of a Bootmaker's Plane." Read, and the Plane exhibited, 8th March 1852. (3432.)

The Society's Silver Medal, value Three Sovereigns.

6. To Daniel Wilson, LL.D., Sec. Soc. of Antiq. of Scotland,—for his "Paper on some New Methods calculated to facilitate the application of Ancient Arts to the Decoration of Sepulchral Monuments." Read, and various Illustrations exhibited, 12th January 1852. (3407.)

The Society's Silver Medal.

7. To Mr Thomas E. Mortimer, Gunmaker, Edinburgh,—for his "Description and Drawing of a Bullet-Mould for Minie Rifle Balls." Read, and the Bullet-Mould exhibited, 12th April 1852. (3442.)

The Society's Silver Medal.

8. To Mr John Goodfellow, Buccleuch Street, Hawick,—for his "Description and Drawing of Public Baths and Washhouses established at Hawick." Read 8th December 1851. (3389.)

The Society's Silver Medal.

9. To Mr William Hart, Gardener, late near Jedburgh, now in Australia,—for "the Ingenuity displayed by him in the construction, under many disadvantages, of a Galvanic Apparatus for Medical purposes," which was exhibited in action, and the Description read, on 12th January 1852. (3386.)

Two Sovereigns.

The Committee recommend, that while the *Thanks* of the Society are justly due to all those gentlemen who have sent Communications, the *Special Thanks* of the Society be given to the following gentlemen, viz.:—

1. To Edward Sang, Esq., Professor of Mechanical Philosophy at the Imperial School, Muhendis-hana, Berii, at Constantinople,—for his "Account of Observations on the Solar Eclipse of 28th July 1851, made at Sebastople." Read 24th November 1851; and printed in the Transactions. (3397.)

2. To Professor C. Piazzi Smyth, F.R.S.E., Astronomer-Royal for Scotland,—for his "Oral Exposition of a Method of Raising Water by means of Wind,—employed by him at the Cape of Good Hope." Exposition given 10th November 1851. (3395–B.)

3. To Robert Wm. Kennard, Esq., 67 Upper Thames Street, London,—for his "Communication on the Substitution of Cast-Iron for Wooden Sleepers." Read, and Illustrative Drawings exhibited, 30th June 1851. (3376.)

4. To James Leslie, Esq., Civil Engineer, Edinburgh,—for his "Account of the Bursting of Bilberry Reservoir." Illustrated with Drawings. Read and exhibited 26th April 1852. (3454.)

5. To J. Lawrenson Kerr, Esq., Civil Engineer, Edinburgh,—for his "Description of a Cast-Iron Swing Bridge, constructed for Peterhead Harbour by Messrs Blackie, Panmure Foundry, from Designs by Messrs Stevenson, Civil Engineers." Read, and Drawings exhibited, 9th February 1852. (3429.)

6. To Mr George H. Slight, Engineer, Edinburgh,—for his "Description and Drawing of an Improved Instrument for Drawing Ellipses." Read and exhibited 23d February 1852. (3430.)

7. To William Campbell, Esq., Civil Engineer, Edinburgh,—for his "Notice of the recently-discovered Iron District of Cleveland, Yorkshire. With Specimens of the large masses of Ironstone now being quarried at Easton-Nab there." Read and exhibited 22d March 1852. (3438.)

8. To Messrs John Dickson & Son, Gunmakers, Edinburgh,—for their "Account of Experiments made on the Minie Rifle at Dalmahoy Moss, with Remarks on its use as proposed in the Army." Communicated, along with some General Views of the Principles of this branch of Gunnery, by Geo. Buchanan, Esq., C.E., F.R.S.E. Read, and Rifles and Balls of different forms, with Bullet-Moulds, exhibited, 22d March 1852. (3443.)

9. To Mr William Grosart, Grangemouth, by Falkirk,—for his "Memoranda in regard to the History of Steam as a power for propelling Ships, &c.; and in particular, as to the late Mr William Symington's connection with that subject." Read, and the original Pattern of the Shaft of the "Charlotte Dundas" exhibited by Dr Wilson, Sec. S. Ant. Scot., 23d February 1852. (3416.)

Your Committee must add, that the Society were much indebted to their former esteemed President, the late Thomas Grainger, Esq., F.R.S.E., for his Account—in continuation of those formerly read before the Society—of the progress made in the Drainage of Haarlem Meer during the last year; and that it is their duty to record in this Report his energy and zeal in personally obtaining on the spot the necessary information, to enable him to present this interesting subject to the Society from the most authentic sources.

The Committee have further granted, for the purchase of a Model, illustrative of a Paper read during the Session, the sum of Three Pounds.

All which is humbly reported by

JAMES TOD, *Sec., Convener ex officio.*

Edinburgh, 22*d* *Oct.* 1852.

APPENDIX (I).

LIST

OF THE

OFFICE-BEARERS AND FELLOWS

OF THE

ROYAL SCOTTISH SOCIETY OF ARTS,

AS AT 1st NOVEMBER 1852.

THE QUEEN, PATRONESS.

OFFICE-BEARERS FOR SESSION 1851–52.

President, George Lees, LL.D.
Vice-Presidents, { William Paterson, Esq., C.E.
Thomas Stevenson, Esq., F.R.S.E., C.E.
Secretary, James Tod, Esq., F.R.S.E., W.S., 55 Great King Street.
Treasurer, John Scott Moncrieff, Esq., Acct., 15 India Street.

Ordinary Councillors.

*John Cay, Esq., F.R.S.E.
*David Rhind, Esq., F.R.S.E.
*Daniel Wilson, LL.D., F.S.A. Scot.
*Patrick Wilson, Esq.
Douglas Maclagan, M.D., F.R.S.E.
Rev. Prof. Kelland, F.R.SS. L. & E.
James Dalmahoy, Esq., F.R.S.E.
†Thomas Grainger, Esq., F.R.S.E.
Richard Whytock, Esq.
Alexander Rose, Esq.
James Leslie, Esq.
Alex. K. Johnston, Esq., F.R.S.E.

Editor of Transactions, George Wilson, M.D., F.R.S.E.
Curator of Museum, Mr Alexander Jamieson.
Medallist, Mr Alexander Kirkwood,
Officer and Collector, Mr Hugh Johnston.

(The four Ordinary Councillors marked * retire by rotation.)
† Vacant by death.

LIST OF THE ORDINARY FELLOWS

AS AT 1ST NOVEMBER 1852.

1822. ABERCORN, The Most Noble the Marquis of, K.G.
,, ABERDEEN, The Right Hon. the Earl of, K.T.
,, Abercromby, Sir Robert, of Birkenbog, F.R.S.E.
,, Adinston, Thomas, of Carcant.
,, Alison, W. P., M.D., F.R.S.E.
,, Adie, Alexander, F.R.S.E.
1826. Aytoun, Robert, W.S.
1837. Aikman, George, engraver.
,, Alves, H. S., 9 Royal Terrace.
,, Alexander, William, F.R.S.E., W.S.
1838. Anderson, Charles J.
,, Adie, John, optician, F.R.S.E.
1841. Anderson, Charles W., merchant.
1843. Anderson, John, Pratis, Fife.
1846. Ainslie, P. B., Chertsey, London.
,, Alexander, James, wine-merchant.
,, Ainslie, Daniel (late Calcutta).
1847. Abbott, Francis, Sec. G. P. O.
1850. Anderson, Thomas, M.D., F.R.S.E., Leith.
,, Adie, Alex. J., F.R.S.E., C.E., Linlithgow.
1851. Archer, William, solicitor, London.
,, Alexander, Wm., M.E., Glasgow.
,, Anderson, William, Andersonian University, Glasgow.

1822. BUCCLEUCH and QUEENSBERRY, His Grace the Duke of, K.G., A.M., F.R.SS. L. & E.
,, Brewster, Prin. Sir David, K.H., D.C.L., F.R.SS. L. & E.
,, Bald, Robert, F.R.S.E., Alloa.
1826. Brisbane, Sir Thomas Macdougall, Bart., G.C.B., President R.S.E.
1830. Bonar, William, F.R.S.E.
,, Brown, Robert, junior, architect.
1832. Black, Alexander, surveyor of buildings.
,, Bryce, David, architect.
1835. Borthwick, James, manager N. B. Insurance Company.
,, Berkely, Frederick Hewett, Chester.
1835. Burn, William, F.R.S.E., architect.
1836. Bryson, Alexander, watchmaker.
,, Ballantyne, James, of Holylee.
1837. Bell, John Beatson, W.S.
1838. Beattie, Alexander, Star Hotel.
,, Bruce, O. Tyndall, of Falkland, F.R.S.E.
,, Blanshard, Lieut.-Col. Thomas, Roy. Eng.
1839. Brown, Thomas, architect.
1840. Brown, James, accountant.
,, Berwick, David.
1841. Baird, Douglas, iron-master, Gartsherrie.
1844. Bell, J. A., architect.
,, Baillie, William R., W.S.
1845. Bowie, William.
1846. Buist, George, LL.D., Bombay.
,, Beattie, George, builder.
,, Bryson, James, engineer, Dunfermline.
1847. Bernard, Thomas, brewer.
,, Buchanan, William Miller, M.D.
1848. Brebner, Allan, engineer, Burntisland.
1849. Bouch, Thomas, C.E.
,, Burn, Robert, engineer.
1850. Black, Rev. Archibald P., A.M., London.
,, Blyth, Benjamin Hall, engineer.
,, Bell, Alex. Melville, Prof. of Elocution.
,, Bruce, George Cadell, C.E.
,, Bryden, Adam, bell-hanger.
1851. Bryden, John, bell-hanger.
,, Black, John Trafalgar, Surrey.
1852. Barlow, John, Ass. Vet. Prof.

1822. Clerk, Sir George, Bart., M.P., F.R.S.E.
,, Campbell, Walter, of Islay, M.P., F.R.S.E.
,, Cadell, W. A., of Banton, F.R.S.E.
,, Cunningham, Charles, W.S.
1827. Chalmers, Charles.
,, Crawfurd, William, of Cartsburn.
1832. Craig, Sir William Gibson, of Riccarton, F.R.S.E.
1834. Campbell, Alexander, brewer.
1835. Crichton, Alex., lithographic-printer.
1836. Cowan, Charles, M.P., Penicuik.
1837. Cowan, Alexander, paper-maker.

1837. Cooper, Wm., glass-manufac., Canada.
1838. Caldwell, Robert, builder.
1840. Christie, Robert, accountant.
„ Crosbie, George.
„ Cormack, David, S.S.C.
„ Carstairs, Drysdale, Liverpool.
1841. Cowan, James, M.D., surgeon R.N.
„ Cameron, Captain Charles.
1842. Cushnie, William, Malta Green.
1845. Cay, John, F.R.S.E., advocate.
1846. Callender, J. A., C.E., Southampton.
1847. Campbell, John Archibald, F.R.S.E.
„ Cousin, David, architect.
1848. Craig, Rev. John, Cupar-Fife.
1849. Clark, Thomas, M.D., Whitburn.
1850. Campbell, William, C.E.
„ Carstairs, James L., C.E., Berwick.
„ Calvert, Frederick B., A.M.
1851. Cormack, James, ironmonger.
„ Cunningham, George, C.E.
„ Craigie, Henry, W.S., Falcon Hall, Morningside.
„ Cadell, Henry, M.E., Dalkeith.
1852. Crichton, And., LL.D.

1822. Davidson, Robert, of Ravelrig.
„ Dunlop, Arch., F.R.S.E., London.
1838. Dunlop, Andrew, W.S.
1840. Dun, Andrew, W.S.
1841. Davidson, Charles F., W.S.
1843. Dove, James, engine-maker.
1844. Dickson, James Jobson, accountant.
„ Dunn, Thomas, optician.
1846. Donaldson, J., advocate, Prof. of Theory of Music.
1847. Dalmahoy, Jas., F.R.S.E., late H.E.I.C.S.
1848. Duff, Rev. Henry, South Leith.
1849. Drury, Rev. Robert, Surrey.
1850. Davidson, Samuel D., Leith Eng. Works.
„ Dickson, John, junior, gunmaker.
1851. Duncan, James, M.D.
„ Dawson, Charles, London.
„ Dawson, John, distiller, Linlithgow.
„ Duncan, Jas., M.A., Southampton.
„ Drummond, Geo. A., builder.

1828. Ellis, Adam Gib, M.W.S., W.S.
1839. Ellis, Thomas, upholsterer.
1843. Erskine, Daniel, Musselburgh.

1822. Forbes, George, F.R.S.E.
„ Fyfe, Prof. A., M.D., F.R.S.E., Aberdeen.
1828. Fraser, Robert, 18 Dublin Street.
1832. Forbes, Prof. J. D., F.R.SS. L. & E.
1838. Fergusson, Lieut.-Col., H.E.I.C.S.
1840. Fleming, Alexander, W.S.
„ Forrester, John, W.S.
1843. Falkner, James P., solicitor.
1844. Foulis, Sir Wm. Liston, Bart., Hermiston.
1847. Fullarton, John A., publisher.
1848. Fairbairn, J., House-Gov. Heriot's Hosp.
1849. Fraser, J. S., engineer Gt. Western Rail.
1850. Ferguson, William B., C.E., Aberdeen.
„ Falshaw, James, C.E., Perth.
„ Fraser, John, actuary and manager Life Association of Scotland.
„ Fraser, Alexander, printer.
1851. Forbes, William, London.

1822. Gordon, Rev. Robert, D.D., F.R.S.E.
„ Graham, Humphrey, W.S.
1829. Græme, James, W.S., yr. of Garvoch.
1832. Gray, James, ironmonger.
1835. Groat, A. G., of Newhall, advocate.
1836. Greig, Thomas, late printer.
1842. Gillespie, John, W.S.
1844. Girdwood, John, North Wales.
„ Gregory, Prof. William, M.D., F.R.S.E.
1848. Gardner, James, Torphichen Street.
1850. Glennie, George, C.E., Melrose.
„ Gowans, James, builder.
„ Gregory, Thomas Currie, C.E.
„ Gordon, James, jun., W.S.
1851. Gordon, John T., F.R.S.E., Sheriff of Mid-Lothian.
„ Gray, David, M.A., F.R.S.E., Prof. of Nat. Phil. Marischal Coll., Aberdeen.
„ Gordon, James Newell, London.

1829. Horne, Archibald, accountant.
1833. Hamilton, Alex., LL.B., F.R.S.E., W.S.
1834. Hamilton, John, W.S.
„ Horsburgh, Robert, Tongue House.
1835. Hay, James, merchant, Leith.
1836. Haldane, James, brassfounder.
„ Hepburn, J. Stewart, of Colquhalzie.
1837. Hopkirk, J. G., LL.B., W.S.
1838. Hunter, Richard, H.E.I.C.S.
„ Henderson, Eagle, 16 Coates Crescent.
1839. Hill, Laurence, jun., C.E., Glasgow.
„ Hill, Henry David, W.S.
1840. Harvey, George, R.S.A., histor. painter.
1841. Hope, David T., C.E., Liverpool.
„ Hughes, John, printer.
1843. Howden, James, watchmaker.
„ Henry, Jardine, writer.
1845. Hay, David Ramsay, F.R.S.E.
1850. Hill, James L., W.S.
„ Hawkins, John, H.E.I.C.S.
„ Henderson, John, C.E., Leeds.
1852. Hunter, David, chemist.
„ Hollis, William, Chelsea.

1822. Jardine, James, F.R.S.E., C.E.
1840. Johnston, Alex. K., F.R.S.E., geographer to the Queen.
1848. Jefferiss, Robert R., M.D., Dalkeith.
1850. Jardine, William Alexander, C.E.
„ Jopp, Charles, C.E.
„ Johnstone, William, C.E., Glasgow.

1851. Johnston, Robert, accountant.
1852. Johnston, Jas., Stockton-on-Tees.

1822. Keith, James, M.D., F.R.S.E.
1836. Kirkwood, Alexander, die-cutter.
1839. Kennedy, William, W.S.
1842. Kronheim, Jos. M., ornamental designer.
1843. Kemp, Alex., lecturer on chemistry.
1844. Kinloch, Alex. J., M.D., Aberdeen.
1845. Kennedy, John, jun., W.S.
1848. Kirkwood, James, goldsmith.
1850. Kelland, Rev. Philip, F.R.SS. L. & E., Professor of Mathematics.
1851. Kirkwood, Robert, C.E.

1822. L'Amy, James, F.R.S.E., advocate.
1834. Lawrie, William A., W.S.
1836. Lees, George, LL.D.
„ Lawson, Charles, seedsman.
1838. Lorimer, George, builder.
1840. Leburn, Thomas, S.S.C.
1842. Leith, Samuel, lithographer.
1844. Leslie, John, cupper.
1845. Lancefield, Alfred, surveyor.
1848. Laurie, Rev. Joseph, D.D., H.E.I.C.S.
1850. Leslie, James, C.E.
„ Lees, Henry, secretary E. P. & D. Ry.
„ Lessels, John, architect.
1851. Lee, Alexander H., C.E.
„ Lawson, W. J., manager Argus Life Co., London.
1852. Landale, Robert, of Pitmedden.
„ Landale, David, M.E.

1822. Maconochie, Alexander, F.R.S.E.
„ More, John S., Professor, F.R.S.E.
„ Murray, Hon. Lord, F.R.S.E.
1826. Maxwell, John Clerk, F.R.S.E., Glenlair.
1829. Miller, John, C.E.
1831. Macdonald, William, of Powderhall.
1834. Murray, W., of Henderland, F.R.S.E.
1835. Marjoribanks, Gilbert, Australia.
„ Mould, J. B., engraver.
1836. Milne, James, brassfounder.
„ Mackay, James, goldsmith.
1838. Macgibbon, Charles, builder.
„ Morton, Hugh, engineer.
„ Maclagan, David, M.D., F.R.S.E.
„ Moncrieff, John Scott, accountant.
„ Mackenzie, James, W.S.
„ Murdoch, J. B., of Gartincaber, F.R.S.E.
1839. Macbrair, D. J., S.S.C.
„ Maclagan, D., M.D., F.R.C.S., F.R.S.E.
„ Menzies, T., ship-builder, Leith.
1840. Murray, James T., W.S.
1841. Maitland, John, accountant.
„ Marshall, J., of Curriehill, advocate.
„ Macpherson, Charles, printer.
1842. Mitchell, Edward, surgeon.
1843. Marshall, G.H., jeweller.
1843. Melville, John, W.S.
„ Murray, Sir W. K., Bart. of Ochtertyre.
1844. Mackie, D., rector Royal Academy, Tain.
1846. M'Dowall, John, engineer, Johnston.
„ Middleton, Captain J., Waltham Lodge.
„ Mortimer, Thomas E., gunmaker.
„ Miller, James, engineer.
1847. Middleton, James, Waltham Lodge.
„ Mackenzie, William M., surgeon, Kelso.
„ Macadam, John, chemist.
1848. Marshall, Rev. William, Leith.
„ Milne, John Kolbe, pocket-book maker.
„ Macfarlan, John F., druggist.
„ Mackenzie, Rev. Kenneth, Bo'ness.
„ Mitchell, Graham Alexander, Whitburn.
1849. M'Intosh, Charles, Dalkeith Park.
„ Mackie, J. W. R., surgeon, Cupar-Fife.
1850. Mackay, John M., chemist and druggist.
„ Melville, James M., W.S.
„ Martin, George, Glasgow.
„ Mitchell, James, contractor.
„ Macintosh, James A., wood-engraver.
„ Mackay, Charles, goldsmith.
„ Moffat, William L., architect.
„ Mein, Archd., M.D., surgeon and dentist.
„ Mitchell, John M., merchant, Leith.
„ Maclagan, David, manager Insurance Company of Scotland.
„ Marjoribanks, William, merchant.
„ Mackain, Daniel, C.E., Glasgow.
„ Marshall, William, accountant.
„ Miller, Colin M., M.D.
„ M'Leod, James B., teacher.
„ Macpherson, Alexander, plumber, Leith.
„ Macdonald, D., cotton-spinner, Aberdeen.
„ MacGillivray, J., Royal Artil^{y}, Woolwich.
„ Mitchell, Thomas Oak, M.D., Greenwich.
1851. Middleton, J., M.D., licentiate R.C.S.E.
„ Milne, Robert, C.E. and land-surveyor, Aberdeen.
„ Maitland, Sir A. Gibson, Bart.
1852. Murray, Thos., LL.D., Sec. School of Arts.
„ M'Callum, Duncan, C.E.
„ M'Farlane, Wardlaw, chemist.
„ Moffat, John, C.E., Ardrossan.

1832. Nasmyth, James, jeweller.
1838. Nachot, Dr H. W., teacher of German.
1846. Newlands, James, architect, Liverpool.
1850. Newbigging, Patrick, M.D., F.R.C.S.E.
„ Nicholson, R., loco. sup., Burntisland.
„ Notman, David, builder.
1851. Nicolson, Rev. Hugh, London.

1848. Oliver, Robert S., hatter.
1849. Ogilvie, George Ramsay, advocate.
1850. Ogilvie, Archibald, merchant.
1852. Orrock, Jas., surgeon and dentist.

1822. Playfair, W. H., F.R.S.E., architect.

1833. Ponton, Mungo, F.R.S.E., W.S.
1840. Pearson, Charles, accountant.
1842. Pyper, Hamilton, advocate.
„ Paterson, George, of Castle Huntly.
1844. Paterson, John, Leith Docks.
„ Paterson, J., M.D., late 42d Regiment.
1846. Pattison, Thomas, M.D.
„ Paterson, W., resid. eng. E. P. & D. Ry.
1847. Purdie, Thomas, painter.
1848. Peddie, John D., architect.
1850. Pender, James B., paper-manufacturer.
1851. Parker, W. A., Sec. Architect. Institute.

1822. Rosebery, The Right Hon. the Earl of, K.T.
1829. Reid, David B., M.D., F.R.S.E., London.
1834. Ritchie, R., C.E., Assoc. Inst. C.E.
1835. Russell, J. S., M.A., F.R.SS.L.& E., Lond.
„ Ranken, Francis, glass-manufacturer.
1838. Roxburghe, His Grace James H. R., Duke of, K.T.
1839. Russell, Thomas, ironmonger.
1840. Rose, Alexander, lecturer on geology.
1842. Rankine, W. J. Macquorn, F.R.S.E., C.E.
1843. Rhind, David, F.R.S.E., architect.
„ Roberts, W. A., M.D., dentist and surgeon.
1844. Robertson, James, M.E.
„ Ronaldson, John, writer.
1846. Robb, Charles, silversmith.
1848. Reid, Robert Little, painter.
1849. Robertson, Alex. D., merchant.
1850. Ramsay, Alex., manager Edin. Water Co.
„ Rae, William Fraser, brassfounder.
„ Richardson, Ralph, merchant.
„ Richardson, James, merchant.
„ Richardson, Robert, merchant.
„ Robson, Neil, C.E., Glasgow.
1851. Rogers, James, ironmonger.
„ Ross, William, of Greenside.

1827. Swinton, George, F.R.S.E.
1828. Sang, Edward, Prof., Constantinople.
1832. Sclater, Robert, die-cutter.
„ Stair, The Right Hon. the Earl of, K.T.
1833. Steele, Wilkinson, merchant.
1835. Steele, Patrick S., merchant.
1836. Slight, James, engineer.
1837. Smith, Jas., of Jordanhill, F.R.SS. L. & E.
1838. Stevenson, David, F.R.S.E., C.E.
„ Seeligmann, F. E., punch-cutter, London.
1839. Smith, David, F.R.S.E., W.S.
1840. Sprot, Thomas, W.S.
„ Stevenson, Peter, philos. instrum. maker.
„ Smith, C. H. J., landscape-gardener.
1841. Steuart, Robert, of Carfin.
„ Simson, George, R.S.A., artist.
„ Steel, John, R.S.A., sculptor.
1842. Spence, Charles, S.S.C.
„ Smail, Will. Arch., of Overmains, R.N.
1843. Sanderson, James H., lapidary.
1843. Stewart, Hope James, artist.
„ Schenck, Frederick, lithographer.
„ Shanks, Thomas, engineer, Johnston.
1846. Stuart, Joseph Gordon, Markinch.
„ Swan, Wm., F.R.S.E., teacher of mathcs.
„ Simpson, Prof. J. Y., M.D., F.R.S.E.
„ Spence, James, W.S.
„ Seller, William, M.D., F.R.C.P., F.R.S.E.
1847. Steuart, James, W.S.
„ Stevenson, Thomas, F.R.S.E., C.E.
„ Sclanders, Alexander, upholsterer.
1850. Smith, Alexander, C.E., Aberdeen.
„ Swan, Alex., manufacturer, Kirkcaldy.
„ Stewart, James W., C.E.
„ Stark, James, M.D., F.R.C.P., F.R.S.E.
„ Smith, George, architect.
„ Scrymgeour, Henry, upholsterer.
„ Sinclair, Alex., manager Shotts Foundry.
„ Scott, Archibald, architect.
„ Smith, Robert, builder.
„ Sibbald, Thomas, ironmonger.
„ Strachan, Robert, accountant.
„ Smith, George C., land-surveyor, Banff.
1851. Smith, Robert, engineer, governor City Workhouse.
„ Simpson, Geo., C. and M. E., Glasgow.
„ Sawers, John, Provost of Stirling.
„ Seton, Major, R.S., Madras Artillery.
„ Stewart, Hon. Robert, of Omoa, Lord Provost of Glasgow.
„ Scott, John, M.D., F.R.C.P.
1852. Sutter, Archd., land-surveyor.

1822. Tweeddale, The Most Noble the Marquis of, K.T., F.R.S.E.
1826. Tod, James, F.R.S.E., W.S., *Sec.*
1830. Tod, Henry, W.S.
1836. Traill, Thomas Stewart, M.D., F.R.S.E., Professor of Medical Jurisprudence.
1838. Trotter, James, teacher.
1839. Thomson, William T., manager Standard Life Assurance Company.
1840. Trevelyan, Sir Walter C., Bart., F.R.S.E.
„ Turnbull, William, Royal Bank.
„ Thomson, Jas., F.R.S.E., M.R.I.A., C.E.
1842. Taylor, John, cabinetmaker.
1846. Trevelyan, Arthur, Wallington, Morpeth.
„ Thornton, Robert, engineer.
1850. Tennant, Thomas, founder and engineer, Dalkeith.
1851. Turner, Richard, engineer, Dublin.
„ Tennant, John, St Rollox, Glasgow.
„ Tennant, Charles, St Rollox, Glasgow.
1852. Thomson, Jas. Boyde, M.I.M.E., Glasgow

1843. Veitch, John, baker.

1822. Wemyss and March, The Right Hon. the Earl of, F.R.S.E.
„ Whytock, Richard, merchant.

1836. Wright, Robert, architect.
1838. Wilkie, John, of Foulden.
,, Wilson, Patrick, architect.
1840. Wood, William, surgeon.
,, Watson, Henry George, accountant.
,, Wright, Peter, linen-merchant.
,, Walker, William, surgeon.
1843. Wilson, Robert, linen-manufacturer.
1844. Wyllie, Henry J., C.E.
,, Wightman, William, contractor.
1845. Wilson, G., M.D., lecturer on chemistry.
,, Wilson, Daniel, LL.D., Sec. S.A. Scot.
1846. Whitelaw, James, watchmaker.
,, Wilson, Hutton, W.S.
1848. Wood, Rev. James George, Aberdeen.
1850. Wright, George, jun., merchant, Leith.
,, Webster, Andrew, S.S.C.
,, Walker, John, M.D., London.
,, Winton, John G., engineer, Newhaven.
1851. Willet, John, C.E., Aberdeen Railway.

1847. Young, Archibald, cutler.
1848. Young, William D., ironmonger.
1850. Young, Rev. John, M.A., Haggs, Denny.

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The following Ordinary Fellows, included in the foregoing List, are ordered to remain, till they return to Scotland, in the following

SUSPENSE LIST.

William Cooper, glass-manufacturer, late of Picardy Place, Edinburgh, and now in America.
Joseph M. Kronheim, ornamental designer, London.
Edward Sang, Professor of Mechanical Philosophy at the Imperial School, Muhendis-hana, Berii, Constantinople.
Lieut.-Col. Blanshard, R.E., Mauritius.
George Buist, LL.D., Bombay.
Mungo Ponton, F.R.S.E., 11 Lansdowne Place, Clifton.
P. B. Ainslie, Chertsey, England.
F. E. Seeligmann, punch-cutter, London.
John S. Fraser, Swindon Station, Great Western Railway.
Thomas C. Gregory, C.E., America.

APPENDIX (K).

PROCEEDINGS OF THE ROYAL SCOTTISH SOCIETY OF ARTS, SESSION 1852–53.

The Annual General Meeting of the Society was held in their Hall, 51 George Street, on Monday, 22d November 1852, —George Lees, Esq., LL.D., President, in the Chair.

Dr Lees, the retiring President, opened this the Thirty-second Session of the Society, in the new Hall of the Society, opposite the Assembly Rooms, with an introductory address.

Dr Lees said that while he had to congratulate them on the increasing prosperity of the Society in regard to numbers, and in regard to the general excellence of the papers which had been submitted to their notice, they had to deplore the loss of several of its most prominent members. Of Honorary Members, they had lost M. Ermann, Berlin, and General Colby, R.E., late of the Ordnance Survey. Of Ordinary Fellows, they had to lament the loss of the Duke of Hamilton, Thomas Grainger, Esq., C.E., F.R.S.E., Sir W. Newbigging, F.R.S.E., and George Buchanan, Esq., C.E., F.R.S.E. They were all aware of the deep interest which Mr Grainger took in drawing up and procuring papers for the Society, and of the anxiety with which he sought to increase its members, and to extend and promote its usefulness. No one had ever discharged the duties of this chair with more zeal and greater success than he did, during the session he presided. In all relations of life he was an exemplary man; and no one ever descended into the grave amidst deeper and more heartfelt regrets. Sir William Newbigging, who was not cut down in the midst of his usefulness, but was gathered to his fathers at a good old age, took a lively interest in all the proceedings of the Society, and was constant in his attendance when his health would permit. He was a warm patron of the arts generally, and indeed of every object having for its purpose the improvement of our moral and social condition. Mr Buchanan was on two different occasions President of the Society, and was at all times a very active member of it. They were all aware of the zeal and talent which he displayed in the excellent papers which from time to time he laid before the Society, more especially on his favourite subject—the strength and strain of materials. So much was the British Association aware of his ability in this department, that he was appointed to draw up an essay unfolding his views on the subject; which he (Dr Lees) very much feared had not been done. The President then proceeded to remark that, in looking back on the history of science, he could not help coming to the conclusion that, with the exception of mathematics and astronomy, they were under no very great obligation to the philosophy of the ancients for the knowledge which they now possessed. Indeed, the ancient philosophers, for the most part, knew nothing of science. Their doctrines in science were founded on dogmas hastily assumed, and which could lead to nothing but error, and not only did they arrive at no correct knowledge of physical nature, but they positively retarded the acquisition of knowledge, by leading and encouraging men to look for it where it could not be found; while their dogmas, handed down from generation to generation, and firmly and implicitly believed by their disciples, formed at length the most obdurate obstruction to the progress of real knowledge. The life of Galileo well testified the truth of this, and when, failing to convince the disciples of Aristotle by reasoning, he proved his theories by experiment, their minds were so enslaved by their devotion to that ancient philosopher that they would not believe their senses. Even when it was discovered that the principles of mathematics might be applied to the improvement of mechanics, the attempt was discouraged on the ground that philosophy was degraded by being made subservient to purposes of mere vulgar utility. In truth, the whole philosophy of the ancients was of the same vapouring character. By aiming at impossibilities—at raising man above the vulgar wants of the body—they did nothing to ameliorate his condition. They filled the world, as Mr Macaulay said, "with long words and long beards, and they left it as ignorant and as wicked as they found it." Dr Lees then alluded to the inductive philosophy of Bacon, which inverted the order of study of the ancients. But, without detracting from the merit of Bacon's great work, it seemed, he said, to be the general opinion that science would have progressed just as well though the *Novum Organum* had never been written. Archimedes, Copernicus, Tycho Brahe, Kepler, and Galileo, all more or less made their discoveries by the inductive method before it was developed by Bacon; and not even Newton made the slightest reference to it in publishing his discoveries. The President then reviewed at some length the vast achievements of physical science since the time of Newton, and stated his opinion that while metaphysicians complained of this "mechanical age," their inquiries had done nothing to ameliorate the condition of man, or raise him in the scale of intelligence; and that, while metaphysics was ever moving in a circle ending where it began, physics was pre-eminently a science of progress. What was "looming in the distance" to-day might become a real possession to-morrow; while to-morrow would start with fresh life in the great march of onward and unceasing progress. But if the metaphysicians were really in earnest, they ought to illustrate their precepts by their example. There was no positive necessity for their adopting the inventions of the age—nay, to be consistent, they ought to avoid them. Instead of gas, they ought to betake themselves to the "crusie or the fir stick;" instead of railroads, to asses, pack-horses, and carts; and instead of living in houses fitted up with modern luxuries, they should, like Diogenes, live in tubs or barrels at the corners of the streets.

When they saw them fairly ensconced within the girds, they would then give them more sympathy in their lamentations about the mechanical tendencies of the age. But when they considered that the purpose of physical science was actually to investigate those wise arrangements, those benevolent purposes, and those beautiful adaptations of means to ends which they saw in every fragment of Nature's works, its study could not surely be held to be unworthy of man; and who could doubt that, in studying the influences by which the material world was upheld, they were carrying forward some of those great purposes which the Creator had in view? Whatever these purposes were, let them extend the advantages of physical science; and whatever cavillers might object, he would say—Let physical science flourish. Dr Lees then, in vacating the chair, tendered his warmest thanks for the uniform kindness and attention which he had received from the members, while President of the Society.

On the motion of Dr Maclagan, seconded by Professor More, the thanks of the Society were warmly tendered to Dr Lees for his interesting address, and for the excellent manner in which he had, during the past session, fulfilled the duties of the chair.

The Report of the Prize Committee, awarding the Prizes for Session 1851–52, was then read, and the Prizes were delivered by the President to the successful Candidates. (See Appendix H. p. 123.)

The Models, Drawings, &c., of Inventions, &c., for which Prizes, &c., were awarded, were exhibited.

The following Donations were laid on the Table, viz.:—

1. Donations by J. J. Pohl, Esq., Assistant in the Chemical Laboratory of the Polytechnic Institute of Vienna, viz.:—
   1. Ueber die Siedepuncte mehrerer alkoholhältiger Flüssigkeiten und die darauf gegründeten Verfahren den Alkoholgehalt derselben zu Chemisch-technischen Zwecken zu bestimmen. (3458–1.)
   2. Ermittelung des Technischen Werthes der Kartoffeln. (3458–2.)
   3. Beitrag zur Statistik des Studiums der Chemie am K. K. Polytechnischen Institute zu Wien. (3458–3.)
   4. Physikalisch-Chemische Notizen. (3458–4.)
   5. Nachtrag zur Thermo-Aräometrischen Bierprobe. (3458–5.)
   6. Ueber die Zusammensetzung und Eigenschaften zweier Legierungen von Zinn und Blei. (3458–5.)

2. Transactions of the Architectural Institute of Scotland:—
   1. Vol. II., Pt. III., Nos. 5 and 6. (3460–1.)
   2. Vol. II., Pt. IV., Nos. 7, 8, and 9. (1852.) (3460–2.)

   Presented by the Institute.

3. On the Manufacture of Hydrocarbon Gas from Boghead Cannel Coal. By Professor Andrew Fyfe, M.D., F.R.S.E., King's College, Aberdeen. (3463.)

Thanks were voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidates were balloted for and elected Ordinary Fellows, viz :—

1. His Grace William Duke of Hamilton and Brandon.
2. Robert Knox Wighton, jeweller, 17 Queen Street.
3. James Lorimer, C.E., 10 Torphichen Street.

III. The Council reported as to their arrangements for securing better and more permanent accommodation for the Meetings of the Society, and its Museum, Committee-Room, and Library, which were approved of.

IV. In terms of Law XV., the Society elected its Office-Bearers for 1852–53, viz. :—

David Stevenson, Esq., F.R.S.E., Memb. Inst. C.E., *President.*
Robert Ritchie, Esq., C.E. } *Vice-Presidents.*
Daniel Wilson, LL.D., F.S.A. Scot. }
James Tod, Esq., F.R.S.E., W.S., 55 Great King St., *Secretary.*
John Scott Moncrieff, Esq., Acct., 20 India Street, *Treasurer.*

Ordinary Councillors.

Douglas Maclagan, M.D., F.R.S.E.	Alex. K. Johnston, Esq., F.R.S.E.
Rev. Prof. Kelland, F.R.SS.L.&E.	George Lees, LL.D.
James Dalmahoy, Esq., F.R.S.E.	William Paterson, Esq., C.E.
Richard Whytock, Esq.	Thomas Stevenson, Esq., F.R.S.E.
Alexander Rose, Esq.	David Landale, Esq., M.E.
James Leslie, Esq.	David Cousin, Esq.

George Wilson, M.D., F.R.S.E., *Editor of Transactions.*
Mr Alexander Jamieson, *Curator of Museum.*
Mr Alexander Kirkwood, *Medallist.*
Mr Hugh Johnston, *Officer and Collector.*

The Society then adjourned.

13*th December* 1852.—David Stevenson, Esq., F.R.S.E., President, in the Chair.

The President delivered a short address on taking the chair; after which, at the request of the Council, William Swan, Esq., F.R.S.E., gave an exposition of Eclipses, with an account of the remarkable phenomena observed at the total solar eclipses of 1842 and 1851.

Before commencing his exposition, Mr Swan craved the indulgence of the Society, as he could only, in the limited time placed at his disposal, give a very imperfect account of the great variety of phenomena attending eclipses. In selecting from a number of facts, all having strong claims to attention, it was difficult to determine what to retain and what to omit; and some of his hearers might differ from him in the propriety of the selection he had made, and might be disappointed in the cursory notice, or entire omission, of subjects which they had expected to hear fully discussed. He then gave a popular explanation of the moon's motion, pointing out the conditions necessary for an eclipse happening, and the circumstances which determine whether it is central or only partial; or, in the case of a solar eclipse, whether it is total or annular. The curious adjustment of the periods of a *lunation*, of the revolution of the moon's *nodes*, and of the line of *apsides*, was next described; owing to which it was shewn that, after a period of about eighteen years and ten days, all eclipses recur in the same order, and nearly of the same magnitude. The remarkable fact that four total eclipses of the sun happen in the month of July in four periods of nine years—namely, the eclipses of 1833, July 17; 1842, July 8; 1851, July 28; and 1860, July 18; was thus explained. In describing the circumstances of a lunar eclipse, it was next shewn how the atmosphere, by refracting the sun's rays, threw a portion of light into the earth's shadow; occasioning the bright copper-coloured light often reflected by the moon, even when totally eclipsed. This effect, however, it was stated, was greatly dependent on the clearness or cloudiness of the earth's atmosphere. Thus, at the eclispe of 1620, July 15, observed by Kepler, and that of 1642, April 25, observed by Hevelius, the moon totally disappeared; whereas, at the eclipse of 1848, March 19, the lunar orb was so little obscured that some persons even doubted whether it had been eclipsed at all. Passing to the subject of solar eclipses, Mr Swan gave an historical sketch of the more remarkable eclipses recorded as having happened in ancient times. He referred to Mr Baily's admirable memoir (in the *Phil. Trans.* for 1811) on the eclipse which Herodotus states (without giving the date) to have occurred during a battle between the Medes and Lydians, and which put an end to a five years' war—as a striking example of the application of astronomical science to chronological research. Mr Baily, by a laborious investigation, recovered not only the year, but the day of the month, of an event which had happened 2451 years before the date of his paper; for he proved that the only eclipse which could have been visible at the scene of the battle was a total one, which happened 610 B.C., September 30. The observations of the *corona*, or ring of light round the moon, at the eclipses of 1567, 1598, 1605, 1706, 1715, and 1733, were then noticed; as well as the first unequivocal observation of the *red prominences*, which have lately excited so much attention, which was made by Vassenius at the eclipse of 1733, May 2. Some account was also given of Halley's interesting description of the eclipse of 1715, May 3. The remarkable effects of a total solar eclipse in producing temporary night—the stars shining at mid-day—and the terror excited both in man and the lower animals—were illustrated by the interesting records which have been preserved of the above-mentioned eclipses. The eclipses of 1842, July

8, and 1851, July 28, were next described,—Mr Swan giving an account of his own observations of the latter eclipse, as seen at Göteborg, in Sweden. The phenomena of "Baily's Beads," and the "red prominences" seen round the moon, were then discussed. With reference to the former, Mr Swan adopted the views of Professor Powell, who regards the "beads" as caused by irregularities on the moon's edge, along with the effects of irradiation, and the diminished brightness of the sun's disc towards the edges. With reference to the "red prominences," Mr Swan argued that the observations of the eclipse of 1851 were best satisfied by the hypothesis that they belong to the sun. He held the opinion of Sir John Herschel and M. Arago, that they were solar clouds; but, in addition to this view, from his observations in 1851, coupled with those of other persons, he had been led to entertain the idea that the prominences are the higher portions of an envelope of cloud surrounding the sun. Mr Swan referred his hearers to his memoirs on the eclipse of 1851, in the *Transactions of the Royal Society of Edinburgh*, for the arguments by which he endeavours to support that hypothesis; and, for an extremely able and interesting account of the eclipse of 1842, he recommended the perusal of M. Arago's memoir in the *Annuaire* for 1846. He also urged upon all who could, to avail themselves of the opportunity of seeing a total eclipse of the sun, which would be afforded by the eclipse of 1860. That eclipse was stated to be visible in the south of Spain; and if a station in the path of the moon's shadow could be at all easily obtained, Mr Swan, from his own experience, could say that the eclipse, regarded merely as a grand spectacle, would amply repay the labour of the journey to see it. The exposition was illustrated by a large number of drawings, exhibiting the principal physical phenomena of eclipses, and the path of the moon's shadow across Europe at the eclipses of 1842 and 1851.

On the motion of Dr Lees, seconded by Mr Adie, the thanks of the Society were unanimously voted to Mr Swan for his very interesting exposition, which he had made so plain by drawings and models. Thanks were accordingly given to him from the Chair.

The following Donations were laid on the Table, viz.:—

1. Report of the Twenty-First Meeting of the British Association for the Advancement of Science, held at Ipswich in July 1851. Presented by the Association. (3465.)

2. Reports of the Juries of the Exhibition of the Works of Industry of all Nations, 1851. (London 1852.) Royal 8vo. Presented by the Royal Commissioners. (3467.)

3. A New General Theory of the Teeth of Wheels. By Edward Sang, Esq., Hon. and Ord. F.R.S.S.A., Professor of Mechanical Philosophy in the Imperial School, Muhendis-Hana, Berrii, at Constantinople. (Edinburgh, 1852.) Royal 8vo. Dedicated and presented to the President, Council, and Members, by the Author. (3469.)

4. Elementary Treatise on Steam and Locomotion, based on the principle of connecting Science with Practice in a popular form, with illustrations. By John Sewell, L.E. Vol. I. (London, 1852.) 12mo. Presented by the Author. (3459.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidates were elected Ordinary Fellows, viz. :—

1. John Lockhart Morton, civil and agricultural engineer, 27 Dundas Street.
2. Robert Gilkison jun., of Blackburn, merchant, Glasgow.
3. Archibald Robert Craig, teacher of mathematics, &c., 8 Clarence Place, Clapton Square, London.

III. In terms of Law XX., the Treasurer's Books were laid on the Table, and a Committee appointed to audit the same, and to report thereon, and generally on the state of the Funds of the Society.

IV. Two copies of Forms of Application were sent to the Fellows to recommend Candidates for admission.

The Society then adjourned.

10*th January* 1853.—David Stevenson, Esq., F.R.S.E., President, in the Chair. The following Communications were made :—

1. On the Principle of Ascent from the Centre of Gravity. By John Campbell, Esq., Carbrook, F.R.S.E. (3486.)

In this short paper, which was preliminary to the one immediately following, the author stated that the law of gravity, which attracts bodies to the centre, is simple and single; but the law of ascent, which makes bodies rise from the centre, and which is the counterpart of gravity, is complex, and is compounded of the principle of gravity and the law of fluids which was defined by Sir Isaac Newton as "that law by which the fluid particles of the greatest density displace those of lesser density." The author stated that the principle of the law of fluids is founded on the different densities which, when the Creator formed the ultimate particles of matter, He impressed upon them respectively, with a view (among other things) to this law of fluids; that the phenomenon of this perpendicular ascent is interestingly illustrated by the experiment of the wine expelled from a phial immersed in a jar of water; that the effects of this principle of ascent are nearly as extensive as those of gravity, embracing, in the author's opinion, the upward growth of vegetables, and every other case where the direction is perpendicular upwards from the centre of gravity. It also, in the author's opinion, solves the problem of the Antilunar Tide, which Laplace describes as "le plus epineaux de toute la mécanique celeste."

2. On the cause of Upright Movement or Ascent from the centre of Gravity, illustrated by the Antilunar Tide. By the Same. (3487.)

Dr Lees, in the absence of the author from indisposition, read this paper. The author stated that the theory of the tides forms no part of the Newtonian philosophy. That which is now established in the British schools is contained in a paper written by Professor John M'Laurin, as a competition essay for a prize offered by the French Academy of Sciences in 1740, for the best explanation of the phenomena of the tides. Mr M'Laurin's theory may be shortly stated as follows:—The lunar tide is caused by the waters being drawn by the moon's attraction from the earth, and the antilunar tide by the earth being drawn from the waters. There is no difficulty as to the lunar tide: all are agreed that the moon attracts the earth; and as attraction increases and diminishes inversely as the squares of the distance, the waters at the equator are more attracted than the waters at the centre and the poles, and, therefore, they rise into a tide. The difficulty arises in accounting for the antilunar tide, where the waters, instead of rising towards the moon, recede from her in an opposite direction. With regard to this tide, Mr M'Laurin states, that in consequence of the increasing distances between the moon and the lunar and antilunar equator, the earth, under the foresaid law, will form a spheroid, whose longest axis would be in the line of the moon. Mr M'Laurin, by way of a postulate, introduces the case of a fluid globe, and puts that fluid globe into a state of movement toward the moon, and on these two assumptions, comes to the conclusion, and correctly too, that it will affect a spheroidal form. That is entirely conceded; but then comes the question—Is this earth a fluid globe, and does it fall to the moon? If either of these conditions fail, the argument vanishes, and both fail. As to the first, we inhabit not a fluid globe, but a globe of earth, with a superficial covering of water. And as to the second, the earth does not fall to the moon, because its orbit is always concave to the sun; and therefore, during half the moon's monthly revolution round their common centre, the moon being in opposition, the antilunar hemisphere of the earth is nearest the sun, and convex to the moon, and therefore falling from her. The following is the author's theory proposed to be substituted:—The attraction of the moon operates on every part of the earth's substance, and it operates on the antilunar hemisphere with a force less only than that with which it operates on the lunar hemisphere by the difference produced by the increase of the distance; and as this attraction is held sufficient to produce the lunar tide, it is clear that, in point of power, the antilunar attraction is sufficient of itself to produce an antilunar tide. Again, as the lunar tide is produced by the difference in the amount of the attraction at the equator, compared to that which operates at the centre and the poles, the waters at the equator being more drawn from their beds than those at the poles, a precisely similar difference arises on the antilunar hemisphere from the waters being more attracted at the poles, and thereby more drawn down upon their beds than the waters at the antilunar equator. Thus the lunar tide is produced by the waters nearest the moon being more attracted at the equator than at the poles, and the antilunar tide by the waters at the poles being more attracted than those at the equator; and being resisted by the beds on which they rest, those that are most attracted displace those that are least attracted, and compel them to ascend and accumulate into a tide. An illustration of this must frequently be observed: on pressing the hand on water in a basin, the water rises at the edges; the pressure of the hand is equivalent to an additional attraction of the water under the hand; for it is the same thing whether a body be itself attracted by a force equal to a pound weight, or be pressed in the same direction by another body attracted to that amount, or which has received an impulse equal to a force of one pound. The contrast between the two theories may be thus shortly expressed:—The common theory ascribes the anti-lunar as well as the lunar tide to attraction and falling freely to the moon; that now proprosed ascribes it to attraction on the one side, and pressure on the other, which is attraction resisted. The one theory confounds endeavours with realities, combining in its cause the hypothesis of a fluid globe and a fall towards the moon—neither of which assumptions exist. The other theory ascribes no effect to anything but to causes universally known to exist, and to exist in circumstances fitted to produce these very effects.

After some discussion, in which different views were taken, thanks were voted to Mr Campbell, and the communication was referred to a Committee. Thanks were also voted to Dr Lees for the clear manner in which he illustrated the paper.

3. Description and Drawing of a Self-acting Railway Signal. By Andrew Carrick, Esq., 14 Holmhead Street, Glasgow. (3466.)

The author stated that the signal consists of a hollow cast-iron column fifteen feet high, having a circular orifice near the top nine inches in diameter. This orifice is obscured by a thin copper disc, six inches in diameter, so that a circle of daylight is seen *through the column* during the day, and a bright circle is seen during the dark by means of a lamp and reflector. A vertical rod, fixed to the locomotive engine, touches a lever at the signal column, and sets a pendulum in motion inside the column. The motion of the pendulum causes the disc to vibrate across the orifice, and indicates to the engine-driver that a train is *ahead of him*. The extent of the vibration will enable him to judge how far the said train may have run since it passed the signal-post. If the disc be at rest, no engine has passed within the last fifteen minutes. The author's intention is, that such a signal should be placed near both ends of tunnels and curves, where the engine-driver cannot see far before him.

Some discussion arose in regard to this proposal, and several objections were stated—some of which resolved themselves into this, that the diameter of the disc was greatly too small to be seen at a proper distance; others had reference to the shock which the lever would sustain by the stroke given by the engine while moving at a rapid rate; and others to the interference of the lever with the locomotive, should it be necessary to run backwards along the line.

The communication was referred to a Committee to consider and report.

The following Donations were laid on the Table, viz.:—

1. 1*st*, The Assurance Magazine, No. VIII., in continuation; and, 2*d*, Report of the Council of the Institute of Actuaries. (3461–1–2.)
   3*d*, The Magazine, No. IX., in continuation.
   4*th*, Constitution and Laws of the Institute. 1852.
   5*th*, Catalogue of the Library of Do. Presented by the Institute. (3471–1, 2, 3.)

2. Journal of the Geological Society of Dublin, in continuation, vol. v. Part 2d. 1851-52. Presented by the Society. (3468.)

3. The Crystal Palace and Park in 1853; addressed to Intending Exhibitors. (London, 1852.) 12mo. Presented by the Secretary to the Directors. (3470.)

4. The Nineteenth Annual Report of the Royal Cornwall Polytechnic Society, 1851. Presented by the Society. (3472.)

Thanks were voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved of.

II. The following Candidates were elected Ordinary Fellows, viz.:—

1. Andrew Peddie How, engineer, 35 Mark Lane, London.
2. Robert Henry Bow, civil engineer, 7 South Gray Street.
3. Andrew Mackenzie Miller, merchant, 7 Fingal Place.
4. James Hosie, coalmaster, Balbardie House, Bathgate.

III. The Report of the Auditing Committee on the Treasurer's Books and on the Funds, was read and approved of. Mr Horne, Convener.

IV. The President granted discharge to the Treasurer, in terms of that Report.

The Society then adjourned.

24th January 1853,—Robert Ritchie, Esq., Assoc. Inst., C.E., Vice-President, in the chair. The following Communications were made:—

1. On the adaptation to everyday practice of the Capillary Tube method of preserving Vaccine Lymph. By William Husband, M.D., A.M., Edinburgh.

The tubes and method of filling and hermetically sealing them were exhibited. (3490.)

Dr Husband began by stating that, till within the last five years, capillary tubes had never been used in the practice of vaccination, except to a limited extent, for the purpose of preserving vaccine lymph for comparatively long periods, and sending it abroad, or to a distance. Previous to the end of the year 1847, the only tubes known or used in Edinburgh were tubes *with bulbs* about three inches long, the diameter of the bulb being from $\frac{1}{3}$ to $\frac{1}{2}$ an inch. These were employed only on rare occasions, and chiefly at the New Town Dispensary, for the purpose of sending lymph to foreign parts. The author happened to see some of these tubes in the autumn of that year, and conceived the idea of employing them in everyday practice, instead of the squares of glass which were then, and still are, in all but universal use. As might have been foreseen, however, he found them quite unfit for the purposes of ordinary practice, and was about to abandon them without further investigation, when it occurred to him that, if they were constructed *without* bulbs, and according to a different and much reduced scale of dimensions, the difficulties connected with their use—which he had found to be insurmountable—would be got rid of. He had them made, accordingly, on a much reduced scale, and the result more than answered his most sanguine anticipations. The tube method of preserving vaccine lymph, which he had found to be complicated and troublesome in a high degree, had become, in his hands, in the highest degree simple and manageable. The author then exhibited the tubes, and described the manner of usingthem, pointing out that the peculiarity of the method, as modified by him, consisted in its *perfect simplicity*, and in the *extreme facility* with which the manipulations connected with it were performed. He stated that in these respects *his* tubes *differed essentially* from every other form of tube hitherto described; and referred, in confirmation of this assertion, to the accounts given of the capillary-tube method by the highest English and French authorities up to the present day. No other form of tube had been shewn. or even pretended, to be suited to the routine of daily practice. On the contrary, it had been the universal impression among medical men, that the tube method was the very reverse of simple and manageable. It had hitherto been recommended only as supplementary and subsidiary to the common methods, and *that* on the single ground of its superior efficiency as a means of preserving vaccine lymph for a length of time in a state of activity. Its manifest inferiority in point of convenience and simplicity had operated as an insuperable obstacle to its coming into general use. The author, however, recommended his tubes, not as supplementary to the common methods—such as the square pieces of glass—but as a substitute for them. He contended that these methods ought to be abandoned, and the tube method, as modified and described by him, adopted in their stead; and this on two grounds:—1st, *On account of its extreme simplicity and manageableness;* and, 2dly, Because it furnishes *a really efficient means of preserving vaccine lymph for future use.* With regard to the first of these reasons, the author shewed that there could not be two opinions upon the subject. No one could see the tubes used without at once perceiving that all the manipulations required in the use of them are accomplished not merely with facility, but with the *highest degree of facility.* As to the second reason, viz., the efficiency of the method, he referred to his own observations and experiments during the last few years, as proving that vaccine lymph hermetically sealed up is highly tenacious of its virtue—that is, of the peculiar contagious principle which resides in it—and hence possesses what that substance does not possess when preserved in any other way, viz., a *permanent and enduring value;* and further, that this method will render every practitioner, without exception, who adopts it, *independent of his brother practitioners, and of public vaccine institutions, for supplies of lymph,* inasmuch as it will enable him to create, as it were, in his own hands, out of his own practice, a capital stock of lymph, which goes on accumulating indefinitely, without an effort on his part, and to which he may have recourse at all times, with perfect confidence, as occasion requires. The author stated that his experiments went to prove this, not only for the climate of Edinburgh, but for climates considerably warmer than that of any part of Great Britain. He stated that he anticipates ere long the universal adoption of the method in question by the medical profession, both in civil and military practice, and the consequent entire cessation of the present system of *borrowing and lending* lymph, with all its attendant annoyances and evils; and that he was prepared to demonstrate that the necessary result will be *a great mitigation of the ravages of smallpox, and a great saving of human life.* After some remarks, the thanks of the Society were voted to Dr Husband for his Communication; which was referred to a Committee to report.

2. Description of a Stop-Cock, with India-Rubber Tube and improved action. By Mr James Robb, Gas-Work, Haddington.

The stop-cock was exhibited. (3480.)

The inventor stated that the advantages sought to be gained by this stop-cock are cheapness, resulting from the simplicity of manufacture—the outer case being of cast-iron—and freedom from leakage, which the use of the vulcanized India-rubber tubing completely secures; whilst the objection to the slow motion of the screw for opening and shutting it is obviated in a neat and efficient manner, by simply lifting up or pushing down the handle. Referred to a Committee.

3. Description of an Elastic Self-Adjusting Castor, applicable to Furniture, Musical Instruments, &c. By Mr James Robb, Gas-Work, Haddington.

The castor was exhibited. (3481.)

The inventor stated that this castor is intended to do away with the disagreeable necessity of wedging up pieces of furniture which stand on uneven floors, and that as it contracts or expands by means of an India-rubber cushion, according to the weight placed on it, it has the effect of making tables, chairs, &c., stand steadily on their legs, even although the floor should be very far off the level. Referred to a Committee.

The Secretary called the attention of the Society to a notice in the proceedings of the American Association for the Advancement of Science, held in 1850, of a peculiar property of a mixture of lard and rosin, which, in place of being harder than lard, is much softer, and, at ordinary temperatures, remains in a semi-fluid state. It is stated to be an excellent substance for applying to pistons, and does not, like lard, corrode brass-work. The best mixture is said to be three parts of lard to one of powdered rosin, *by weight*, stirred together under a gentle heat.

The Secretary also exhibited the new India-rubber door-spring, capable of being applied, by means of two screws, to any ordinary door; and which works well, without the least noise.

The following Donations were laid on the Table, viz.:—

1. Smithsonian Contributions to Knowledge. Vol. III. (1852) 4to, pp. 564, and 35 plates; and nineteen other American Works. Presented by the Smithsonian Institution, Washington. (3473, 1–20.)

2. The Illustrated Indian Journal of Arts. Part IV. (1852). Presented by Alexander Hunter, M.D., Madras. (3474.)

3. Indian Journal of Arts, Sciences, and Manufactures. Part IX. (Madras, 1852.) Presented by the Same. (3475.)

4. On the Total Eclipse of the Sun, July 28, 1851, observed at Goteborg, with a Description of a New Position Micrometer. By William Swan, Esq., F.R.S.E.; from the Transactions of the Royal Society, Edinburgh. (1852.) Presented by the Author. (3476.)

Thanks voted to the Donors.

The Minutes of last Meeting were read and approved of, and the following Candidate elected an Ordinary Fellow, viz.:—

James Young, chemical manufacturer, Murrayfield.

The Society then adjourned.

28th February 1853.—David Stevenson, Esq., F.R.S.E., President, in the Chair. The following Communications were made:—

1. On the Initial Velocity of Shot;—Range at different Velocities; —Eccentric Shot. By George Lees, LL.D.

Dr Lees, after giving a short exposition of the parabolic theory of gunnery, proceeded to give an account of Mr Benjamin Robin's experiments on the initial velocities of balls, by means of the ballistic pendulum. He then compared the actual range at different velocities, and shewed how little was gained in range by a great increase of velocity. He then referred to eccentric shot, observing that the range had been increased by this means to the extent of from 500 to 600 yards; and remarked that these effects were so very striking, as to be well worthy of the attention of the artillerist. There was no doubt that artillery was our right arm, and everything tending to improve it was eminently worthy of attention. (3497.)

The thanks of the Society were voted to Dr Lees for his clear exposition of this interesting subject; which were given to him from the Chair.

2. Description of a new process of Stereotype Moulding; with notices of the history and results of the process of Stereotyping. By Daniel Wilson, LL.D., F.S.A. Scot., V.P.

Dr Daniel Wilson, in exhibiting this new method, stated that it was calculated to facilitate the process, and to introduce it into more general use, by diminishing the cost. In introducing the subject, he reverted to the curious fact—by no means singular in the progress of inventions—that, in the economic adaptation of printing to its fullest extent by means of stereotype plates, we are returning to a state of things nearly similar to the "Block Books," as they are called, which, in the beginning of the fifteenth century, preceded the great discovery of moveable types, and by means of which the first essays in printing were made by Guttenburg, Faust, and Mentz. Dr Wilson also called attention to the character of a certain class of bronze Roman stamps, of common occurrence, several of which he exhibited, both from Scottish localities and from Pompeii. These were obviously designed to be used for impressing certain characters by means of a pigment applied to the flat surface like types or woodcuts; and afford one of those curious examples so frequently seen in relation to modern inventions, of others—many centuries previous to their practical application—having trod, as it were, on the very threshold of the discovery. He then entered on the subject of stereotyping, or the process of taking casts from forms of moveable types. The discovery of this important process was made by William Ged, a goldsmith of Edinburgh, about the year 1725; though imperfect attempts had been previously made to attain the same important end by Van der Mey, of Leyden, by soldering together the forms of ordinary moveable types for a quarto Bible, so early as 1711. Dr Wilson exhibited to the meeting one of the original plates of the edition of Sallust, published by Ged in the 18th century, and interesting as the first specimens of the practical application of the stereotyping process ever executed. He then detailed the various efforts at further improvement on this process—including those of Brunell, Allan, Sinclair, &c.; after which he described and exhibited a process recently introduced in some of our printing-offices, which he wished to bring before the notice of the Society. This consists in taking the casts of the types, not in gypsum or stucco, but in blotting-paper, overlaid with a thin layer of whiting, starch, and flour-paste, covered with a sheet of tissue paper, and impressed on the types by means of beating it with a fine brush. It is then dried on a hot steam-chest, while still adhering to the types; and by this means a matrix is produced, and the types are again ready for distribution to the compositors within one hour. The advantages of the new process, which owes its perfection to several parties, are—1*st*, The greater certainty of the process; the new matrix not being liable to warp or break, as the stucco is. 2*d*, The greater rapidity; the process being completed in one hour by it, which could not be done in less than six by the other. 3*d*, The practicability of using the matrix in certain cases for casting several plates; whereas the stucco mould is always destroyed in a single casting. And, 4*th*, The much greater simplicity of the apparatus required; which, added to the economy of time, and the consequent diminution of the quantity of type required for the compositors, give the important economic results which form the great merit of the new plan. A mould was made, and a cast taken, in presence of the meeting; and Dr Wilson concluded by remarking that he believed it was by the improvement and more general application of such processes as this, that the great desideratum of cheap literature was to be achieved, and not by diminishing the profits of retail booksellers, as had recently been attempted. If publishers could be induced to try it, there was no great obstacle in the way of applying the stereotyping process, with all its adjuncts, to such standard works as Layard's "Nineveh," or Macaulay's "History of England," than to Mrs Stowe's "Uncle Tom;" and if the publisher calculated his price for editions of ten, twenty, or thirty thousand of the one, as they had already done of the other, people would learn to purchase, instead of merely borrowing a hasty reading from a lending library. This, he thought, was the direction in which we must now look for securing the grand desideratum of cheap literature of the highest class, in a way that would serve at once the best interests of author, publisher, and readers; whereas, by reducing the profits of the retailer on the present costly two or three guinea editions, the price was in reality brought no nearer the means of the ordinary reader; while the bookseller's interest in their sale, and even in their publication, must be greatly diminished with the increase of his risk; and the chance of sale of costly and valuable books was thereby not unlikely to be diminished. (3495.)

The thanks of the Society were voted to Dr Wilson for his interesting communication, and were given to him from the Chair.

Mr Dixon Vallance, Greenshields, exhibited, in action, a working model of his Condensed Water-Pressure Wheel, by which he endeavoured to shew its superiority to the Overshot Water-Wheel; the water being applied to it in both ways. (3498–3411.)

Referred to a Committee.

The following Donations were laid on the Table, viz.:—

1. Donations by Charles Cowan, Esq., M.P., being twenty various Parliamentary Papers, including the subjects of the Navy—Railways—Maritime Surveys—Harbours of Refuge—Westminster Bridge—Steam Navigation—Highland Roads and Bridges—Ventilation and Lighting of House of Commons—Schools of Design, &c. (3478, 1–20.)

2. Proceedings of the Philosophical Society of Glasgow, 1851–52. Vol. III., No. IV. Presented by the Society. (3479.)

3. The Journal of the Society of Arts of London, and of the Institutions in union with it. No. I., Friday, 26th Nov. 1852. (To be continued weekly, in lieu of the Annual Volume of Transactions.) Presented by the Society. (3488.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

The Minutes of last Meeting were read and approved.

The Society adjourned.

14*th March* 1853.—David Stevenson, Esq., F.R.S.E., President, in the Chair. The following Communications were made:—

1. On the Prevalence of Colour-Blindness in the Human Subject, and the limit which it puts to the use of Coloured Signals on Railways, at Sea, and elsewhere. By George Wilson, M.D., F.R.S.E. (3496.)

The author commenced by stating that Colour-blindness, otherwise named Daltonism, or Chromato-Pseudopsis, is an affection of vision which may be regarded as of three kinds. 1. Inability to discern any colour properly so called, so that black and white alone are distinguished from each other. This is very rare. 2. Inability to discriminate between the more composite colours, such as grays, drabs, and neutral tints. This is very common. 3. Inability to discriminate between the primary colours—red, blue, or yellow; or between these and the secondary colours—green, purple, and orange. This is the most important variety of colour-blindness, and the one to which the author almost solely referred. After describing the more famous cases already on record, and detailing at some length the peculiarities of several undescribed subjects of the affection, Dr Wilson pointed out that the great majority of those in whom colour-blindness is strongly marked, agree in seeing only blue and yellow in the spectrum and rainbow, and confound red with green; whilst many of them in addition have an imperfect apprehension of all colours, and name the same tint differently at different times. The second point to which the author drew attention was the extent to which colour-blindness prevails. This he believed to be much greater than is generally imagined. Prevost believed one person in twenty to possess this peculiarity. Seebeck found five cases among forty pupils in one school. Wartmann readily found a number of examples of colour-blindness. So did Professor Allen Thomson of Glasgow. Professor Kelland found three extreme cases among 150 students attending the University of Edinburgh this winter. Dr Wilson had, without special search, found two marked cases among 120 students; and ten additional strongly pronounced examples of the affection had become known to him within a month. He was on the track also of several more. With one exception, all the cases known to him occurred in males; and all authors agree in reporting colour-blindness as rare in the female sex. The author proceeded to point out that persons affected by colour-blindness could not fail to be found among the servants on every railway line; and that as those in whom this peculiarity of vision is marked, cannot distinguish a red danger-signal from a green, and have an imperfect apprehension of all colours, they can neither guard themselves, nor the public intrusted to their care, from those dangers which coloured signals are intended to prevent. In connection with this matter, it was noticed that our railways have been very unfortunate in their selection of colours for signals, inasmuch as—1. Red and green being complementary colours, may, if seen together (as pointed out by Mr Tyndall), appear white, so that the combination of the two danger-signals may convey the impression of the one safety-signal. 2. Red, intently regarded, develops its complementary green, and green its complementary red, so that an engine-driver or other railway servant, fixedly gazing at one danger-signal, to make certain which it was, would speedily seem to see the opposite colour to that which was shewn him. 3. Red and green are the two colours which, upon the whole, most perplex sufferers from colour-blindness. Red, for many of them, has no existence; and green is a negative colour, including every tint that is not yellow or blue, and therefore the *invisible* red, which is as likely to be green as any other colour. The author accordingly contended, that if the coloured signals at present in use on railways were retained, it was incumbent on their directors to make the strictest scrutiny into the colour-vision of all their servants; and he further noticed, that as the subjects of marked colour-blindness see at best but two primary colours, and those two at times imperfectly, no *tricolor* system of signals was admissible in their case, and all colours except black and white were liable to be mistaken. The author concluded by urging the propriety of making the cultivation of the sense of colour an essential part of the education of boys, as the prevalence of colour-blindness in the male sex, as contrasted with its rarity in females, appeared to shew that it was the result in men of an inherited defect, occasioned by neglect.

After a good deal of discussion on this interesting subject, Dr Wilson received the thanks of the Society; and his communication was referred to a Committee.

2. Description of a new Gas Stove for economically heating Ornamental Tools and Glue; specially adapted for Dressing and Fancy Leather Case Makers. By Mr John Kolbe Milne, Hanover Street.

The stove was exhibited in action. (3499.)

Mr Milne stated that the stove consists of an oblong box of black sheet iron, about 12 inches long, 9 inches high, and 6 inches broad, with perpendicular sides and back, but with the front sloping outwards like the side of a pyramid, the stove being thus broadest at the bottom;—there are four short legs or feet which drop into holes in an iron plate screwed to the bench. In the top of the stove two holes are cut to let in the glue-pots; in the front of the stove is a broad, low doorway about $6\frac{1}{4}$ by 3 inches, just within which stands the gas-box;—the gas-box has a heating surface, 6 inches long by 1 inch broad—the gas rises through wire gauze sprinkled with gravel, and is burned as in the stoves used by bookbinders' finishers, with a blue smokeless flame. Whether ornamental tools are being heated or not, the air within the stove is maintained at about 150°, which is the best heat for both dissolving and using glue; a zinc pipe, leading away to a chimney, is attached to the back of the stove, causing the heated air to circulate round the glue-pots, and carrying off the unhealthy fumes. One stove gives ample accommodation to two men, and is not intended for more; the object being to get the use of fire without having to move one step towards it, not even to turn round. The consumption of gas for one stove does not exceed 12 feet in a day of 10 hours, costing at the rate of 5s. 10d. per 1000 feet—7-8ths of a penny, or within a halfpenny a-day for each man. The glue in the pots cannot possibly burn; nor can the ornamental tools be injured by smoke or overheating.

Referred to a Committee.

The following Donations were laid on the Table, viz.:—

1. Morse's Patent. Full Exposure of Dr Charles T. Jackson's pretensions to the invention of the American Electric Telegraph. By Hon. Amos Kendall, late Postmaster-General, U.S. Presented by the Author. (3484)

2. Catalogue of Scientific Books. Hippolyte Baillière, 219 Regent Street, London, and Broadway, New York. Presented by M. Baillière. (3485.)

3. Industrial Instruction on the Continent. (Being the Introductory

Lecture of the Session 1852–53, in the Government School of Mines, and of Science applied to the Arts.) 8vo. London, 1852. By Lyon Playfair, C.B., F.R.S. Presented by the Author. (3489.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

The Minutes of last Meeting were read and approved of.
The Society adjourned.

28*th March* 1853.—Professor More, F.R.S.E., in the Chair.
The following Communications were made :—

1. Suggestions for the Prevention of Railway Accidents arising from Collision. By J. Stewart Hepburn, Esq. of Colquhalzie. (3493.)

In reflecting on the increased frequency of railway collisions, the author stated that it appeared to him that one cause (admitting of a remedy) of these accidents is the defective means of rapidly transmitting notice along the line, by signals, of any stoppage that occurs, by the breaking down of a train, or otherwise; and he suggested, for the consideration of practical men, whether the electric wire might not be made the means of conveying an instantaneous signal of danger along the line between the two nearest stations to where the stoppage occurs. The author suggested that, at each angular bend of the line, elevated "danger" lamps might be permanently fixed up, covered on either side by day with a mask (removeable at night), and having the established danger *day* signal, and these again both covered, when the line is clear, by another mask turning vertically on a pivot at the bottom, but secured in its upright position by a catch in connection with an electric wire extending to a battery at the nearest station. Furnished with this apparatus, the clerk or policeman on duty at the station might instantly, on the arrival of intelligence of any stoppage, cause the masks of the danger-signals along the line to drop simultaneously, in the manner in which the time-ball is dropped by the electric wire at Greenwich Observatory. On the cessation of the obstruction, the masks might be returned to their places by the policeman or platelayers along the line. The author stated that it seems unaccountable that no means have been yet adopted for communicating with the engine-driver from the carriages of a railway train; and he suggested that, in night trains, the roof lamps of the carriages be made capable of being caused to start up in any particular carriage when anything went wrong. On a former occasion, the author suggested, in order to prevent accidents by collision, that there ought to be placed at each extremity of the train, a carriage or goods waggon, mounted at each end with a compression frame containing from thirty to forty elliptic springs; but the committee to whom it was referred considered these superfluous, as the common buffer springs they thought answered the same purpose. The author, however, stated that it is notorious that, though useful in regulating the smaller inequalities of motion, the buffer springs are wholly inoperative, from the shortness of their range, in breaking the shock of a real collision; and he stated that he could not but think that, if the locomotive-engine at least were fronted with such a powerful compression frame, it would tend greatly to prevent the destructive effects on the engine itself of a collision, as well as lessen the actual shock of the collision in all the carriages. He stated that it would be better still if such a compression frame were attached in front and rear of the engine, and in front and rear of the last carriage of the train—at all events, in the rear of it, to provide against collisions from behind.

The communication was referred to a Committee.

2. Some notices of attempts to discover Perpetual Motion. By Daniel Wilson, LL.D., V.P. Illustrated with Models, &c. (3502.)

Dr Daniel Wilson exhibited a curious collection of models, executed by various ingenious pursuers of the mechanical fallacy of perpetual motion, and gave some account of R. Aird, an indefatigable enthusiast, the constructor of several of the models exhibited, and liberally forwarded for that purpose by the Directors of the Andersonian University of Glasgow. Some of the models belong to the Society of Arts; and one, a drawing of which was exhibited by him, was, he confessed, a device of his own, in pursuit of the same fallacy—but for which it would perhaps be sufficient apology to say that it was the occupation of his leisure hours when a High School boy. Fifteen models in all were exhibited, some of them displaying great ingenuity. Dr Wilson, after pointing out the arguments by which the theory of perpetual motion is demonstrable as an impossibility, remarked that there was one light in which the aim of such attempts might be viewed, which, though curious, he was not aware had yet been noticed. The attempts to endow dead matter with a self-originating and self-sustaining principle of motion, was, in other words, an attempt to *create life.* If the theory of a perpetual motion in mechanics was possible, then its execution, or even the demonstration of its possibility, amounted to the most practical establishment of Materialism that could be conceived; and the idea of a self-originating universe would no longer be open to dispute. As, however, the attempt at the discovery of perpetual motion originated in an ignorance of the laws of motion, such as a very brief study is needed to remove, such far-reaching tendencies were most probably never dreamt of by the mechanical enthusiasts who have wasted their ingenious toil in pursuit of this *ignis fatuus.*

The thanks of the Society were voted to Dr Wilson for this communication ; and also to the Directors of the Andersonian University of Glasgow for their kindness in sending their models for exhibition.

3. On means which might be adopted in Public Buildings and Dwelling-Houses for the speedy extinction of Fire. By James Stark. M.D., F.R.S.E., &c. (3500.)

Dr Stark read a paper on means which might be used in dwelling-houses, &c., for the speedy extinction of fires. The plan proposed was to have stop-cocks with screw mouth-pieces soldered to the supply pipe of the upper cistern as it passed through each floor, and a hose of gutta percha tubing, with a coupling screw on its one extremity and a brass nozzle on its other, kept ready to be coupled on when wanted. In towns where the water is on constant service this supply pipe is always full, so that by attaching the hose and turning this stop-cock, the water, without loss of time, could be directed on the fire, and this without admitting a fresh supply of air to the fire, which last was one of the main causes of fires extending when the windows or doors were opened to convey the hose or water from the street. In cases where the supply was abundant, but on interrupted service, as in Edinburgh, it was suggested that an arrangement might be effected by which the water might be turned on from six evening till six morning, as it was during that period that most fires occurred. In cases where the supply of water was defective, or was raised by means of a force-pump, it would be necessary to have a cistern at the top of the house, with a pipe descending from it through each floor, furnished with stop-cocks as in the former case. It was mentioned that a less perfect plan had been tried at New York, but from the system of pipes being carried outside the buildings they were liable to be frozen during winter—at the very season when fires were most frequent.

Referred to a Committee.

The following Donations were laid on the Table, viz. :—

1. Lectures on the Results of the Great Exhibition of 1851, delivered before the Society of Arts, Manufactures, and Commerce, at the suggestion of H.R.H. Prince Albert, President of the Society. 2 vols. (London, 1852.) Presented by the Society. (3501.)

2. The Assurance Magazine, in continuation, No. X., for January 1853. Presented by the Institute of Actuaries of Great Britain and Ireland. (3492.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved of.

II. The Fellows received the Printed Annual Abstract of the Revenue and Expenditure of the Society for Session 1851–52, and State of the Funds.

The Society adjourned.

11*th April* 1853.—David Stevenson, Esq., President, in the Chair. The following Communications were made :—

1. On mechanical and other contrivances for Ventilation, with a description of a new method for ventilating buildings by means of steam apparatus. By Robert Ritchie, Esq., C.E., V.P. (3506.)

Mr Ritchie commenced his paper by shewing the difference between ventilation going on spontaneously, and when it was aided by mechanical and other contrivances. He stated that the height of the extracting chimney formed a powerful element in the success which attended the employment of any agent to extract the vitiated air. He noticed the effects produced by common fires in rooms, and the numerous contrivances which had been tried to aid ventilation by means of fire-draught. Sometimes the rarefaction of the air was accomplished by heat, and sometimes a current was obtained by the application of fans, pumps, and screws, driven by motive power. Sometimes the air was forced into buildings by an impulsive, and sometimes drawn out by an exhausting movement. He shewed the uncertainty which appertained to the whole system of ventilation. Some scientific men advocated a *downward* extraction of the exhaled air, and others an *upward*. He shewed the advantages of the latter, and the fallacy of the former method, and its violation of the laws of nature as regards specific gravity; and that to draw down exhaled air by artificial means to the floor is only to cause it to be re-inhaled before it can send it to be discharged. He then shewed what had been done by himself, in the introduction of hot-water apparatus some years ago, to produce an efficient means for ventilation—a plan which he held to be free from commixture of the products of combustion with the air of the apartments to be ventilated. He then pointed out the advantages which steam possessed in these respects, and that there were two ways by which it might be employed—the one by radiation of heat from a surface heated by the steam, the other by the momentum caused by the discharge into a flue or shaft of the steam itself at high pressure; that the steam jet is an example of the latter method, and that it had proved powerful and effective. He shewed that, for domestic ventilation, agents of great power are not generally required. He then shewed how, by a simple arrangement, steam heat could be made available to produce an effective current by the former method, namely, by radiation—a method applicable to general purposes—that this ventilating power was capable of being increased as circumstances required; and concluded by stating that what is wanted is some safe, economical, and simple method of extracting vitiated air from public and other buildings,—which from experience he was well assured was of much importance to the public.

The thanks of the Society were voted to Mr Ritchie for his communication, which was referred to a Committee.

2. On an apparatus for Cauterizing the Dental Nerve by means of Electricity. By W. A. Roberts, M.D., Dentist and Surgeon, Edinburgh. (3508.)

This apparatus consists of a cylindrical glass vessel seven inches high by three and a half broad, inside of which is a porous jar with a zinc plate, and outside a platina plate—the glass vessel containing sulphuric acid and water; the porous jar nitric and sulphuric acids. The communication is made by means of elastic strings of fine copper wire, terminated by a platina wire brought to a fine point. When brought into action, by passing down a small spring at the end of the conducting wires, thereby bringing them into contact, the platina wire is instantaneously heated to redness; while by taking off the pressure on the spring, the current of electricity is again interrupted, and the wire immediately becomes cold. Dr Roberts stated that he had been uniformly successful in curing pain by the use of this apparatus, and in preserving such teeth as were worth preserving. The advantage of the application of the cautery has always been admitted when it could be effectually applied, but, from the fineness of the wire requisite, it lost its heat before the point desired could be touched, so that in most cases it did more harm than good. But Dr Roberts explained that by this method the advantages were great, from the certainty of its effects and simplicity of application; as, when brought into contact with the tooth or point to be cauterized, the wire is quite cold, and by the depression of the conducting spring it is instantaneously heated to redness, and destroys the sensibility of the nerve.

The elegance of this application of galvanism was much admired, and the communication was referred to a committee.

3. Description of an improved Self-acting Railway Signal, constructed so as to dispense with coloured lights at night. By William Fraser Rae, brassfounder, Edinburgh. (3505.)

This signal is designed so that a train when it passes the signal-post presses down one end of a series of levers, and elevates three oval-shaped arms which are connected to their other extremity. These arms are unfolded above a hollow pillar, and, after the passing of the train, they slowly descend into it. Their ascent draws up a piston which works air-tight in a cylinder placed at the base of the pillar, and air passes beneath this piston through valves into the cylinder. By this air escaping faster or slower through an aperture in the piston, the length of time which the arms take to descend is regulated. To convert this into a night signal, three lanterns (each burning a white light) are fixed to the top of the pilar, one being immediately over the centre, the other two on brackets, and lower at each side of it. The ascent of the signal arms obscures the centre light, thus denoting " danger;" their descent slowly brings it into view, and shews that the line is clear. Referred to a Committee.

4. Description and drawing of a Safety and Alarm Lock. By Alexander M'Coll, Auchermuchty. (3491.)

The external appearance of this lock resembles common door locks; and the safety principle consists of a bolt as usual, but upon the upper edge of the bolt is sunk a mortise, in which a ratch is placed, and supported upon two stout springs to keep it firmly up, so that, when the door is opened from the *outside*, the teeth of the ratch are acted upon by a pinion, which slowly pushes out the bolt, or brings it back. But upon the axle of the driving pinion three pegs are fixed, which act upon the points of two or more very highly-tempered steel tongues, so that as the key is turned the tongues emit a loud booming sound, sufficient to arouse the inmates of the property, or secure the attention of the night-watch: and, for an *inside* conveniency, there is a small snib and stop placed upon the upper edge of the lock, to push down the ratch when required, so that the bolt can be slid out and in without giving any alarm. The key somewhat resembles a common pass-key.

Referred to a Committee.

The following Donation was laid on the Table, viz.:—

Report of Select Committee of House of Representatives of U.S. on Dr William T. G. Morton's claim to be the discoverer of the successful application of the Inhalation of the vapour of Sulphuric Ether, as having an anæsthetic or pain-subduing property. 28th June 1852. 8vo. pp. 128. Presented by M. H. Baillière, Bookseller, 219 Regent Street, London. (3503.)

Thanks voted.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved of.

II. A List of Prizes to be offered by the Society for Session 1853-54, prepared by the Council, was submitted for approval.

III. The following Candidate was elected an Ordinary Fellow, viz :—

The Rev. William Graham, Newhaven.

The Society adjourned.

25th April 1853.—Robert Ritchie, Esq., V.P., in the Chair. The following Communications were made : —

1. On a method of Communication between the Guards and Engine-Driver of a Railway Train, available also for Passengers. By the Rev. William Mitchell, Raefield, Portobello. A drawing was exhibited. (3507.)

The author explained the various plans of communication that have been proposed—some being by means of electricity, and otherwise greatly too complicated for use. He stated that experience has shewn that the agent employed in the electric telegraph is too volatile, and its action too uncertain, to render it suitable for the purpose to which it is proposed to be applied; whereas the mode adopted by the author had the qualities of simplicity of construction, facility of adjustment, and certainty of action. These were united in the following details :—A light chain (or wire) is coiled up on a windlass or drum in front of the guard's seat behind the last carriage, which can be extended or shortened according to the number of carriages, to the first or luggage van, where a signal bell is fixed, and thus be the means of preventing a collision, because a direct communication is at once available between the guard and engine-driver ; and by conveying the wire cord along the roofs of the carriages at the one side, it can also be made available to the passengers in cases of emergency, such as fire, an axle broken, sudden illness, robbery, &c., by any of the passengers stretching out of the window and grasping it. The author further remarked that, at a recent meeting of the delegates of the Associated Railway Companies, who conduct their general and common affairs at the Clearing House, Euston Square, London, in arranging a communication between guards and drivers only, they have adopted the substantial points of the invention already described, but are not prepared to allow the passengers to give any signal in case of fire, sudden illness, robbery, &c., because they are afraid that it would put it in the power of the drunken, the timid, or reckless, to control the discretion of the guard or engine-driver, and thus, they say " the safety of the whole train might be put in peril ;" but the author was of opinion, that the advantages of providing passengers with the plan suggested in his model would countervail its dangers. He stated that it is only necessary that the Legislature should guard against the abuse of the privilege, by making it penal to give an alarm, except on good grounds; but that, with regard to intoxicated persons, he stated that no passengers in this state should be admitted into any railway carriage. If the railway servants permit them to enter, and "put the safety of the whole train in peril"—as the committee dread—the directors and managers of such railway companies will be held responsible; and, if this should occur on any of our Scottish railways, the Court of Justiciary will not fail to punish it in this part of the United Kingdom.

Referred to a Committee.

2. Description of a new plan of a Railway Signal, and of Communication between the Engine-Driver and Guards. By Mr Daniel Erskine, engineer, Musselburgh. A drawing was exhibited. (3515.)

This signal consists of a tube of iron fitted on the top of the carriages above the lanterns, and supported by three or four ornamental brackets on each carriage. The tube is fitted with couplings. There are also vulcanized India-rubber tubes fitted between the carriages; and faced flanches, with springs and lever handles, which are simply coupled and air-tight, and come separate by an over-pressure to the tube, if the coupling of any of the carriages were giving way. The engineer and guards are provided with an air-pump, mouth-piece, and alarm-bell, and, when an alarm is to be communicated, the engineer first works the pump which raises the hammer to strike the bell; when one bell is struck, he is sure that all the other bells will be struck, which causes the guards to apply the drag, while he himself reverses the engine. The next step is to open the mouth-piece of the tube and give instructions what to do, as the air-tube becomes a speaking trumpet. The guards have the same means of communication with the engineer. The great advantage is, that the guards and engineer may speak to each other, and be distinctly understood. The engineer should sound the bell two minutes before starting to shew that all is right, and all the bells will give any number of strokes that may be fixed upon by the engineer and guards.

3. On Railway Inclines, and on Improvement of the Locomotive Engine, for enabling it to ascend Steep Inclines. By J. Stewart Hepburn, Esq. of Colquhalzie. With a drawing. (3504.)

Referred to a Committee.

This was stated by the author to be an attempt to provide the means of obviating the cumbrous machinery of a stationary traction engine, and, more especially, of surmounting the numerous inclines of such railways as may be constructed on the principle of alternate inclines and levels; or which may, for the purpose of economy, be conducted on more direct lines than at present over a hilly country, in place of a needless prolongation of base; and by which railway trains may be enabled to traverse such lines without stoppages. This is proposed to be effected by fixing a spur-wheel on the axle of the driving wheel of the locomotive, which, on coming to an incline shall engage in the teeth of a rack, fixed between the rails; providing for the free action of the spur-wheel by a simple mechanism for raising the driving wheels an inch from the rail during the passage of the incline, and for bringing them down again to the rail as soon as the spur-wheel quits the rack, so as to proceed without any stoppage. The axle of the driving-wheel revolves in a rectangular block, made to slide one inch upwards and downwards, in a panel in the side-frame of the engine, in which it can be alternately raised and depressed by simple mechanical means.

Referred to a Committee.

4. New Designs for Iron Roofs of great clear span—with the results of calculations made with a view to compare these with the best forms at present in use. By Robert Henry Bow, Esq., C.E., Edinburgh. Illustrative diagrams, &c., were exhibited. (3509.)

After some introductory remarks, and insisting upon the propriety of employing roofs of great clear span for principal railway stations, the author instituted a comparison between the different classes of structures employed for the principals of roofs, and deduced that the triangular frame (in which the rafters constitute the main compressed member of the fabric) deserves to be preferred before all arched, compound, or other forms, when an inclined surface is demanded by the covering, of the character required for slating. And he further shewed that, where untied or abutting principals can be used, rafters, when made straight and treated as bridges, form principals of a very economical character; but that, for such a situation, rigid arched structures are quite inadmissible. He arranged those straight-raftered principals (in which the rafters are the main compressed members) into two classes: the first class embracing those which are tied, or exert only vertical pressures on the supports; and the second those which are untied, or of the abutting character. The principals of the tied class are of two kinds; in the principals of the first variety each rafter acts as a bridge, but the principals of the second partake of the nature of a framed girder. The designs proposed by Mr Bow are of the former variety, *i.e.*, each rafter is treated as a bridge; and they may therefore be employed either in the tied or untied state. In order to test their merits as suitable forms for long spans, they are compared with the best form at present in use, and which is of the latter, or girder character. In the calculations undertaken in order to make the comparisons, the weight of each part is represented by the product of the successive multiplication of its length by its strain, and the allowance of metal per ton of strain. For ties, the sectional area of metal is estimated at one-eighth of a square inch; for rafters, at a quarter of a square inch; and for the struts of the bracing at half a square inch for each ton of strain.

Referred to a Committee.

5. Specimens of Morthan, or the Reed Mace (*Typha latifolia*), from the Lochan Dhu, or Black Loch, near Oban, and of the nutritious Meal obtained from it; also of its fibre, suitable for textile fabrics; the external coating of this plant—capable of being used in the manufacture of Paper—were exhibited and described by Mr Malcolm M'Callum, 15 Cannon Street, Leith. (3514.)

Referred to a Committee.

6. Method of Escape from a Ship in Distress, particularly for Females and Children; with a sketch. By Mr Alex. M'Coll, Auchtermuchty. (3594.)

The recommendation under the above title consists of a stout rope, of any convenient length, say twenty or thirty fathoms long, having at each end an iron ring to facilitate its being lashed to any convenient point of either ship or boat. This main rope is passed between the double pulleys of a block. This block is free, and is made to travel backwards and forwards upon the main rope between the ship and boat as frequently as is required; the main rope being kept as tight as possible by the seamen in the boat using their oars. Attached to this slide-block are two stout buoyant life-belts, prepared so as to be tied under the armpits of the passengers before the persons are to be conveyed along the main rope; and upon the top of this slide-block is fixed a line, double the length of the main rope, to guide the descent of the passenger bound to the slide-block safely to the boat. Although the main rope should lose its tension, yet the person cannot sink, although burdened with a child in each arm—the chief intention of the suggestion. That the same apparatus could be used with success between a ship and the shore is very clear; therefore, every shorehead ship and steamer should be in possession of such a simple apparatus.

Referred to a Committee.

The following Donations were laid on the Table, viz.:—

1. Donations by Dr J. J. Pohl, of Vienna:—
   1. Nachtrag zur Thermo-Aräometrischen Bierprobe. Von Dr J. J. Pohl. Wien, 1852. (3510–1.)
   2. Tafeln zur Reduction der in millimetern abgelesenen Barometerstände auf die normaltemperatur von 0° Celsius. Berechnet von J. J. Pohl und J. Schabus. 1852. (3510–2.)
   3. Tafeln zur Vergleichung und Reduction der in verschiedenen längenmassen abgelesenen Barometerstände. Von J. J. Pohl und J. Schabus. 1852. (3510–3.)
   4. Ueber die Anwendung der Pikrinsäure zur unterscheidung von Geweben Vegetabilischen und Thierischen Ursprunges. Von Dr J. J. Pohl. 1852. (3510–4.)
   5. Ueber die Chemische Beschaffenheit zweier im Handel vorkommender Seesalze. Von A. Schrotter und J. J. Pohl. (3510–5.)

2. The Assurance Magazine, in continuation, No. XI. April 1853. Presented by the Institute af Actuaries. (3511.)

3. Transactions of the Architectural Institute of Scotland, Nos. XII. and XIII. Vol. II., Part vi. Presented by the Institute. (3512.)

4. Description of certain improvements in Vessels, partly applicable to other purposes. Patented by Richard Roberts, Esq., C.E., Manchester. Presented by the Author. (3513.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved of.

II. Copies of the List of Prize Subjects for Session 1853–54, were distributed. It was stated that more might be had on application to the Secretary.

III. In terms of Law XX., the Treasurer laid on the Table a List of Ordinary Fellows who were in arrear of their Annual Contributions.

IV. The following Candidates were elected Ordinary Fellows, viz :—

John T. Rose, shipbuilder, 5 Albany Street, North Leith.
James Shepperd, accountant, Raefield Cottage, Portobello.
Alexander Craig Moodie, publisher, 17 South Bridge Street, Edinburgh.

The Society adjourned till July.

11*th July* 1853.—Daniel Wilson, LL.D., Vice-President, in the Chair. The following Communications were made :—

1. Dr Lees read a Review of the different Theories of the cause of the Antilunar Tide held by different Philosophers. By John Campbell, Esq., F.R.S.E. (3519.)

The review commenced with the opinions of MM. Bernoulli & Clairaut, the French Academicians, and Professor M'Laurin, whose papers shared the prize of the French Academy in 1740 for the best Essay on Tides. It then proceeded to consider the published opinions of the succeeding philosophers down to 1852, viz., Mr R. Ferguson, Laplace, Mrs Somerville, Sir D. Brewster, Sir J. Herschel, and Professor Airey, and explained what the author considered the erroneous views which throughout the whole of the investigation of the subject have, during that long period, obscured the simple explanation afforded by the combination of the law of gravity with that of fluids. In the author's opinion the fundamental errors are—1*st*, The assumption that the earth performs a circle round the centre of gravity between it and the moon during each lunation. 2*d*, That, in consequence of that monthly revolution, the earth falls from the tangent of its orbit to the moon. 3*d*, The supposition of the earth being a *fluid* globe. These views are not broadly stated by all: Laplace and Sir John Herschel only state the differential attractions affecting the portions of the earth placed at different distances from the attracting body. But, supposing that principle sufficient in itself, the author considered it could only be effectual in the case of a fluid globe; and therefore, though these philosophers do not say so, they must, in order to sustain their theory, assume that which is a necessary condition, and adopt the supposition of a *fluid* globe. Mr Ferguson alone clears himself of all these difficulties by discarding Mr M'Laurin's theory altogether, and substituting the difference of the centrifugal force of the earth in its imaginary revolution round the common centre of the earth and moon. By that exchange the author thought that Ferguson threw no light on the matter. In the author's opinion, the answer to all those positions is, that they are unfounded assumptions; and, therefore, that the theories founded on them cannot be true.

2. Communication of a Method of Preserving Butter, Cheese, Ham, &c., during a Voyage, when exported to warm Climates, as practised in Holland, but not generally known. By Mr Malcolm M'Callum, Cannon Street, Leith. (3518.)

This method was obtained from a Dutch shipmaster, who had seen it successfully practised, and had carried out fresh butter from Holland to Java in good condition. The method consists in putting the articles to be preserved, whether butter, cheese, ham, &c., into a cask, the lid of which is to be well fastened on. This cask is then to be put into another cask a little larger, so as to leave an inch and a half at least all round the inner cask, and the interstice closely packed with common salt. The salt must be well stuffed betwixt the casks, on top, bottom, and sides. If the casks be of a larger size, more space for salt must be left betwixt them. The outer cask and salt will cost little, as both can be sold to advantage at the end of the voyage. The salt is said to be a complete preservative either from cold or warm weather. The author stated that not only would this method be useful for shipments to our colonies, but be of great benefit to the army, navy, and merchant service.

3. Description and Drawing of the Torricellium, a proposed self-acting Instrument for effecting a more perfect Vacuum than the Air-Pump. By Mr P. M'Farlane, Comrie. (3524.)

This instrument, or machine, appropriately designated the Torricellium, the author stated, was designed, and appears calculated to effect a vacuum more efficiently and amply than the air-pump, and which, he thought, might be adopted in many cases as an economical and effectual substitute. In this instrument the vacuum produced, and its means of production, are almost identical with those of the well-known vacuum on the top of the mercurial column in the barometer, and what in the case of the latter is but a small and inaccessible tube, in the other is expanded into an ample and easily accessible receiver.

The following Report of Committee was read and recommitted, adding Mr A. K. Johnston to the Committee List:—

On Mr Campbell's Theory of the Cause of the Antilunar Tide. Dr Lees, Convener. (3486-3487.)

The following Reports of Committees were read and approved, viz:—

1. On Mr Carrick's Railway Signal. Mr Ritchie, Convener. (3466.)
2. On Dr Husband's Capillary Tubes for Vaccine Lymph. Dr G. Wilson, Convener. (3490.)

3. On Mr Robb's India-rubber Stop-Cock. Mr Ritchie, Convener. (3480.)
4. On Mr Robb's Elastic Castor. Mr Steele, Convener. (3481.)
5. On Vallance's Condensed Water-Pressure Wheel. Mr Slight, Convener. (3498.)
6. On Dr George Wilson's Communication on Colour-Blindness or Chromatopseudopsis. Mr Swan, Convener. (3496.)
7. On Mr Milne's Gas-Stove for Heating Tools and Glue. Dr D. Wilson, Convener. (3499.)
8. On Dr Stark's Method of speedily extinguishing Fire in Buildings. Dr D. Wilson, Convener. (3500.)
9. On Mr Ritchie's Paper on Ventilation by Steam Apparatus. Mr Slight, Convener. (3506.)
10. On Dr Roberts' apparatus for Cauterizing the Dental Nerve. Dr Douglas Maclagan, Convener. (3508.)
11. On Mr Rae's Railway Signal without Coloured Lights. Mr Ritchie, Convener. (3505.)
12. On Rev. W. Mitchell's Method of communicating betwixt Guards and Engine-Driver of a Railway Train. Mr Ritchie, Convener. (3507.)
13. On Mr Erskine's do. do. Mr Ritchie, Convener. (3515.)
14. On Mr Stewart Hepburn's Method of surmountiug Steep Railway Inclines. Mr Blyth, Convener. (3504.)
15. On Mr Bow's New Designs for Iron Roofs of Great Clear Span. Mr Blyth, Convener. (3509.)
16. On Mr M'Callum's specimens and uses of Morthan (*Typha latifolia*). Dr Stark, Convener. (3514.)
17. On Mr M'Coll's Means of Escape from a Ship in Distress. Mr Smaill, Convener. (3494.)
18. On Mr Campbell's Paper on the principle of Ascent from the Centre of Gravity. Dr Lees, Convener. (3486.)

The following Donations were laid on the Table, viz.:—

1. Model of the Two-Arch Cast-Iron Bridge over the River Calder, on the Leeds, Dewsbury, and Manchester Railway; for which the late Thomas Grainger, Esq., C.E., was engineer. Presented by Mrs Grainger, his Widow, "as a slight memorial of the warm interest which he took in the prosperity and welfare of the Society." (3517.)

2. Report of Select Committee of the Senate of the U.S., in regard to the discovery of the means by which the Human Body is rendered uniformly and safely insensible to pain under Surgical Operations. (Feb. 1853.) Presented by M. H. Baillière, 219 Regent Street, London. (3516.)

3. Observations on different modes of Educating the Blind. A Lecture given at the Royal Institution of Great Britain on 8th April 1853. By the Rev. W. Taylor, F.R.S. Presented by the Author. (3520.)

4. Transactions of the Royal Society of Edinburgh, Vol. XX., Part III., Session 1851–52. Presented by the Royal Society. (3521.)

5. Proceedings of the Royal Society of Edinburgh, Session 1851–52. Presented by the Same. (3522.)

6. Observations on the Vinegar Plant. By W. Fraser, Esq., M.R.C.S.E., Drum's Lane, Aberdeen. Presented by the Author. (3523.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved of.

II. The Society appointed the following Prize Committee to award the Prizes for Session 1852–53, viz.:—

David Stevenson, Esq., F.R.S.E., *President.*
Daniel Wilson, LL.D., F.S.A. Scot., *Vice-President.*
George Lees, LL.D.
Alexander Sclanders, Esq.
James Slight, Esq.
William Swan, Esq., F.R.S.E.
William Paterson, Esq., C.E.
Douglas Maclagan, M.D.
James Gray, Esq.
Benjamin Hall Blyth, Esq., C.E.
John Cay, Esq., F.R.S.E.
Patrick Newbigging, M.D.
James Tod, F.R.S.E., Secretary, Convener *ex officio.*

III. The following Candidates were elected Ordinary Fellows, viz.:—

David Charles Bell, Professor of Elocution, 1 Kildare Place, Dublin.
William Smith, engineer, St Margaret's Works, Edinburgh.

The Society then adjourned till next Session.

APPENDIX (L).

LIST OF PRIZE SUBJECTS FOR SESSION 1853–54.

The ROYAL SCOTTISH SOCIETY of ARTS proposes to award Prizes of different values, none exceeding Thirty Sovereigns, in Gold or Silver Medals, Silver Plate, or Money, for approved Communications *primarily* submitted to the Society, relative to Inventions, Discoveries, and Improvements in the *Mechanical* and *Chemical* Arts in general, and also to means by which the *Natural Productions* of the Country may be made more available; and, in particular, to—

I. Inventions, Discoveries, or Improvements in the Useful Arts; such as, but not limited to, the following, viz. :—

1. *Mechanical Arts.*

1. Improvements in Sewerage,—in Economical Appliances for increasing the Sanitary Condition of Towns,—in Methods of Warming and Ventilating Buildings,—in Ventilation of Mines,—in constructing Economical and Salubrious Dwellings for the Working-Classes,—in Extinguishing Fires,—in applying Glass to new and useful purposes,—in methods of Uniting the Joints of Glass or Earthenware Water-Pipes, without employing White Lead or other poisonous substance, &c. &c.

2. Inventions or Improvements in preserving Timber and Metals in Marine Works,—in Locomotive, Stationary, and Marine Engines,—in Screw Propellers,—in Railways, Plant, and Signals,—in Flax Machinery, and in preparing Flax for manipulation,—in Steam Machinery, as applied to Agriculture,—in Tools, Implements, and Apparatus for the various Trades,—in Rifle Guns and Bullets,—in Bricks,—in Cements and Mortars,—in Machines for Planing Wood,—in Printing Machines, Cases, and Rollers,—in Stereotyping,—in Cranes,—in the Machinery for Collieries, &c.,—in Machines for Cutting, Dressing, and Boring Stone,—in Microscopic Apparatus,—in Steel or other Metallic Pens,—in new or improved Motive Power, &c. &c.

2. *Chemical Arts.*

Improvements in Dyes, and in their economical extraction from Dye Woods, &c.,—in Paints,—in Paper,—in Glass—in Writing Inks,—in the Manufacture of Hats,—in the Manufacture of thin sheets of Gutta Percha, of equal strength in all directions, for Surgical purposes,—in substitutes for, or improvements upon, the process of Vulcanizing India Rubber, &c.,—in new and useful applications of Gutta Percha and Vulcanized India Rubber, or similar Gums,—in Oil for fine Machinery, Clocks, and Watches,—in Metallurgy.

3. *Relative to the Fine Arts.*

Improvements in Articles of Porcelain, Common Clay, or Metal,—in Fire-Clay Articles for Architectural purposes,—in Terra Cotta,—in Glass Staining,—in Engraving on Stone,—in Chromatic Lithography,—in Photographic processes, and their application to taking microscopic objects and machinery,—in Electrotype processes,—in Die-sinking,—in methods of illustrating Books to be printed with the Letterpress,—in Ornamental Metallic Casting,—in adaptation of new Materials for Sepulchral Monuments,—in Paper-Hangings, combining economy with good design, and harmony of colours,—in Harmony and Contrast in Colours of Carpet, Walls, and Curtains, so as to produce the best effect in the decoration of Interiors, &c. &c.

4. *Natural Productions.*

Discovery of Plumbago in the United Kingdom or Colonies, equal to that of Cumberland, &c. &c.

II. Experiments applicable to the Useful Arts.

III. Communications of Processes in the Useful Arts practised in this or other Countries, but not generally known.

IV. Practical Details of Public or other Undertakings of National importance, already executed, but not previously published;—or valuable suggestions for originating such undertakings.

The SOCIETY also proposes to award the KEITH PRIZE, value Thirty Sovereigns,

For some important "Invention, Improvement, or Discovery, in the Useful Arts, which shall be primarily submitted to the Society" during the Session.

GENERAL OBSERVATIONS.

Communications lodged *in competition for Prizes*, shall not have been Patented, nor have been previously Published, nor read before any other Society. Patent articles may, however, be exhibited.

The Descriptions of the various inventions, &c., must be *full* and *distinct*;—be legibly written on *Foolscap* paper, leaving margins at least one inch broad, on *both sides of the writing on every page*, so as to allow of their being bound up in volumes; and, when necessary, be accompanied by *Specimens*, *Drawings*, *or Models*. All drawings to be on *Imperial* Drawing Paper, unless a larger sheet be requisite. The Drawings to be in *bold* lines, not less than an eighth of an inch thick, or *strongly coloured*, so as to be easily seen at about the distance of thirty feet when hung up in the Hall of Meeting, and the Letters or Figures of Reference to be at least 1½ inch long. When necessary, smaller and more minutely detailed Drawings should accompany the larger ones, for the use of the Committees, having the same letters or figures of reference.

The Society shall be at liberty to publish in their Transactions copies or abstracts of all Papers submitted to them. All Models, Drawings, &c., for which Prizes shall be given, to be held to be the property of the Society; the Value of the Model, &c., being separately allowed for.

Communications, Models, &c., are to be addressed to James Tod, Esq., the Secretary, 55 Great King Street, Edinburgh, Postage or Carriage paid; and they are expected to be lodged *on or before* 1*st November* 1853, in order to ensure their being read and reported on during the Session, (the ordinary Meetings of which commence in November 1853 and end in April 1854); but *those which cannot be lodged earlier*, will be received up to 1st April 1854;—those lodged after that date may not be read or reported on till the following Session.

By order of the Society.

James Tod, *Secretary.*

Edinburgh, 11*th April* 1853.

APPENDIX (M).

REPORT

OF

THE COMMITTEE

APPOINTED BY

THE ROYAL SCOTTISH SOCIETY OF ARTS

TO AWARD PRIZES FOR COMMUNICATIONS READ AND EXHIBITED DURING SESSION 1852–53.

Your COMMITTEE having met and carefully considered the various Communications laid before the Society during Session 1852–53, beg leave to report that they have awarded the following Prizes :—

1. To WILLIAM ALFRED ROBERTS, M.D., Dentist and Surgeon, Duke Street, Edinburgh,—for his "Description of an Apparatus for Cauterizing the Dental Nerve by means of Galvanism." Read and exhibited 11th April 1853. (3508)

The Society's Silver Medal and Plate, value Ten Sovereigns.

2. To Mr JOHN KOLBE MILNE, Dressing-Case Maker, Hanover Street, Edinburgh,—for his "Description of a New Gas-Stove for economically heating Ornamental Tools and Glue for Dressing-Case Makers." Read and exhibited 14th March 1853. (3499)

The Society's Silver Medal, value Five Sovereigns.

3. To William Husband, M.D. and A.M., Clarence Street, Edinburgh,—for his paper "On the Adaptation to every-day practice of the Capillary Tube Method of preserving Vaccine Lymph." Read and method exhibited 24th January 1853. (3490

The Society's Silver Medal.

The Committee recommend, that while the *Thanks* of the Society are justly due to all those gentlemen who have sent Communications, the *Special Thanks* of the Society be given to the following gentlemen, viz.:—

1. To George Wilson, M.D., F.R.S.E., Lecturer on Chemistry, Edinburgh,—for his "Communication on the Prevalence of Colour-Blindness or Chromato-Pseudopsis, and the limit which it puts to the use of Coloured Signals on Railways, at Sea, and elsewhere." Read 14th March 1853. (3496)

Dr Wilson having the intention of making still farther investigations on this subject, and of communicating these to the Society, your Committee, on the recommendation of the Special Committee, have made him a grant of Ten Pounds to assist in defraying the expense of the prosecution of his important researches.

2. To Robert Ritchie, Esq., C.E., V.P., Hill Street, Edinburgh,—for his elaborate communication "On Mechanical and other contrivances for Ventilation, with a description of a New Method for Ventilating Buildings by means of Steam Apparatus," with a Model. Read and exhibited 11th April 1853. (3506)

The present communication contains a farther development and useful application of the principle for which Mr Ritchie obtained the Society's Medals in 1844 and 1847.

3. To Robert Henry Bow, Esq., C.E., Edinburgh,—for his "Description of New Designs for Iron Roofs of great clear span," &c.; with Drawings. Read and exhibited 25th April 1853. (3509)

Your Committee, considering the importance of this subject, and the manner in which Mr Bow has treated it, are of opinion that when it has been completed, Mr Bow will be entitled to a Prize; but before indicating the amount, the Committee request Mr Bow to prosecute the subject, and supply the requisite data and formulæ suitable not for one angle of roof, but for all angles.

The Committees on Mr STEWART HEPBURN's Suggestions for the prevention of Railway Accidents arising from Collision (3486), and on Mr CAMPBELL's Communication on the cause of the Anti-lunar Tide (3487), and his Review of the Theories held by different Philosophers on that subject (3519), have not yet given in their Reports.

In conclusion, your Committee regret that there has been no communication read during the past Session to which it seemed proper to award the KEITH PRIZE of Thirty Sovereigns.

All which is humbly reported by

JAMES TOD, *Sec., Convener ex officio.*

SOCIETY'S HALL, 51 GEORGE STREET,
13*th October* 1853.

APPENDIX (N).

LIST

OF THE

OFFICE-BEARERS AND FELLOWS

OF THE

ROYAL SCOTTISH SOCIETY OF ARTS.

AS AT 1st NOVEMBER 1853.

THE QUEEN, PATRONESS.

OFFICE-BEARERS FOR SESSION 1852-53.

President,	David Stevenson, Esq., F.R.S.E., Memb. Inst. C.E.
Vice-Presidents,	Robert Ritchie, Esq., Assoc. Inst. C.E. Daniel Wilson, LL.D., F.S.A. Scot.
Secretary,	James Tod, Esq., F.R.S.E., W.S., 55 Great King Street.
Treasurer,	John Scott Moncrieff, Esq., Acct., 20 India Street.

Ordinary Councillors.

*Douglas Maclagan, M.D., F.R.S.E.
*Rev. Prof. Kelland, M.A., F.R.SS. L. & E.
*James Dalmahoy, Esq., F.R.S.E.
*Richard Whytock, Esq.
Alexander Rose, Esq.
James Leslie, Esq.
Alex. K. Johnston, Esq., F.R.S.E.
George Lees, LL.D.
William Paterson, Esq., C.E.
Thomas Stevenson, Esq., F.R.S.E.
David Landale, Esq., M.E.
David Cousin, Esq.

Editor of Transactions,	George Wilson, M.D., F.R.S.E.
Curator of Museum,	Mr Alexander Jamieson.
Medallist,	Mr Alexander Kirkwood.
Officer and Collector,	Mr Hugh Johnston.

(The four Ordinary Councillors marked * retire by rotation.)

LIST OF THE ORDINARY FELLOWS

AS AT 1st NOVEMBER 1853.

1822. Abercorn, The Most Noble the Marquis of, K.G.
„ Aberdeen, The Right Hon. the Earl of, K.T.
„ Abercromby, Sir Robert, of Birkenbog, F.R.S.E.
„ Adinston, Thomas, of Carcant.
„ Alison, W. P., M.D., F.R.S.E.
„ Adie, Alexander, F.R.S.E.
1826. Aytoun, Robert, W.S.
1837. Aikman, George, engraver.
„ Alves, H. S., 9 Royal Terrace.
„ Alexander, William, F.R.S.E., W.S.
1838. Adie, John, optician, F.R.S.E.
1841. Anderson, Charles W., merchant.
1843. Anderson, John, Pratis, Fife.
1846. Alexander, James, wine-merchant.
„ Ainslie, Daniel (late Calcutta).
1847. Abbott, Francis, Sec. G. P. O.
1850. Anderson, Thomas, M.D., F.R.S.E., Leith.
„ Adie, Alex. J., F.R.S.E., C.E., Linlithgow.
1851. Archer, William, solicitor, London.
„ Alexander, Wm., M.E., Glasgow.
„ Anderson, William, Andersonian University, Glasgow.

1822. Buccleuch and Queensberry, His Grace the Duke of, K.G., A.M., F.R.SS. L. & E.
„ Brewster, Prin. Sir David, K.H., D.C.L., F.R.SS. L. & E.
„ Bald, Robert, F.R.S.E., Alloa.
1826. Brisbane, Sir Thomas Macdougall, Bart., G.C.B., President R.S.E.
1830. Bonar, William, F.R.S.E.
„ Brown, Robert, junior, architect.
1832. Black, Alexander, surveyor of buildings.
„ Bryce, David, architect.
1835. Borthwick, James, manager N. B. Insurance Company.
„ Berkely, Frederick Hewett, Chester.
„ Burn, William, F.R.S.E., architect.
1836. Bryson, Alexander, watchmaker.
1836. Ballantyne, James, of Holylee.
1837. Bell, John Beatson, W.S.
1838. Beattie, Alexander, Star Hotel.
„ Bruce, O. Tyndall, of Falkland, F.R.S.E.
„ Blanshard, Lieut.-Col. Thomas, R.E.
1839. Brown, Thomas, architect.
1840. Brown, James, accountant.
„ Berwick, David.
1841. Baird, Douglas, iron-master, Gartsherrie.
1844. Bell, J. A., architect.
„ Baillie, William R., W.S.
1845. Bowie, William.
1846. Buist, George, LL.D., Bombay.
„ Beattie, George, builder.
1847. Bernard, Thomas, brewer.
„ Buchanan, William Miller, M.D.
1848. Brebner, Alan, engineer, Burntisland.
1849. Bouch, Thomas, C.E.
„ Burn, Robert, engineer.
1850. Black, Rev. Archibald P., A.M., London.
„ Blyth, Benjamin Hall, C.E.
„ Bell, Alex. Melville, Prof. of Elocution.
„ Bruce, George Cadell, C.E.
„ Bryden, Adam, bell-hanger.
1851. Bryden, John, bell-hanger.
„ Black, John Trafalgar, Surrey.
1852. Barlow, John, Ass. Vet. Prof.
1853. Bow, Robert H., C.E.
„ Bell, David C., Prof. of Elocution, Dublin.

1822. Clerk, Sir George, Bart., M.P., F.R.S.E.
„ Campbell, Walter, of Islay, M.P., F.R.S.E.
„ Cadell, W. A., of Banton, F.R.S.E.
„ Cunningham, Charles, W.S.
1827. Chalmers, Charles.
„ Crawfurd, William, of Cartsburn.
1832. Craig, Sir William Gibson, of Riccarton, F.R.S.E.
1834. Campbell, Alexander, brewer.
1836. Cowan, Charles, M.P., Penicuik.
1837. Cowan, Alexander, paper-maker.
„ Cooper, Wm., glass-manufac., Canada.
1840. Christie, Robert, accountant.

1840. Crosbie, George.
„ Cormack, David, S.S.C.
„ Carstairs, Drysdale, Liverpool.
1841. Cowan, James, M.D., surgeon R.N.
„ Cameron, Captain Charles.
„ Curriehill, Hon. Lord.
1842. Cushnie, William, Malta Green.
1845. Cay, John, F.R.S.E., advocate.
1846. Callender, J. A., C.E., America.
1847. Campbell, John Archibald, F.R.S.E.
„ Cousin, David, architect.
1848. Craig, Rev. John, Cupar-Fife.
1849. Clark, Thomas, M.D., Whitburn.
1850. Campbell, William, C.E.
1851. Cormack, James, ironmonger.
„ Cunningham, George, C.E.
„ Craigie, Henry, W.S., Falcon Hall, Morningside.
„ Cadell, Henry, M.E., Dalkeith.
1852. Crichton, And., LL.D.
„ Craig, Archibald R., London.

1822. Davidson, Robert, of Ravelrig.
„ Dunlop, Arch., F.R.S.E., London.
1838. Dunlop, Andrew, W.S.
1843. Dove, James, engine-maker.
1844. Dickson, James Jobson, accountant.
„ Dunn, Thomas, optician.
1846. Donaldson, J., advocate, Prof. of Theory of Music.
1847. Dalmahoy, Jas., F.R.S.E., late H.E.I.C.S.
1848. Duff, Rev. Henry, South Leith.
1849. Drury, Rev. Robert, Surrey.
1850. Davidson, Samuel D., Leith Eng. Works.
„ Dickson, John, junior, gunmaker.
1851. Duncan, James, M.D.
„ Dawson, Charles, London.
„ Dawson, John, distiller, Linlithgow.
„ Duncan, Jas., M.A., Southampton.
„ Drummond, Geo. A., builder.

1828. Ellis, Adam Gib, M.W.S., W.S.
1839. Ellis, Thomas, upholsterer.
1843. Erskine, Daniel, Musselburgh.

1822. Forbes, George, F.R.S.E.
„ Fyfe, Prof. A., M.D., F.R.S.E., Aberdeen.
1828. Fraser, Robert, 18 Dublin Street.
1832. Forbes, Prof. J. D., F.R.SS. L. & E.
1838. Fergusson, Lieut.-Col., H.E.I.C.S.
1840. Fleming, Alexander, W.S.
„ Forrester, John, W.S.
1843. Falkner, James P., solicitor.
1844. Foulis, Sir Wm. Liston, Bart., Hermiston.
1847. Fullarton, John A., publisher.
1849. Fraser, J. S., engineer Gt. Western Rail.
1850. Ferguson, William B., C.E., Aberdeen.
„ Falshaw, James, C.E., Perth.
„ Fraser, John, actuary and manager Life Association of Scotland.
1850. Fraser, Alexander, printer.
1851. Forbes, William, London.

1822. Graham, Humphrey, W.S.
1829. Græme, James, W.S., yr. of Garvoch.
1832. Gray, James, ironmonger.
1835. Groat, A. G., of Newhall, advocate.
1836. Greig, Thomas (late printer), Elie.
1842. Gillespie, John, W.S.
1844. Girdwood, John, North Wales.
„ Gregory, Prof. William, M.D., F.R.S.E.
1848. Gardner, James, Torphichen Street.
1850. Glennie, George, C.E., Melrose.
„ Gowans, James, builder.
„ Gregory, Thomas Currie, C.E.
„ Gordon, James, jun., W.S.
1851. Gordon, John T., F.R.S.E., Sheriff of Mid-Lothian.
„ Gray, David, M.A., F.R.S.E., Prof. of Nat. Phil. Marischal Coll., Aberdeen.
„ Gordon, James Newell, London.
1852. Gilkison, Robert, jun., of Blackburn, merchant, Glasgow.
1853. Graham, Rev. Wm., Newhaven.

1829. Horne, Archibald, of Inverchroskie.
1833. Hamilton, Alex., LL.B., F.R.S.E., W.S.
1834. Hamilton, John, W.S.
„ Horsburgh, Robert, Tongue House.
1835. Hay, James, merchant, Leith.
1836. Haldane, James, brassfounder.
„ Hepburn, J. Stewart, of Colquhalzie.
1837. Hopkirk, J. G., LL.B., W.S.
1838. Hunter, Richard, H.E.I.C.S.
1839. Hill, Laurence, jun., C.E., Glasgow.
„ Hill, Henry David, W.S.
1840. Harvey, George, R.S.A., histor. painter.
1841. Hope, David T., C.E.
1843. Howden, James, watchmaker.
„ Henry, Jardine, writer.
1845. Hay, David Ramsay, F.R.S.E.
1850. Hill, James L., W.S.
„ Henderson, John, C.E., Leeds.
1852. Hunter, David, chemist.
„ Hollis, William, Chelsea.
„ Hamilton and Brandon, His Grace the Duke of
„ How, And. Peddie, engineer, London.
„ Hosie, James, coalmaster, Bathgate.

1822. Jardine, James, F.R.S.E., C.E.
1840. Johnston, Alex. K., F.R.S.E., geographer to the Queen.
1848. Jefferiss, Robert R., M.D., Dalkeith.
1850. Jardine, William Alexander, C.E.
„ Jopp, Charles, C.E.
„ Johnstone, William, C.E., Glasgow.
1851. Johnston, Robert, accountant.
1852. Johnston, Jas., Stockton-on-Tees.

1822. Keith, James, M.D., F.R.S.E.

1836. Kirkwood, Alexander, die-cutter.
1839. Kennedy, William, W.S.
1842. Kronheim, Jos. M., orn. designer, London.
1843. Kemp, Alex., lecturer on chemistry.
1844. Kinloch, Alex. J., M.D., Aberdeen.
1845. Kennedy, John, jun., W.S.
1848. Kirkwood, James, goldsmith.
1850. Kelland, Rev. Phil., M.A., F.R.SS. L. & E., Professor of Mathematics.
1851. Kirkwood, Robert, C.E.

1822. L'Amy, James, F.R.S.E., advocate.
1834. Lawrie, William A., W.S.
1836. Lees, George, LL.D.
„ Lawson, Charles, of Borthwick Hall.
1838. Lorimer, George, builder.
1840. Leburn, Thomas, S.S.C.
1842. Leith, Samuel, lithographer.
1845. Lancefield, Alfred, surveyor.
1848. Laurie, Rev. Joseph, D.D., H.E.I.C.S.
1850. Leslie, James, C.E.
„ Lees, Henry, secretary E. P. & D. Ry.
„ Lessels, John, architect.
1851. Lee, Alexander H., C.E.
„ Lawson, W. J., manager Argus Life Co., London.
1852. Landale, Robert, of Pitmedden.
„ Landale, David, M.E.
„ Lorimer, James, C.E.

1822. Maconochie, Alexander, of Meadowbank, F.R.S.E.
„ More, John S., Professor, F.R.S.E.
„ Murray, Hon. Lord, F.R.S.E.
1826. Maxwell, John Clerk, F.R.S.E., Glenlair.
1829. Miller, John, C.E., F.R.S.E.
1831. Macdonald, William, of Powderhall.
1834. Murray, W., of Henderland, F.R.S.E.
1835. Marjoribanks, Gilbert, Australia.
„ Mould, J. B., engraver.
1836. Milne, James, brassfounder.
„ Mackay, James, goldsmith.
1838. Macgibbon, Charles, builder.
„ Morton, Hugh, engineer.
„ Maclagan, David, M.D., F.R.S.E.
„ Moncrieff, John Scott, account^{t}., treasurer.
„ Mackenzie, James, W.S.
„ Murdoch, J. B., of Gartincaber, F.R.S.E.
1839. Macbrair, D. J., S.S.C.
„ Maclagan, Douglas, M.D., F.R.S.E.
1840. Murray, James T., W.S.
1841. Maitland, John, accountant.
„ Macpherson, Charles, printer.
1842. Mitchell, Edward, surgeon.
1843. Marshall, G.H., jeweller.
„ Melville, John, W.S.
„ Murray, Sir W. K., Bart. of Ochtertyre.
1846. M'Dowall, John, engineer, Johnston.
„ Middleton, Captain J., Waltham Lodge.
„ Mortimer, Thomas E., gunmaker.
„ Miller, James, engineer.
1847. Middleton, James, Waltham Lodge.
„ Macadam, John, chemist.
1848. Milne, John Kolbe, dressing-case maker.
„ Macfarlan, John F., druggist.
„ Mackenzie, Rev. Kenneth, Bo'ness.
„ Mitchell, Graham Alexander, Whitburn.
1850. Mackay, John M., chemist and druggist.
„ Melville, James M., W.S.
„ Martin, George, Glasgow.
„ Macintosh, James A., wood-engraver.
„ Mackay, Charles, goldsmith.
„ Moffat, William L., architect.
„ Mein, Archd., M.D., surgeon and dentist.
„ Mitchell, John M., merchant, Leith.
„ Maclagan, David, manager Insurance Company of Scotland.
„ Marjoribanks, William, merchant.
„ Marshall, William, accountant.
„ Miller, Colin M., M.D.
„ Macpherson, Alexander, plumber, Leith.
„ Macdonald, D., cotton-spinner, Aberdeen.
„ MacGillivray, J., Royal Artil^{y}, Woolwich.
1851. Middleton, J., M.D., licentiate R.C.S.E.
„ Milne, Robert, C.E. and land-surveyor, Aberdeen.
„ Maitland, Sir A. Gibson, Bart.
1852. Murray, Thos., LL.D., Sec. School of Arts.
„ M'Callum, Duncan, C.E.
„ M'Farlane, Wardlaw, chemist.
„ Moffat, John, C.E., Ardrossan.
„ Morton, John L., civ. and agr. engineer.
1853. Miller, And. M., merchant.
„ Moodie, Alex. Craig, publisher.

1832. Nasmyth, James, jeweller.
1838. Nachot, H. W., Ph. D., teacher of German.
1846. Newlands, James, architect, Liverpool.
1850. Newbigging, Patrick, M.D., F.R.C.S.E.
„ Notman, David, builder.
1851. Nicolson, Rev. Hugh, London.

1848. Oliver, Robert S., hatter.
1850. Ogilvie, Archibald, merchant.
1852. Orrock, Jas., surgeon and dentist.

1822. Playfair, W. H., F.R.S.E., architect.
1833. Ponton, Mungo, F.R.S.E., W.S.
1840. Pearson, Charles, accountant.
1842. Pyper, Hamilton, advocate.
„ Paterson, George, of Castle Huntly.
1844. Paterson, John, Leith Docks.
1846. Pattison, Thomas, M.D.
„ Paterson, W., resid. eng. E. P. & D. Ry.
1847. Purdie, Thomas, decorator.
1848. Peddie, John D., architect.
1851. Parker, W. A., advocate

1822. ROSEBERY, The Right Hon. the Earl of, K.T.
1829. Reid, David B., M.D., F.R.S.E., London.
1834. Ritchie, R., C.E., Assoc. Inst. C.E.
1835. Russell, J. Scott, M.A., F.R.SS. L. & E.

1835. Ranken, Francis, glass-manufacturer.
1838. ROXBURGHE, His Grace JAMES H. R., Duke of, K.T.
1839. Russell, Thomas, ironmonger.
1840. Rose, Alexander, lecturer on geology.
1842. Rankine, W. J. Macquorn, F.R.S.E., C.E.
1843. Rhind, David, F.R.S.E., architect.
„ Roberts, W. A., M.D., dentist and surgeon.
1844. Robertson, James, M.E.
„ Ronaldson, John, writer.
1846. Robb, Charles, silversmith.
1848. Reid, Robert Little, painter.
1849. Robertson, Alex. D., merchant.
1850. Ramsay, Alex., manager Edin. Water Co.
„ Rae, William Fraser, brassfounder.
„ Richardson, James, merchant.
„ Richardson, Robert, merchant.
„ Robson, Neil, C.E., Glasgow.
1851. Rogers, James, ironmonger.
„ Ross, William, of Greenside.
1853. Rose, John T., shipbuilder, Leith.

1827. Swinton, George, F.R.S.E.
1828. Sang, Edward, Prof., Constantinople.
1832. Sclater, Robert, die-cutter.
1833. Steele, Wilkinson, merchant.
1835. Steele, Patrick S., merchant.
1836. Slight, James, engineer.
1837. Smith, Jas., of Jordanhill, F.R.SS. L. & E.
1838. Stevenson, David, F.R.S.E., C.E.
„ Seeligmann, F. E., punch-cutter, London.
1839. Smith, David, F.R.S.E., W.S.
1840. Sprot, Thomas, W.S.
„ Stevenson, Peter, philos. instrum. maker.
„ Smith, C. H. J., landscape-gardener.
1841. Steuart, Robert, of Carfin.
„ Simson, George, R.S.A., artist.
„ Steell, John, R.S.A., sculp. to the Queen.
1842. Spence, Charles, S.S.C.
„ Smail, Will. Arch., of Overmains, R.N.
1843. Sanderson, James H., lapidary.
„ Schenck, Frederick, lithographer.
„ Shanks, Thomas, engineer, Johnston.
1846. Swan, Wm., F.R.S.E., teacher of mathcs.
„ Simpson, Prof. J. Y., M.D., F.R.S.E.
„ Spence, James, W.S.
„ Seller, William, M.D., F.R.C.P., F.R.S.E.
1847. Steuart, James, W.S.
„ Stevenson, Thomas, F.R.S.E., C.E.
„ Sclanders, Alexander, upholsterer.
1850. Smith, Alexander, C.E., Aberdeen.
„ Swan, Alex., manufacturer, Kirkcaldy.
„ Stewart, James W., C.E.
„ Stark, James, M.D., F.R.C.P., F.R.S.E.
1850. Scrymgeour, Henry, upholsterer.
„ Sinclair, Alex., manager Shotts Foundry.
„ Scott, Archibald, architect.
„ Smith, Robert, builder.
„ Sibbald, Thomas, ironmonger.
1850. Strachan, Robert, accountant.
„ Smith, George C., land-surveyor, Banff.
1851. Smith, Robert, engineer, governor City Workhouse.
„ Simpson, Geo., C. and M. E., Glasgow.
„ Sawers, John, Provost of Stirling.
„ Seton, Major, R.S., Madras Artillery.
„ Stewart, Hon. Robert, of Omoa, Lord Provost of Glasgow.
1852. Sutter, Archd., land-surveyor.
1853. Shepherd, Jas., accountant, Portobello.
„ Smith, William, engineer, St Margaret's Works.

1822. TWEEDDALE, The Most Noble the Marquis of, K.T., F.R.S.E.
1826. Tod, James, F.R.S.E., W.S., *Sec.*
1830. Tod, Henry, W.S.
1836. Traill, Thomas Stewart, M.D., F.R.S.E.
1838. Trotter, James, teacher.
1839. Thomson, William T., manager Standard Life Assurance Company.
1840. Trevelyan, Sir Walter C., Bart., F.R.S.E.
„ Turnbull, William, Royal Bank.
1846. Trevelyan, Arthur, of Pencaitland.
„ Thornton, Robert, engineer.
1851. Turner, Richard, engineer, Dublin.
„ Tennant, John, St Rollox, Glasgow.
„ Tennant, Charles, St Rollox, Glasgow.
1852. Thomson, Jas. Boyde, M.I.M.E., Glasgow.

1843. Veitch, John, baker.

1822. Whytock, Richard, merchant.
1836. Wright, Robert, architect.
1838. Wilkie, John, of Foulden.
„ Wilson, Patrick, architect.
1840. Wood, William, surgeon.
„ Watson, Henry George, accountant.
„ Wright, Peter, linen-merchant.
„ Walker, William, surgeon.
1843. Wilson, Robert, linen-manufacturer.
1844. Wyllie, Henry J., C.E.
„ Wightman, William, contractor.
1845. Wilson, George, M.D., F.R.S.E.
„ Wilson, Prof. Daniel, LL.D., Canada.
1846. Whitelaw, James, watchmaker.
„ Wilson, Hutton, W.S.
1850. Wright, George, jun., merchant, Leith.
„ Webster, Andrew, S.S.C.
„ Walker, John, M.D., London.
„ Winton, John G., engineer, Newhaven.
1851. Willet, John, C.E., Aberdeen Railway.
1852. Wighton, Rob. K., jeweller.

1847. Young, Archibald, cutler.
1848. Young, William D., manufg. ironmonger.
1853. Young, James, chemical manufacturer, Murrayfield.

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The following ORDINARY FELLOWS, included in the foregoing List, are ordered to remain, till they return to Scotland, in the following

SUSPENSE LIST.

1844. William Cooper, glass-manufacturer, late of Picardy Place, Edinburgh, and now in Canada.
„ Joseph M. Kronheim, ornamental designer, London.
„ Edward Sang, Professor of Mechanical Philosophy at the Imperial School, Muhendishana, Berii, Constantinople.
1845. Lieut.-Col. Blanshard, R.E., Mauritius.
1846. George Buist, LL.D., Bombay.
„ Mungo Ponton, F.R.S.E., 11 Lansdowne Place, Clifton.
1849. F. E. Seeligmann, punch-cutter, London.
1851. John S. Fraser, Swindon Station, Great Western Railway.
1852. Thomas C. Gregory, C.E., America.
„ Colin Miller, M.D., late of Edinburgh.
1853. James Newlands, C.E., superintendent of works, Liverpool.
„ David T. Hope, C.E., late of Liverpool.

APPENDIX (O).

Proceedings of the Royal Scottish Society of Arts, Session 1853–54.

The Annual General Meeting of the Society was held in their Hall, 51 George Street, on Monday, 14th November 1853,—David Stevenson, Esq., C.E., F.R.S.E., President, in the Chair. The following Communications were made :

1. The President opened the Session with an appropriate Address.

2. The Report of the Prize Committee awarding the Prizes for Session 1852–53 was read, and the Prizes were delivered by the President to the successful Candidates. See Appendix (M) p. 166.

The Models, Drawings, &c., of Inventions, &c., for which Prizes, &c., awarded were exhibited. The following Donations were laid on the Table, viz. :—

1. Report of Twenty-second Meeting of the British Association for the Advancement of Science, held at Belfast in 1852. (8vo. London, 1853.) Presented by the Association. (3526.)

2. Donations from the Smithsonian Institution, Washington, U.S., viz. :— (3527.)

(1.) Smithsonian Contributions to Knowledge, Vol. V. (4to. Washington, 1853.)

(2.) Sixth Annual Report of the Board of Regents of that Institution for 1851. (8vo. Washington, 1852.)

(3.) Catalogue of Portraits of North American Indians, painted by J. M. Stanley, deposited with the said Institution. (8vo. Washington, 1852.)

(4.) Report of the Commissioners of Patents for 1851, Part I. Arts and Manufactures. (8vo. Washington, 1852.)

(5.) Do., Part II., Agriculture. (8vo. Washington, 1852.)

The five following Charts are presented by the United States Coast Survey Office of the Treasury Department, through the Smithsonian Institution, viz. :—

(6.) Chart of Hell Gate and its Approaches.
(7.) Do. Western part of South Coast of Long Island.
(8.) Do. Entrance to Mobile Bay.
(9.) Do. Hart and City Island and Sachem's Head Harbour.
(10.) Do. Richmond's Island Harbour.
(11.) Norton's Literary Register, 1852.
(12.) Another Copy of Do.

3. The Conservation and Improvement of Tidal Rivers. By Edward Killwich Calver, R.N., Admiralty Surveyor. (8vo. London, 1853.) Presented by the Author. (3536.)

Thanks were voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidates were elected Ordinary Fellows, viz.:—

1. John Mouat, C.E., 11 Salisbury Road.
2. Andrew Ritchie, Clock and Watch Maker, 29 Leith Street.
3. Rev. Nathan Davis, 16 Upper Stamford Street, London.
4. James Elliot, 1 St Vincent Street.

III. In terms of Law XV., the Society elected its Office-Bearers for 1853–54, viz.:—

Rev. Philip Kelland, M.A., F.R.SS. L. and E., *President.*
William Swan, Esq., F.R.S.E.
Heinrich Wilhelm Nachot, Ph. D. } *Vice-Presidents.*
James Tod, Esq., F.R.S.E., W.S., 55 Great King Street, *Secretary.*
John Scott Moncrieff, Esq., Accountant, 20 India Street, *Treasurer.*

Ordinary Councillors.

Alex. Rose, Esq.
James Leslie, Esq., C.E.
Alex. K. Johnston, Esq., F.R.S.E.
George Lees, LL.D.
Wm. Paterson, Esq., C.E.
T. Stevenson, Esq., F.R.S.E., C.E.
David Landale, Esq., M.E.
David Cousin, Esq.
David Stevenson, Esq., F.R.S.E., M.I.C.E.
Robert Ritchie, Esq., C.E., Ass. I.C.E.
George Wilson, M.D., F.R.S.E.
William A. Roberts, M.D.

George Wilson, M.D., F.R.S.E., *Editor of Transactions.*
Mr Alex. Jamieson, *Curator of Museum.*
Mr Alex. Kirkwood, *Medallist.*
Mr Hugh Johnston, *Officer and Collector.*

IV. A List of the Office-Bearers, and Alphabetical List of the Fellows, as at 1st November 1853, in the order of their admission, was distributed.

28th November 1853.—Rev. Professor Kelland, A.M., President, in the Chair. The following Communication was made:—

Dr George Wilson—in continuation of his Communication on Colour-Blindness or Chromato-Pseudopsis—reported the results of an extended inquiry into the prevalence of it,—including an investigation of the quality of Colour-vision in upwards of a thousand healthy males; and announced some conclusions to which he has been led, and their bearing on the use of Coloured Signals on Railways, at Sea, and elsewhere.

(3539-3496.)

The following Donations were laid on the Table, viz.:—

1. The Illustrated Indian Journal of Arts. Parts I. and II.
   The Indian Journal of Arts, Sciences, and Manufactures, Parts I. and II. (Madras, 1851.)
   Presented by Alex. Hunter, M.D., Madras. (3525-1, 2, 3.)
2. The Assurance Magazine, No. 13, October 1853.
   Constitution and Laws of Institute of Actuaries, 1853.
   List of Members of the Institute, 1853.
   Presented by the Institute. (3529-1, 2, 3.)
3. Journal of the Geological Society of Dublin, Vol. V., Part III., for 1852-53. (8vo. Dublin, 1853.) Presented by the Society. (3531.)
4. Premiums awarded, Session 1852-53, and Subjects for Premiums, 1853-54. Presented by the Institution of Civil Engineers, London. (3534.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidates were elected Ordinary Fellows, viz.:—

1. Michael A. Levy, 21 Clarendon Crescent.
2. George W. Hay, of Whiterigg, near Melrose.

III. Copies of the Report of the Prize Committee for Session 1852-53 were distributed.

12th December 1853.—Rev. Professor Kelland, A.M., President, in the Chair. The following communications were made:—

1. At the request of the Council, an Exposition of the Time-Ball lately erected at the Royal Observatory of Edinburgh was given by Professor C. Piazzi Smyth, F.R.S.E., Astronomer-Royal for Scotland. A working model, 9 feet high, and diagrams were exhibited. (3542.)

After alluding to the past labours of the late Astronomical Institution in endeavouring to supply the public with a knowledge of the true time, the author introduced the time-ball as being but a further development of those wise beginnings made by the founders of the now Royal Observatory.

He then described the progress of time-ball signals from their first proposition by Captain (now Admiral) Wauchope, in 1830, to their establishment in various forms at Greenwich, Portsmouth, St Helena, Liverpool, Madras, the Cape of Good Hope, and, finally, on the Calton Hill.

This last, which has just been completed by Messrs Maudslay and Field of London, was then described in all its parts; and, finally, a large wooden model was exhibited and worked before the Society, and was considered to favour the project of time-ball extension; for while it yielded in refinement and in accuracy to none, its arrangement and construction, which were contrived by the author, were so extremely simple and economical, that expense would be no longer an objection; and if only a wire connection be established between such additional balls and the present one, the same electric touch at the Observatory would drop them all at the same instant; and thus the sea-going vessels of the Clyde might, with great ease, have their chronometers regulated by the time-signals from the Royal Observatory of Edinburgh.

On the motion of Professor Kelland, the thanks of the Society were given from the chair to Professor Smyth, for his very interesting exposition.

The thanks of the Society were also given to Captain Dall for his kindness in allowing his model of time-ball to be exhibited.

2. Suggestions for a *Simple* System of Decimal Notation and Currency, in contrast to that now before the Country, involving a change in the value of the Penny. By James Alexander, Esq., Wine-Merchant, Edinburgh.

The author remarked that the fatal objection, in his opinion, to any of the proposed systems yet submitted to the country, including that developed in the Blue-Book recently issued, was the proposed change in the value of the penny and farthing, and of all the coins that were multiples of these up to the shilling. The penny had so many associations in familiar sayings and proverbs—it was the standard of so many taxes and charges, such as postage, receipt stamps, newspaper stamps, railway mileage, &c., that it would be impossible, without great confusion, to depart from it, and adopt the pound as the unit of account, with its decimal gradations of florins, cents, and mils, requiring four columns to register the sum. The author proposed, as it was not so much an actual circulating coinage that we wanted as a simple and easily worked denomination of account, to reduce the standard to farthings under the name of mils, without otherwise changing the value or name of the other coins now used, and to disregard the sovereign as a money of account, but retain it as the standard of value, and as a circulating coin of 960 mils, and adopt for the expression of 1000 mils the term guinea, which would then bear the value of 20s. 10d., instead 21s. Accounts would then be kept simply as guineas and mils, the penny and shilling being still used in currency, but commercially expressed as ·004 and ·048 mils. The author did not propose a gold coin of 20s. 10d., but expected the new guinea would find sufficient representation as a "value" in paper currency. The author also considered that the adoption of a system of accounts, independent of either a gold or a silver standard, was the only way of escape from the confusion likely to arise to commerce from the recent gold discoveries. Probably, he thought, silver bullion would acquire such a value as to entitle the florin, shilling, and sixpence to take value respectively as representing 100, 50, and 25 mils.

After some complimentary remarks by the chairman (Professor Kelland) and Mr Cowan, M.P., the communication was referred to a committee.

IV. The following Donations were laid on the Table, viz.:—

1. Transactions of the Royal Society of Edinburgh. Vol. XX., Part IV. Session 1852-53. Presented by the Society. (3537.)

2. Proceedings of the Royal Society of Edinburgh. Session 1852-53. Presented by the same. (3538.)

3. Transactions of the Architectural Institute of Scotland. Vol. III., Part I. (Royal 8vo, Edin. 1853.) Presented by the Institute. (3535.)

Thanks voted to the Donors.

Purchased for the Library:—

4. The Patentees' Manual, by James Johnson, of Middle Temple, and Henry Johnson, Solicitor and Patent Agent, London and Glasgow. (8vo, London 1853.) (3528.)

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidate was elected an Ordinary Fellow, viz.:—

Alex. K. Smith, C.E., City Saw-Mills, Exeter.

III. In terms of Law XX., the Treasurer's Books were laid on the Table, and a Committee appointed to audit the same, and to report thereon, and, generally, on the state of the funds of the Society.

IV. Two copies of Forms of Applications, to enable the Fellows to recommend Candidates for admission were distributed.

The Society adjourned.

9th January 1854.—Rev. Professor Kelland, A.M., President, in the Chair. The following Communications were made:—

1. Description of Life-Boats to be carried on board of Ships. By the Rev. James Brodie, Monimail, Fife. With a Diagram. (3540.)

2. An Inquiry into the Principles on which the Action of Sails and Rudders depend. By the same. With a Diagram. (3541.)

In the first of these papers the author explained the principles by the application of which he proposes to combine safety with speed in the construction of sailing vessels, and showed how these might be applied in various ways in forming life-boats, and substitutes for life-boats, to be carried on board ships. In the second he gave the results of some inquiries he had made into the principles on which the action of sails and rudders depends. After showing the importance of distinguishing between the overturning and impelling influence of the wind, he gave, as the result of his calculations and observation, the following rule:—"The faster any vessel sails in proportion to the velocity of the wind, when the wind is on the side, the more acute should be the angle which the sail makes with the line of the vessel's motion, in order to produce the greatest impelling force; and, on the other hand, the slower the vessel's motion in proportion to that of the wind, the more obtuse should that angle be made, in order to prevent at once a diminution of the impelling force, and a dangerous increase of the overturning influence of the wind." He then directed attention to the alteration which should be made on the position of the after-part of the sail, in consequence of the wind rebounding from the anterior portion of it, and showed that the effect of the air rebounding from the fore-part of the sail would require the general angle of inclination to the line of the vessel's motion to be more acute than it would otherwise have been, and that all fore and aft sails should be drawn as tight as the strength of the materials will permit. In regard to the action of rudders and other appliances for steering a vessel, he showed the different forces on which that action depends, and directed attention to the fact that the action of a sail near the stern not only resembles that of the rudder, but, being independent of the vessel's motion, might, in many cases, be advantageously substituted for it; and suggested that, in tacking sharp-built vessels, the mizzen-sail should be brought round much farther to windward than is usually done, in order to prevent them missing stays.

3. An Appendix to Mr Bow's paper on Roofs (No. 3509), containing explanations of the methods of calculating the Strains, was laid before the Society. Some of the principles upon which the strains were calculated were illustrated by a model and drawings. (3543.)

Referred to the original Committee.

4. Photography—Two specimens of Calotype by the Collodion process, by Mr Rodger, St Andrews, were exhibited. (3551-1-2.)

The following Donations were laid on the Table, viz.:—

1. Model of one of the Pumping Engines used for draining Haarlem Meer, in Holland. Presented by Mrs Grainger, widow of the late Thomas Grainger, Esq., C.E., President of the Society. (3546.)

2. The Twentieth Annual Report of the Royal Cornwall Polytechnic Society, 1852. Presented by the Society. (3545.)

3. Decimal Coinage, a brief comparison of the existing system of Coins and Money of Account,—of that proposed by the Decimal Coinage Committee,—and of another system. By E. Ryley, London (8vo, pp. 20, 1853). Presented by Charles Cowan, Esq., M.P., F.R.S.S.A. (3547.)

4. Report of the Edinburgh Chamber of Commerce on the subject

of a Decimal Coinage, 18th April 1853. Presented by the Chamber. (3548.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidates were elected as Ordinary Fellows, viz. :—

1. Sir George Scott Douglas, Bart., of Springwood Park, Kelso.
2. James B. Watt, S.S.C., 9 York Place.
3. Robert Seton, Bookseller, 121 Princes Street.
4. Patrick M'Farlane, Comrie, Perthshire.
5. John Kilgour Johnston, Teacher of Mathematics, 3 West Preston Street.
6. John Rutherfurd, W.S., 14 Albany Street.
7. J. T. Thomson, F.R.G.S., Government Surveyor at Singapore.
8. James Robertson, C.E., Manager of Edinburgh, Perth, and Dundee Railway, 10 Manor Place.
9. Allan Livingston junior, Brick Manufactory, Joppa House, Portobello.

III. The Report of the Auditing Committe on the Treasurer's Book and on the Funds was read,—Mr Horne, Convener.

Thanks voted especially to the Convener.

23*d January* 1854.—Rev. Professor Kelland, A.M., President, in the Chair. The following Communications were made :—

1. The President exhibited the action of Artificial Tourmaline, as compared with Nichol's Prisms.

He also exhibited Microscopic Writing done for him in Paris. On a spot no larger than the head of a small pin, the Professor showed, by means of powerful microscopes, several specimens of distinct and beautiful writing—one of them containing the whole of the Lord's Prayer executed within this minute compass. (3553.)

During the exhibition of these, Dr Nachot took the chair.

2. On Dipping and Apparent or Fictitious Lights ; with a description of an Apparent Light, the illumination of which is derived from a distant light situated on the shore,—erected in 1851 by the Commissioners of the Northern Lighthouses, on a sunk rock in the bay of Stornoway. By Thomas Stevenson, Esq., F.R.S.E., &c., Civil Engineer.

Diagrams were exhibited. (3555.)

The author alluded to the great and well-known difficulties and expense, and, in some cases, the impossibility of constructing lighthouses upon sunken rocks. To remedy such difficulties the author proposed two methods, which he termed Dipping and Apparent Lights, in order to make lighthouses on the shore answer the same ends as if they were placed on the isolated rocks at sea.

The author described the plan of dipping lights as being applicable to cases where the rocks or shoals whose position required to be indicated were surrounded with sufficient sea-room to enable vessels to pass to and fro without approaching near to the rocks themselves. The dipping light, instead of throwing its beam of parallel rays to the horizon, in the same manner as ordinary lights, throws it downward at some given angle of depression to suit the distance of the rocks from the shore, so that, whenever a vessel crosses the margin of safety, the dipping light is seen, and she has ample time to change her course.

The apparent light is useful for sunk rocks in narrow sounds where the fairway is not broad, and where the dangers must be passed very closely; also for pier-heads at the mouths of artificial harbours, and such like situations. The apparent light at the entrance to Stornoway Bay, in the Hebrides, is erected on a sunk rock distant about 630 feet from the lighthouse on the shore, and consists of a hermetically sealed lantern containing certain forms of optical apparatus, upon which a beam of light is thrown from the lighthouse ashore. The effect of this apparatus is to reassemble the rays in a focus, from which they again diverge, presenting to vessels entering the bay the appearance of a real light on the beacon, when, in fact, there is none. So dangerous was this sunken rock, that many thought the lighthouse should be built upon it, instead of on the shore. By means of the apparent light, however, every end has been gained that could have been secured by the lighthouse, while the great expense of construction and of after maintenance has been saved. From the very small power which is used at Stornoway (a holophotal apparatus of only twenty inches diameter, with a burner one inch diameter), the author concludes that such a plan could be applied to very much greater distances. The optical power at Stornoway could, were it necessary, be increased about a hundredfold, if fitted with a holophotal apparatus of the first order. If the electric light were employed in connection with such powerful apparatus, the limits of visibility would, of course, be still farther extended. The apparatus necessary for illuminating floating buoys on the same principle was also explained, and the paper was concluded with extracts from letters from ten different shipmasters, who certified to the utility of the beacon light *in all weathers.* The distances to which it had been seen varied from *one to one and a half* miles—distances greatly beyond the wants of the locality.

Referred to a Committee.

3. Sketch of the various changes and improvements in the Manufacture of Paper during the last thirty years. By Charles Cowan, Esq., M.P. (3561.)

Mr Cowan first described the old mode of manufacture in vats, now fallen almost entirely into desuetude, and replaced by the paper-machine. There were twelve or fourteen processes, he said, in the old vat mill, requiring a period of three weeks to produce the paper, whereas now it was manufactured in almost as many minutes. The paper-machine at present in use was invented early in the century by Fourdrinier, a Frenchman; but, being patented also in this country, it did not come into general use till the patent expired in 1822. Since that period, various important improvements in the manufacture had been introduced, such as the strainer, and the sand-trap, which cleared the pulp of all knots, dust, and extraneous matter. The manufacture of "laid" paper by the machine, which was at first thought impossible, had been in operation for the last six years, and as fine paper was produced by it as formerly could have been turned out by the hand. With regard to the material used in the manufacture, waste-cotton from the mills, which formerly was considered quite useless, money being often paid to get rid of it, was now largely used in the production of such paper, particularly newspapers. Straw was another material which had lately been successfully tried. The paper produced from it was pleasant to look upon; it took a clear impression from types, and, as it did not require to be damped, considerable time was saved in printing upon it. Mr Cowan showed some specimens of straw paper from Maidstone, with a copy of Bradshaw's Continental Guide for December printed on paper made from that material. Straw available for the manufacture could be had at about £2 per ton; it was, however, loaded with an excise duty of £15. Four years ago, when in the south of France, the Messrs Montgolfier had shown him paper made of untanned leather, to be used as cartridges for cannon, for which purpose we used in this country flannel bags. On returning home he sent a specimen of it to the Right Honourable Fox Maule, then Secretary of War, who, however, told him that there was an objection to its use from portions remaining in the piece after discharge, rendering the next charge liable to ignition. Mr Cowan then exhibited a variety of beautiful transparencies, closely resembling porcelain, produced on paper by Mr Saunders of Dartford. Mr Cowan concluded by stating that in the county of Edinburgh, which was a considerable seat of the paper manufacture, there were about 24 machines in operation. Supposing these machines travelled at the average rate of 36 feet per minute (some of them travelled at 50), and supposing that they worked 15 hours a day (some of them went day and night), this would be equal to about 147 miles of paper per day, about 5 feet broad. He believed that there were about 360 machines in Great Britain, producing daily about 2160 miles of paper. Considering the great results of the paper-machine in producing an abundant and cheap supply of paper for every purpose—in affording the means of enlarging the newspapers, in bringing paper-hangings within the reach of the humbler classes, and in giving an impetus to popular literature—he considered that it was one of the most useful and important inventions of modern times.

After some complimentary remarks by the Chairman, the thanks of the Society were awarded to Mr Cowan for his statement.

4. Description of a Parallel Motion producing a perfectly straight line. By Mr John Sang, Land-Surveyor, Kirkcaldy. (3549.)

A Model was exhibited.

This motion, it was stated, is suitable for steam-engines or other purposes. It is produced by combining two guides, consisting of levers working on centres, each of which limits the path of the piston to a single plane; so that the path of the combination is the intersection of two planes, and hence perfectly straight from end to end. The working parts consist entirely of centre points or journals, so that there is very little friction.

Referred to a Committee.

5. There was exhibited to the Society a Bank Safe Lock, applicable to other securities, invented and patented by William Simpson, Esq., Bank of Scotland, and manufactured by James Gray and Son, 85 George Street, Edinburgh. (3562.)

The lock was examined with much curiosity and attention, and elicited a general approval for strength and security. Thanks voted.

The following Donations were laid on the Table, viz.—

1. The Chemistry of Common Life. No. II. The Soil we cultivate. The Plants we rear. By James F.W. Johnston, M.A. Presented by the Author. (3556.)

2. Fourth Report of the Council of the Architectural Institute of Scotland, 1853. Presented by the Institute. (3557.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidates were elected Ordinary Fellows, viz. :—

1. Alexander F. Foster, A.M., 339 High Street, Edinburgh.
2. Randall Poole Dale, Designer for Manufacture, 5 Buccleuch Place.

The Society then adjourned.

16*th February* 1854.—Rev. Professor Kelland, M.A., President, in the Chair. The following Communications were made :—

1. On a New Principle of Stenography or Short-hand Writing. By Alexander Melville Bell, Esq., Edinburgh. (3550.)

The author stated that the novelty of this system consists in the adoption of a principle of writing the consonants of words, which renders altogether superfluous the insertion of vowel points, either at the beginning, or in the middle of words—the presence or absence of preceding vowels being indicated by the mode in which the consonants are written. The following is the principle :—" Those letters only that are *preceded by a vowel sound* are written of the *full alphabetic size* (this size being optional), and consonants that are *not preceded by a vowel* are written of such a manifestly *subordinate size,* as plainly and at a glance to indicate that they are *not syllabic letters.*" Thus the writing not only shows at once where vowels do and where they do not occur, but also indicates, in the number of full-sized characters, the number of syllables of which words are composed. The alphabet consists of simple straight and curved lines, to all of which the above principle of notation is applicable—each elementary sound being denoted by a single line. Distinctive vowel marks may be inserted in this system ; but they are never necessary except in the writing of *foreign words, proper names*, &c. The consonant delineation presents this *important peculiarity*, that the full-sized writing of those letters which have a preceding vowel admits of the free insertion of vowel marks where they may be required; while the contracted writing of the letters which have no preceding vowel *precludes their insertion in the wrong places*, or where they do not occur. The rudimental principle of contracting the less important letters of syllables is also applied to the less important syllables of words, and words of sentences, by writing *without full-sized characters* all prefixes and terminations, and words of the subordinate parts of speech—articles, prepositions, pronouns, and connectives. The effect of this is to give prominence to the radical syllables in each word, and the leading word in every sentence; and thus to make the words which are most important to the sense *emphatic to the eye*, as if presented in bold capitals on a printed page. A further application of the same principle consists in writing but *one full-sized character* in any word, thus giving prominence to the most distinctive syllable, that on which the *accent* falls. In this way words which occur with a double accentuation—such as presént, present′, desért, desert′, &c.—are distinguished in their different senses, without the use of separate accentual marks. This system claims a degree of simplicity in the acquisition, and an ease of legibility, which have hardly been approached—which, perhaps, can never be surpassed. The full alphabetic writing may be learned in an hour; and this, when familiarised by practice, may, with almost nothing new to learn, be contracted at pleasure, either into the curt or manuscript, or the more abbreviated reporting style.

After some complimentary remarks made by the President and others, the thanks of the Society were voted to Mr Bell for this communication; and were given to him from the Chair.

2. A Description of an Original Invention for preventing Railway Collisions by means that shall act independently of Guard or Engineer, and without the premonition of a Signal. A brief Review and Analysis of Railway Casualties was read, and a Working Model exhibited. By Mr J. C. Blackwell, Edinburgh. (3570).

Mr Blackwell presented a model of his new invention for preventing railway collisions. Before explaining its principle of action, he referred to the published reports of the Commissioners of the Railway Department of the Board of Trade, which have been ably analysed by Mr Neison, of London, whose valuable tables show the nature, number, causes, and fatalities of all the railway casualties that have occurred in the United Kingdom from 1840 to 1853, inclusive; and the *collisions* from 1844 to 1852, and their fatalities. From these tables Mr Blackwell showed very clearly that the means at present in use for preventing the latter class of casualties are not only inefficient themselves, but fearfully uncertain and precarious, from the fallibility of the human agency required to work them. That this fact suggested to the author the first idea of discovering or contriving a method that should not be dependent on such frail instrumentality, and that the present invention is the result; it being remarkably simple both in principle and practice. The inventor proposes placing in the centre of the roadway, between each line of rail, and at equal distances from each other, *self-adjusting levers*, or cranks, of a rectangular form (thus L), and turning on a pivot at the point of angle. Each of these levers is to be connected with the alternate one in advance by a wire that acts in a case or tube a few inches below the surface. The effect of these communicating wires is, that, when any one of the horizontal levers has had its *position inverted* by the stroke of a lever attached to the engine, and communicating with the valve that shuts off the steam, it is immediately restored to its first position, when the engine reaches and knocks down the next-but-one lever in advance; and this reciprocal falling and rising takes place along the whole line. The author stated that it would thus be obvious that, if a train be impeded on any part of its course, the lever behind is *left standing in a resistant position;* so that, if another train were to follow, it must have its steam shut off at once, without the cognizance of guard or engineer, because the road lever not yielding to the engine lever, the latter is forced back, and the same effect produced as if the steam had been designedly shut off by the driver. That thus no train could run into another from behind, as the road lever would shut off the steam, and the train be stopped before it could reach the train in advance. That another most important effect of this arrangement would be, that a *meeting of trains* could not by possibility occur.

After some remarks, the communication was referred to a committee.

3. Description of a Safe Lock incapable of being opened by any other means than by its own key. By Mr George Mitchell, Edinburgh. The lock was exhibited, and also a drawing of its interior. (3552.)

The author stated that this lock is incapable of being opened by any other means than by its own key, as no picker can be made applicable to it, neither can an impression be taken. The method adopted by the inventor, to secure the above advantages, consists in a protector revolver, and false chamber. The key is made to pass through the protector and revolver into the false chamber, where, having made one-fourth of its revolution, it is drawn into the lock, when it is made to open or shut the lock, as the case may be; after which the key is again passed into the false chamber, where it completes the revolution; or, in other words, the half of the key's revolution is performed in the false chamber, the remaining half in the lock. The revolver moves along with the key, so that the entrance into the lock (which is from the false chamber) is never exposed until the entrance to the false chamber is guarded against.

Referred to a committee.

A Report of Committee on Mr Alexander's paper on a Simple System of Decimal Notation and Currency—Mr Swan, Convener—was read and approved. (3544.)

The following Donations were laid on the Table, viz.:—

1. Report of the Select Committee of the House of Commons on a Decimal System of Coinage; with a Letter from William Brown, Esq., M.P., to the President of the Liverpool Chamber of Commerce, on that subject, dated 13th December 1853. Presented by the Chamber. (3567.)

2. The Decimal Coinage. A Letter to the Right Hon. the Chancellor of the Exchequer, advocating, as a preliminary step, the issue of a five-farthing piece, by A. Milward, Esq. (8vo. pp. 47. London, 1853.) Presented by the Author. (3568.)

3. The Assurance Magazine and Journal of the Institute of Actuaries, No. XIV. Presented by the Institute. (3559.)

Thanks voted to the donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidate was elected as an Ordinary Fellow, viz.:—

John Stewart, 28 Abercromby Place.

The Society adjourned.

27th February 1854.—Professor Kelland in the Chair.

The following Communications were made:—

1. Dr Buist, of Bombay, gave an account of some of the East Indian Arts and Manufactures, with Specimens of the Tools and Manufactured Articles, including Salt, Bombay or Moultan Inlaid Work, Gold Wire, Gold Lace and Spangles, Cambay Stones, and Calico-Printing. (3573.)

Dr Buist laid before the meeting a number of short notices of native manufactures as practised in India. The first of these was that of salt, of which 110,000 tons were manufactured in Bombay, 24,000 being exported. It was made by the natives by solar evaporation, without any European supervision; it cost about 3s. 3d. a ton, and paid 36s. of duty. At Calcutta the salt was made by boiling; it cost 36s. a ton, and paid 130s. of duty. There were about 5000 salt-makers at the former place, and 100,000 at the latter. The salt revenue of India amounted to about two and a half millions. Each individual being supposed to consume 12 lb. a-year, equal to five days' wages, or one and a half per cent. on the income of a working man without a family. A man and his family would probably consume 36 lbs.; supposing his wife and children to earn amongst them half as much as he did, this would be about three per cent. on the income of the house. At Bombay large spaces of low land, covered at every tide, were enclosed, and the sea admitted and retained at spring tides. Thousands and thousands of acres are thus flooded, from five feet to a few inches, exposed to a temperature of 120 degrees, with an evaporation of a quarter of an inch daily. A number of square little ponds a foot deep, and from ten to twenty feet each way, were filled with this, when concentrated to near the point of saturation; and in these, in the course of a fortnight or a month, the salt was collected and carried away by boats brought alongside the embankment, at the smallest imaginable expenditure of time or money. There was now no salt monopoly in Bengal; any one might import or manufacture on paying the duty. India consumed about five millions of tons annually; about ninety thousand tons were imported at Calcutta, of which about 24,000 tons were from England, and a like quantity from Bombay.

Black Wood Furniture.—Bombay had long been famous for its black wood carved furniture, which had excited universal admiration at the Exhibition of 1851. There were seven great furniture makers, and the work turned out by them was valued at from £3000 to £6000 annually. Massive round tables, from three to nine feet in diameter, cost from £2 to £9; large dinner tables in pieces about a third more; carved tables from £5 to £6; teapoys, per pair, from £1, 12s. to £3; sideboards, £3, 10s. to £7; easy chairs, from £1 to £8; drawing-room chairs with silk damask cushions from 10s. to £1 each. Parties in England curious in carved furniture might supply themselves from Bombay more economically, all charges included, than at home.

Bombay or Moultan Inlaid Work was formed of a mosaic of small pieces of ivory, white metal, ebony, or other coloured woods, laid in veneer over card-cases, desks, boxes, baskets, &c., of camphor or sandal-wood. Thin slips of these, two feet long, were drawn through triangular holes in steel, from the tenth to the twentieth of an inch in diameter. They were then made up in bundles of from one to two inches thick, saturated with glue, and thickly bound together with pack-thread. When dry they were sawn in thin slices, and so laid on. Writing-desks and work-boxes cost from £2 to £6; cheroot and card-cases from 6s. to 8s.; and other things in proportion.

Cambay Stones and Lapidary Work.—Cambay was mentioned in the Periplus as famous for its cornelians and onyxes two thousand years ago, and celebrated for those productions by Italian travellers of the sixteenth century. They were mentioned as sold at the Company's sales at the time of the monopoly to the extent of from £3000 to £4000. They had of late years almost ceased to be brought to Europe, though £10,000 worth were annually exported to China. The rough stones were found in the mountains of Goozerat; they were carried down to Cambay and manufactured there, and thence their name. They are mostly heated red-hot, to improve their colours, then splintered and rough-shaped like gun-flints, and finally ground and polished by powdered corundum mixed up with shell-lac into a cake. Stones for brooches sold from 2s. to 4s. each; knife-handles for betwixt £1 and £2 a dozen; paper-cutters from 2s. to 10s.; shirt studs from 2s. to 4s. a dozen; finger rings from 1s. to 3s. each. (A large collection of specimens was exhibited, together with a native lapidary's wheel, and a wheel as used by the English lapidary.)

Gold and Silver Gilt Work.—Gilding was practised by purely mechanical means in India, no amalgam or solution being employed. For the preparation of gold lace, gilt wire, and spangles, a rod of silver, about eighteen inches in length, three in circumference, and tapering at the extremities, was roughened with a file, and a thin sheet of gold wrapped round it, and rubbed in with an agate burnisher over a charcoal fire. The rod was then drawn into a very fine wire in the ordinary way. For gold lace this was hammered flat, and wound round orange-coloured silk thread. This was used in the manufacture of lace, and cloth of gold, or Kincob, which was consumed to a wonderful extent. For spangles, the wire was coiled up into a long spiral, then cut into rings, these being flattened by a single blow from a burnished hammer on a bright steel anvil into spangles. The spangles were extensively used in ladies' dresses, either sewed on, or stuck with gum on coloured talc. This mineral was found in Bengal; about £70,000 worth annually were consumed for window lights, watercoloured pictures, or the ground of spangle work. The number of goldsmiths in the large towns of India was many times that to be met with in Europe. In Bombay, with 120,000 inhabitants in the town (there were half a million on the island), there were 736 goldsmiths' shops, with probably 4000 workmen. In Lahore, with 68,000 inhabitants, there were 440 goldsmiths' shops, with probably 1200 workmen.

A Chinese Umbrella was presented to the Society. It was made of oil-paper, singularly strong, neat, and efficient; the wholesale price about 4d. each; £10,000 worth, or above half a million, were imported to Hamburgh annually; probably two millions were required for India at large. Dr Buist concluded by a short notice of a peculiar variety of calico-printing, where the colour was obtained by tying the white parts of the pattern out with pack-thread.

Thanks voted to Dr Buist for his interesting communications, and given to him from the Chair.

2. Part I. of a description of certain Mechanical Illustrations of the Planetary Motions, with some Theoretical Investigations connected with the subject; and, in particular, a New Explanation of the Stability of Equilibrium of Saturn's Rings. By Mr James Elliot, Teacher of Mathematics, Edinburgh. Illustrated by Experimental Models. (3558.)

Part II. was reserved for next meeting.

The following Donations were laid on the Table, viz. :—

1. Account of the Horsburgh Lighthouse, erected on Pedra Branca, near Singapore. By J. T. Thomson, Esq., F.R.G.S., Government Surveyor. (8vo, pp. 123. Singapore, 1852.) Presented by the Author. (3572.)

2. The Civil Engineer and Architect's Journal, Vol. XVI., for 1853. (London.) Presented by W. Laxton, Esq. (3564.)

3. The Artisan, Vol. XI., for 1853. (London.) Presented by the Editor. (3565.)

4. The Practical Mechanic's Journal. Vol. V., April 1852 to April 1853. (Glasgow.) Presented by Messrs Johnston. (3556.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidates were elected Ordinary Fellows, viz. :—

1. Adam Morrison, S.S.C., 45 York Place.
2. Thomas Parke Ivison, C.E., 17 Elder Street.

Adjourned.

13*th March* 1854.—William Swan, Esq., F.R.S.E., Vice-President, in the Chair. The following Communications were made :—

1. Part II. of a description of certain Mechanical Illustrations of the Planetary Motions, with some Theoretical Investigations connected with the subject; and, in particular, a New Explanation of the Stability

of Equilibrium of Saturn's Rings. By Mr James Elliot, Teacher of Mathematics, Edinburgh. Illustrated by Experimental Models. (3558.)

The author stated that the principal object of the communication was to show how the greater part of the motions of the planets may be imitated by means much less complicated than the contrivances of orreries, and at the same time much more closely resembling them in their moving principles. The motions capable of being so imitated are the rotation of the earth on its axis—its elliptic orbit; the conical revolution of the axis, and that in a direction opposite to the rotation; the precession of the equinoxes; the nutation of the earth's axis; the change in the obliquity of the ecliptic; the retrogradation of the moon's nodes; the perturbation of the planetary objects; and the rotation and eccentric revolution of Saturn's ring. The author endeavoured to show that all of these motions, except the diurnal rotation and the annual revolution, derive their origin, in the case of the planets themselves, from one principle, the same as that which directs the movements of a common spinning top, and prevents it from falling. To establish that point, he commenced with the theory of the top, and after alluding to the fallacy of the common idea that centrifugal force prevents its fall, he controverted the newer theory of Dr Arnott, that it arises from the shifting of the point of support. He then proceeded to demonstrate that the real cause is the conversion of the tendency to fall into the conical motion of the axis; that the same cause prevents the equator from falling into the plane of the ecliptic by converting its tendency to do so into a similar motion of the earth's axis; that the same cause gives rise to the retrogradation of the moon's nodes, and even the rotation of the earth's axis; that the same preserves Saturn's ring from collision with the planet, by the conversion of the tendency to approach it, into a slow eccentric revolution; and, finally, that the same cause occasions the greater part of the effects of perturbation, viz., all that affect the plane of the orbit, differing as they do in four different positions of the centre of the disturbing force. In the first position, increasing the obliquity of the plane to the ecliptic; in the second, diminishing that obliquity; in the third, producing a forward motion of the nodes; and, in the fourth, a retrogradation. A model was employed to show what had previously been deduced from reasoning, that the conical revolution of the axis of a spinning-top in the same direction with the top's rotation, may be annihilated by bringing the centre of gravity to *coincide* with the point of the pivot, or centre of motion, illustrating the parallelism of the earth's axis; and that the same revolution is changed into one in the opposite direction, by bringing the centre of gravity *below* the centre of motion. The author showed what are the corresponding centres in the case of the earth itself,—viz., the centre of gravity and the centre of momentum. Another model was introduced to exhibit the retrogradation of the moon's nodes. The experimental illustration of the effects of perturbation was produced by a magnet; the singular effect of a magnet upon a horizontal iron ring being first pointed out,—viz., that when placed immediately above the ring, at one side of it, it does not, when the ring is in rapid rotation, draw that side towards it, as would have been anticipated, but raises the side, which is a quadrant in advance, depressing the preceding quadrant. The theory of Saturn's ring was also illustrated by a magnet within an iron ring in rotation. The ring, when rotating with sufficient rapidity, being no longer drawn towards the magnet, but *apparently* repelled, so as, when placed eccentrically, gradually to bring itself into a central position, and, in doing so, giving rise to a slow eccentric revolution of the ring, corresponding to that which telescopic observation detects in the actual ring of Saturn. The author's theory regarding the equilibrium of Saturn's ring being contrary to the opinions received among astronomers, led him into an examination of the hypothesis of Laplace and of Sir John Herschel. He showed that Laplace's demonstration of the necessary instability of a uniform ring attracted toward an eccentric point, although perfectly good as far as it goes, errs fatally in its application to Saturn's ring by the omission of the principal element—viz., the *rotation of the ring*—and by estimating the attractive force only in one direction, and that although a uniform ring at rest, but free to move, drawn towards a fixed point of attraction coincident with its centre, will be in instable equilibrium, yet that it will cease to be so as soon as a sufficient velocity of rotation is given to the ring. That Laplace's hypothesis of a load on one side of the ring is therefore wholly uncalled for, as well as contrary to observation, and liable to other objections; that in like manner Sir John Herschel's hypothesis is equally unnecessary, and (utterly untenable as the author regards it) would probably never have been suggested, but from the belief that Laplace's demonstration was unimpeachable.

After some interesting remarks by the Chairman at last meeting and this evening, and also by the Hon. Lord Murray and the author, the thanks of the Society were voted to Mr Elliot for his communication, and the excellence and ingenuity of his mechanical illustrations, which was then referred to a Committee.

2. Description of a Semi-Revolving Light. By J. T. Thomson, Esq., F.R.G.S., &c. Defects of Revolving Lights when placed on Coasts. Reciprocating Light;—Reversing Light;—First form of Semi-Revolving Light; second form of same;—The introduction of the Holophotal System rendering the Reversing and Semi-Revolving Lights of more importance than they otherwise would be;—For open Seas the Eclipsing Light greatly superior to the Fixed Light.

The author explained how the common revolving light, when placed on a coast, was so far defective, inasmuch as in making a revolution round the whole circumference of the horizon, it wasted half its light uselessly to landward, where light was evidently not required. The reciprocating light of Captain Smith, of the Madras Engineers, was then mentioned, which shows its light only to seaward, but does not imitate the revolving light in having eclipses at and of equal intervals of time. The reversing light of Thomas Stevenson, Esq., was mentioned as possessing all the characteristics of revolving lights, and at the same time the light given out by it being confined to the sea-half of the horizon, whereby no unnecessary expenditure of lighthouse stores takes place. Two forms of semi-revolving lights, invented by the author, were then described, by which it is anticipated that the same results may be obtained as by the reversing light. The importance of these inventions was shown to be enhanced by the introduction of the holophotal system into lighthouse engineering by Mr Thomas Stevenson; as prior to this system being introduced, the only eclipsing or revolving light of maximum intensity was that of Fresnel, which, however, cannot be adapted to a semi-horizon apparatus, but must totally revolve, and therefore waste half its power when placed on coast lines. The holophotal system introduces a light of maximum intensity, suitable for the reversing and semi-revolving apparatus, which only shed their light to seaward, where the power is solely required. The paper concluded by noticing the advantages of eclipsing lights over fixed lights in open seas, where coasts are approached from over-sea voyages, by their properties of superior power and distinctiveness. A model of Mr Stevenson's reversing light was by his permission exhibited.

After some commendatory remarks by the Chairman and Mr T. Stevenson, the thanks of the Society were voted to Mr Thomson, and his communication referred to a Committee.

3. An Appendix to his Paper on Railway Collisions (No. 3570), and a method of preventing them; with farther illustrations. By J. C. Blackwell, Esq., Taaphall, Edinburgh. (3567.) A model was exhibited. Referred to the Committee on 3570.

4. Report of Committee on Mr Thomas Stevenson's Paper on Dipping and Apparent or Fictitious Lights in Lighthouses.—Mr Leslie, Convener—was read and approved of. (3555.)

The following Donations were laid on the table, viz.:—

1. Cyclopædia, or an Universal Dictionary of Arts and Sciences. By E. Chambers, F.R.S. With the Supplement and Modern Improvements, by Abraham Rees, D.D. Large fol., 4 vols. (Dublin, 1787.) Presented by Mungo Ponton, Esq., W.S., F.R.S.E., F.R.S.S.A. (3576.)

2. The Chemistry of Common Life. No. III. The Bread we Eat; The Beef we Cook. By James F. W. Johnston, M.A. Presented by the Author. (3569.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidates were elected as Ordinary Fellows, viz.:—

1. Henry Henderson, St Ann's, Lasswade.
2. Thomas W. E. Robson, Circus Place School.

III. The Fellows received the Printed Annual Abstract of the Revenue and Expenditure of the Society for Session 1852–53, and State of the Funds.

The Society then adjourned.

27th March 1854.—Professor Kelland, President, in the Chair. The following Communications were made :—

1. Mr C. Meinig, of 103 Leadenhall Street, London, exhibited specimens of his Patent Pocket Batteries, for the use of physicians, surgeons, &c. &c., generating primary voltaic currents always in one direction; being two batteries of 120 cells each, one waistcoat-pocket battery, three portable electro-generators, one voltameter, with paste and fluid for filling the batteries. The batteries were exhibited in action. (3560.)

2. On a Method of Electric Signals on Railways. By Mr J. Stewart Hepburn of Colquhalzie. (3574.) The author stated that this is an attempt to remedy the imperfection and uncertainty of night signals on a railway, when obstructed by any accident, inferring danger to approaching trains. The noise of a moving train rendering signals by *sound* precarious, and signal-*lights* during fogs being invisible at safe distances, it is proposed to employ, on an enlarged scale, the electrical phenomenon of the transmission of visible sparks or flashes along an interrupted conductor, by coating one of the telegraph wires connected moveably with the battery at each station with gutta percha, and then the side of it next the railway with tinfoil, broken at short intervals by minute spaces, where the flashes transmitted from the battery would be visible to a passing train even during fogs, to warn it of the occurrence of an obstruction in front. By transmitting the flashes at variable regulated intervals of time, the apparatus may be made to indicate to considerable distances the position and nature of the obstruction, and such other intelligence respecting it as may be urgently necessary. The author gave examples of the manner of signalling by such an apparatus.

Referred to a Committee.

3. On Collodion Calotype. By Mr Thomas Rodger junior, St Andrews. With illustrative specimens. (3578.) After some introductory remarks on the comparative merits of different modes of calotype, on the purity of chemicals employed, the author proceeded to give directions for making gun-cotton, recipe for collodion, cleansing of glass plate, recipe for nitrate of silver bath, method of excluding the actinic rays of light from work-room, position of sitter with regard to light, shading the head, recipe for negative developing solution, recipe for positive developing solution, recipe for fixing solution, varnish for protecting negatives on glass, directions for intensifying weak negatives, directions for transferring to paper, kind of paper best adapted for copying on, recipe for chloride solution, description of copying-frame used, recipe for ammonio-nitrate solution, recipe for hyposulphite of soda bath.

Thanks voted, and referred to a Committee.

4. Description and Drawing of a Method of constructing a Screw, by which speed is gained without increasing the pitch or distance between the threads. By Mr John Fleming, 18 New Street Square, Dean Street, Fetter Lane, London. (3549.)

5. Report of Committee on Mr John Sang's Parallel Motion, producing a perfectly straight line, was read and approved. Mr Slight, Convener. (3549.)

The following Donation was laid on the table, viz. :—

Specimens of Wire Rope and of Submarine Telegraph Cable :—
Wire rope, 14, 12, 6, and 2 lb. per fathom.
Telegraph cable, same as Forth and Tay.
Do. do. England and Belgium.
Do. do. England and Holland.
Copper lightning-conductor.
Iron do. do.
Presented by W. R. S. Newall and W. Spencer, Manufactory, Gateshead. (3563-1-9.)
Thanks voted.

PRIVATE BUSINESS.

The Minutes of last Meeting read and approved.
Adjourned.

10*th April* 1854.—Professor Kelland, President, in the Chair. The following Communications were made :—

1. Part I.—The Archimedian Screw and Wirtz's Spiral Pump applied in exhausting a Receiver, producing an Air-Pump without either Valve or Piston, by which the exhaustion may be carried to any extent; also a method of exhausting a Receiver by means of Flexible Tubes, the instrument having neither piston, valve, nor revolving joint.

The same engines applied in constructing a Suction-Pump of a similar description.

Defects of Wirtz's Pump pointed out, and an improved construction suggested, by which these may be remedied.

Other applications and properties of Spiral Pumps illustrated. By John Scott, Esq., Teacher of Mathematics, Edinburgh.

Models were exhibited in illustration. (3554.)

The author stated that the above machines depend for their action chiefly on a new property of the screw of Archimedes, which may be thus illustrated :—With the upper orifice of an Archimedian screw closed, and the lower entirely immersed in a liquid, let it be turned in the opposite direction to that by which water ascends its threads, and the air which it contains will be gradually carried downwards, and discharged from the lower orifice. As the rarefaction advances, the liquid will rise to a greater height in the screw, and by increasing the length of the screw until its altitude exceeds that of a column of the liquid, which would balance the pressure of the atmosphere, the exhaustion may be carried to any extent. Wirtz's spiral pump, when slightly modified, is equally capable of producing the same effect, and that by means of less liquid. In applying the preceding principle to construct an air-pump, the tube of which the screw is formed, prolonged in the direction of the axis of its cylinder, passes into the receiver by means of an air-tight revolving joint, and the lower extremity either terminates in a bulb, or consists of a tube with the orifice turned in an upward direction. The height of the exhausting apparatus is reduced to any extent by winding on a cylinder such a number of tubes, in the form of a screw, that their aggregate height will equal that of the single one already described, the lower extremity of the inner being connected to the upper of the second by means of a straight tube, the lower extremity of the second to the upper of the third, and in like manner to the last of the series, which communicates with the external atmosphere. The air withdrawn from the receiver is thus delivered to each helix in succession until finally discharged, and the weight of the external atmosphere is balanced by the aggregate elevation of the liquid in the helices, the respective pressures being transmitted from one helix to another, as the liquid columns in Amonton's barometer or in Wirtz's pump. A mercurial revolving joint which acts on the principle just stated renders perfectly air-tight the connection between the screw and the receiver. It consists of several columns of mercury, in the form of thin cylindrical rings, separated by air from each other, and arranged around a tube that forms their common axis. By a different construction an air-pump is produced which has all the essential properties of the last, with the additional one that no joint is required to connect it to the receiver, and the exhaustion will be effected with less mercury. The improvements in Wirtz's pump the author stated to be briefly these :—In the construction hitherto followed the air is discharged into the rising pipe, and allowed to escape along with the water, thereby occasioning, in most cases, a considerable waste of power, depending both on its increased elasticity and volume. If, however, this air be employed to raise other water than that which has passed through the spiral wheel, and thence be conveyed to the outer extremity of the wheel to supply it with air of increased elasticity, it will surrender in useful effect all the energy which it contained, whilst a continuous stream of water will be discharged from the upper extremity of the rising pipe. The improvement is effected by means of cisterns, and a slight modification of the outer extremity of the spiral wheel.

After some observations by the members, the thanks of the Society were given to Mr Scott for his interesting paper.

He stated that Part II. would be read at a future meeting.

2. Description of a Method of preventing Water-Cocks from bursting during Frost. By Mr John Wilson, 47 Portugal Street, Glasgow.

A specimen water-cock was exhibited. (3575.)

The author stated that the cause of the bursting of stop-cocks during frost is owing to the water left in the water-way of the key when shut. This having no way of egress, when overtaken by the frost, expansion takes place, which forces the cock out of its original shape, and leaves it quite leaky. The author stated that the improvement consisted in having a small excavation in the interior of the cock, communicating betwixt the water-way of the key when shut and the interior of the cock. By this means the water, when expanding in the act of freezing, is allowed to escape from the cavity of the key, and thus prevents it from bursting or being forced out of shape. The provision made for this in the plan suggested does not in any way injure the cock, and adds nothing to its original cost; and for all stop-cocks in any way exposed to frost it would, in the author's opinion, be a decided benefit.

The thanks of the Society were voted to Mr Wilson.

The following Donation was laid on the table, viz.:—

Actuarial Tables—Carlisle Three Per Cent.—Single Lives and Single Deaths, with Auxiliary Tables. By William Thomas Thomson, F.R.S.E., F.I.A., Manager of the Standard Life Assurance Company and of the Colonial Life Assurance Company, (Edinburgh, 1853.) 4to. Presented by the Author. (3580.)

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidates were elected Ordinary Fellows, viz.:—

1. John Small, University Library.
2. Edward James Jackson, B.A., Oxon., F.R.S.E., 6 Coates Crescent.
3. William Bertram, millwright and engineer, 14 East Sciennes Street.
4. John Dalgleish, teacher, 1 Park Place.

A List of Prize Subjects for Session 1854–55, prepared by the Council, was submitted and approved.

Adjourned.

24th April 1854.—Professor Kelland, President, in the Chair. The following Communications were made:—

1. On the Chemical Constitution and Properties of Coal. Is Torbane Mineral a Coal?

By Andrew Fyfe, M.D., F.R.S.E., Professor of Chemistry, King's College, Aberdeen.

Illustrated by Tables and Specimens. (3585.)

Thanks voted.

2. Part II.—The Archimedian Screw and Wirtz's Spiral Pump applied in exhausting a Receiver, producing an Air-Pump without either Valve or Piston, by which the exhaustion may be carried to any extent; also a method of exhausting a Receiver by means of Flexible Tubes, the instrument having neither Piston, Valve, nor Revolving Joint.

The same engines applied in constructing a Suction-Pump of a similar description.

Defects of Wirtz's Pump pointed out, and an improved construction suggested, by which these may be remedied.

Other applications and properties of Spiral Pumps illustrated. By John Scott, Esq., assistant to Mr Moffat, 63 South Bridge.

Models were exhibited in illustration. (3554.)

Referred to a Committee.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. A Copy of the List of Prize Subjects for Session 1854-55 was distributed. Copies might be had for distribution on application to the Secretary. The Fellows were requested to make the List known in their several localities.

III. In terms of Law XX., the Treasurer laid on the Table at this Meeting a List of those Ordinary Fellows who were in *arrear* of their Annual Contributions.

The Society adjourned.

19*th June* 1854.—William Swan, Esq., F.R.S.E., V.P., in the Chair. The following Communications were made :—

1. Additional Observations on Colour-Blindness, with special reference to the employment of yellow eye-glasses, to assist the vision of the colour-blind by daylight. By George Wilson, M.D., F.R.S.E. (3586.)

Dr Wilson stated that the number of colour-blind persons who cannot distinguish red from green by daylight, whilst they are able, more or less completely to distinguish them by gas or candle light, had led him to suggest the employment of yellow eye-glasses by daylight as a means of assisting their vision of colours. The proposition of such glasses was founded on two considerations,—the one, that yellow rays predominate over blue and red in ordinary artificial light; the other, that yellow is the colour best seen by the colour-blind. Three colour-blind parties known to Dr Wilson, had made trial at his request of yellow eye-glasses by daylight. To one they had been of no service; the second found them give him considerable assistance in distinguishing doubtful colours; to the third they made colours appear almost exactly the same by daylight as without the eye-glasses they did by lamp-light, so that he could discriminate readily reds and greens, which otherwise seemed the same to him. The author further observed that the great point to be attended to was to find a kind of coloured glass which would reduce daylight to the quality of artificial light (so far as glass could do that), without greatly diminishing its luminous intensity. It was added, in conclusion, that after the results which had been obtained, it could not admit of doubt that yellow eye-glasses would prove of service to a certain class of the colour-blind, who had also, it should not be forgotten, the means of assisting themselves by using a candle or lamp, or gas-flame, when dealing with doubtful colours.

Thanks were voted ; and the communication was remitted to the original Committee,—Mr Swan, Convener.

2. A description, by Dr George Wilson, of Dr J. Stenhouse's Charcoal Respirator for breathing without danger infectious atmospheres ; with an account of the recent researches into the deodorizing and disinfectant properties of charcoal. A specimen of the charcoal respirator was shown. (3594.)

Dr Wilson commenced by stating, that having read with much interest the account of Dr Stenhouse's researches on the deodorizing and disinfectant properties of charcoal, and the application of these to the construction of a new and important kind of respirator, he had requested that accomplished chemist to send one of his instruments for exhibition to the Society, which he had kindly done. Two of the instruments were now on the table, differing, however, so slightly in construction that it would be sufficient to explain the arrangement of one of them. Externally, it had the appearance of a small fencing-mask of wire-gauze, covering the face, from the chin upwards to the bridge of the nose, but leaving the eyes and forehead free. It consisted, essentially, of two plates of wire-gauze, separated from each other by a space of about $\frac{1}{4}$ or $\frac{1}{8}$ of an inch, so as to form a cage filled with small fragments of charcoal. The frame of the cage was of copper, but the edges were made of soft lead, and were lined with velvet, so as to admit of their being made to fit the cheeks tightly, and inclose the mouth and nostrils. By this arrangement no air could enter the lungs without passing through the wire-gauze, and traversing the charcoal. An aperture is provided with a screw or sliding valve, for the removal and replenishment of the contents of the cage, which consist of the siftings or riddlings of the lighter kinds of wood-charcoal. The apparatus is attached to the face by an elastic band passing over the crown of the head and strings tying behind, as in the case of the ordinary respirator. The important agent in this instrument is the charcoal, which has so remarkable a power of absorbing and destroying irritating and otherwise irrespirable and poisonous gases or vapours that, armed with the respirator, spirits of hartshorn, sulphuretted hydrogen, hydrosulphuret of ammonia and chlorine, may be breathed through it with impunity, though but slightly diluted with air. This result, first obtained by Dr Stenhouse, has been verified by those who have repeated the trial, among others by Dr Wilson, who has tried the vapours named above on himself and four of his pupils, who have breathed them with impunity. The explanation of this remarkable property of charcoal is two-fold. It has long been known to possess the power of condensing into its pores gases and vapours, so that if freshly prepared and exposed to these, it absorbs and retains them. But it has scarcely been suspected till recently, when Dr Stenhouse pointed out the fact, that if charcoal be allowed to absorb simultaneously such gases as sulphuretted hydrogen and air, the oxygen of this absorbed and condensed air rapidly oxidises and destroys the accompanying gas. So marked is this action, that if dead animals be imbedded in a layer of charcoal a few inches deep, instead of being prevented from decaying, as it has been hitherto supposed they would be by the supposed antiseptic powers of the charcoal, they are found by Dr Stenhouse to decay much faster, whilst at the same time no offensive effluvia are evolved. The deodorizing powers of charcoal are thus established in a way they have never been before; but at the same time it is shown that the addition of charcoal to sewage-refuse lessens its agricultural value contemporaneously with the lessening of odour. From these observations, which have been fully verified, it appears that by strewing charcoal coarsely powdered, to the extent of a few inches, over churchyards, or placing it inside the coffins of the dead, the escape of noisome and poisonous exhalations may be totally prevented. The charcoal respirator embodies this important discovery. It is certain that many of the miasmata, malaria, and infectious matters which propagate disease in the human subject, enter the body by the lungs, and impregnating the blood there, are carried with it throughout the entire body, which they thus poison. These *miasms* are either gases and vapours, or bodies which, like fine light dust, are readily carried through the air; moreover, they are readily destroyed by oxidising agents, which convert them into harmless, or at least non-poisonous, substances, such as water, carbonic acid, and nitrogen. There is every reason, therefore, for believing that charcoal will oxidise and destroy such miasmata as effectually as it does sulphuretted hydrogen or hydrosulphuret of ammonia, and thus prevent their reaching and poisoning the blood. The intention accordingly is, that those who are exposed to noxious vapours, or compelled to breathe infected atmospheres, shall wear the charcoal respirator, with a view to arrest and destroy the volatile poisons contained in these. Some of the more obvious applications of the respirator were then referred to:—1. Certain of the large chemical manufacturers in London are now supplying their workmen with the charcoal respirators as a protection against the more irritating vapours to which they are exposed. 2. Many deaths have occurred among those employed to explore the large drains and sewers of London, from exposure to sulphuretted hydrogen, &c. It may with confidence be asserted that fatal results from exposure to the drainage gases will cease as soon as the respirator is brought into use. 3. In districts such as the Campagna of Rome, where malaria prevails, and to travel during night or to sleep in which is certainly followed by an attack of dangerous and often fatal ague, the wearing of the respirator for even a few hours may be expected to render harmless the marsh poison. 4. Those who, as clergymen, physicians, or legal advisers, have to attend the sick-beds of sufferers from infectious disorders, may, on occasion, avail themselves of the protection afforded by Dr Stenhouse's instrument during their intercourse with the sick. 5. The longing for a short and decisive war has led to the invention of "a suffocating bomb-shell," which, on bursting, spreads far and wide an irrespirable or poisonous vapour; one of the liquids proposed for the shell is the strongest ammonia, and against this it is believed that the charcoal respirator may defend our soldiers. As likely to serve this end, it is at present before the Board of Ordnance. Dr Wilson stated, in conclusion, that Dr Stenhouse had no interest but a scientific one in the success of the respirators. He had declined to patent them, and desired only to apply his remarkable discoveries to the abatement of disease and death. Charcoal had long been used in filters, to render wholesome poisonous water; it was now to be employed to filter poisonous air.

The thanks of the Society were voted to Dr Wilson for describing the properties of the respirator, &c., and the communication was referred to a committee.

3. The third communication was a description of a Simple Variation Compass. By William Swan, Esq., F.R.S.E., V.P. (3591.)

The author stated that the instrument he was about to describe had been made for him by Mr John Adie in the year 1852. In the beginning of that year Mr Adie had exhibited to the Society a very elegant instrument, intended to be used in conjunction with a theodolite, for determining the magnetic meridian; and the author at the time was desirous of having an equivalent instrument applied to a Kater's circle in his possession. As, however, the use of Mr Adie's instrument involved the temporary removal of the theodolite telescope from its Ys, while the telescope in Kater's circle does not admit of being removed, it was necessary to adopt an arrangement different from Mr Adie's. The instrument which the author showed to the Society consists of a collar fitted to the object-end of the telescope of a theodolite, carrying an arm furnished with a fine point, on which the agate cap supporting the needle turns. The needle is a collimating magnet facing the object-glass of the telescope, so that the cross wires of the collimator can be distinctly seen in the field of view. A light cylindrical tube, having a small aperture at its end covered with glass, with a reflector attached to illuminate the wires of the collimator, slides over the rest of the apparatus to protect the needle from currents of air. The needle is observed by causing the intersection of the collimator wires, as seen through the telescope, to coincide with the intersection of the middle wires of the diaphragm. The author stated that his instrument, like Mr Adie's, was intended to supply the desideratum of a cheap and portable azimuth compass, capable of determining the variation of the needle with much greater accuracy than is attainable by means of the ordinary theodolite compass, or even by the use of the prismatic compass. He conceived that Mr Adie's instrument and his own had each its peculiar advantages; while to Mr Adie exclusively belonged the merit of being the first to furnish the surveyor with a cheap and simple apparatus by which he could determine with precision the magnetic meridian line of a station.

Referred to a Committee.

The following Communications were also made to the Society:—

Description of a new invention for Shutting Doors. By Mr Thomas Steven, builder, Bonnyrigg. A model was exhibited. (3588.)

Referred to a Committee.

Mr Bald exhibited two old drawings, the one of Alloa House, by the Earl of Mar in 1703, and the other a design for a circular building at the Caldron Linn, by James Francis Erskine, Esq. of Mar. He also exhibited a beautiful specimen of Chinese wood-carving and a shepherd's sun-dial ring. (3584.)

Thanks voted.

The circle divided as a rule for pitching of compound levers or wheels with tables. By Mr Edward Crais, Gorebridge, near Fushiebridge. (3582.)

Referred to a Committee.

The following Reports of Committees were read and approved, viz. :—

1. On Mr Elliot's Mechanical Illustrations of the Planetary Motions and Equilibrium of Saturn's Rings. Professor Kelland, Convener (3558.)
2. On Mr Rodger's Collodion Calotype. Mr Cay, Convener. (3578.)
3. On Mr George Mitchell's Safe Lock. Mr A. Bryden, Convener. (3552.)
4. On Mr J. T. Thomson's Semi-Revolving Lights. Mr Leslie, Convener. (3571.)
5. On Mr Wilson's Water-Cock. Mr Kirkwood, Convener. (3575.)
6. On Mr Scott's Applications of Spiral Pump. Mr Elliot, Convener. (3654.)
7. On Mr Stewart Hepburn's Method of Electric Signals on Railways. Mr Leslie, Convener. (3574.)
8. On Rev. James Brodie's Paper on the Action of Sails and Rudders. Mr J. T. Rose, Convener. (3541.)

The following Donations were laid on the table, viz.—

1. Model of a Collating Wheel or Machine for a Library. Presented by Robert Bald, Esq., M.E., F.R.S.E. (3583-1.)
2. A Specimen of Cutlery 200 years old, from Liege, being a Dessert-Knife, having the ferule of silver, and haft of porcelain. Presented by the same. (3583-2.)
3. The Assurance Magazine, No. 15, in continuation (April 1854). Containing Mr W. T. Thomson's Paper on Decimal Numeration and Coinage. Presented by the Institute of Actuaries. (3581.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidate was elected an Ordinary Fellow, viz. :—

Graham Mitchell, Veterinary Surgeon, Springfield House, Abbeyhill.

The Society held an Extraordinary Meeting in their Hall, 51 George Street, on Monday, 24th July 1854, at Eight o'clock P.M. — William Swan, Esq., V.P., in the Chair. The following Reports of Committees were read and approved—

1. On Dr G. Wilson's Communications on Colour-Blindness and Yellow Eye-Glasses. Mr Swan, Convener. (3496, 3539, and 3586.)
2. On Mr Bow's Appendix to 3509. Mr Slight, Convener. (3543.)

3. On Dr Stenhouse's Charcoal Respirator, &c. Dr G. Wilson, Convener. (3594.)

4. On Mr Steven's Method of Shutting Doors. Mr P. Wilson, Convener. (3588.)

5. On Mr Crais's Division of the Circle, in relation to the Pitching of Wheels. Mr Slight, Convener. (3582.)

The following Reports not being given in, were remitted to Prize Committee when lodged—

1. On Mr Blackwell's Prevention of Railway Collisions. Mr Paterson, Convener. (2570.)

2. On Mr Fleming's Screw. Mr A. Rose, Convener. (3532.)

3. On Mr Swan's simple Variation Compass. Mr Elliot, Convener. (3591.)

The following Donations were laid on the table, viz.:—

1. Journal of the Geological Society of Dublin. Vol. VI. Part I. (1853-4). Dublin, 1854. 8vo. Presented by the Society. (3589.)

2. Donations by Charles Cowan, Esq , M.P. :—

   1. Abstract of Report of Conference at Brussels on Metereological Observations in 1853. (1854.)
   2. Public Works, Bengal, &c. 1854.
   3. Report on Loss of the "Tayleur." 1854.
   4. Do. do. "Olinda." 1854.
   5. Do. do. "Annie Jane." 1854.
   6. Report on Capabilities of Mercantile Steam Navy for Purposes of War. 1853.
   7. Report on Drainage of Lands, Ireland, 1852. (3590-1-7.)

3. A Complete Set (wanting first paper, out of print) of the Proceedings of the Institution of Mechanical Engineers, Birmingham, from 1847 to January 1854 inclusive. Presented by the Institution. (3592.)

4. Proceedings of the Institution of Mechanical Engineers, 3d May 1854. (3598.)

5. Bell's Popular Stenography. By Alex. M. Bell, Esq., F.R.S.S.A., &c. Pp. 46, and Plates. Presented by the Author. (3593.)

6. Donations by William Fairbairn, Esq., C.E., F.R.S., F.G.S., Manchester :—

   1. On the Application of Cast and Wrought Iron to Building Purposes. 1854. 8vo. Pp. 183.
   2. Experimental Researches to determine the Strength of Locomotive Boilers, and the causes which lead to Explosion. 1854. 8vo. Pp. 66.
   3. On the Mechanical Properties of Metals, as derived from repeated Meltings, exhibiting the maximum point of strength, and the causes of deterioration. 1854. 8vo. Pp. 116. (3599-1-2-3.)

7. Peat Charcoal for Sanitary and Agricultural Purposes, with Directions for its use. Prepared by the Irish Amelioration Society. 1852. 8vo. Pp. 16. Presented by Richard Hunter, Esq. (3600.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidate was elected an Ordinary Fellow, viz. :—

John Short, M.D., M.R.C.S.L., 4 Elder Street.

III. The Society appointed the following Prize Committee to award prizes for Session 1853-54, viz. :—

Professor Kelland, President.
Dr Nachot, V.P.
Mr David Stevenson, C.E.
Mr Cay.
Mr Leslie, C.E.
Mr W. Paterson, C.E.
Mr Alex. Rose.
Mr P. Wilson.
Mr Slight, M.E.
Mr J. T. Rose.
Mr A. Bryden.
Mr Alex. Kirkwood.
The Secretary, *Convener ex officio.*

IV. It was moved by Mr A. Kirkwood, seconded by Mr Edward Sang, and adopted, that an extraordinary Billet should be issued, recommending to the Members to exhibit in the French proposed international Exhibition of 1855.

The Society then adjourned till next Session.

APPENDIX (P).

LIST OF PRIZE SUBJECTS FOR SESSION 1854-55.

The ROYAL SCOTTISH SOCIETY of ARTS proposes to award Prizes of different values, none exceeding Thirty Sovereigns, in Gold or Silver Medals, Silver Plate, or Money, for approved Communications *primarily* submitted to the Society, relative to Inventions, Discoveries, and Improvements in the *Mechanical* and *Chemical* Arts in general, and also to means by which the *Natural Productions* of the Country may be made more available; and, in particular, to—

I. Inventions, Discoveries, or Improvements in the Useful Arts; such as, but not limited to, the following, viz :—

1. *Mechanical Arts.*

Improvements in Flax Machinery, and in preparing Flax for manipulation,—in the construction of Fire-Proof Buildings,—in applying Glass to new and useful purposes,—in methods of Uniting the Joints of Glass or Earthenware Water-Pipes, without employing White Lead or other poisonous substance,—in Sewerage,—in Economical Appliances for increasing the Sanitary Condition of Towns,—in Methods of Warming and Ventilating Buildings,—in Ventilation of Mines,—in constructing Economical and Salubrious Dwellings for the Working-Classes,—in Extinguishing Fires,—in Locks,—in Tools, Implements, and Apparatus for the various Trades,—in Rifle Guns and Bullets,—in Bricks,—in Cements and Mortars,—in Machines for Planing Wood,—in Printing Machines, Cases, and Rollers,—in Stereotyping,—in Cranes,—in the Machinery for Collieries, &c.,—in preserving Timber and Metals in Marine Works,—in Locomotive, Stationary, and Marine Engines,—in Screw Propellers,—in Railways, Plant, and Signals,—in Machines for Cutting, Dressing, and Boring Stone,—in Microscopic Apparatus,—in Steel or other Metallic Pens,—in new or improved Motive Power,—in the construction of Cameras and other Apparatus used in Photography,—in the Temperature Correction of the Aneroid Barometer, &c. &c.

2. *Chemical Arts.*

Improvements in methods of rendering the Electric Light available in practice, particularly in the Illumination of Mines, &c. &c.,—in new and useful applications of Gutta Percha and Vulcanized India Rubber, or similar Gums,— in the Manufacture of thin sheets of Gutta Percha, of equal strength in all directions, for Surgical purposes,—in substitutes for, or improvements upon, the process of Vulcanizing India Rubber,—in Dyes, and in their economical extraction from Dye Woods, &c.,—in Paints,—in Paper,—in Glass,—in Writing Inks,—in the Manufacture of Hats.

3. *Relative to the Fine Arts.*

Improvements in Photographic processes, and their application to taking microscopic objects and machinery,—in Electrotype processes,—in Die-sinking,—in methods of illustrating Books to be printed with the letterpress,—in Ornamental Metallic Casting,—in adaptation of new Materials for Sepulchral Monuments,—in Paper Hangings,—in Articles of Porcelain, Common Clay, or Metal,—in Glass Staining,—in Engraving on Stone,—in Chromatic Lithography.

4. *Natural Productions.*

Discovery of Plumbago in the United Kingdom or Colonies, equal to that of Cumberland, &c. &c.

II. Experiments applicable to the Useful Arts.

III. Communications of Processes in the Useful Arts practised in this or other Countries, but not generally known.

IV. Practical Details of Public or other Undertakings of National importance, already executed, but not previously published;—or valuable suggestions for originating such undertakings.

KEITH PRIZE, value Thirty Sovereigns.

For some important "Invention, Improvement, or Discovery, in the Useful Arts, which shall be primarily submitted to the Society" during the Session.

REID and AULD PRIZES.

For the First, Second, and Third best Models of "anything new in the Art of Clock or Watch Making, by Journeymen or Master Watch and Clock Makers,"—if these should be considered worthy of Prizes,—the sum of Ten Sovereigns, divided among them in such proportions as the Prize Committee shall fix, according to merit.

GENERAL OBSERVATIONS.

Communications lodged *in competition for Prizes* shall not have been Patented, nor have been previously published, nor read before any other Society. Patent articles may, however, be *exhibited.*

The Descriptions of the various inventions, &c., must be *full* and *distinct*;—be legibly written on *Foolscap* paper, leaving margins at least one inch and a-half broad, on *both sides of the writing on every page*, so as to allow of their being bound up in volumes; and, when necessary, be accompanied by *Specimens, Drawings, or Models.* All drawings to be on *Imperial* Drawing Paper, unless a larger sheet be requisite. The Drawings to be in *bold* lines, not less than a quarter of an inch thick, or *strongly coloured*, so as to be easily seen at about the distance of thirty feet when hung up in the Hall of Meeting, and the Letters or Figures of Reference to be at least $1\frac{1}{2}$ inch long. When necessary, smaller and more minutely detailed Drawings should accompany the larger ones, for the use of the Committees, having the same letters or figures of reference.

The Society shall be at liberty to publish in their Transactions copies or abstracts of all Papers submitted to them. All Models, Drawings, &c., for which Prizes shall be given, to be held to be the property of the Society; the Value of the Model, &c., being separately allowed for.

Communications, Models, &c., are to be addressed to James Tod, Esq., the Secretary, 55 Great King Street, Edinburgh, Postage or Carriage paid; and they are expected to be lodged *on or before* 1*st November* 1854, in order to insure their being read and reported on during the Session (the ordinary Meetings of which commence in November 1854 and end in April 1855); but *those which cannot be lodged earlier*, will be received up to 1st April 1855;—those lodged after that date may not be read or reported on till the following Session.

By order of the Society.

James Tod, *Secretary.*

Edinburgh, 10*th April* 1854.

APPENDIX (Q).

REPORT

OF

THE COMMITTEE

APPOINTED BY

THE ROYAL SCOTTISH SOCIETY OF ARTS

TO AWARD PRIZES FOR COMMUNICATIONS READ AND EXHIBITED DURING SESSION 1853–54.

Your COMMITTEE having met and carefully considered the various Communications laid before the Society during the Session 1853–54, beg leave to report that they have awarded the following Prizes :—

1. To THOMAS STEVENSON, Esq., F.R.S.E., Civil-Engineer, Edinburgh,—for his "Description and Drawings of Dipping and Apparent Lights for Sunk Reefs and Pier-heads of Harbours." Read and exhibited on 23d January 1854, and printed in the Transactions. (3555)

   The Society's Gold Medal, value Ten Sovereigns.

2. To JAMES ELLIOT, Esq., Teacher of Mathematics, Edinburgh, —for his "Mechanical Illustrations of the Planetary Motions," including an Illustration of his Theory of the Stability of Equilibrium of Saturn's Ring. Read and exhibited 27th February and 13th March 1854. (3558)

   The Society's Silver Medal, value Ten Sovereigns.

3. To ROBERT HENRY BOW, Esq., C.E., Edinburgh,—for his "Description of New Designs for Iron Roofs of great clear span," &c.; with Drawings. Read and exhibited 25th April 1853; with Appendix. Read 9th June 1854. (3509, 3543)

   The Society's Silver Medal, value Ten Sovereigns.

4. To WILLIAM SWAN, Esq., F.R.S.E., Teacher of Mathematics, Edinburgh,—for Description of his "Simple Variation Compass." Read and exhibited 19th June 1854. (3591)

The Society's Silver Medal, value Five Sovereigns.

5. To JOHN SCOTT, Esq., Teacher of Mathematics, Edinburgh, —for his Paper "On New properties and applications of Spiral Pumps, &c., with Models and Diagrams." Read and exhibited 10th and 24th April 1854. (3554)

The Society's Silver Medal, value Five Sovereigns.

6. To Mr GEORGE MITCHELL, 101 High Street, Edinburgh,—for his Description of a "Safe Lock, incapable of being opened by any other means than by its own key." Read and exhibited 16th February 1854. (3552)

The Society's Silver Medal, value Five Sovereigns.

7. To the Reverend JAMES BRODIE, Monimail, Fife,—for his "Enquiry into the principles on which the action of Sails and Rudders depends, with Diagrams." Read and exhibited 9th January 1854. (3541)

The Society's Silver Medal.

8. To J. T. THOMSON, Esq., F.R.G.S., Civil-Engineer and Government Surveyor at Singapore,—for his Description and Drawing of a "Semi-Revolving Light for Lighthouses." Read and exhibited 13th March 1854. (3571)

The Society's Silver Medal.

9. To THOMAS RODGER jun., Esq., St Andrews,—for his Paper "On Collodion Calotype," with Illustrative Specimens. Read and exhibited 27th March 1854. (3578)

The Society's Silver Medal.

10. To ALEXANDER MELVILLE BELL, Esq., Teacher of Elocution, Edinburgh,—for his Paper on a "New Principle of Stenography or Shorthand Writing." Read, and Diagrams exhibited, 14th February 1854. (3550)

The Society's Silver Medal.

11. To Mr Thomas Steven, Builder, Bonnyrig, Lasswade,—for his Description of a "New Method of Shutting Doors," with a Model. Read and exhibited 19th June 1854. (3588)

The Society's Silver Medal.

The Committee have also recommended the Model to be purchased for the Museum.

The Committee recommend, that while the *Thanks* of the Society are justly due to all those gentlemen who have sent Communications, the *Special Thanks* of the Society be given to the following gentlemen, viz.:—

1. To Charles Cowan, Esq., M.P.,—for his oral "Sketch of the various Changes and Improvements which have taken place in the Manufacture of Paper during the last Thirty years," with copious Illustrations. Given on 23d January 1854. (3561)

2. To Andrew Fyfe, M.D., F.R.S.E., Professor of Chemistry, King's College, Aberdeen,—for his Communication "On the Chemical Constitution of Coal," and on the question, "Is Torbane Mineral a Coal?" Read on 24th April 1854, and printed in the Transactions. (3585)

3. To George Buist, LL.D., Bombay,—for his oral "Account of some of the East Indian Arts and Manufactures, with Specimens of the Tools and Manufactured Articles, including the Manufacture of Salt, Bombay or Mooltan Inlaid Work, Gold Wire, Gold Lace, and Spangles, Cambay Stones, and Calico Printing." Given on 27th February 1854. (3573)

4. To J. Stenhouse, M.D., London,—for the "Description of his Charcoal Respirator, for breathing without danger infectious atmospheres, with an Account of his recent Researches into the Deodorizing and Disinfectant Properties of Charcoal" Communicated by Dr George Wilson. Read and exhibited 19th June 1854. (3594)

5. To George Wilson, M.D., F.R.S.E., Lecturer on Chemistry, Edinburgh,—for his "Communication on the Prevalence of Colour-Blindness or Chromato-Pseudopsis, and on the limit which it puts to the use of Coloured Signals on Railways, at Sea, and elsewhere," and "on the Use of Yellow Eye-Glasses to assist the vision of the Colour-Blind by Daylight." Read 14th March 1853 and 19th June 1854. (3496, 3586)

   Dr Wilson being engaged in making still farther investigations on this subject, and of communicating these to the Society, your Committee, on the recommendation of the Special Committee, and provided he shall find it necessary, have made him a farther grant of not exceeding Ten Pounds, to assist in defraying the expense of the prosecution of his important researches, the Committee having made a mere Interim Report till the investigations be completed.

6. To James Alexander, Esq., Wine Merchant, Edinburgh,—for his "Suggestions for a Simple System of Decimal Notation and Currency, after the Portuguese Model." Read on 12th December 1853. (3544)

7. To Mr John Wilson, 47 Portugal Street, Glasgow,—for his "Description of a Method of preventing Water-Cocks from bursting during Frost." Read, and Water-Cock exhibited, on 10th April 1854. (3575)

Your Committee may remark that they have not been able to report on Mr J. C. Blackwell's Paper on Preventing Collisions on Railways, No. 3570, nor on Mr John Fleming's Screw, No. 3532, as the Special Committees on these Papers have not yet given in their Reports. They must therefore be postponed for this Session.

In conclusion, your Committee regret that there has been no communication read during the past Session to which it seemed proper to award the Keith Prize of Thirty Sovereigns.

All which is humbly reported by

JAMES TOD, *Sec., Convener ex officio.*

Society's Hall, 51 George Street,
23*d October* 1854.

APPENDIX (R).

LIST

OF THE

OFFICE-BEARERS AND FELLOWS

OF THE

ROYAL SCOTTISH SOCIETY OF ARTS,

AS AT 1st NOVEMBER 1854.

THE QUEEN, PATRONESS.

OFFICE-BEARERS FOR SESSION 1853-54.

President, Rev. PHILIP KELLAND, M.A., F.R.SS. L. & E.

Vice-Presidents, WILLIAM SWAN, Esq., F.R.S.E.; HEINRICH WILHELM NACHOT, Ph. D.

Secretary, JAMES TOD, Esq., F.R.S.E., W.S., 55 Great King Street.

Treasurer, JOHN SCOTT MONCRIEFF, Esq., Acct., 20 India Street.

Ordinary Councillors.

*ALEXANDER ROSE, Esq.
*JAMES LESLIE, Esq., C.E.
*ALEX. K. JOHNSTON, Esq., F.R.S.E.
*GEORGE LEES, LL.D.
WILLIAM PATERSON, Esq., C.E.
THOMAS STEVENSON, Esq., F.R.S.E.
DAVID LANDALE, Esq., M.E.
DAVID COUSIN, Esq.
DAVID STEVENSON, Esq., F.R.S.E., M.I.C.E.
ROBT. RITCHIE, Esq., C.E., A.I.C.E.
GEORGE WILSON, M.D., F.R.S.E.
WILLIAM A. ROBERTS, M.D.

Editor of Transactions, GEORGE WILSON, M.D., F.R.S.E.
Curator of Museum, Mr ALEXANDER JAMIESON.
Medallist, Mr ALEXANDER KIRKWOOD.
Officer and Collector, Mr HUGH JOHNSTON.

(The four Ordinary Councillors marked * retire by rotation.)

LIST OF THE ORDINARY FELLOWS,

AS AT 1ST NOVEMBER 1854.

1822. Abercorn, The Most Noble the Marquis of, K.G.
" Aberdeen, The Right Hon. the Earl of, K.T.
" Abercromby, Sir Robert, of Birkenbog, F.R.S.E.
" Alison, W. P., M.D., F.R.S.E.
" Adie, Alexander, F.R.S.E.
1826. Aytoun, Robert, W.S.
1837. Aikman, George, engraver.
" Alves, H. S., 9 Regent Terrace.
" Alexander, William, F.R.S.E., W.S.
1838. Adie, John, optician, F.R.S.E.
1841. Anderson, Charles W., merchant.
1843. Anderson, John, Pratis, Fife.
1846. Alexander, James, wine-merchant.
" Ainslie, Daniel, 48 Moray Place.
1847. Abbott, Francis, Sec. G. P. O.
1850. Anderson, Tho., M.D., F.R.S.E., Glasg.
" Adie, A. J., F.R.S.E., C.E., Linlithgow.
1851. Archer, William, solicitor, London.
" Alexander, Wm., M.E., Glasgow.
" Anderson, William, Islington, London.

822. Buccleuch and Queensberry, His Grace the Duke of, K.G., A.M., F.R.SS. L. & E.
" Brewster, Principal Sir David, K.H., D.C.L., F.R.SS. L. & E.
" Bald, Robert, F.R.S.E., Alloa.
1826. Brisbane, Sir Thomas Macdougall, Bart., G.C.B., President R.S.E.
1830. Bonar, William, F.R.S.E.
" Brown, Robert, junior, architect.
1832. Black, Alexander, architect.
" Bryce, David, architect.
1835. Borthwick, James, manager N. B. Insurance Company.
" Berkely, Frederick Hewett, Chester.
" Burn, William, F.R.S.E., architect.
1836. Bryson, Alexander, watchmaker.
" Ballantyne, James, of Holylee.
1837. Bell, John Beatson, W.S.
1838. Blood, Bindon, M.R.I.A., F.R.S.E., of Cranaker, Ireland.
" Beattie, Alexander, Star Hotel.
" Bruce, O. Tyndal, of Falkland, F.R.S.E.
" Blanshard, Lieut.-Col. Thomas, R.E.
1839. Brown, Thomas, architect.
1840. Brown, James, accountant.
" Berwick, David.
1841. Baird, Douglas, ironmaster, Gartsherrie.
1844. Bell, J. A., architect.
" Baillie, William R., W.S.
1845. Bowie, William.
1846. Buist, George, LL.D., Bombay.
" Beattie, George, builder.
1847. Bernard, Thomas, brewer.
" Buchanan, William Miller, M.D.
1848. Brebner, Alan, engineer.
1849. Bouch, Thomas, C.E.
" Burn, Robert, engineer.
1850. Black, Rev. Archibald P., A.M., London.
" Blyth, Benjamin Hall, C.E.
" Bell, Alex. Melville, Prof. of Elocution.
" Bruce, George Cadell, C.E.
" Bryden, Adam, bell-hanger.
1851. Bryden, John, bell-hanger.
" Black, John Trafalgar, Surrey.
1853. Bow, Robert H., C.E.
" Bell, D. C., Prof. of Elocution, Dublin.
1854. Bertram, William, millwright.

1822. Clerk, Sir George, Bart., M.P., F.R.S.E.
" Campbell, Walter, of Islay, M.P., F.R.S.E.
" Cadell, W. A., of Banton, F.R.S.E.
" Cunningham, Charles, W.S.
1827. Chalmers, Charles.
" Crawfurd, William, of Cartsburn.
1832. Craig, Sir William Gibson, of Riccarton, F.R.S.E.
1834. Campbell, Alexander, brewer.
1836. Cowan, Charles, M.P., Penicuik.
1837. Cowan, Alexander, papermaker.
" Cooper, Wm., glass-manufac., Canada.
1840. Christie, Robert, accountant.

1840. Crosbie, George,
„ Cormack, David, S.S.C.
„ Carstairs, Drysdale, Liverpool.
1841. Cowan, James, M.D., surgeon R.N.
„ Cameron, Captain Charles.
„ Curriehill, Hon. Lord.
1842. Cushnie, William, Malta Green.
1845. Cay, John, F.R.S.E., advocate.
1846. Callender, J. A., C.E., Canada.
1847. Campbell, John Archibald, F.R.S.E.
„ Cousin, David, architect.
1848. Craig, Rev. John, Cupar-Fife.
1849. Clark, Thomas, M.D., Whitburn.
1850. Campbell, William, C.E.
1851. Cormack, James, ironmonger.
„ Cunningham, George, C.E.
„ Craigie, Henry, W.S., Falcon Hall, Morningside.
„ Cadell, Henry, M.E., Dalkeith.
1852. Crichton, And., LL.D.
„ Craig, Archibald R., London.

1822. Davidson, Robert, of Ravelrig.
„ Dunlop, Arch., F.R.S.E., London.
1838. Dunlop, Andrew, W.S.
1843. Dove, James, engine-maker.
1844. Dickson, James Jobson, accountant.
„ Dunn, Thomas, optician.
1846. Donaldson, J., advocate, Prof. of Theory of Music.
1847. Dalmahoy, Jas., F.R.S.E., late H.E.I.C.S.
1848. Duff, Rev. Henry, South Leith.
1849. Drury, Rev. Robert, Surrey.
1850. Davidson, Samuel D., Leith Eng. Works.
„ Dickson, John, junior, gunmaker.
1851. Duncan, James, M.D.
„ Dawson, Charles, London.
„ Dawson, John, distiller, Linlithgow.
„ Duncan, Jas., M.A., Southampton.
„ Drummond, Geo. A., builder.
1853. Davis, Rev. Nathan, London.
1854. Douglas, Sir Geo. Scott, Bart., Kelso.
„ Dale, Randall P., designer.
„ Dalgleish, John, teacher.

1828. Ellis, Adam Gib, M.W.S., W.S.
1839. Ellis, Thomas, upholsterer.
1843. Erskine, Daniel, Glasgow.
1853. Elliot, James, teacher of mathematics.

1822. Forbes, George, F.R.S.E.
„ Fyfe, Prof. A., M.D., F.R.S.E., Aberdeen.
1828. Fraser, Robert, 18 Dublin Street.
1832. Forbes, Prof. J.D., F.R.SS.L. & E.
1838. Fergusson, Lieut.-Col., H.E.I.C.S.
1840. Fleming, Alexander, W.S.
„ Forrester, John, W.S.
1843. Falkner, James P., solicitor.
1844. Foulis, Sir Wm. Liston, Bart., Hermiston.
1847. Fullarton, John A., publisher.
1849. Fraser, J.S., engineer, Gt. Western Rail.
1850. Ferguson, William B., C.E., Aberdeen.
„ Falshaw, James, C.E., Perth.
„ Fraser, John, actuary and manager Life Association of Scotland.
„ Fraser, Alexander, printer.
1851. Forbes, William, London.
1854. Foster, Alex. F., A.M.

1822. Graham, Humphrey, W.S.
1829. Græme, James, W.S., yr of Garvoch.
1832. Gray, James, ironmonger.
1835. Groat, A. G., of Newhall, advocate.
1836. Greig, Thomas (late printer), Elie.
1842. Gillespie, John, W.S.
1844. Girdwood, John, North Wales.
„ Gregory, Prof. William, M.D., F.R.S.E.
1848. Gardner, James, Torphichen Street.
1850. Glennie, George, C.E., Melrose.
„ Gowans, James, builder.
„ Gregory, Thomas Currie, C.E., America.
„ Gordon, James, jun., W.S.
1851. Gordon, John T., F.R.S.E., Sheriff of Mid-Lothian.
„ Gray, David, M.A., F.R.S.E., Prof. of Nat. Phil., Marischal Coll., Aberdeen.
„ Gordon, James Newell, London.
1852. Gilkison, Robert, jun., of Blackburn, merchant, Glasgow.
1853. Graham, Rev. Wm., Newhaven.

1829. Horne, Archibald, of Inverchroskie.
1833. Hamilton, Alex., LL.B., F.R.S.E., W.S.
1834. Hamilton, John, W.S.
„ Horsburgh, Robert, Tongue House.
1835. Hay, James, merchant, Leith.
1836. Haldane, James, brassfounder.
„ Hepburn, J. Stewart, of Colquhalzie.
1837. Hopkirk, J. G., LL.B., W.S.
1838. Hunter, Richard, H.E.I.C.S.
1839. Hill, Lawrence, jun., C.E., Glasgow.
„ Hill, Henry David, W.S.
1840. Harvey, George, R.S.A., histor. painter.
1841. Hope, David T., C.E.
1843. Howden, James, watchmaker.
„ Henry, Jardine, writer.
1845. Hay, David Ramsay, F.R.S.E.
1850. Henderson, John, C.E., Leeds.
1852. Hunter, David, chemist.
„ Hollis, William, Chelsea.
„ Hamilton and Brandon, His Grace the Duke of
„ How, And. Peddie, engineer, London.
„ Hosie, James, coalmaster, Bathgate.
1853. Hay, Geo. W., of Whiterig, Melrose.
1854. Henderson, Henry, Lasswade.

1854. Ivison, Thos. P., C.E.

1822. Jardine, James, F.R.S.E., C.E.

1840. Johnston, Alex. K., F.R.S.E., geographer to the Queen.
1848. Jefferiss, Robert R., M.D., Dalkeith.
1850. Jardine, William Alexander, C.E.
„ Jopp, Charles, C.E.
„ Johnstone, William, C.E., Glasgow.
1851. Johnstone, Robert, accountant.
1852. Johnston, Jas., Stockton-on-Tees.
1854. Johnston, J. K., teacher of mathematics.
„ Jackson, Ed. jun., B.A., Oxon.

1822. Keith, James, M.D., F.R.S.E.
1836. Kirkwood, Alexander, die-cutter.
1839. Kennedy, William, W.S.
1842. Kronheim, Jos. M., ornamental designer, London.
1844. Kinloch, Alex. J., M.D., Aberdeen.
1845. Kennedy, John, jun., W.S.
1848. Kirkwood, James, goldsmith.
1840. Kelland, Rev. Phil., M.A., F.R.SS.L.&E., Professor of Mathematics.
1851. Kirkwood, Robert, C.E.

1834. Lawrie, William A., W.S.
1836. Lees, George, LL.D., St Andrews.
„ Lawson, Charles, of Borthwick Hall.
1838. Lorimer, George, builder.
1840. Leburn, Thomas, S.S.C.
1842. Leith, Samuel, lithographer.
1845. Lancefield, Alfred, surveyor.
1850. Leslie, James, C.E.
„ Lees, Henry, secretary E. P. & D. Ry.
„ Lessels, John, architect.
1851. Lee, Alexander H., C.E.
„ Lawson, W. J., manager Argus Life Co., London.
1852. Landale, Robert, of Pitmedden.
„ Landale, David, M.E.
„ Lorimer, James, C.E.
1853. Levy, Michael A., 21 Claremont Crescent.
1854. Livingston, Allan, junior, Portobello.

1822. Maconochie, Alexander, of Meadowbank, F.R.S.E.
„ More, Professor John S., F.R.S.E.
„ Murray, Hon. Lord, F.R.S.E.
1826. Maxwell, John Clerk, F.R.S.E., Glenlair.
1829. Millar, John, C.E., F.R.S.E.
1831. Macdonald, William, of Powderhall.
1835. Marjoribanks, Gilbert, Australia.
„ Mould, J. B., engraver.
1836. Milne, James, brassfounder.
„ Mackay, James, goldsmith.
1838. Macgibbon, Charles, builder.
„ Morton, Hugh, engineer.
„ Maclagan, David, M.D., F.R.S.E.
„ Moncrieff, John Scott, acct., *Treasurer*.
„ Mackenzie, James, W.S.
„ Murdoch, J. B., of Gartincaber, F.R.S.E.
1839. Macbrair, D. J., S.S.C.
„ Maclagan, Douglas, M.D., F.R.S.E.
1840. Murray, James T., W.S.
1841. Maitland, John, accountant.
„ Macpherson, Charles, printer.
1842. Mitchell, Edward, surgeon.
1843. Marshall, G. H., jeweller.
„ Melville, John, W.S.
„ Murray, Sir W. K., Bart. of Ochtertyre.
1846. M'Dowall, John, engineer, Johnston.
„ Middleton, Captain J., Waltham Lodge.
„ Mortimer, Thomas E., gunmaker.
„ Miller, James, engineer.
1847. Middleton, James, Waltham Lodge.
„ Macadam, John, M.D., chemist.
1848. Milne, John Kolbe, dressing-case maker.
„ Macfarlan, John F., druggist.
„ Mackenzie, Rev. Kenneth, Bo'ness.
„ Mitchell, Graham Alexander, Whitburn.
1850. Mackay, John M., chemist and druggist.
„ Melville, James M., W.S.
„ Martin, George, Glasgow.
„ Macintosh, James A., wood-engraver.
„ Mackay, Charles, goldsmith.
„ Moffat, William L., architect.
„ Mein, Archd., M.D., surgeon and dentist.
„ Mitchell, John M., merchant, Leith.
„ Marjoribanks, William, merchant.
„ Marshall, William, accountant.
„ Miller, Colin M., M.D.
„ Macpherson, Alexander, plumber, Leith.
„ Macdonald, D., cotton-spinner, Aberdeen.
„ MacGillivray, J., Royal Artil^y, Woolwich.
1851. Middleton, J., M.D., L. R.C.S.E.
„ Milne, Robert, C.E., and land-surveyor, Aberdeen.
„ Maitland, Sir A. Gibson, Bart.
1852. M'Callum, Duncan, C.E.
„ M'Farlane, Wardlaw, chemist.
„ Moffat, John, C.E., Ardrossan.
„ Morton, John L., civ. and agr. engineer.
1853. Miller, And. M., merchant.
„ Moodie, Alex. Craig, publisher.
„ Mouat, John, C.E.
1854. M'Farlane, Patrick, Comrie.
„ Morrison, Adam, S.S.C.
„ Mitchell, Graham, V.S.

1832. Nasmyth, James, jeweller.
1838. Nachot, H.W., Ph. D., teacher of German.
1846. Newlands, James, architect, Liverpool.
1850. Newbigging, Patrick, M.D., F.R.C.S.E.
„ Notman, David, builder.
1851. Nicolson, Rev. Hugh, London.

1848. Oliver, Robert S., hatter.
1850. Ogilvie, Archibald, merchant.
1852. Orrock, Jas., surgeon and dentist.

1822. Playfair, W. H., F.R.S.E., architect.

1833. Ponton, Mungo, F.R.S.E., W.S.
1840. Pearson, Charles, accountant.
1842. Pyper, Hamilton, advocate.
„ Paterson, George, of Castle Huntly.
1844. Paterson, John, Leith Docks.
1846. Pattison, Thomas, M.D.
„ Paterson, W., resid. eng. E. P. & D. Ry.
1847. Purdie, Thomas, decorator.
1848. Peddie, John D., architect.
1851. Parker, W. A., advocate.

1822. ROSEBERY, The Right Hon. the Earl of K.T.
1829. Reid, David B., M.D., F.R.S.E., London.
1834. Ritchie, R., C.E., Assoc. Inst. C.E.
1835. Russell, J. Scott, M.A., F.R.SS. L. & E.
„ Ranken, Francis, glass-manufacturer.
1838. ROXBURGHE, His Grace JAMES H. R., Duke of, K.T.
1839. Russell, Thomas, ironmonger.
1840. Rose, Alexander, lecturer on geology.
1842. Rankine, W. J. Macquorn, F.R.S.E., C.E.
1843. Rhind, David, F.R.S.E., architect.
„ Roberts, W.A., M.D., dentist & surgeon.
1844. Ronaldson, John, writer.
1846. Robb, Charles, silversmith.
1848. Reid, Robert Little, painter.
1849. Robertson, Alex. D., merchant.
1850. Ramsay, Alex., manager Edin. Water Co.
„ Rae, William Fraser, brassfounder.
„ Richardson, James, merchant.
„ Richardson, Robert, merchant.
„ Robson, Neil, C.E., Glasgow.
1851. Rogers, James, ironmonger.
„ Ross, William, of Greenside.
1853. Rose, John T., shipbuilder, Leith.
„ Ritchie, And., watchmaker.
1854. Rutherfurd, John, W.S.
„ Robertson, James, C.E., E. P. & D. Ry.
„ Robson, Thomas W. E., C. P. School.

1828. Sang, Edward, teacher of mathematics.
1832. Sclater, Robert, die-cutter.
1833. Steele, Wilkinson, merchant.
1835. Steele, Patrick S., merchant.
1836. Slight, James, engineer.
1838. Stevenson, David, F.R.S.E., C.E.
„ Seeligmann, F.E., punch-cutter, London.
1839. Smith, David, F.R.S.E., W.S.
1840. Sprot, Thomas, W.S.
„ Stevenson, Peter, philos. instrum. maker.
„ Smith, C. H. J., landscape-gardener.
1841. Steuart, Robert, of Carfin.
„ Simson, George, R.S.A., artist.
„ Steell, John, R.S.A., sculp. to the Queen.
1842. Spence, Charles, S.S.C.
„ Smail, Will. Arch., of Overmains, R.N.
1843. Sanderson, James H., lapidary.
„ Schenck, Frederick, lithographer.
„ Shanks, Thomas, engineer, Johnston.
1846. Swan, Wm., F.R.S.E., teacher of math.
„ Simpson, Prof. J.Y., M.D., F.R.S.E.
„ Spence, James, W.S.
„ Seller, William, M.D., F.R.C.P., F.R.S.E.
1847. Steuart, James, W.S.
„ Stevenson, Thomas, F.R.S.E., C.E.
„ Sclanders, Alexander, upholsterer.
1850. Smith, Alexander, C.E., Aberdeen.
„ Swan, Alex., manufacturer, Kirkcaldy.
„ Stewart, James W., C.E.
„ Stark, James, M.D., F.R.C.P., F.R.S.E.
„ Scrymgeour, Henry, upholsterer.
„ Sinclair, Alex., manager Shotts Foundry.
„ Scott, Archibald, architect.
„ Smith, Robert, builder.
„ Sibbald, Thomas, ironmonger.
„ Strachan, Robert, accountant.
„ Smith, George C., land-surveyor, Banff.
1851. Smith, Robert, engineer, governor City Workhouse.
„ Simpson, Geo., C. and M.E., Glasgow.
„ Seton, Major, R.S., Madras Artillery.
„ Stewart, Hon. Robert, of Omoa, Lord Provost of Glasgow.
1852. Sutter, Archd., land-surveyor.
1853. Shepherd, Jas., accountant, Portobello.
„ Smith, William, engineer, Melbourne.
„ Smith, Alex. K., C.E., Australia.
1854. Stewart, John, 28 Abercromby Place.
„ Small, John, University Library.
„ Shortt, John, M.D., Madras.

1822. TWEEDDALE, The Most Noble the Marquis of, K.T., F.R.S.E.
1826. Tod, James, F.R.S.E., W.S., *Sec.*
1830. Tod, Henry, W.S.
1836. Traill, Prof. Tho. Stewart, M.D., F.R.S.E.
1839. Thomson, William T., manager Standard Life Assurance Company.
1840. Trevelyan, Sir Walter C., Bart., F.R.S.E.
„ Turnbull, William, Royal Bank.
1846. Trevelyan, Arthur, of Pencaitland.
„ Thornton, Robert, engineer.
1851. Turner, Richard, engineer, Dublin.
„ Tennant, John, St Rollox, Glasgow.
„ Tennant, Charles, St Rollox, Glasgow.
1852. Thomson, Jas. Boyde, M.I.M.E., Glasgow.
1854. Thomson, J. T., F.R.G.S., Singapore.

1843. Veitch, John, baker.

1822. Whytock, Richard, merchant.
1836. Wright, Robert, architect.
1838. Wilkie, John, of Foulden.
„ Wilson, Patrick, architect.
1840. Wood, William, surgeon.
„ Watson, Henry George, accountant.
„ Wright, Peter, linen-merchant.
„ Walker, William, surgeon and oculist.
1844. Wyllie, Henry J., C.E.

1845. Wilson, George, M.D., F.R.S.E.
„ Wilson, Prof. Daniel, LL.D., Canada.
1846. Whitelaw, James, watchmaker.
1850. Wright, George, jun., merchant, Leith.
„ Webster, Andrew, S.S.C.
„ Walker, John, M.D., London.
„ Winton, John G., engineer, Newhaven.
1851. Willet, John, C.E., Aberdeen Railway.
1852. Wighton, Rob. K., jeweller.
1854. Watt, James B., S.S.C.

1847. Young, Archibald, cutler.
1848. Young, William D., manuf. ironmonger
1853. Young, James, chemical manufacturer, Murrayfield.

TOTAL ORDINARY FELLOWS, 409.

The following ORDINARY FELLOWS, included in the foregoing List, are ordered to remain, till they return to Scotland, in the following

SUSPENSE LIST.

1844. William Cooper, glass-manufacturer, late of Picardy Place, Edinburgh, and now in Canada.
„ Joseph M. Kronheim, ornamental designer, London.
1845. Lieut.-Col. Blanshard, R.E., Mauritius.
1846. George Buist, LL.D., Bombay.
„ Mungo Ponton, F.R.S.E., 11 Lansdowne Place, Clifton.
1849. F. E. Seeligmann, punch-cutter, London.
1851. John S. Fraser, Swindon Station, Great Western Railway.
1852. Thomas C. Gregory, C.E., America.
„ Colin Miller, M.D., late of Edinburgh.
1853. James Newlands, C.E., superintendent of works, Liverpool.
„ David T. Hope, C.E., late of Liverpool.
1854. Dr Daniel Wilson, Professor, Canada.
„ J. T. Thomson, C.E., Government Surveyor, Singapore.
„ J. A. Callender, C.E., Canada.
„ John Macadam, M.D., Surgeon, late chemist, Glasgow, now lecturer on Nat. Science, Free Seminary, Melbourne, Australia.

HONORARY FELLOWS ADMITTED SINCE APRIL 1848.

1849.

Nov. 12. John Maxton, Esq., Superintendent Engineer to the Viceroy of Egypt.

1851.

Dec. 8. His Excellency Baron Titoff, Russian Minister at the Ottoman Porte.

...... M. Gevers Van Endegeest, Counsellor of State, Member of the States-General of Holland, President of the Commission for the Drainage of Haarlem Meer.

...... Sir William Cubitt, F.R.S., President Inst. C.E., London.

...... General Harry Jones, R.E., M.I.C.E.

...... Robert Stephenson, Esq., M.P., F.R.S., V.P. Inst. C.E., London.

...... Isambard K. Brunel, Esq., F.R.S., V.P. Inst. C.E., London.

HONORARY FELLOWS DECEASED SINCE APRIL 1848.

M. Schumacher, Altona.
M. Berzelius, Stockholm.
M. Ermann, Berlin.
General Colby, R.E.
J. J. Audubon.
Sir John Barrow, Secretary, Admiralty.
Mr Pritchard, London.
Sir Mark J. Brunel, C.E., London.
M. Daguerre.
F. P. Smith, Esq., London.
George Stephenson, Esq., C.E., Newcastle.
The Most Noble Spencer, Marquis of Northampton, P.R.S.

ASSOCIATE ADMITTED SINCE APRIL 1848.

1850.

Feb. 11. Rev. Graham Mitchell, LL.D., Whitburn.

ASSOCIATES DECEASED SINCE APRIL 1848.

James Smith, Esq., Deanston.
Mr George Grieve, Midfield, Musselburgh.
Mr James Forbes, Old Meldrum.

CONTINUATION OF LIST OF OFFICE-BEARERS FROM VOL. III., APP. (P) p. 190.

SESSION.	PRESIDENT.	VICE-PRESIDENT.	SECRETARY.	TREASURER.	EDITOR OF TRANSACTIONS.	CURATOR.
1848–49.	JOHN CAY, Esq., F.R.S.E.	GEORGE LEES, A.M. DAVID RHIND, Esq. F.R.S.E.	JAMES TOD, Esq., F.R.S.E.	J. SCOTT MONCRIEFF, Esq., Accountant.	GEO. WILSON, M.D.	Mr A. JAMIESON.
1849–50.	THOS. GRAINGER, Esq., C.E.	PAT. WILSON, Esq., Architect. DOUGLAS MACLAGAN, M.D., F.R.S.E.	Ditto.	Ditto.	Ditto.	Ditto.
1850–51.	Ditto.	RICHARD WHYTOCK, Esq. ALEXANDER ROSE, Esq.	Ditto.	Ditto.	Ditto.	Ditto.
1851–52.	GEORGE LEES, L.L.D.	WILLIAM PATERSON, Esq., C.E. THOMAS STEVENSON, Esq., F.R.S.E., C.E.	Ditto.	Ditto.	Ditto.	Ditto.
1852–53.	DAVID STEVENSON, Esq., F.R.S.E., M.I.C.E.	ROBT. RITCHIE, Assoc. I.C.E. DANIEL WILSON, LL.D., F.S.A. Scot.	Ditto.	Ditto.	Ditto.	Ditto.
1853–54.	Rev. PHILIP KELLAND, A.M., F.R.SS. L. & E.	WILLIAM SWAN, F.R.S.E. HEINRICH WILHELM NACHOT, Ph. D.	Ditto.	Ditto.	Ditto.	Ditto.
1854–55.	DAVID RHIND, Esq., F.R.S.E.	EDWARD SANG, Esq. WM. ARCHD. SMAIL, Esq. of Overmains, R.N.	Ditto.	Ditto.	Ditto.	Ditto.

APPENDIX (O*).

PROCEEDINGS OF THE ROYAL SCOTTISH SOCIETY OF ARTS, SESSION 1854–55.

The Annual General Meeting of the Royal Scottish Society of Arts was held in their Hall, 51 George Street, on Monday, 13th November 1854.—Rev. Professor Kelland, A.M., President, in the Chair.

The PRESIDENT opened the session with an eloquent address, of which the following is an abstract:—After thanking the Society for the honour of having filled the President's chair, and paying a tribute to the memory of those members who had been removed by death since their last meeting, referring particularly to Sheriff L'Amy, Mr Murray of Henderland, and Mr Kemp, the learned Professor congratulated the Society on the results of the last session. Without disparagement to the merits of other papers, he particularised four of those read as illustrations of a position which formed a principal point in his address, viz., the twofold office of the Society, in holding up excellence as a model and incitement on the one hand, and on the other encouraging and fostering every indication of rising genius. The first was exemplified in the papers of Messrs Stevenson and Thomson, the second in those of Messrs Elliott and Scott. On their various merits the Professor spoke in terms of high eulogy. He then proceeded to some remarks on the objects and advantages of an association such as the Society of Arts. Such a Society cannot have the power of controlling outward circumstances; it must yield to them, and improve on them. To judge of this Society by a comparison with the French Institute or the Royal Society of London, would be as preposterous as to compare the latter as it now is with what it was at its foundation. The Professor here recalled the circumstances connected with that event, and said that the founders of the Royal Society seemed to be conscious that they belonged to a transition era, when combination for mutual assistance was necessary to make up for individual helplessness. As a sample of the style of their proceedings, he read some extracts from the minutes of their early meetings, as recorded by Birch, *e.g.*, March 20, 1661.—"The amanuensis was ordered to make the experiment of the calcination of antimony, whether it increaseth or not, and to weigh it before and after, in and out of the water." March 25.—"Mr Boyle was requested to report the name of the place in Brazil where that wood is which attracts fishes, and of the fish which turns to the wind when suspended by a thread." March 27.—" It was ordered to inquire whether the flakes of snow are bigger in Teneriffe than in England." July 24.—A report was made of the trial of the diving-engine at Deptford, by the amanuensis, who staid in it twenty-eight minutes under water. " I may mention," the Professor said, " by the way, that the poor amanuensis appears to have had a hard time of it. Perhaps they considered his salary a little high, as it had been recently doubled, *i.e.*, raised from £2 to £4 per annum !" These extracts, he said, would perhaps give no very lofty conception of the meetings or aims of that Society. But we must remember that it is characteristic of a true philosopher to try and examine all things, except those which from the very nature of the case must be absurdities. On this principle they acted, and in the end they made experiments and attained results of the very highest importance. Circumstances since then had changed. Individuals, not societies, are now the investigators of truth. The duty of societies is *to make known, to encourage*, or *to educe*. On these three points he entered at some length, remarking, in connection with the first, that from the character of the British Government, exercising so little central supervision, individual enterprise and ingenuity must trust to the practical value of their labours, and not to any State interference. Thus, without the assistance of a Society, the publication of the papers he had already mentioned would, he thought, be a hazardous speculation. The Society are both publishers and public for the members. It is otherwise on the Continent. The deepest and most crabbed speculations are published in Germany, and find a sale simply because the State compels public institutions to support them. The State wills that you be scientific, and scientific you are. With us, on the contrary, there is neither coaxing nor constraint; and though the result may be that the lighter bodies sometimes swim to the surface and catch the public eye, yet in the end the heavier bodies generally find their way down the stream too, and reach their landing place. Here it is that a Society like this comes in with its invaluable assistance. In connection with the second head, he called attention to the fact, that in the history of science and literature eminent names appear in clusters. The discoveries of one man excite the undeveloped talents of others. Intellects strike fire by their mutual friction. Thus it happens that posterity finds it difficult sometimes to assign to each man his exact share in every branch of discovery. Hence the value of societies for circulating information, and bringing minds to bear upon each other and on particular subjects. The native inertness of some minds needs to be overcome by the example of others. The quiet of the country, the absence of disturbing excitements, the freedom from cares, which at first sight seem conducive to a life of study, these are not in practice found to be the concomitants of high eminence. The men who do great things are those who vividly echo in every fibre the sentiment that society expects every man shall do his duty. These facts, he said, indicate the true object and the value of an association for the encouragement of genius and the reward of exertion. They place its members in the proud position of men who are anxious to see their younger brethren raised up to and above their own level—of men who strive to do something towards fulfilling the injunction, " care for others,"—an injunction which may be said to be the touchstone of our humanity. On the motion of James Gardner, Esq., the Society passed a vote of thanks to the President for his excellent address.

At the special request of the Council, Part I. of an Exposition of the Arts and Manufactures and Social Condition, &c. of Turkey, was given by Edward Sang, Esq., Teacher of Mathematics, and Actuary, Edinburgh, late Professor of Mechanical Philosophy in the Imperial School, Muhendishana, Berii, Constantinople.

Mr Sang gave an introduction to his subject in the shape of some remarks on the state of agriculture in Turkey. He attributed the depressed state of farming to the operation of the tithe system, and to the pernicious effect of surcharges, which, he stated, generally brought up the land-tax to one-seventh of the gross produce. The badness, or rather the total want of roads, was pointed out, and the enormous expense of carriage. Altogether, it would appear from what he said, that the agriculture of Turkey is in the very lowest state, and that Turks suffer quite as much as Christians from the mal-administration of affairs. Mr Sang pointed to a complete reformation of the taxation, to the reduction of the amount of the tithe, or to the commutation of it into a fixed annual charge, as essential to the consolidation of a permanent peace. He proposed to continue his remarks at subsequent meetings of the Society.

Thanks were voted to Mr Sang for his interesting introduction.

The Report of the Prize Committee awarding the Prizes for Session 1853–54 was read, and the Prizes were delivered by the President to the successful Candidates. See Appendix (Q.), p. 207.

The Models, Drawings, &c. of Inventions, &c., for which Prizes, &c. had been awarded, were exhibited.

The following Donations were laid on the Table, viz.:—

1. Report of Twenty-third Meeting of the British Association for the Advancement of Science, held at Hull, in September 1853. Presented by the Association. (3605.)
2. The Assurance Magazine, in continuation, Vol. IV. Part IV., and Vol. V. Part I., and separate List of Members of the Institute of Actuaries of London. Presented by the Institute. (3601 and 3602-1-2.)
3. The Annual Report of the Royal Cornwall Polytechnic Society 1853. Presented by the Society. (3603.)
4. Proceedings of the Architectural Institute of Scotland, Session 1853-4, Vol. III. No. IV. Presented by the Institute. (3604.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidates were elected Ordinary Fellows, viz.:—

1. James George Syme, 111 Princes Street.
2. David Page, F.G.S., 30 Gilmore Place.

III. In terms of Law XV., the Society elected the following Office-Bearers for Session 1854-55.

David Rhind, Esq., F.R.S.E., *President.*
Edward Sang, Esq.
William A. Smail, Esq. of Overmains, R.N. } *Vice-Presidents.*
James Tod, Esq., F.R.S.E., W.S., 55 Great King Street, *Secretary.*
John Scott Moncrieff, Esq., Accountant, 20 India Street, *Treasurer.*

Ordinary Councillors.

William Paterson, Esq., C.E.	Robt. Ritchie, Esq., C.E., A.I.C.E.
Thos. Stevenson, Esq., F.R.S.E., C.E.	George Wilson, M.D., F.R.S.E.
	William A. Roberts, M.D.
David Landale, Esq., M.E.	Rev. Professor Kelland, M.A.
David Cousin, Esq.	William Swan, Esq., F.R.S.E.
David Stevenson, Esq., F.R.S.E., M.I.C.E.	H. W. Nachot, Ph.D.
	James Elliot, Esq.

George Wilson, M.D., F.R.S.E., *Editor of Transactions.*
Mr Alexander Jamieson, *Curator of Museum.*
Mr Alexander Kirkwood, *Medallist.*
Mr Hugh Johnston, *Officer and Collector.*

IV. A List of the Office-Bearers and Alphabetical List of the Fellows, as at 1st November 1854, in the order of admission, was distributed.

V. It was stated that a copy of the Report of the Prize Committee for Session 1853-54 would be sent in the Billet for next meeting.

27*th November* 1854.—David Rhind, Esq., F.R.S.E., President, in the Chair. The following Communications were made:

1. The President, on taking the chair, suggested for the consideration of the Society and the public, the following amongst other subjects, on which it would be desirable to receive communications during this session, being all of them more or less connected with building, and the improvement and comfort of dwellings, viz.—drainage and sewerage; fire-proof flooring; keeping down damp in walls; heating and ventilation; culinary apparatus; bath-heating, water-closets, &c.; bell-hanging, speaking-tubes, &c.; locks and hinges, window-hangings, &c.; improvement in labourers' dwelling-houses; dry rot in timber, causes and cure; machinery for saving manual labour; scaffolding, simplicity, economy, and safety; building material, stone, brick, concrete, asphalte, mortar, timber, metals, slates, glass, and generally everything used in building; improvement in Calotype, in showing from time to time the state of a building in progress.

The thanks of the Society were voted to Mr Rhind for his excellent address, and it was ordered to be printed and circulated among the Fellows.

2. Description of a Tool-Holder, applicable particularly to the Screwing-Lathe, constructed by Mr George Taylor, Imperial Mint, Constantinople. This was exhibited and described by Mr Sang, Vice-President. (3611.)

The tool-holder consists of a steel stock squared for the purpose of being secured in the slide-rest. It is pierced through its whole length, and is sawn up from each end to near the middle. The bore thus prepared receives a cylindric stock, having at the end an oblique piece, through which is worked a hole triangular or round, according to the nature of the cutter. Into this hole the cutting tool is passed until the cutting edge lie at the height of the lathe centre. In order to secure the cutter in its place, there is a small screw worked by capstan-holes, and pressing upon the back of the cutter. The head of this screw is placed in a recess, so as to be out of the way of the work, and yet conveniently reached by means of a bent tommy; and as this arrangement requires no split in the stock, that sliding of the cutter which often takes place in Holtzapffel's tool-holder, is avoided. The cylindric stock admits of being turned round, so as to incline the direction of the cutter to either side, for the purpose of following the slope of a right or left hand screw. At the same time, the split in the square stock allows the slide-rest pinching-screws to bind the cylinder firmly in its place while they secure the square stock. Thanks were voted to Mr Sang for making the communication, which was referred to a Committee.

3. Design for a Chronofore, or improved Hack-Watch, for minutely subdividing a Second. By Edward Sang, Esq., V.P. Explanatory experiments were exhibited. (3612.)

The author stated that this instrument, which he calls a chronofore or time-carrier, is intended to be used in the comparison of clocks and chronometers with each other Every one who has tried to compare two chronometers must have felt the difficulty of estimating that fraction of the beat by which the one may be in advance of the other; and that the nearest half-second is almost the limit of our power. In order then to obtain the rate of the chronometer, we are compelled to allow it to go on for a considerable time, even for several days, and after all it is only the average rate for that time which is got. The mode of comparison proposed by the author is to use an intermediate watch, or rather chronometer, and to compare this with each of the time-keepers whose relative rates are to be observed; and to arrange the beats of this intermediate or hack-watch, so as to allow of comparison to a minute fraction of a second. For this purpose the hack-watch is constructed to make one beat per minute more or less than the usual number of beats—say 119 in place of 120 beats. In this way we are able, just as with the Vernier and scale, to compare the position in time of our watch with that of the chronometer; and comparing it again with a second chronometer, we get the difference, between the two, true to the 238th part of a second, if the ear can go to that nicety, or otherwise to the utmost degree of precision to which the ear can attain. When the chronofore is compared with a clock beating whole seconds, the accuracy attainable by it is only the 119th part of a second; but even this precision is at the very limit of the delicacy of the ear. It was remarked that by this method there would be much saving of time in rating ships' chronometers—a thing of vast consequence both to the royal and mercantile navy. Referred to a Committee.

4. Description of an Improved Boring Machine for Blasting Rocks. By Mr Hugh Cleland, smith at Craigleith Quarry, near Edinburgh. A model and drawing of a machine were exhibited. (3597.)

This machine has been in use in Craigleith and Redhall Quarries for four years, and gets the highest character from Mr Johnstone and Mr Gowans, who have used it. It is of simple construction, can work at any angle as well as at the perpendicular, is not liable to be deranged even when worked by the most ignorant hands, and during the four years it has been in use has required no repair except the sharpening of the borer. The machine is formed of a timber frame, axle, crank, and fly-wheel. The crank is part of a circle, is hollow, with steel rollers set in it, which act on the under side of a metal flanch fixed on the boring rod by a steel key—which flanch is shifted up to the boring-rod eight or nine inches at a time, as the boring proceeds, without much hindrance or difficulty. The crank, in lifting the boring-rod by acting on the under part of the flanch, turns the rod a quarter round at every lift. The fall of the boring-rod is two feet; it may be from 20 to 50 feet long, and $2\frac{3}{8}$ inches in diameter. The mouth-piece or borer at the end of it is so constructed as to form a perfectly round hole $4\frac{1}{2}$ to $7\frac{1}{2}$ inches in diameter, or much larger if required. It is worked by three or four men, and in ordinary cases bores from ten to fifteen feet per day. This machine has bored to the depth of forty feet. Much larger masses of rock can be loosened with the same quantity of gunpowder than by any method of boring before in use. The author stated that the cost of the machine does not exceed £20, whereas the price of the American one was £50. Referred to a Committee.

5. Description of the Improvement of a Thrashing Mill, by Mr George Johnston, Craigleith Hill House, near Edinburgh. (3596.)

The author stated that in the course of repairing his thrashing mill at Hillhouse, Kirknewton, it occurred to him that to put a fly-wheel on the drum shaft would improve the working of the mill, by rendering the work easier for the horses. The mill is what is termed a six-horse one; the outer or horse-wheel, is 9 feet in diameter: the spur-wheel, $4\frac{1}{2}$ feet. The drum is 5 feet long, and 4 feet in diameter. A fly-wheel was put on a short shaft, coupled to the outer end of the drum shaft,—the fly-wheel being 6 feet in diameter, and weighing 7 cwt. The author stated that being sufficiently tried by thrashing all last year's crop, his expectation had been more than realized. The uniformity of motion produced by the fly-wheel eases the working so much that he is able now, with four horses, to do the work of six with equal ease. These alterations and improvements were executed by Mr Hugh Cleland, smith at Craigleith Quarry. Referred to a Committee.

The following Donations were laid on the Table, viz. :—

1. Proceedings of the Institution of Mechanical Engineers, Birmingham, 26th July 1854, in continuation. Presented by the Institution. (3607.)

2. Description of,—(1st,) a New Apparatus for taking the Specific Gravity of Floating Bodies; (2d,) of the new Preparation Jar for Museums — invented by Mr Peter Stevenson, philosophical instrument maker, 9 Lothian Street. Presented by the inventor. (3609-1-2.)

3. Bell's Popular Stenography.—Readings in Curt Hand. Presented by the author. (3610.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

Minutes of last Meeting read and approved.

11*th December* 1854.—David Rhind, Esq., President, in the Chair. The following Communications were made:—

1. At the special request of the Council, Part II. of an Exposition of the Arts and Manufactures and Social Condition of Turkey was given by Edward Sang, Esq., V.P. (3608.)

In this paper Mr Sang took up the subject of prices fixed by the State in Turkey, and adverted to their bad effect on industry and commercial enterprise. He instanced the sale of charcoal during the severe winter of 1849-50, when, as the price was kept down by law, the supply was exhausted long before the severity of the storm was over; and the sale of butcher-meat, of which, as all qualities must be sold at the same price, the very worst is exposed in the stalls; the better articles being secreted for those customers who are willing to give a higher price. This led him to notice the virtual monopolies which exist, although monopoly be abolished by treaty. The same yielding in appearance he exemplified in the abolition of the slave market, while the trade in slaves goes on as briskly as ever, and while, he might have added, the revenue continued to benefit by the tax levied on their importation. The mention of slavery led Mr Sang away from his proper subject into a warm denunciation of the horrors of Eastern slavery. Thanks voted. The subject is to be continued.

2. On a Smokeless Furnace, by Robert H. Bow, Esq., C.E., Edinburgh. Diagrams were exhibited. (3613.)

After stating the conditions under which smoke is produced in a furnace, as commonly constructed and managed, and the necessity for a very high temperature, combined with an abundant supply of oxygen, in order to effect the combustion of the smoke, the author described three general arrangements under which could be classified nearly all the furnaces that have been brought forward as smokeless; and maintained that the more practicable of these owed their success more to the regular manner in which the fuel was supplied than to any peculiar properties of the arrangements; and that in order to effect the regular feeding of the furnace somewhat complicated machinery was required, or an amount of attention was necessary on the part of the furnacemen that could seldom be counted upon. The author stated that his invention does away with this necessity for great regularity in the supply of the coal. In his furnace the draught is reversed,—that is, the flame, air, &c. proceed downwards through and from the fire; and it is therefore proposed to call it "The Down-Draught Furnace." The principle of its action was stated to be very simple. The smoke, liberated from the superincumbent coal, is, by means of the suction of the chimney, carried, along with a due admixture of air, down through the brightly burning fuel which forms the lower stratum of the fire, and thus becomes intensely heated and completely burnt. Contrary to what might have been expected, the combustion is very rapid: in some experiments, made in 1852, with a grate of five-eighths of a square foot in area, the combustion was at the rate of 30 lbs. of coal per square foot of grate per hour; the height of the chimney being nearly 35 feet. This result is probably due to the self-clearing power of the furnace, and the comparatively dense state of the air when it mingles with the fuel. The combustion readily spreads upwards to the fresh coal from the action of the strong radiant heat. The author stated that a common iron grating cannot be employed in this furnace, as it would rapidly become oxidised or burnt. That the following are some of the methods that may be adopted for overcoming this difficulty:—1st, The fuel may be burnt in a V or L shaped cavity: 2d, A perforated or open-work structure of fire-proof clay or stone may be employed to support the fire; and 3d, Tubes containing water, either communicating with a boiler, or otherwise supplied, may be substituted for the fire-bars. Referred to a Committee.

3. On the Antipodal Land of the Globe,—its positions and its proportion to the whole land of the Earth's Surface, by James Gardner, Esq., Edinburgh. Illustrations were exhibited. (3587.)

The author stated that the antipodal land of the earth's surface is defined to be that land which is under opposite parallels of latitude and meridians, being equidistant from the equator, but on different sides, and in opposite hemispheres. On a common globe the simple way of finding the antipodal point is to bring the place to the brass meridian, and reckon 180 degrees either north or south, and where the reckoning ends is the antipodal point required; but as we can see only one-half of the globe at a time, we have thus only a partial view of the antipodal points. Many years ago it occurred to the author to construct a projection on a plane surface, bringing the contents of both hemispheres into one, preserving the relative positions of land as respects the equator, but reversing the poles, placing the north pole with the old continents on the southern hemisphere, and the contents of the southern hemisphere on the north. In this way the whole amount of antipodal land becomes apparent at one view. The very small proportion of land which thus appears in the map as actually opposite to land is remarkable, amounting to only one twenty-seventh of the whole land of the globe. The greater portion of this antipodal surface lies in South America, where, in the opposite meridians, lie parts of Eastern Asia, Borneo, Sumatra, and some other islands of the Asiatic Archipelago. No part of Australia has corresponding antipodes, but the northern half of New Zealand is antipodal to part of Spain. The principal groups of the Polynesian islands are antipodal to Africa. There are no inland seas or lakes that have not sea opposite. When Columbus in 1492 "unbarred the gates of ocean, and discovered a new world," he did not touch upon any land that had land opposite to it; and the first antipodal land known to Europe was discovered by Abel Tasman, being part of the island of New Zealand. The ratio of land to water on the globe is as 1 to 2·75; and from the great preponderance of land in the northern hemisphere, in the existing arrangement on the earth's surface, it no doubt results that so small a proportion of this surface has antipodal land,—for had other arrangement existed, had the continents and islands been more diffused, the probability is that there would have been a much greater proportion of land opposite land than we now find to be the case. On inspecting the diagram before us, it will be perceived that the whole land on the earth's surface could be contained in one of the hemispheres, and yet there would be still an ample extent of ocean to circumnavigate the globe. But doubtless the arrangement of earth and ocean, of mountains and plains, lakes and rivers, has not been left to chance, but is in unison with the laws which are evident in every other department of creation. It would seem from the great extent of ocean that it was intended, in addition to the other purposes, to serve as the highway for man, as almost every country borders somewhere on the sea. The author stated that twenty years ago the facts exhibited in this diagram were stated to Mr Greenough, and noticed by him in his address to the Geological Society, and that they will also be found briefly stated by Sir Charles Lyell and Mrs Somerville, and in the *Quarterly Review*. A copy of the diagram was also presented many years ago to the late Professor Jameson. Referred to a Committee.

4. Projects for the introduction of, 1st, A New Species of Fuel; 2d, A New Species of Manure. By Colonel Graham Graham of Jarbruck, Moniaive, Dumfriesshire. (3595.)

Fuel.—This is a project for introducing a fuel manufactured somewhat on the principle of the French "Tourbes," which are composed of the refuse bark from tanneries—useless for any other purpose than, in small quantities, for raising pine apples. The bark is compressed in round moulds, three or four inches thick, and six or eight inches in diameter, having holes in the centre. Long poles are thereafter passed through these holes, and are hung up in drying-houses. When dried, the "Tourbes" are fit for use. The author some years since tried the experiment of mixing sawdust with peat coom or dust, with a little coal tar to moisten them,—then had this composition put into moulds and dried in open sheds, and found that good useful fuel was obtained from articles otherwise useless, and that it might have been greatly improved by a portion of bark being mixed up in the other ingredients. *Manure.*—The author stated that when at Naples and other places he had noticed considerable quantities of volcanic ashes used with advantage in gardens that supplied the markets, for rearing small seeds, and most kinds of vegetation either natural or artificial. He suggested that the same article, on trial elsewhere, and by adopting scientific experiments, might be useful in this country in rearing turnip crops, and for this purpose might supersede bone-dust. That, if successful, immense quantities of volcanic ashes might, at the present juncture, be transported at low freights by steamers and transports employed in conveying troops, stores, &c., to the East, and returning in ballast; and should it prove a useful article, large quantities might be had nearer at hand from Iceland, and whale ships that were unsuccessful, or merely what are called "clean ships," might find some compensation by loading at Iceland with ashes, even at low freights. Thanks voted.

5. Report of Committee on Mr John Fleming's Screw, No. 4 (Mr Rose, Convener), was read and approved. (3532.)

PRIVATE BUSINESS.

I. The Minutes of last Meeting read and approved.

II. The following Candidates were elected Ordinary Fellows, viz.:—

1. John Dauglish, 7 Fingal Place.
2. Peter Currie, F.E.I.S., teacher, 13 Gayfield Square.
3. Robert Girdwood, merchant, 7 Bellevue Crescent.

III. In terms of Law XX., the Treasurer's Books were laid on the Table, and a Committee appointed to audit the same, and to report thereon, and generally on the state of the funds of the Society.

8*th January* 1855.—William Smail, R.N., Vice-President, in the Chair. The following Communications were made:—

1. On the Combinations of Colour and Form for Railway and Ship Signals, best fitted to guard against their being mistaken by the Subjects of Colour-Blindness. By George Wilson, M.D. Diagrams were exhibited. (3616.)

2. Description of an Instrument for taking the Density of Floating Bodies. By Mr Peter Stevenson, Philosophical Instrument Maker, 19 Lothian Street. The instrument was exhibited. (3617).

3. Mr William Hart exhibited in action his Improved Medical Galvanic Battery, of a more portable size, yet of equal power with the larger one formerly exhibited, with regulating Index giving more or less power. The advantages were stated to be:—1st, The double bell, the one being filled with the acid, while the other is empty to contain the battery when not in use—the battery being removed from the acid bell without danger of drops of acid being spilt. 2d, The regulating apparatus, which consists, as in the larger one formerly exhibited, of a moveable index, pointing round a disc or dial-plate, on which twelve different degrees of power are indicated, so that the strength of the shock can be easily regulated according to the patient's wish. 3d, The freedom from the annoyance of connecting wires and screws, coupled with its portability.

Referred to a Committee. (3615.)

The following Donations were laid on the Table, viz. :—

Du Dessechément du Lac de Harlem, par M. Gevers D'Endegeest, Conseiller d'Etat, President de la Commission pour le dessechément du Lac de Harlem (Seconde Partie). 1st Oct. 1853. Amsterdam, 1854. 8vo, pp. 113, with Portfolio of 5 Plates. Presented by the Author. (3614-1-2.)

Thanks voted.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidate was elected an Ordinary Fellow, viz. :—

Thomas Dunn, S.S.C., 78 George Street.

III. Copies of the President's Address, pointing out Subjects for Communications to be read during the Session, were sent to the Fellows in December.

22*d January* 1855.—Edward Sang, Esq., V.P., in the Chair. The following Communications were made :—

1. A Letter from W. J. Macquorn Rankine, Esq., on the part of a Committee of the Royal Society of London, relative to Space being reserved by the Board of Trade for Astronomical and Philosophical Instruments until the end of January.

2. A short Sketch of the Rise and Progress of the Royal Steam Navy, with a few Practical Suggestions growing out of fourteen years' experience in Her Majesty's Service. By James Spence, Esq., Chief Foreman of the Steam Factory at Portsmouth Dockyard. (3606-1.)

After giving a view of the rise and progress of the Royal Steam Navy of Great Britain, the author gave a summary of what he had before proved (by giving the names, guns, and tonnage of each ship) and concluded as follows :—In briefly recapitulating the leading facts, he stated that it would be found that in 1840 the Royal Steam Navy consisted of between thirty-eight and fifty vessels (paddle-wheel), of all classes. That in 1845, when the Queen reviewed the Channel Fleet, the *steam* branch was on that occasion represented by one solitary ship, the Rattler. That in 1853, when the Queen again reviewed the fleet at Spithead, the steam branch had increased to twenty-seven paddle-wheel vessels, and thirteen screws, while there were only three sailing ships present. It was also remarked that when it was seen that the country was actually to be engaged in war, the exertions of the Admiralty have been on the grandest scale, and worthy of the greatest maritime nation of the world ; and he gave the following table to show the present strength of this arm of the public service, being a summary of the Baltic and Black Sea Fleets :—

SUMMARY OF THE BALTIC FLEET, SEPTEMBER 1854.

	Ships.	Guns.	Horse Power.	Tons.
The Screw Fleet…………	28	1636	10,702	58,550
The Paddle do……………	23	169	7,580	20,702
The Sailing do……………	4	400	———	10,600
Grand Total…………	55	2205	18,282	89,852

SUMMARY OF THE BLACK SEA FLEET, SEPTEMBER 1854.

	Ships.	Guns.	Horse Power.	Tons.
The Screw Fleet…………	10	277	3020	14,869
The Paddle do……………	18	129	6622	18,695
The Sailing do……………	12	933	———	———
Grand Total…………	40	1339	9642	———

3. On a new form of the Platometer; an instrument for ascertaining the area of plane surfaces. By James Clerk Maxwell, Esq., Trinity College, Cambridge. Drawings of the instrument were exhibited. (3622.)

The author stated that the name of Platometers, or Planimeters, has been given to instruments which by a mechanical contrivance measure the superficial contents of any area round which a tracing point connected with the instrument is made to pass. In all those hitherto constructed the essential part of the instrument has consisted of a wheel, which is turned by the friction of another revolving body connected with the instrument, the radii of which are unequal; and the change of position of this wheel is affected by a lateral slipping along the surface of this body. Now, it might be shown mathematically from the laws of friction, and confirmed by the simplest experiments, that, though the friction is sufficient to ensure perfect rolling when there is no lateral sliding, yet, when such lateral sliding takes place, the very slightest disturbing force produces a deviation from the result of perfect rolling, the amount of which depends on the amount of this disturbing force, and on the distance over which the lateral dragging takes place. Mr John Sang, in a paper in the Transactions of this Society, has explained this effect, and shown how to measure and correct it. The instrument described by the author was stated to be the result of an attempt to do away with slipping altogether, and as far as the theory goes it is perfectly successful. The working parts of the instrument consist of a hemisphere revolving round a horizontal axis, and a sphere mounted on a framework, so that its axis remains always horizontal, but changes in position, so as to admit of different points of the sphere and hemisphere coming in contact. The radii of these two surfaces are equal, and the framework is arranged so as to keep them always in contact, in such a way that while the ratio of their velocities of rotation changes according to the position of the tracing point, the action between the points in contact is always that of perfect rolling, without the possibility of slipping. In this way, it is presumed that a necessary source of error in all former instruments has been disposed of, and the instrument rendered mathematically perfect. Whether the actual construction of the instrument will be more or less difficult than that of those already made, and whether other inconveniences belonging to the peculiarities of the parts may interfere with its working, are questions for practical men to decide. It is thrown out by the author, partly as a suggestion to instrument-makers, and partly as an addition to the theory of a class of instruments which, for the ingenuity of their construction and the accuracy of the performance of those already made, deserve more attention than they have hitherto received. Referred to a Committee.

4. Notice of a simple Compressible Siphon. By Alexander Bryson, Esq., F.S.A. Scot. The siphon was exhibited in action. (3624.)

This invention consists in attaching an India-rubber flexible tube to the longer leg of a glass siphon, and then, on immersing the shorter leg in the acid or other liquid to be drained off, the finger and thumb of the right hand are applied to the flexible part of the tube, compressing it with a downward motion, as in milking a cow, by which a vacuum is created (in place of sucking with the mouth, which would be dangerous), and the acid or other liquid flows over into the longer leg till the whole is drained off. Mr Bryson exhibited in motion this very simple and elegant siphon. Referred to a Committee.

The following Donations were laid on the Table, viz. :—

1. The Civil Engineer's and Architect's Journal for 1854. Presented by Mr Laxton. (3618.)

2. The Artizan for 1854. Presented by the Proprietor. (3619.)

3. The Practical Mechanic's Journal for 1854. Presented by Mr Johnson. (3620.)

4. The Society of Art's Journal for 1854. Presented by the Society of Arts, London. (3621.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

The Minutes of last Meeting read and approved.

12*th February* 1855.—Edward Sang, Esq., Vice-President, in the Chair. The following Communications were made :—

1. On Writing Inks. By James Stark, M.D., F.R.S.E. The inks were exhibited. (3626.)

The author stated that in 1842 he had commenced a series of experiments on writing inks, and up to this date had manufactured 229 different inks, and tested the durability of writings made with these on all kinds of paper. As the result of his experiments, he showed that the browning and fading of inks resulted from many causes, but in ordinary inks chiefly from the iron becoming peroxygenated and separating as a heavy precipitate. Many inks, therefore, when fresh made, yielded durable writings; but when the ink became old, the tannogallate of iron separated, and the durability of the ink was destroyed. From a numerous series of experiments, the author showed that no salt of iron and no preparation of iron equalled the common sulphate of iron, that is, the commercial copperas, for the purposes of ink-making, and that even the addition of any persalt, such as the nitrate or chloride of iron, though it improved the present colour of the ink, deteriorated its durability. The author failed to procure a persistent black ink from manganese or other metal or metallic salt. The author exhibited a series of eighteen inks which had either been made with metallic iron, or with which metallic iron had been immersed, and directed attention to the fact, that though the depth and body of colour seemed to be deepened, yet in every case the durability of writings made with such inks was so impaired that they became brown and faded in a few months. The most permanent ordinary inks were shown to be composed of the best blue gall-nuts with copperas and gum, and the proportions found on experiment to yield the most persistent black were six parts of best blue galls to four parts of copperas. Writings made with such an ink stood exposure to sun and air for twelve months without exhibiting any change of colour, while those made with inks of every other proportion or composition had more or less of their colour discharged when similarly tested. This ink, therefore, if kept from moulding, and from depositing its tannogallate of iron, would afford writings perfectly durable. It was shown that no gall and logwood ink was equal to the pure gall ink in so far as durability in the writings was concerned. All such inks lost their colour and faded sooner than pure gall inks, and several inks were exhibited which, though durable before the addition of logwood, faded rapidly afterward logwood was added to them. Sugar was shown to have an especially hurtful action on the durability of inks containing logwood—indeed on all inks. Many other plain inks were exhibited and their properties described—as gallo-sumach ink, myrobalans ink, Range's ink—inks in which the tannogallate of iron was kept in solution by nitric, muriatic, sulphuric, and other acids, or by oxalate of potash, chloride of lime, &c. The myrobalans ink was recommended as an ink of some promise for durability, and as the cheapest ink it was possible to manufacture. All ordinary inks, however, were shown to have certain drawbacks, and the author endeavoured to ascertain by experiment whether other dark substances could be added to inks to impart greater durability to writings made with them, and at the same time prevent those chemical changes which were the cause of ordinary inks fading. After experimenting with various substances, and, among others, with Prussian blue and indigo dissolved in various ways, he found the sulphate of indigo to fulfil all the required conditions, and, when added in the proper proportion to a tannogallate ink, it yielded an ink which is agreeable to write with, which flows freely from the pen, and does not clog it, which never moulds, which, when it dries on the paper, becomes of an intense pure black, and which does not fade or change its colour however long kept. The author pointed out the proper proportions for securing these properties, and showed that the smallest quantity of the sulphate of indigo which could be used for this purpose was eight ounces for every gallon of ink. The author stated that the ink he preferred for his own use was composed of twelve ounces of galls, eight ounces of sulphate of indigo, eight ounces of copperas, a few cloves, and four ounces of gum-arabic, for a gallon of ink. It was shown that immersing iron wire or filings in these inks destroyed their durability as much as similar treatment destroyed ordinary inks. He therefore recommended that *all legal deeds or documents should be written with quill pens*, as the contact of steel invariably destroys more or less the durability of every ink. The author concluded his paper with a few remarks on copying inks, and indelible inks, showing that a good copying ink has yet to be sought for, and that indelible inks, which will resist the pencillings and washings of the chemist and the forger, need never be looked for. After some discussion on the importance of the subject treated of in this paper, in which Messrs Elliot, Turnbull, Pattison, Beatson Bell, J. F. Macfarlane, and the Secretary, took part, the paper was referred to a Committee for their report.

2. Prorogated time for reporting on Mr Johnston's improved Thrashing Mill till 12th March.

3. Prorogated time for reporting on Mr Bryson's Siphon, and Mr P. Stevenson's Densimeter, till 12th March.

The following Donations were laid on the Table :—

1. Assurance Magazine and Journal of the Institute of Actuaries, Vol. V. Part II. No. XVIII. January 1855. Presented by the Institute. (3623.)

2. Two Copies of The Combustion of Coal, and the Prevention of Smoke chemically and practically considered, with numerous Illustrations. By C. W. Williams, Esq., Assoc. Inst., C.E., &c. &c., Hon. F.R.S.S.A., Liverpool. Presented by the Author. (3627–1–2.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidate was proposed and balloted for as an Ordinary Fellow, viz. :—

Adam Mossman, jeweller, 14 Blacket Place.

III. The Report of the Auditing Committee on the Treasurer's Books, and on the Funds of the Society, was read and approved, and thanks voted to the Committee, especially to the Convener. Mr Horne, Convener.

IV. The President granted discharge to the Treasurer.

The Council reported that they had been requested by the Committee of Management of the Glasgow Architectural

Exhibition to give publicity to the following Notice, to which the Council had given their sanction.

PRIZE MEDALS.

GREAT SCOTTISH EXHIBITION OF ARTS AND MANUFACTURES CONNECTED WITH ARCHITECTURE.

The Council of Management beg to draw the attention of all who are in any way connected with Building operations to the following Subjects, for which they have much pleasure in announcing that the Medal of the ROYAL SCOTTISH SOCIETY OF ARTS will be given by David Rhind, Esq., F.R.S.E., the President of the Society, with the view of advancing the interests of Architecture.

The subjects have been selected as most comprehensively embracing the objects of the Exhibition; and, as a stimulus to exertion, the Council think it right to add, that these are the only Medals of the Society of Arts that can be awarded in connection with the Exhibition.

1st, For the most important Invention or Improvement connected with the Practical detail of Public or Domestic Buildings, or any of the appliances used in their erection, exhibited at the Exhibition, and described in a Paper read before the Society of Arts during the Session.

2d, For the best short Descriptive Account of the Exhibition read at the Society of Arts during the Session, showing how it can best be taken advantage of for increasing the knowledge of Architecture both of the Profession and the Public.

Inventions in competition for the first Medal may be added to the Exhibition at any time; and Papers in competition for the Second Medal must be lodged on or before the 1st day of March next, with JAMES TOD, Esq., R.S.S.A., Secretary, 55 Great King Street, Edinburgh; or with CHARLES HEATH WILSON, Esq., Art Secretary to the Exhibition, 93 Bath Street, Glasgow.

26th February 1855.—Edward Sang, Esq., V.P., in the Chair. The following Communications were made:—

1. Description and Drawing of a Railway Lighthouse Signal. By Andrew Carrick, Esq., 14 Holmhead Street, Glasgow. (3625.)

This signal is a stationary clear light, placed at the beginning of any tunnel or curve, or near to a junction. Every passing engine changes the light to a *red colour*, which disappears gradually in ten minutes. The smallest glimpse of red light will caution the conductor of any approaching train that there is danger of running into another train not far in advance. The proximity of the latter to the lighthouse may be estimated from the perpendicular degree of red light observable. Referred to a Committee.

2. Remarks on the Strength of Screw Blades, with Drawings; and Description of an Instrument for measuring the Pitch and proving the correct Form of Screw-Propellers, called a Pitch-Compass, with Drawings. By James Spence, Esq., Chief Foreman of the Steam Factory of her Majesty's Dockyard, Portsmouth. (3606-2-3.)

The author stated that the form, length, diameter, and area of the screw had all been carefully examined and experimented on, and well authenticated data recorded; but he was not aware that so much attention had been paid to the *strength* of the screw blade. Hence we are frequently hearing of accidents from breakage. The author remarks that in all the broken screws they have had in the navy, the fractures have taken place at about one-third of the length of the blade from the boss. The Duke of Wellington's, the Phœnix's, and Sir Thomas Mitchell's Boomerang, all broke at about this point. Hence the peculiar converse form of the blade should be carried well out beyond one-third of the length of the blade. The author then went on to describe a very useful instrument called a pitch-compass, for measuring the pitch and proving the correctness of the form of screw-propellers. This machine was suggested by Mr Rawson, head-master of the School of Shipwright Apprentices at the dockyard. A chuck provides a centre pivot in the exact line of the axis of the screw. A trammel, made in two pieces, for strength and convenience, is filled with two trap bushes, having holes made to fit on the centre spindle of the chuck. It therefore forms a correct moveable base line at right angles to the axis of the screw. The circular plate on the chuck is divided into twelfths of the circumference, that is, the holes in it are thirty degrees apart. The trammel being secured in one of these holes, a measurement is taken from the trammel, as the base line, to the screw blade by means of a moveable pointed rod at right angles to the trammel, and capable of being moved along the trammel as the length of the blade increases. The trammel is then moved to the next hole in the circular plate of the chuck and secured, it having passed through thirty degrees. A second measurement is then taken from the trammel to the screw blade, when the difference in inches between the first and second measurement will be equal to the whole pitch in feet, and so on, so that by indicating the commencement and end of the measurement, by rings clamped on the moveable pointed rod, and measuring the alternate distances between them in inches, we get the whole pitch of the screw in feet. Thanks voted.

3. Report of Committee on Mr Sang's Chronofore. Mr Bryson, Convener. (3612.) Re-committed.

4. Report of Committee on Mr Bow's Smokeless Furnace. Mr Leslie, Convener. (3613.) Read and approved.

5. Report of Committee on Mr Gairdner's Antipodal Land of the Globe. Mr Sang, V.P., Convener. (3587.) Read and approved.

6. Report of Committee on Mr William Hart's Improved Medical Gal-

vanic Apparatus. Dr Douglas Maclagan, Convener. (3615.) Read and approved.

7. Report of Committee on Mr George Taylor's Tool-Holder for the Screwing-Lathe, &c. Mr A. Kirkwood, Convener. (3611.) Read and approved.

The following Donations were laid on the Table, viz. :—

1. Transactions of the Royal Society of Edinburgh, Vol. XXI. Part I. for Session 1853-54. Presented by the Society. (3629.)

2. Proceedings of the Royal Society of Edinburgh, Session 1853-54. Presented by the Society. (3630.)

3. Proceedings of the Institution of Mechanical Engineers, Birmingham, for November 1854. Presented by the Institution. (3628.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

Minutes of last Meeting read and approved.

12th March 1855.—W. A. Roberts, M.D., Councillor, in the Chair. The following Communications were made :—

1. On the Theory of the Driving Belt, Part I. By Edward Sang, Esq., F.R.S.E., V.P. (3635.) Thanks voted.

2. On a method of taking Permanent Impressions of Flowers and Leaves, &c., on Glass, in Ornamental Designs in Glass Staining. By Mr R. Smith, Analytical Chemist, Blackford, Auchterarder. Four illustrative specimens were exhibited.

In order to stain or figure glass by this method, flowers, leaves, or other objects are first wet over on the one side with a solution of gum-arabic, which makes them adhere to the glass. The whole of the glass is then covered over with another composition, consisting of three parts of tallow, one part of bees' wax, and one part of olive oil, melted together, and laid on when in a liquid state ; the objects are removed, and the plate is then submitted to the hydrofluoric acid, which acts on the uncovered parts of the glass, forming beautiful representations of the objects used. If required, the designs thus formed may be coloured in the ordinary way with fluxes containing portions of the oxides of metals. (3632.) Referred to a Committee.

3. Report of Committee on Mr James Clerk Maxwell's Platometer. Professor Kelland, Convener. (3022.) Read and approved.

The following Donations were laid on the Table, viz. :—

From the Smithsonian Institution, Washington, viz. :— (3631-1-9.)

1. Smithsonian Contributions to Knowledge, Vol. VI. (4to. Washington, 1854.)

2. Patent Office Report, U.S., 1851-52, Agricultural (8vo. Washington, 1853).

3. Patent Office do. 1852-53, do.

4. Do. do. Mechanical, 1852-53, do.

5. Do. do. Arts and Manufactures, 1853 (8vo. Washington, 1854).

6. Seventh Annual Report of Board of Regents of Smithsonian Institution, for 1852 (8vo. Washington, 1852, pp. 96.)

7. List of Foreign Institutions in correspondence with the Smithsonian Institution (pp. 19, 8vo).

8. Directions for Collecting, Preserving, and Transporting Specimens of Natural History (8vo, pp. 28). Washington, 1854.

9. Smithsonian Institution, Form for Registering Periodical Phenomena (Folio, pp. 4).

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The Fellows received the Printed Annual Abstract of the Revenue and Expenditure of the Society for Session 1853-54, and State of the Funds.

26th March 1855.—David Rhind, Esq., President, in the Chair. The following Communications were made:—

1. On the Theory of the Driving Belt, Part II. By Edward Sang, Esq., F.R.S.E., V.P. (3635.) Thanks voted.

2. Description of Drawing of an Apparatus for Drawing in correct Perspective any object or landscape. By Rev. William Taylor, Hon. F.R.S.S.A., 73 Oxford Terrace, Hyde Park, London. (3634.)

This apparatus consists of a wooden box, fifteen by twelve inches, and one inch deep. The lid is made, when open, to stand at right angles, and fixed there. On the opposite side of the box a slip of wood is fixed, having a hole at the top through which the eye looks at the object to be copied. Opposite to this parallel tubes are fixed upon the open lid of the box, operating as a photograph; at the upper end of the parallel tubes is a hole through which the eye sees the object to be copied, and this orifice is made to travel along the outline of the object. The other end of the parallel tubes has a pencil fixed in it, which is pressed by a spring to a piece of paper fastened to the inside of the lid by button pins, and which accordingly traces the outline of the object, being the counterpart of the object itself traced by the other end of the parallel tubes. By means of this instrument the author stated that any object or landscape can be more correctly copied than by the camera lucida or any other instrument known to him, that a few trials will be found sufficient to enable a person to use the instrument, and that it has the advantage of being portable, easily made, not difficult to use, and not expensive. Referred to a Committee.

3. Description and Drawings of some new Platometers. By Mr P. M'Farlane, Comrie. (3638.)

4. Report of Committee on Mr George Johnstone's Improvement on the Thrashing Mill. Mr Bertram, Convener. (3596.) Read and approved.

The following Donation was laid on the Table, viz.:—

A four-inch Electro-Magnet, said to have sustained 1500 lbs. weight, made many years ago for the purpose of ascertaining what number of coils would produce the greatest effect with reference to the weight of iron required for these coils; in the course of which experiments it was found that the best relative effect was produced with four coils, and that an *even* was better than an *odd* number of coils. Presented by the inventor, Richard Roberts, Esq., engineer, Globe Works, Manchester, Hon. F.R.S.S.A. (3633.)

Thanks voted to the Donor.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidate was elected an Ordinary Fellow, viz.:—

Frederick Hallard, advocate, Scotland Street.

9th April 1855.—Edward Sang, Esq., V.P., afterwards David Rhind, Esq., President, in the Chair. The following Communications were made:—

1. Description and Drawing of a Self-Acting Feed and Brine apparatus for Marine Boilers. By Mr James Spence, Chief Foreman of the Steam Factory at H.M. Dock-Yard, Portsmouth. (3606-4.)

Sea-water contains salt in the proportion of 1 to 32; to get rid of this salt, which crystallizes very rapidly in the marine boiler, many plans have been adopted. It was an early and long-standing practice to blow off large *indefinite* quantities every four hours. It was then found more economical to pump out, by pumps worked by the steam-engine, a given *proportion* of surcharged or *brine* water. This self-acting feed and brine apparatus is designed to discharge the brine by means of the pressure in the boiler, a *proportionate* quantity, say 2·7 brine to 9·6 feed. The brine valve is in connection with the feed valve, the latter is acted on by the engine, and is opened or shut more or less in proportion as the engines are going slow or fast, or suddenly stopped. The principle on which it is designed is, that the out-going brine is always in proportion to the in-coming feed, however much that may vary. Thanks voted.

2. Description and Drawing of the Condensers used in the Royal Navy for Distilling Fresh Water. By Mr James Spence. (3606–5.)

To convert salt water into *fresh* on board-ship at sea has long been a desideratum. A French steam-cooking galley, constructed so that the fuel expended in cooking should also be used in distilling fresh water, was a few years ago so altered and improved by Mr Grant of the Royal Clarence Victualling Yard that Grant's Galleys were coming into general use in the royal navy. It was afterwards proposed to fix a condenser on board all steam screw-ships, and to connect these condensers with the boilers of the steam-engines. The condensers are placed under the water-line of the ship, when the sea-water is, by a simple arrangement of pipes, allowed to flow round the outsides of a series of small tubes through which the steam is passed, condensed, and run into the tank-hold of the ship, without any manual labour being required in the operation. The proportions of condensing surface in the tubes are, for every 100 men, where one condenser only is used, 20 square feet; where two are used, 16 square feet; the quantity made per hour about 150 gallons, or three tons. Thanks voted.

3. The instrument called the Gyroscope was exhibited in Action, and described by James Elliot, Esq. (3641.)

After alluding to the general interest excited in the theory of rotatory motion within the last three or four years by the famous pendulum experiment of M. Foucault, and by the supposed connexion of the same theory with certain irregularities in the motion of rifle balls, Mr Elliot briefly described the various instruments employed for the illustration of the subject by Bohnenberger, Tessel, Magnus, and Foucault, and showed the greater part of the experiments performed by these parties, at the same time explaining the principle of the composition of rotatory motions, and the different results of that principle under different circumstances. The very beautiful experiment of M. Foucault was described, in which a rotatory disc or siphon, nicely balanced, adjusts itself so as to place its own axis parallel to that of the earth itself, and to bring the direction of its rotation into coincidence with that of the earth; but this result was not attempted to be exhibited, in consequence of the gyroscope employed not being constructed with sufficient delicacy. A similar result, however, was shown, by giving to the disc, when in rotation, a simultaneous revolution round an external centre, when the axis and direction of rotation immediately came into parallelism and coincidence with those of revolution, the one or the other pole rising according as the direction of revolution was from east to west or from west to east. The last-mentioned result Mr Elliot thought *might possibly* be employed to throw some light on the hitherto unexplained facts of the coincidence of the direction of rotation of each planet with that of its revolution,—of the coincidence in the direction of revolution of most of the satellites round their primaries, with that of the primaries themselves round the solar centre,—and, finally, of the general agreement, in the direction of revolution, of all the planets round the sun, that direction probably harmonizing with a revolution of the whole solar system round a remote sidereal centre. An original experiment was shown in illustration of the same theory. A sphere, made hollow from beneath to above its centre, and with a steel axis, was made to rotate with the point of the axis coinciding with the centre of gravity. A magnet was then brought near the upper external part of the axis; but instead of drawing the axis towards it, it produced an incipient rotation *at right angles to the direction of the attracting force.* It was also stated that in a previous experiment a cylindrical magnet, placed vertically, was found to produce a *rotation* of the steel axis round the magnet in an opposite direction to that of the rotation of the ball, and consequently changing with it. The resemblance of the result to the effect produced by a magnet upon a wire conveying an electric current was pointed out, with a hint as to a possible similarity in their causes. The causes of the deflection of a rifle-ball to the right hand, and of the boomerang to the left, as assigned by Magnus and others, were fully explained, but not regarded as altogether satisfactory. For the illustration of the former, the gyroscope, in rotation, was suspended by a string, and when made to swing in the direction of its axis it was found that, invariably, with a left to right rotation, the axis turned towards the right, and with a right to left rotation, the axis turned towards the left. Since rifles are all made with left to right screws, the ball requires a rotation in that direction, and consequently, as Professor Magnus considers, a deflection to the right. That, however, will depend upon the question, whether the resistance of the air has the same tendency as the suspending cord, viz. to raise the advancing extremity of the axis of rotation, and that, again, probably depends on the form of the ball. Thanks were voted to Mr James Bryson for contributing the gyroscope, and to Mr Elliot for his description of it and his interesting experiments.

4. Report of Committee on Mr Sang's Chronofore. Mr Bryson, Convener. (3612.) Read and approved.

5. Report of Committee on Mr Andrew Carrick's Railway Lighthouse Signal. Mr Thornton, Convener. (3625.) Read and approved.

6. Report of Committee on Mr R. Smith's method of taking permanent impressions of Flowers, &c., on Glass for Ornamental Glass-Staining. Dr Stark, Convener. (3632.) Read and approved.

The following Donations were laid on the Table, viz. :—

1. Vertical Section showing the average position of the principal Seams of the Coal and Ironstone in Lanarkshire, with probable corresponding position in other Counties of Scotland. By Ralph Moore, Esq., Mining Engineer, Glasgow. (3673.)

2. First Annual Report of the Directors of the Association for Promoting Improvement in the Dwellings and Domestic Condition of Agricultural Labourers in Scotland, with Practical Hints on Cottage Buildings. By Mr William Fowler, Architect of the Association. Presented by the Association.

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. A List of Prize Subjects for Session 1855–6, prepared by the Council, was submitted and approved, and ordered to be printed and advertised as usual.

III. The Council reported that they had prepared and sent off a Memorial by the Society to the Lords of the Treasury, again earnestly recommending the Ordnance Survey of Scotland to be vigorously proceeded with, on the scale of *six* inches to the mile, and that the engraved map should, in the first instance, at least be on the reduced scale of *one* inch to the mile, with provision for access being given to the six inch plotting, to making tracing for Government or private purposes, and for afterwards engraving a map on the six inch scale if called for. The Society approved.

23*d April* 1855—David Rhind, Esq., President, in the Chair. The following Communications were made :—

1. Various specimens of improved Lithography, and of new applications of that art, were exhibited and described by Messrs Schenck and Macfarlane, lithographers, James' Square, Edinburgh. (3644.) Referred to a Committee.

2. Description and drawing of an improved double-action Force-pump, by Robert Aytoun, Esq., W.S. A working model was exhibited. (3648.)

The inventor's attention was drawn to this subject in consequence of the bad performance of the common double-action force-pump, which was generally found to be inoperative in the *up-stroke*, from the presence of air. He stated that he had succeeded in the present machine in rendering the presence of air harmless, and in making both *down* and *up-strokes* completely effective, at the same time that the machine itself is more simple and less cumbersome. It consists of an ordinary plunger working through a stuffing-box fixed upon the end of a working-barrel. The area of the cross section of the working-barrel is double that of the plunger. Attached to the lower end of this plunger, and working in the barrel, is an ordinary *lifting bucket* with valves. Below the working-barrel is a stationary valve, and below this, again, is the suction-pipe. Near the top of the working-barrel, a bent pipe leads to the bottom of the stand of pumps. The action of the pump is as follows :—The plunger being forced through the stuffing-box into the barrel, displaces its own bulk of water, and sends it through the bent tube into the stand of pipes ; while the lifting bucket, descending with open valves, allows the whole contents of the working barrel to pass through and to get upon its upper side. On the return stroke the whole water in the working barrel is raised by the lifting bucket. One-half of this water serves to fill up the void caused by the simultaneous withdrawal of the plunger, and the other half escapes as before through the bent tube into the stand of pipes. Thus a quantity of water is raised at each half stroke of the engine exactly equal in bulk to the plunger. As the upper part of the working barrel where the stuffing-box is situated has at all times a free communication with the water in the stand of pipes, without the intervention of any valve, it is plain that no air can leak through the stuffing-box into the working-barrel ; and if any air enter through the suction-pipe, or wind-bore, it will at once rise to the top of the working-barrel, where it will assist by its elasticity in maintaining a continuous flow of water, until it find its way through the stuffing-box into the atmosphere.

Mr Landale, M.E., rose and made some remarks in favour of Mr Aytoun's pump, which, he said, had been lucidly described. It was a pump admirably suited for many purposes, particularly where it could be got at readily for renewal of cluck and bucket, such as shafts of moderate depth, where the water would not flow over the working parts, and where the pump rods were neither long nor heavy. Where they were so, the single plunger was preferable, because the column of water to be lifted balanced the rods. In many situations where the engine was near the pump, and for inclined mines under ground, it was an excellent contrivance, and simple in its parts, and a vast improvement over the old four valve double-action solid plunger-pump, which was a troublesome customer, and very often lost the water on one side, and was being very generally abandoned about collieries. Mr Landale said, however, that although he knew his friend Mr Aytoun had really invented it, yet it was not new, as he had had it from Mr Nelson, of Hyde Park, London, some four years before, and he believed that gentleman had got it from some water work in England, which he could not now name; but it could be easily got at. Mr Landale also pointed out one similar in principle, recommended in the last month's *Glasgow Mechanics' Magazine;* but it having two sets of rods, two barrels, and too small an area suction-cluck, it could not be at all compared with the simplicity of Mr Aytoun's pump. But neither was new; both he and his brother had been familiar with them for years; but Mr Aytoun had not the less merit or the less pleasure in inventing it over again. Thanks were voted.

3. Should Lightning-Conductors for the protection of Buildings terminate at the upper extremity in a Point or in a Ball? By J. Stewart Hepburn, Esq., Colquhalzie. (3646.)

A discussion followed, in which Messrs Elliot, Sang, Adie, and Professor Macdonald took part. Mr Elliot maintained that the advantage of pointed terminations to lightning-conductors is so well known (being universally practised and equally universally acknowledged by men of science) that there is no room for doubt on the subject. That (in reply to Mr Hepburn's question, whether a point would present sufficient surface to transmit a large quantity of electricity?) he (Mr Elliot) had ascertained, by experiment on electricity of low intensity, that although a fine wire of considerable length offered an impediment to the transmission of a large quantity, yet that a point, however fine, caused imperceptible diminution of the current passing through it, if the point was not too much elongated, but quickly widened into a conductor of sufficient thickness; that the alleged failure of lightning-rods never occurred when the communication with the ground was perfect, and when not too distant from exposed parts of the building; but that, to ensure the former point, the lower extremity of the rod must be led into a body of wet soil, or connected with the gas or water pipes. Mr Sang maintained that lightning-rods had not the effect of attracting the lightning, but were useful in so far as that when the lightning struck a building, the rod, being the best conductor, gave a free passage to the lightning towards the earth; and hence, that it signified little what was the shape of the apex of the rod, as it would be better still if we could encase the whole building in a metallic coat. Mr Sang further maintained, that experimenting in a laboratory was a very different thing from a thunder-storm, ranging perhaps sixty miles along the clouds, as he had frequently seen it, and that, in point of fact, we knew little or nothing on the subject. Mr Adie stated that practically, in fitting up lightning-rods, he did not trust entirely to the apex of the rod, but connected by metallic straps all the metal work of the building, such as the lightning-rod itself, and the head of the roof, and water-pipes, &c., so as to give free passage to the lightning to the earth from whatever part of the building should be struck. In answer to Mr Sang's remark, that the quantity of electricity in a thunder-cloud was so great that it could not be compared with the ordinary experiments, Mr Elliot said that a battery was in all cases discharged by a point at a much greater distance than by a ball, the size of the battery making no difference whatever; that some batteries have been constructed so large as to make a near approach to containing a flash of lightning; and that Professor Faraday had established the fact that the quantity of electricity in a thunder-cloud was not great. In reply to another objection of Mr Sang's, or Mr Adie's, that it was not likely that a flash of lightning dashing from a cloud would light just on the point placed to receive it, Mr Elliot maintained that Faraday's experiments led to the belief that a flash of lightning does not issue from the thunder-cloud at random, but has its whole course marked out for it before its motion commences, which course is simply the line of least resistance or of greatest tension, whether straight or curved. Mr Hepburn, in a letter to the Secretary, stated that in the view of erecting a lightning conductor, he was led, on consideration, to doubt the efficiency of the conductors usually adopted, terminating in *points;* being contrary to the plan found to be necessary in the management of artificial electricity, in which, while the fluid is *gradually* collected from the excited cylinder by a row of pointed wires attached to the prime conductor, its transmission from the conductor to the battery, and the discharge of the battery itself, is always effected by *balls.* It thus appears that for the absorption and transmission of an accumulated mass of electricity, an *extended surface* is required; and as, in the protection of buildings, it is necessary to provide for the instantaneous absorption of a concentrated mass of electricity darting through the air in the form of a flash or ball, Mr Hepburn conceived that the conductor ought to terminate in one or more pear-shaped *balls*, having a surface sufficient to absorb at least as much of the fluid as the descending rod is capable of conveying to the earth. It remains to be determined whether a large hollow ball or smaller solid one is preferable.

4. Description and Drawimg of a Reversing Turbine. By Mr George Weir, at Messrs Tod & Macgregor's, engineers, Glasgow. A working model was exhibited. (3643.)

This invention was stated to consist of an improvement on the common turbine, which only runs the one way, consequently, when an opposite direction is required, it can only be obtained by the intervention of a clutch and reversing wheels, which method is attended with the danger of breaking down all the gearing connected therewith; whereas the reversing turbine, being supplied with two sets of arms, and a valve so adjusted that it throws the water either into the right-about or left-about arms, or stops it altogether. These evolutions can be easily performed, merely by shifting the lever connected with the valve. Referred to a Committee.

5. Description of a Plan of Stereotype Moulding for Casting Brass Nails, &c., as practised at Portsmouth Dockyard. By Mr James Spence, Chief Foreman of the Steam Factory at H.M. Dockyard, Portsmouth. A model was exhibited. (3600-6.)

This is a contrivance by which the old system of moulding, even the smallest article (by taking out of the sand and manipulating every separate pattern, and where skilled labour is used), is superseded. By this plan of a fixed pattern on a plate carefully fitted up, any number of castings can be produced from the same pattern, by which skilled labour is entirely superseded, the production of small articles especially indefinitely increased, and the quality of the articles produced materially improved. This and the former communications of Mr Spence were referred to a Committee.

6. Suggestions:—1st, For an Improved Construction of Ball-proof Floating Batteries; and 2d, For Steam Tenders or Generators for the Royal Navy, and Mercantile Marine. By John Steane, Esq., Commander, R.N., transport service, Balaklava. Communicated by James MacGilvray, Esq., Ordnance Commissary, Balaklava, Crimea. (3647-1-2.)

7. Report of Committee on Rev. William Taylor's Apparatus for Drawing in Correct Perspective. Mr Sang, V.P., Convener. (3634.)

8. An Interim Report of Committee on Dr Stark's Paper on Writing Inks—Dr Douglas Maclagan, Convener—was read and recommitted. (3620.)

9. Report of Committee on Mr P. Macfarlane's proposed Platometers,—Rev. Professor Kelland, Convener—was read and approved. (3638.)

The following Donations were laid on the Table, viz.:—

1. Transactions of the Institution of Civil Engineers of Ireland, for January 1855, being Mr Heman's Observations on River Walls and Flood Banks in the Upper Rhine, &c. Presented by the Institution. (3639.)

2. Journal of the Geological Society of Dublin, Vol. IV. Part II. No. 2. Presented by the Society. (3640.)

3. The Assurance Magazine and Journal of the Institute of Actuaries, No. XIX., April 1855. Presented by the Institute. (3642.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. Copies of the List of Prize Subjects for Session 1855-56 were distributed. The Fellows were requested to make the List known in their several localities.

III. In terms of Law XX., the Treasurer laid on the Table a List of those Ordinary Fellows who are in arrear of their Annual Contributions.

23d July 1855.—David Rhind, Esq., President, in the Chair. The following Communications were made:—

1. Description of a Hinge for Bank and other Office Doors, acted on

by Weights instead of Springs. By Mr Alexander Steven, Joiner, Bonnyrigg, presently at 6 Preston Street, Edinburgh. A working model was exhibited. (3659.) Referred to a Committee.

The following Reports of Committees were read and approved :—

2. On Dr George Wilson's Paper on Railway and Ship Signals. Mr Swan, Convener. (3616.)

3. On Mr P. Stevenson's Mode of taking the Density of Floating Bodies. Dr George Wilson, Convener. (3617.)

4. On Mr Bryson's Compressible Siphon. Dr George Wilson, Convener. (3624.)

5. On Mr George Weir's Reversing Turbine. Mr Aytoun, Convener. (3643.)

The following Reports not being ready, were ordered to be sent, when lodged, to the Prize Committee, viz. :—

6. On Mr H. Cleland's Boring Machine. Mr D. Stevenson, Convener. (3597.)

7. On Messrs Schenck and Macfarlane's Lithography. Mr Sang, Convener. (3644.)

8. On Mr Spence's Papers on Naval Affairs and Mechanical Appliances in H.M. Dockyards. Mr Lang, Convener. (3606-1-6.)

The following Donations were laid on the Table, viz. :—

1. Proceedings of the Institution of Mechanical Engineers, Birmingham, 24th January 1855. Presented by the Institution. (3649.)

2. Journal of the Geological Society of Dublin, Vol. VI. Part II. (Dublin 1855.) Presented by the Society. (3650.)

3. Two Copies Return ordered by the House of Commons on the subject of James Dowie's Patent Boots, 1852, 1853, 1854. Presented by Mr Dowie, Bootmaker, 455 Strand, London. (3658-1-2.)

4. Transactions of the Architectural Institute of Scotland. Session 1854-55, Vol. IV. Part I. Presented by the Institute. (3660.)

5. Objects and Regulations of the Statistical Society of London. (London 1855.) Presented by the Society. (3661.)

6. List of the Fellows of the Statistical Society of London. (London 1855.) Presented by the Society. (3662.)

7. The Assurance Magazine, in continuation, No. XX. July 1855. Presented by the Institute of Actuaries of London. (3663.)

8. Formal Report of John A. Roebling, C.E., to the Directors of the Great Railway Suspension Bridge at Niagara Falls. 1855. Presented by Thomas C. Gregory, Esq., F.R.S.E., F.R.S.S.A., Resident Engineer, Great Western Railway, Canada West. (3664.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The Society appointed the following Prize Committee to award Prizes for Session 1854-55, viz. :—

David Rhind, Esq., President.
W. A. Smail, Esq., Vice-President.
Alexander Kirkwood, Esq.
David Stevenson, Esq.
William Bertram, Esq.
James Leslie, Esq.
William Swan, Esq.
Rev. Professor Kelland.
Robert Thornton, Esq.
Robert Aytoun, Esq.
Professor Gregory.
Dr Douglas Maclagan.
The Secretary, *ex-officio* Convener.

The Society adjourned till next Session.

APPENDIX (P*).

LIST OF PRIZE SUBJECTS FOR SESSION 1855-56.

THE ROYAL SCOTTISH SOCIETY OF ARTS proposes to award Prizes of different values, of Thirty Sovereigns and under, in Gold or Silver Medals, Silver Plate, or Money, for approved Communications *primarily* submitted to the Society, relative to Inventions, Discoveries, and Improvements in the *Mechanical* and *Chemical* Arts in general, and in their relation to the Fine Arts, and also to means by which the *Natural Productions* of the Country may be made more available; and, in particular, to—

I. INVENTIONS, DISCOVERIES, or IMPROVEMENTS in the Useful Arts; such as, but not limited to, the following, viz.:—

1. *Mechanical Arts.*

INVENTIONS or IMPROVEMENTS in Flax Machinery, and in preparing Flax for manipulation,—in the construction of Fire-Proof Buildings,—in applying Glass to new and useful purposes,—in methods of uniting the Joints of Glass or Earthenware Water-Pipes, without employing White Lead or other poisonous substance,—in Sewerage,—in Economical Appliances for increasing the Sanitary Condition of Towns,—in Methods of Warming and Ventilating Buildings,—in Ventilation of Mines,—in constructing Economical and Salubrious Dwellings for the Working-Classes,—in Extinguishing Fires,—in Locks,—in Tools, Implements, and Apparatus for the various Trades,—in Rifle Guns and Bullets,—in Bricks,—in Cements and Mortars,—in Machines for Planing Wood,—in Printing Machines, Cases, and Rollers,—in Stereotyping,—in Cranes,—

in the Machinery for Collieries, &c.,—in preserving Timber and Metals in Marine Works,—in Locomotive, Stationary, and Marine Engines,—in Screw Propellers,—in Railways, Plant, and Signals,—in Machines for Cutting, Dressing, and Boring Stone,—in Microscopic Apparatus,—in Steel or other Metallic Pens,—in new or improved Motive Power,—in the construction of Cameras and other Apparatus used in Photography,—in the Temperature Correction of the Aneroid Barometer, &c. &c.

2. *Chemical Arts.*

Inventions or Improvements in methods of rendering the Electric Light available in practice, particularly in the Illumination of Mines, &c. &c.,—in new and useful applications of Gutta Percha and Vulcanized India Rubber, or similar Gums,—in substitutes for, or improvements upon, the process of Vulcanizing India Rubber,—in Dyes, and in their economical extraction from Dye Woods, &c.,—in Paints,—in Paper,—in Glass,—in Writing Inks,—in the Manufacture of Hats.

3. *Relative to the Fine Arts.*

Inventions or Improvements in Photographic processes, and their application to taking Microscopic objects and machinery,—in Electrotype processes,—in Die-sinking,—in methods of illustrating Books to be printed with the letterpress,—in Paper Hangings,—in Articles of Porcelain, Common Clay, or Metal,—in Glass Staining,—in Engraving on Stone,—in Chromatic Lithography.

4. *Natural Productions.*

Discovery of Plumbago in the United Kingdom or Colonies, or a good substitute for it, equal to that of Cumberland.

II. Experiments applicable to the Useful Arts.

III. Communications of Processes in the Useful Arts practised in this or other Countries, but not generally known.

IV. Practical Details of Public or other Undertakings of National importance, already executed, but not previously published;—or valuable suggestions for originating such undertakings.

KEITH PRIZE, value Thirty Sovereigns.

For some important "Invention, Improvement, or Discovery, in the Useful Arts, which shall be primarily submitted to the Society" during the Session.

REID AND AULD PRIZES.

For the First, Second, and Third best Models of "anything new in the Art of Clock or Watch Making, by Journeymen or Master Watch and Clock Makers,"—if these should be considered worthy of Prizes,—the sum of TEN SOVEREIGNS, divided among them in such proportions as the Prize Committee shall fix, according to merit.

GENERAL OBSERVATIONS.

Communications lodged *in competition for Prizes* shall not have been Patented, nor have been previously published, nor read before any other Society. Patent articles may, however, be *exhibited* and described.

The Descriptions of the various inventions, &c., must be *full* and *distinct*;—be legibly written on *Foolscap* paper, leaving margins at least one inch and a-half broad, on *both sides of the writing on every page*, so as to allow of their being bound up in volumes; and, when necessary, be accompanied by *Specimens, Drawings, or Models.* All drawings to be on *Imperial* Drawing Paper, unless a larger sheet be requisite. The Drawings to be in *bold* lines, not less than a quarter of an inch thick, or *strongly coloured*, so as to be easily seen at about the distance of thirty feet when hung up in the Hall of Meeting, and the Letters or Figures of Reference to be at least $1\frac{1}{2}$ inch long. When necessary, smaller and more minutely detailed Drawings should accompany the larger ones, for the use of the Committees, having the same letters or figures of reference.

The Society shall be at liberty to publish in their Transactions copies or abstracts of all Papers submitted to them. All Models, Drawings, &c., for which Prizes shall be given, to be held to be the property of the Society ; the Value of the Model, &c., being separately allowed for.

Communications, Models, &c., are to be addressed to James Tod, Esq., the Secretary, 55 Great King Street, Edinburgh, Postage or Carriage paid; and they are expected to be lodged *on or before* 1*st November* 1855, in order to insure their being read and reported on during the Session (the ordinary Meetings of which commence in November 1855 and end in April 1856) ; but *those which cannot be lodged earlier*, will be received up to 1st April 1856 ;—those lodged after that date may not be read or reported on till the following Session.

By order of the Society,

James Tod, *Secretary*.

Edinburgh, 9*th April* 1855.

APPENDIX (Q*).

REPORT

OF

THE COMMITTEE

APPOINTED BY

THE ROYAL SCOTTISH SOCIETY OF ARTS

TO AWARD PRIZES FOR COMMUNICATIONS READ AND EXHIBITED DURING SESSION 1854–55.

Your COMMITTEE having met and carefully considered the various Communications laid before the Society during the Session 1854–55, beg leave to report that they have awarded the following Prizes:—

1. To GEORGE WILSON, M.D., F.R.S.E., Professor of Technology in the University of Edinburgh,—for his "Researches on Chromato-Pseudopsis, or Colour-Blindness, especially in relation to the danger attending the present system of Railway and Marine Signals." Read on 14th March and 20th November 1853, 19th June 1854, and 8th January 1855, and printed in the Society's Transactions. (3496, 3539, 3586, and 3616.)

   The KEITH PRIZE, *value Thirty Sovereigns.*

   Note.—The Society, considering the great importance of this subject, has also circulated at its own expense among the Railway Companies a reprint of Professor Wilson's Paper from its Transactions.

2. To Mr HUGH CLELAND, Smith at Craigleith Quarry, near Edinburgh,—for his "Description of an Improved Boring Machine for Blasting Rocks." Read and Model exhibited 27th Nov. 1854. (3597.)

   The Society's Silver Medal, value Ten Sovereigns.

   The Committee have also made an allowance for the model.

3. To Mr James Spence, Chief Foreman in the Steam Factory at Her Majesty's Dockyard, Portsmouth,—for his

(1.) "Sketch of the Rise and Progress of the Royal Steam Navy, with a few practical suggestions, growing out of a practical superintendence of the Steam Factory at Her Majesty's Dockyard, Portsmouth, during fourteen years." (3606.)

(2 and 3.) "Remarks on the Strength of Screw Blades, with Drawings; and description of an Instrument for measuring the Pitch and proving the correct Form of Screw-Propellers, called a Pitch Compass, with Drawings." (3606–2 and 3.)

(4.) "Description and Drawing of a Self-Acting Feed and Brine Apparatus for Marine Boilers invented by him." (3606–4.)

(5.) "Description and Drawing of the Condensers used in the Royal Navy for Distilling Fresh Water." (3606–5.)

Read and exhibited 22d January, 26th February, and 9th April 1855.

The Society's Silver Medal, value Ten Sovereigns.

4. To Mr Peter Stevenson, Philosophical Instrument Maker, Edinburgh,—for his "Description of an Instrument for taking the Density of Floating Bodies." Read and exhibited 8th January 1855. (3617.)

The Society's Silver Medal, value Seven Sovereigns.

5. To Mr George Weir, at Messrs Tod and M'Gregor, Engineers, Glasgow,—for his "Description and Drawing of a Reversing Turbine." Read, and Working Model exhibited, 23d April 1855. (3643.)

The Society's Silver Medal, value Five Sovereigns.

The Committee have also made an allowance for the Model.

6. To Mr Alexander Steven, Joiner, Bonnyrig,—for his "Description of a Hinge for Bank and other Office Doors, acted on by Weights instead of Springs." Read, and Working Model exhibited, 23d July 1855. (3659.)

The Society's Silver Medal, value Five Sovereigns.

The Committee have also made an allowance for the Model.

7. To Mr William Hart, Philosophical Instrument Maker, Young Street,—for his "Improved Medico-Galvanic Bat-

tery, with regulating Index giving more or less power." Exhibited 8th January 1855. (3615.)

The Society's Silver Medal, value Five Sovereigns.

8. To Mr George Taylor, Imperial Mint, Constantinople,—for his "Description and Drawing of a Tool-holder, applicable particularly to the Screwing Lathe." Communicated by Edward Sang, Esq., *V.P.* Read and exhibited 27th November 1854. (3611.)

The Society's Silver Medal.

9. To Mr Alexander Bryson, F.G.S., Edinburgh,—for his "Notice of a simple Compressible Syphon," invented by him. Read and exhibited 22d January 1855. (3624.)

The Society's Silver Medal.

Your Committee recommend, that while the *Thanks* of the Society are justly due to all those gentlemen who have sent Communications, the *Special Thanks* of the Society be given to the following gentlemen, viz. :—

1. To Edward Sang, Esq., F.R.S.E., Vice-President,—
   (1.) For his "Exposition of the Arts and Manufactures, and Social Condition of Turkey." Read 13th November and 12th December 1854, and 12th February 1855. (3608.)
   (2.) For his paper "On the Theory of the Driving Belt." Read 12th and 20th March 1855. (3635.)
   (3.) For his "Design for a Chronofore, or Improved Hack-Watch, for minutely subdividing a Second." Read 27th November 1854. (3612.)
   The Committee request Mr Sang to complete the Instrument thus designed by him, having no doubt it will answer the purpose intended.

2. To James Clerk Maxwell, Esq. Fellow of Trin. Coll., Camb.,—for his "Paper and Drawings of a new form of the Platometer; an instrument for ascertaining the area of plane surfaces." Read and exhibited 22d January 1855. (3622.)
   The Committee have also made a grant to him of Ten Pounds towards constructing the Instrument.

3. To Messrs SCHENCK and MACFARLANE, Lithographers, Edinburgh,—for their "Specimens of Improved Lithography," and the excellence of their execution. Exhibited 23d April 1855. (3644.)

4. To JAMES GARDNER, Esq., Edinburgh,—for his paper "On the Antipodal Land of the Globe,—its positions and its proportion to the whole land of the Earth's Surface." Read, and Illustrations exhibited, 11th December 1854. (3587.)

5. To Mr GEORGE JOHNSTON, Craigleith Hill House,—for his "Description of the Improvement of a Thrashing Mill." Read 27th November 1854. (3596.)

6. To ROBERT H. BOW, Esq., C.E.,—for his Paper "On a Smokeless Furnace." Read 12th December 1854. (3613.)

7. To Colonel GRAHAM GRAHAM, of Jarbruck, Moniaive, Dumfriesshire,—for his "Projects for the introduction of, 1st, A New Species of Fuel; 2d, A New Species of Manure." Read 11th December 1854. (3595.)

Your Committee have to remark, that a Paper upon Writing Ink was read by JAMES STARK, M.D., F.R.S.E. (3626), giving an account of his laborious and interesting experiments on the best composition for that valuable liquid; but as the Committee appointed to report upon the Paper has given in merely an interim report, craving longer time in order to test the permanence of the colour of the different kinds of ink, your Committee have no alternative but to postpone consideration of Dr STARK's Paper, thanking him, in the meantime, for the great labour and pains bestowed by him on his multiplied experiments.

All which is humbly reported by

JAMES TOD, *Sec., Convener ex officio.*

SOCIETY'S HALL, 51 GEORGE STREET,
19*th October* 1855.

APPENDIX (R.*)

LIST

OF THE

OFFICE-BEARERS AND FELLOWS

OF THE

ROYAL SCOTTISH SOCIETY OF ARTS.

AS AT 1st NOVEMBER 1855.

THE QUEEN, PATRONESS.

OFFICE-BEARERS FOR SESSION 1854–55.

President, DAVID RHIND, Esq., F.R.S.E.
Vice-Presidents, EDWARD SANG, Esq.; WILLIAM A. SMAIL, Esq., of Overmains, R.N.
Secretary, JAMES TOD, Esq., F.R.S.E., W.S., 55 Great King Street.
Treasurer, JOHN SCOTT MONCRIEFF, Esq., Acct., 20 India Street.

Ordinary Councillors.

*WILLIAM PATERSON, Esq., C.E.
*THOMAS STEVENSON, Esq., F.R.S.E., C.E.
*DAVID LANDALE, Esq., M.E.
*DAVID COUSIN, Esq.
DAVID STEVENSON, Esq., F.R.S.E., M.I.C.E.
ROBT. RITCHIE, Esq., C.E., A.I.C.E.
GEORGE WILSON, M.D., F.R.S.E.
WILLIAM A. ROBERTS, M.D.
Rev. PROFESSOR KELLAND, M.A.
WILLIAM SWAN, Esq., F.R.S.E.
H. W. NACHOT, Ph.D.
JAMES ELLIOT, Esq,

Editor of Transactions, GEORGE WILSON, M.D., F.R.S.E.
Curator of Museum, Mr ALEXANDER JAMIESON.
Medallist, Mr ALEXANDER KIRKWOOD.
Officer and Collector, Mr HUGH JOHNSTON.

(The four Ordinary Councillors marked * retire by rotation.)

LIST OF THE ORDINARY FELLOWS,

AS AT 1st NOVEMBER 1855.

1822. Abercorn, The Most Noble the Marquis of, K.G.
,, Aberdeen, The Right Hon. the Earl of, K.T.
,, Alison, W. P., M.D., F.R.S.E.
,, Adie, Alexander, F.R.S.E.
1826. Aytoun, Robert, W.S.
1837. Aikman, George, engraver.
,, Alves, H. S., 9 Regent Terrace.
,, Alexander, William, F.R.S.E., W.S.
1838. Adie, John, optician, F.R.S.E.
1841. Anderson, Charles W., merchant.
1843. Anderson, John, Pratis, Fife.
1846. Alexander, James, wine-merchant.
1847. Abbott, Francis, Sec. G. P. O.
1850. Anderson, Thomas, Professor, F.R.S.E., Glasgow.
,, Adie, A. J., F.R.S.E., C.E., Linlithgow.
1851. Archer, William, solicitor, London.
,, Alexander, Wm., M.E., Glasgow.
,, Anderson, William, Islington, London.

1822. Buccleuch and Queensberry, His Grace the Duke of, K.G., A.M., F.R.SS. L. & E.
,, Brewster, Principal Sir David, K.H., D.C.L., F.R.SS. L. & E.
,, Bald, Robert, F.R.S.E., Alloa.
1826. Brisbane, Sir Thomas Makdougall, Bart., G.C.B., President R.S.E.
1830. Bonar, William, F.R.S.E.
,, Brown, Robert, junior, architect.
1832. Black, Alexander, architect.
,, Bryce, David, architect.
1835. Borthwick, James, manager N. B. Insurance Company.
,, Berkely, Frederick H.
,, Burn, William, F.R.S.E., architect.
1836. Bryson, Alexander, watchmaker.
,, Ballantyne, James, of Holylee.
1837. Bell, John Beatson, W.S.
1838. Beattie, Alexander, Star Hotel.
,, Blanshard, Lieut. Col. Thomas, R.E.
1839. Brown, Thomas, architect.
1840. Brown, James, accountant.
,, Berwick, David.
1844. Bell, J. A., architect.
,, Baillie, William R., W.S.
1845. Bowie, William.
1846. Buist, George, LL.D., Bombay.
,, Beattie, George, builder.
1847. Bernard, Thomas, brewer.
1848. Brebner, Alan, engineer.
1849. Bouch, Thomas, C.E.
,, Burn, Robert, engineer.
1850. Black, Rev. Archibald P., A.M., London.
,, Blyth, Benjamin Hall, C.E.
,, Bell, Alex. Melville, Prof. of Elocution.
,, Bruce, George Cadell, C.E.
,, Bryden, Adam, bell-hanger.
1851. Bryden, John, bell-hanger.
,, Black, John Trafalgar, Surrey.
1853. Bow, Robert H., C.E.
,, Bell, D. C., Prof. of Elocution, Dublin.
1854. Bertram, William, millwright.

1822. Clerk, Sir George, Bart., M.P., F.R.S.E.
,, Cunningham, Charles, W.S.
1827. Chalmers, Charles.
,, Crawfurd, William, of Cartsburn.
1832. Craig, Sir William Gibson, of Riccarton, F.R.S.E.
1834. Campbell, Alexander, brewer.
1836. Cowan, Charles, M.P., Penicuik.
1837. Cowan, Alexander, papermaker.
,, Cooper, Wm., glass-manufac., Canada.
1840. Christie, Robert, accountant.
,, Crosbie, George,
,, Cormack, David, S.S.C.
,, Carstairs, Drysdale, Liverpool.
1841. Cowan, James, M.D., surgeon R.N.
,, Cameron, Captain Charles.
,, Curriehill, Hon. Lord.
1845. Cay, John, F.R.S.E., advocate.
1846. Callender, J. A.C. C.E., Canada.
1847. Campbell, John Archibald, F.R.S.E.

1847. Cousin, David, architect.
1848. Craig, Rev. John, D.D., St Andrews.
1849. Clark, Thomas, M.D., Whitburn.
1850. Campbell, William, C.E.
1851. Cormack, James, ironmonger.
„ Cunningham, George, C.E.
„ Craigie, Henry, W.S., Falcon Hall, Morningside.
„ Cadell, Henry, M.E., Dalkeith.
1852. Crichton, And., LL.D.
„ Craig, Archibald R., London.
1854. Currie, Peter, 13 Gayfield Square.

1822. Davidson, Robert, of Ravelrig.
„ Dunlop, Arch., F.R.S.E., London.
1838. Dunlop, Andrew, W.S.
1843. Dove, James, engine-maker.
1844. Dickson, James Jobson, accountant.
„ Dunn, Thomas, optician.
1846. Donaldson, J., advocate, Prof. of Theory of Music.
1848. Duff, Rev. Henry, South Leith.
1849. Drury, Rev. Robert, Surrey.
1850. Davidson, Samuel D., Leith Eng. Works.
„ Dickson, John, junior, gunmaker.
1851. Duncan, James, M.D.
„ Dawson, Charles, London.
„ Dawson, John, distiller, Linlithgow.
„ Duncan, Jas., M.A., Southampton.
„ Drummond, Geo. A., builder.
1853. Davis, Rev. Nathan, London.
1854. Douglas, Sir Geo. Scott, Bart., Kelso.
„ Dale, Randall P., designer.
„ Dalgleish, John, teacher.
„ Dauglish, John, 7 Fingal Place.
1855. Dunn, Thomas, S.S.C.

1828. Ellis, Adam Gib, M.W.S., W.S.
1839. Ellis, Thomas, upholsterer.
1843. Erskine, Daniel, Glasgow.
1853. Elliot, James, teacher of mathematics.

1822. Forbes, George, F.R.S.E.
„ Fyfe, Prof. A., M.D., F.R.S.E., Aberdeen.
1828. Fraser, Robert, 18 Dublin Street.
1832. Forbes, Prof. J.D., F.R.SS.L. & E.
1838. Fergusson, Lieut.-Col., H.E.I.C.S.
1840. Fleming, Alexander, W.S.
„ Forrester, John, W.S.
1843. Falkner, James P., solicitor.
1844. Foulis, Sir Wm. Liston, Bart., Hermiston.
1847. Fullarton, John A., publisher.
1849. Fraser, J.S., engineer, Gt. Western Rail.
1850. Ferguson, William B., C.E., Aberdeen.
„ Falshaw, James, C.E., Perth.
„ Fraser, Alexander, printer.
1851. Forbes, William, London.
1854. Foster, Alex. F., A.M.

1822. Graham, Humphrey, W.S.
1829. Græme, James, W.S., yr of Garvoch.
1832. Gray, James, ironmonger.
1835. Groat, A. G., of Newhall, advocate.
1836. Greig, Thomas (late printer), Elie.
1842. Gillespie, John, W.S.
1844. Girdwood, John, North Wales.
„ Gregory, Prof. William, M.D., F.R.S.E.
1848. Gardner, James, Torphichen Street.
1850. Glennie, George, C.E., Melrose.
„ Gowans, James, builder.
„ Gregory, Thomas Currie, C.E., America.
„ Gordon, James, jun., W.S.
1851. Gordon, John T., F.R.S.E., Sheriff of Mid-Lothian.
„ Gordon, James Newell, London.
1852. Gilkison, Robert, jun., of Blackburn, merchant, Glasgow.
1853. Graham, Rev. Wm., Newhaven.
1854. Girdwood, Robert, merchant.

1829. Horne, Archibald, of Inverchroskie.
1833. Hamilton, Alex., LL.B., F.R.S.E., W.S.
1834. Hamilton, John, W.S.
„ Horsburgh, Robert, Tongue House.
1835. Hay, James, merchant, Leith.
1836. Haldane, James, brassfounder.
„ Hepburn, J. Stewart, of Colquhalzie.
1837. Hopkirk, J. G., LL.B., W.S.
1838. Hunter, Richard, H.E.I.C.S.
1839. Hill, Lawrence, jun., C.E., Glasgow.
„ Hill, Henry David, W.S.
1840. Harvey, George, R.S.A., histor. painter.
1841. Hope, David T., C.E.
1843. Henry, Jardine, writer.
1845. Hay, David Ramsay, F.R.S.E.
1850. Henderson, John, C.E., Leeds.
1852. Hunter, David, chemist.
„ HAMILTON and BRANDON, His Grace the Duke of
„ How, And. Peddie, engineer, London.
„ Hosie, James, coalmaster, Bathgate.
1853. Hay, Geo. W., of Whiterig, Melrose.
1854. Henderson, Henry, Lasswade.
1855. Hallard, Fred., sher.-sub. Edinburgh.

1854. Ivison, Thos. P., C.E.

1822. Jardine, James, F.R.S.E., C.E.
1840. Johnston, Alex. K., F.R.S.E., geographer to the Queen.
1848. Jefferiss, Robert R., M.D., Dalkeith.
1850. Jardine, William Alexander, C.E.
„ Jopp, Charles, C.E.
„ Johnstone, William, C.E., Glasgow.
1854. Johnston, J. K., teacher of mathematics
„ Jackson, Ed. jun., B.A., Oxon.

1822. Keith, James, M.D., F.R.S.E.
1836. Kirkwood, Alexander, die-cutter.
1839. Kennedy, William, W.S.

1842. Kronheim, Jos. M., ornamental designer, London.
1844. Kinloch, Alex. J., M.D., Aberdeen.
1845. Kennedy, John, jun., W.S.
1848. Kirkwood, James, goldsmith.
1850. Kelland, Rev. Phil., M.A., F.R.SS.L.&E., Professor of Mathematics.
1851. Kirkwood, Robert, C.E.

1834. Lawrie, William A., W.S.
1836. Lees, George, LL.D., St Andrews.
„ Lawson, Charles, of Borthwick Hall.
1838. Lorimer, George, builder.
1840. Leburn, Thomas, S.S.C.
1842. Leith, Samuel, lithographer.
1850. Leslie, James, C.E.
„ Lees, Henry, secretary E. P. & D. Ry.
„ Lessels, John, architect.
1851. Lee, Alexander H., C.E.
„ Lawson, W. J., manager Argus Life Co., London.
1852. Landale, Robert, of Pitmedden.
„ Landale, David, M.E.
„ Lorimer, James, C.E.
1853. Levy, Michael A., 21 Claremont Crescent.
1854. Livingston, Allan, junior, Portobello.

1822. Maconochie, Alexander, of Meadowbank, F.R.S.E.
„ More, Professor John S., F.R.S.E.
„ Murray, Hon. Lord, F.R.S.E.
1826. Maxwell, John Clerk, F.R.S.E., Gleanlair.
1829. Millar, John, C.E., F.R.S.E.
1831. Macdonald, William, of Powderhall.
1835. Marjoribanks, Gilbert, Australia.
1836. Milne, James, brassfounder.
„ Mackay, James, goldsmith.
1838. Macgibbon, Charles, builder.
„ Morton, Hugh, engineer.
„ Maclagan, David, M.D., F.R.S.E.
„ Moncrieff, John Scott, acct., *Treasurer*.
„ Mackenzie, James, W.S.
„ Murdoch, J. B., of Gartincaber, F.R.S.E.
1839. Macbrair, D. J., S.S.C.
„ Maclagan, Douglas, M.D., F.R.S.E.
1840. Murray, James T., W.S.
1841. Maitland, John, accountant.
„ Macpherson, Charles, printer.
1843. Marshall, G. H., jeweller.
„ Melville, John, W.S.
„ Murray, Sir W. K., Bart. of Ochtertyre.
1846. M'Dowall, John, engineer, Johnston.
„ Middleton, Captain J., Waltham Lodge.
„ Mortimer, Thomas E., gunmaker.
1847. Macadam, John, M.D., Melbourne.
1848. Milne, John Kolbe, dressing-case maker
„ Macfarlan, John F., druggist.
„ Mackenzie, Rev. Kenneth, Bo'ness.
„ Mitchell, Graham Alexander, Whitburn.
1850. Mackay, John M., chemist and druggist.
„ Melville, James M., W.S.
„ Martin, George, Glasgow.
„ Macintosh, James A., wood-engraver.
„ Mackay, Charles, goldsmith.
„ Moffat, William L., architect.
„ Mein, Archd., M.D., surgeon and dentist.
„ Mitchell, John M., merchant, Leith.
„ Marjoribanks, William, merchant.
„ Marshall, William, accountant.
„ Miller, Colin M., M.D.
„ Macpherson, Alexander, plumber, Leith.
„ Macdonald, D., cotton-spinner, Aberdeen.
„ MacGillivray, J., Royal Artily, Woolwich.
1851. Middleton, J., M.D., Lic.R.C.S.E.
„ Maitland, Sir A. Gibson, Bart.
1852. M'Farlane, Wardlaw, chemist.
„ Moffat, John, C.E., Ardrossan.
„ Morton, John L., civ. and agr. engineer.
1853. Miller, And. M., merchant.
„ Moodie, Alex. Craig, publisher.
„ Mouat, John, C.E.
1854. M'Farlane, Patrick, Comrie.
„ Morrison, Adam, S.S.C.
„ Mitchell, Graham, V.S.
1855. Mossman, Adam, jeweller.

1832. Nasmyth, James, jeweller.
1838. Nachot, H.W., Ph.D., teacher of German.
1846. Newlands, James, architect, Liverpool.
1850. Newbigging, Patrick, M.D., F.R.C.S.E.

1848. Oliver, Robert S., hatter.
1850. Ogilvie, Archibald, merchant.
1852. Orrock, Jas., surgeon and dentist.

1822. Playfair, W. H., F.R.S.E., architect.
1833. Ponton, Mungo, F.R.S.E., W.S.
1840. Pearson, Charles, accountant.
1842. Pyper, Hamilton, advocate.
„ Paterson, George, of Castle Huntly.
1844. Paterson, John, Leith Docks.
1846. Pattison, Thomas, M.D.
„ Paterson, W., Scot. Cent. Ry. Perth.
1847. Purdie, Thomas, decorator.
1848. Peddie, John D., architect.
1854. Page, David, F.G.S. 30 Gilmour Place.

1822. ROSEBERY, The Right Hon. the Earl of, K.T.
1829. Reid, David B., M.D., F.R.S.E., London.
1834. Ritchie, R., C.E., Assoc. Inst. C.E.
1835. Russell, J. Scott, M.A., F.R.SS. L. & E.
„ Ranken, Francis, glass-manufacturer.
1838. ROXBURGHE, His Grace JAMES H. R., Duke of, K.T.
1839. Russell, Thomas, ironmonger.
1840. Rose, Alexander, lecturer on geology.
1842. Rankine, W. J. Macquorn, F.R.S.E., C.E.
1843. Rhind, David, F.R.S.E., architect.

1843. Roberts, W.A., M.D., dentist & surgeon.
1844. Ronaldson, John, writer.
1846. Robb, Charles, silversmith.
1848. Reid, Robert Little, painter.
1850. Ramsay, Alex., manager Edin. Water Co.
„ Rae, William Fraser, brassfounder.
„ Richardson, James, merchant.
„ Richardson, Robert, merchant.
„ Robson, Neil, C.E., Glasgow.
1851. Rogers, James, ironmonger.
„ Ross, William, of Greenside.
1853. Rose, John T., shipbuilder, Leith.
„ Ritchie, And., watchmaker.
1854. Rutherfurd, John, W.S.
„ Robertson, James, C.E., E. P. & D. Ry.
„ Robson, Thomas W. E., teacher.

1828. Sang, Edward, F.R.S.E.
1832. Sclater, Robert, die-cutter.
1833. Steele, Wilkinson, merchant.
1835. Steele, Patrick S., merchant.
1838. Stevenson, David, F.R.S.E., C.E.
„ Seeligmann, F.E., punch-cutter, London.
1839. Smith, David, F.R.S.E., W.S.
1840. Sprot, Thomas, W.S.
„ Stevenson, Peter, philos. instrum. maker
1841. Steuart, Robert, of Carfin.
„ Simson, George, R.S.A., artist.
„ Steell, John, R.S.A., sculp. to the Queen.
1842. Spence, Charles, S.S.C.
„ Smail, Will. Arch., of Overmains, R.N.
1843. Sanderson, James H., lapidary.
„ Schenck, Frederick, lithographer.
„ Shanks, Thomas, engineer, Johnston.
1846. Swan, Wm., F.R.S.E., teacher of math.
„ Simpson, Prof. J. Y., M.D., F.R.S.E.
„ Spence, James, W.S.
„ Seller, William, M.D., F.R.C.P., F.R.S.E.
1847. Steuart, James, W.S.
„ Stevenson, Thomas, F.R.S.E., C.E.
„ Sclanders, Alexander, upholsterer.
1850. Smith, Alexander, C.E., Aberdeen.
„ Swan, Alex., manufacturer, Kirkcaldy.
„ Stewart, James W., C.E.
„ Stark, James, M.D., F.R.C.P., F.R.S.E.
„ Scrymgeour, Henry, upholsterer.
„ Sinclair, Alex., manager Shotts Foundry.
„ Scott, Archibald, architect.
„ Smith, Robert, builder.
„ Sibbald, Thomas, ironmonger.
„ Strachan, Robert, accountant.
„ Smith, George C., land-surveyor, Banff.
1851. Smith, R., eng., gov., City Workhouse.
1851. Simpson, Geo., C. and M.E., Glasgow.
„ Seton, Major, R.S., Madras Artillery.
„ Stewart, Robert, of Omoa.
1852. Sutter, Archd., land-surveyor.
1853. Sheperd, Jas., accountant, Portobello.
„ Smith, William, engineer, Melbourne.
„ Smith Alex. K., C.E., Australia.
1854. Stewart, John, 28 Abercromby Place.
„ Small, John, University Library.
„ Shortt, John, M.D., Madras.
„ Syme, Jas. George, 111 Princes Street.

1822. Tweeddale, The Most Noble the Marquis of, K.T., F.R.S.E.
1826. Tod, James, F.R.S.E., W.S., *Sec.*
1830. Tod, Henry, W.S.
1836. Traill, Prof. Tho. Stewart, M.D., F.R.S.E.
1839. Thomson, William T., manager Standard Life Assurance Company.
1840. Trevelyan, Sir Walter C., Bart., F.R.S.E.
„ Turnbull, William, Royal Bank.
1846. Trevelyan, Arthur, of Pencaitland.
„ Thornton, Robert, engineer.
1851. Turner, Richard, engineer, Dublin.
„ Tennant, John, St Rollox, Glasgow.
„ Tennant, Charles, St Rollox, Glasgow.
1852. Thomson, Jas. Boyde, M.I.M.E., Glasgow.
1854. Thomson, J. T., F.R.G.S., Singapore.

1843. Veitch, John, baker.

1822. Whytock, Richard, merchant.
1836. Wright, Robert, architect.
1838. Wilkie, John, of Foulden.
„ Wilson, Patrick, architect.
1840. Wood, William, surgeon.
„ Watson, Henry George, accountant.
„ Walker, William, surgeon and oculist.
1845. Wilson, Prof. George, M.D., F.R.S.E.
„ Wilson, Prof. Daniel, LL.D., Canada.
1846. Whitelaw, James, watchmaker.
1850. Wright, George, jun., merchant, Leith.
„ Webster, Andrew, S.S.C.
„ Winton, John G., engineer, Newhaven.
1851. Willet, John, C.E., Aberdeen Railway.
1852. Wighton, Rob. K., jeweller.

1847. Young, Archibald, cutler.
1848. Young, William D., manuf. ironmonger.
1853. Young, James, chemical manufacturer, Murrayfield.

Total Ordinary Fellows, 384

The following ORDINARY FELLOWS, included in the foregoing List, are ordered to remain, till they return to Scotland, in the following

SUSPENSE LIST.

1844. William Cooper, glass-manufacturer, late of Picardy Place, Edinburgh, and now in Canada.
,, Joseph M. Kronheim, ornamental designer, London.
1845. Lieut.-Col. Blanshard, R.E., Mauritius.
1846. George Buist, LL.D., Bombay.
,, Mungo Ponton, F.R.S.E., 11 Lansdowne Place, Clifton.
1849. F. E. Seeligmann, punch-cutter, London.
1851. John S. Fraser, Swindon Station, Great Western Railway.
1852. Thomas C. Gregory, C.E., America.
,, Colin Miller, M.D., late of Edinburgh.
1853. James Newlands, C.E., superintendent of works, Liverpool.
,, David T. Hope, C.E., late of Liverpool.
1854. Dr Daniel Wilson, Professor, Canada.
,, J. T. Thomson, C.E., Government Surveyor, Singapore.
,, J. A. Callender, C.E., Canada.
,, John Macadam, M.D., Surgeon, late chemist, Glasgow, now lecturer on Nat. Science, Free Seminary, Melbourne, Australia.

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APPENDIX (S.)

PROCEEDINGS OF THE ROYAL SCOTTISH SOCIETY OF ARTS, SESSION 1855-56.

SESSION XXXV.

The Annual General Meeting of the Royal Scottish Society of Arts was held in their Hall, 51 George Street, on Monday, 12th November 1855,—David Rhind, Esq., F.R.S.E., President, in the Chair. The following Communications were made:

1. The President delivered the following opening Address:

GENTLEMEN,—I take the chair at this meeting for the purpose of enabling you to appoint my successor as President of the Society; and before proposing for your approval the gentleman unanimously selected by the Council for this distinction, permit me to express how much gratification I have felt in having officiated as your President for the past year, during which many papers have been brought before us, all interesting, and some well calculated to render our meetings useful as well as attractive.

In deference to the custom of the Society, I shall address to you a few observations, and I shall do so not so much with reference to the past as the future. Although it may be said perhaps that the appropriate address at our opening meeting would be a resumè of the general progress of scientific discovery during the past year, in my opinion it is more profitable to look forward, as we must necessarily either greatly underestimate the progress of the year by confining our allusion to what we have done ourselves, or by travelling over everything that has been done elsewhere, assume to ourselves a position that would only be appropriate to a society acknowledged as the medium of making known all great and important discoveries. We lay claim to no such position, indeed it is no part even of the object of our Society; and, therefore, I will simply confine myself to one or two plain practical suggestions, in the hope that they may possibly prove of some utility in the working of our Society; and, as the occasion may warrant our looking a little beyond ourselves, the general advancement of all classes of the people, and the improved position of science and art in Scotland.

The Royal Scottish Society of Arts embraces a wide range of membership, more varied perhaps than any other of our popular societies, and I think might therefore appropriately occupy a somewhat wider field of popular scientific investigation than has yet been allowed it; and as an architect it may be allowed me specially to suggest that we endeavour more than we have yet done to aid in the improvement of the various appliances used in the construction of buildings and other works of national importance; and also the more general application to use and ornament of the valuable products of our own and other countries. I drew your attention at some length to these subjects a year ago, and therefore will not repeat or dwell upon them on the present occasion, as I feel more inclined to take the opportunity now offered me to press upon the attention of the Society the propriety of encouraging, more than we have yet done, educated workmen to devote their leisure hours to inventions and improvements connected with their own department of labour. These are the inventors that specially require such assistance as ours, and who, but for our encouraging aid, would probably fail to attract attention. I think, therefore, we ought to make it known that we look on them with peculiar favour, that our Society is specially interested in giving them assistance and advice, and that it will, at all times, be our special pleasure to acknowledge the full merits of their inventions. This must always be a pleasing department of our labours, and one which, from the increasing advantages possessed by our working classes, ought every session to become of more practical importance.

I feel pleasure in impressing upon the working classes themselves the importance of this subject, and the desirableness of making known everything that occurs to them tending to facilitate the carrying on of their department of labour, as this is a branch of invention that is peculiarly their own; and as an example of the sort of inventions I have in view, I may allude to a valuable Boring Machine for blasting rocks brought before us during last session, and to be marked this evening by the approval of the Society. Such inventions as this can only come from practical workmen; and with a Society like ours impartially to investigate and decide upon the practical value of what is brought forward, we ought not to find machinery and tools used now merely because they had been used formerly, but workmen should vie with each other in bringing before their fellows everything that seems in any way calculated to make their labour less toilsome, at the same time improving the quality, and increasing the value of their work. This is the duty of our workmen to each other, and they cannot have a safer channel than through the Society of Arts.

I may perhaps to some appear to attach too much importance to this subject, but to me it seems impossible to over-estimate what may result from the improved position of our skilled workmen, and what a Society like ours may do to encourage it. I have myself seen and experienced the marked advance and improvement of those engaged in carrying out my own ideas; but every one must have observed that for some time there has also been a marked increase in the number of those who come to our Society to improve themselves, and also to lay before us important mechanical inventions. It is surely then not out of place here, but rather a subject coming peculiarly within our care, and to which attention should be specially drawn on such an occasion as the present, with the hope that we may lend a helping hand in raising the standard of every grade of labour, from the skilled workman engaged in the higher departments of machinery and the different branches of art manufacture to the navvie who has gone with the "Army's Works Corps," and assisted in paving the way for that unbroken succession of brilliant achievements which step by step have lately led to our successes in the East.

One word further of explanation on this subject both to the Society and to workmen. To the Society I would only say, that this proposed increased encouragement of the working classes would not interfere with our more important duty to those inventors of the highest class to whom we must at all times look for the chief interest of our proceedings; and to workmen I would offer a caution against the supposition that when they have produced any useful invention they are to cast aside their tools and become men of science. Although it would not be difficult to give a long list of those who have successfully done so, and whose names have become household words, it will be found that those men who leave the work to which they have been trained, when a Society like ours encourages their inventions, are very frequently disappointed in their over-sanguine expectations. It would be better for them could they look for their reward in the consciousness that their time has been well spent in lessening the drudgery and adding to the dignity of labour.

Having stated how I think the Society of Arts, in addition to its more important labours, may with advantage to the public be instrumental in encouraging the working classes in improving the character of their work, and relieving themselves from drudgery, I shall now endeavour to show how we can also help to improve the hours saved from labour by finding the means of combined instruction and amusement; as, in my opinion, unless we can do so it had been as well for our workmen that they had not kindled in them the desire for knowledge and progress, and that their hours of labour had never been shortened. It is an important subject, therefore, and like the improvement of the education and general advancement of the working classes, appropriate to the Society of Arts, to inquire how the leisure hours of the people can best be occupied; and as it appears to me this cannot be done in any way so generally attractive as by the establishment of Free Public Libraries in Edinburgh, and a comprehensive Museum of Art, Practical Science, Classical and Mediæval Antiquities, Natural History, Geology, &c. such as the British Museum. The library, of course, is, in the meantime, only attractive to the select few, while the museum would at once draw together and instruct while it amused the whole body of the population. We have many small and interesting collections, but they can never possess their full value and attraction till they are brought together. If this be done, I would not care much where the place selected for the museum was situate, because if the collection itself is varied and extensive, the public will be attracted to it, and enjoy it whether behind the College or on the Mound. I am well aware, of course, that there is a proper time for bringing forward such a proposal as this; and what better opportunity could we have than now, when a commencement is about to be made with the Industrial Museum; and when it is joined with the Natural History Museum in the College, we have already much of what would be required, all the addition necessary being a very plain building for the sculptures now in the Royal Institution, and the contents of the Antiquarian Museum, with a small vacant space perhaps, for the extension of the different departments of the museum, as further accommodation might be required. There will be a lecture room in the University for our distinguished professor of technology and director of the Industrial Museum, whose varied talent and lucid power of communicating information, in every way so peculiarly qualify him for the task he has undertaken; but this would not be enough, and I think there should also be a separate lecture room for the people, where they might, during the winter evenings, get popular lectures on the industrial applications of science, illustrative of the different sections of the museum. I believe I may be permitted, while on this subject, to make allusion to a gentleman who, I trust, will soon be again among us, illustrating by his antiquarian knowledge and researches the mediæval history of our country, and throwing light upon her pre-historic annals. No one could arrange and have the custody of the antiquarian department of a National Museum in Scotland with a more enlightened knowledge of the subject, with more enthusiasm, or with more power of imparting his knowledge to others, than Dr Daniel Wilson. We have already enough scattered over Edinburgh to form an important nucleus for a museum such as I propose; and all we want, therefore, at present, is to have them brought together under one roof, as being essentially necessary if we are to give them a national importance, in educating all classes of the community in what is beautiful and interesting in art, and instructive in science. If our present collections were brought together and popularly illustrated, we would have no difficulty, at any time, in making the Saturday half-holiday, and all other holidays, seasons of combined instruction and amusement to the working classes, and a blessing to them and their families.

Leaving these subjects, with an apology for having dwelt so long upon them, deeply interesting as they are, I think it is not possible in the commencement of a new session of a society devoted to scientific investigation altogether to overlook the peculiar circumstances in which we find our country placed in being leagued with France in putting down a powerful and unscrupulous enemy of civilization and progress, while at the same time we are peacefully uniting together in Paris in a generous rivalry for the advancement of the scientific, artistic, commercial, and agricultural prosperity of the world. Our great wars have, on former occasions, thrown stagnation over everything connected with the civilizing arts of peace; but now times are happily changed, and, as yet, at least, we are enabled to go on, in our own and similar societies, progressing in scientific investigation as if our country had no part in the war, and under the circumstances, therefore, we feel ourselves in advance of former times, to be able to open this session in the quiet enjoyment of our privileges.

I have no intention of entering upon the subject of the Paris Exhibition, interesting as it must be to every member of this society, but will only say, further, that in comparing the Paris Palace of Industry with that of London in 1851, we may feel with pride that in such work we have no rival, and that this is the only country in the world that could have constructed the Crystal Palace in Hyde Park.

There is another exhibition connected with art and art manufacture

I would not omit noticing on an occasion like the present, and that is the Exhibition in Glasgow connected with Architecture and the useful Arts. This was a most tasteful display, and very creditable to those who had the charge of its arrangement, and yet, contrary to my expectation, the Prize Committee have not been able to award the two medals which, as President of this society, I offered, and the Exhibition Committee accepted at the commencement of last session for the most important practical invention exhibited, and for the best short description of the exhibition and its contents. The field was necessarily limited, but I hoped it might yet have afforded scope enough for something practically and permanently useful in the advancement of architecture in Scotland, for which these much esteemed medals of the Society of Arts could have been awarded.

These observations are desultory, and put down as they occur to me, and there is still one subject of general interest I cannot help making allusion to, but before doing so, would desire to guard against the suspicion of being desirous of government aid for our Society. The advance of scientific investigation, as we all well know, has always in this country been free and unconstrained in the hands of voluntary societies like the Society of Arts, while, under the control of the government it has been the slave of ceremony, and hampered by obstructions. We want no interference, therefore, with the free working of our Society, but with this reservation, I think we should join in a strong effort, such as is now being made by the friends of art and science in London, to have all societies in Edinburgh embracing any branch of these subjects, brought together under one roof at the Royal Institution on the Mound. I have already suggested a place for the sculptures and antiquities now in that building, and if they were removed, there would be nothing left but the Herring Fishery Office and the School of Design; and, although no one is more a friend of the School of Design than I am, it yet seems an abuse of this national building to see it appropriated to such purposes when it is so admirably suited, both in situation and apartments, for the more dignified purpose to which I have alluded, and to which I trust we may soon see it entirely devoted. If it would be a great advantage in London to have the scientific societies of the metropolis concentrated in Burlington House, it cannot be necessary, I think, to add much here in favour of a similar arrangement in our own capital; and with the present state of public feeling, I have little doubt that by combination and effort on the part of the Royal Society, the Antiquarian Society, the Royal Scottish Society of Arts, the Royal Medical Society, the Botanical Society, the Royal Physical Society, the Architectural Institute of Scotland, and others, such a result would very soon be brought about. These societies ought to have accommodation at the public expense, as self-supporting and of acknowledged usefulness, and if done in the way I propose, it would be nothing more than a graceful acknowledgment of the important service they have rendered the public, while, at the same time, it would be an inexpensive way of putting art and science in the honourable position they ought to occupy. It would be easy to find appropriate and less costly apartments for the Herring Fishery Office and the School of Design, so that this is a difficulty not to be thought of in carrying out so great and desirable an object as that to which I have drawn your attention.

I have trespassed on your patience, and will only now add a few words on the business of the Society, and I am happy to have to report its continued prosperity and progress. We have had several new members added to the roll, but I am sorry also to say, death has deprived us of some who have long been of much use in the Society. One gentleman whose intelligent knowledge of science and regular attendance at our meetings made him a valuable and well-known member, has been only a week ago suddenly removed from us by death; and there are others whose loss is also very greatly to be regretted. I feel unwilling to name any of them, but there is one of the number I cannot resist making an exception, and that is Mr Slight. We are all well aware how much service this gentleman rendered in our committees, how ready he was with his valuable assistance in many delicate and difficult investigations as to the merits of supposed inventions, and how much on all occasions we profited by his varied acquaintance with scientific subjects, and his accurate knowledge of everything that had been done in the Society since its commencement. I believe that Mr Slight began life as a country wright in Tranent, where he was born, and came to Edinburgh to be employed by the late Mr Stevenson, engineer, as his assistant in carrying on the Bell Rock Lighthouse. He remained some time in this employment, where he became known for his useful and varied information. Of course we have only here to do with Mr Slight as a member of our own Society, but at the same time it is profitable to point attention to one who so raised himself, and lived long to be respected and appreciated, as having rendered service to the public in the manufacture and improved construction of all kinds of agricultural implements requiring practical scientific knowledge.

In allusion to the prizes which will be presented later in the evening, I have peculiar pleasure in announcing that the Committee have had no hesitation in awarding the Keith Medal to Professor Wilson, for his researches on Colour-Blindness; and they feel confident the Society will agree that this, the highest honour they have to confer, could not have been given for more original and valuable researches on a subject of much practical importance.

The other communications for which prize medals and the special thanks of the Society have been awarded, will appear in the Report of the Prize Committee about to be read.

I have now to offer, and I feel the Society will agree with me, our special thanks to Mr Tod, W.S., the Secretary, for his invaluable services, and I trust he will look upon this annual expression of our thanks as something much more than routine, which it may be apt to appear from frequent repetition. Every member feels how much we owe Mr Tod for his unwearied exertions in connection with all our proceedings. Our thanks are also, I think, specially due to Mr Scott Moncrieff, our Treasurer, a gentleman in every way well fitted to co-operate with the secretary. I feel satisfied the continued success of our Society has been mainly owing to the efficiency of these office-bearers, and the deep interest they take in upholding its usefulness.

In bringing before you the name of Professor George Wilson as President for the year on which we are entering, I am happily spared any formal or eulogistic introduction, from his being very well and favourably known to us all. Professor Wilson has lately entered upon a new and wide field of public usefulness, and he has been long known in our Society as the author of many valuable papers, and as the editor of our Transactions. I shall have very great pleasure therefore this evening in being the organ of the Council in proposing that he be elected to succeed me as President of the Society.

Permit me in conclusion to repeat, how deeply sensible I am of the high distinction you conferred upon me in electing me your President, and to thank you for the kind and cordial support you have given me in the discharge of my duties. I have extreme pleasure in being able to say that we this evening have entered upon a session that promises in every way to uphold the increasing usefulness and importance of the Royal Scottish Society of Arts.

2. At the special request of the Council, an Exposition of the Mechanical Inventions of Dr Robert Hooke was given by Alexander Bryson, Esq.

The Instruments referred to were exhibited. (3673.)

Mr Bryson commenced his exposition by alluding to the small share of popular fame which had fallen to the lot of Hooke. Three circumstances had combined to produce this result—his proximity to Newton, his want of method, and the scarcity of his works. Mr Bryson exhibited a variety of instruments invented by Hooke, and in daily use, to none of which, with one exception, that of Hooke's universal joint, had his name been conjoined. Among the principal inventions of Hooke might be enumerated, the air pump, the transit sextant, the double-tubed barometer, the wheel barometer, the marine barometer, now known as Adie's sympiesometer, the quadrant, the Watch-wheel cutting engine, the stethoscope, the conical pendulum, the duplex escapement (which is now used as the best pocket timekeeper), and the balance spring for the watch, and the spring scales now known as Salter's improved weighing machine.

Mr Bryson continued his interesting exposition for an hour, and at its close, on the motion of Professor George Wilson, seconded by Edward Sang, Esq. V.-P., the thanks of the Society were unanimously voted to him and were given from the chair.

3. The Report of the Prize Committee awarding the Prizes for Session 1854–55 was read, and the Prizes were delivered by the President to the successful Candidates. See Report, Appendix ( ).

The Models, Drawings, &c., of Inventions, &c., for which Prizes, &c., have been awarded, were exhibited.

4. Report of Committee of Council on the test by fire of Milner's Patent Safes, and Solid Lock, (the President, Convener,) was read and approved.

The following Donations were laid on the Table, viz.:—

1. Report of 24th Meeting of the British Association for the Advancement of Science, held at Liverpool, in September 1854. Presented by the Association. (3660.)

2. Transactions of the Royal Society of Edinburgh, Vol. XXI., Part II., for Session 1854–55. Presented by the Society. (3668.)

3. Proceedings of the Royal Society of Edinburgh, Session 1854–55. Presented by the Society. (3669.)

4. Eröffnung der Optischen und Astronomischen Werkstätte von C. A. Steinheil, in München. Presented by Professor Steinheil, Hon. F.R.S.S.A. (3667.)

Thanks were voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidates were elected Ordinary Fellows, viz.:—

1. Peter Hunter, Draughtsman, Loco. Dept. Cowlairs Station, Edinburgh and Glasgow Railway.
2. William Hart, Philosophical Instrument Maker, 6 Young Street.

III. In terms of Law XV., the Society elected its Office-Bearers for 1855–56, viz.:—

Professor George Wilson, M.D., F.R.S.E., *President.*
James Leslie, Esq., C.E. } *Vice-Presidents.*
James Elliot, Esq. }
James Tod. Esq., F.R.S.E., W.S., 55 Great King Street, *Secretary.*
John Scott Moncrieff, Esq., Accountant, 20 India Street, *Treasurer.*
Edward Sang, Esq., F.R.S.E., 36 George St., *Editor of Transactions.*

Ordinary Councillors.

David Stevenson, Esq., F.R.S.E., C.E.	H. W. Nachot, Ph. D.
Robt. Ritchie, Esq., C.E., A.I.C.E.	David Rhind, Esq., F.R.S.E.
William A. Roberts, M.D.	Edward Sang, Esq., F.R.S.E.
Rev. Professor Kelland, M A., F.R.S.E.	William A. Smail, Esq., R.N.
William Swan, Esq., F.R.S.E.	James Stark, M.D., F.R.S.E.
	Pat. Newbigging, M.D., F.R.S.E.
	Thomas Bouch, Esq., C.E.

Mr Alexander Jamieson, *Curator of Museum.*
Mr Alexander Kirkwood, *Medallist.*
Mr Hugh Johnston, *Officer and Collector.*

IV. A List of the Office-Bearers, and Alphabetical List of the Fellows, as at 1st November 1855, in the order of their admission, had been previously sent to the Fellows.

V. A Copy of the Report of the Prize Committee for Session 1854–55 had been also sent.

26th November 1855.—Professor George Wilson, M.D., F.R.S.E., President, in the Chair. The following Communications were made :—

1. Professor George Wilson, on taking the Chair, delivered the following Address :—

It is the alleged practice of many societies, and even it is said of august assemblies, when troubled by the presence of a member who too frequently disturbs their silence, but who, nevertheless, does not overtly transgress their laws, to promote him to the silent office of President; and even it may be to dignify him with the quietly sarcastic title of "Speaker." I was in hopes that such dumb forgetfulness had been the recognised accompaniment of elevation to this Chair, and that I might, till I recovered speech on resigning it, sit with closed lips, except when some brief official utterance was to be made, or a vote of thanks to be given in name of the Society to such eloquent members as had pleased and instructed it. But that depository of the unwritten law of the Society, our honoured secretary, has, in his own mildly authoritative, paternal way, admonished me that I must earn my year of silence by some words on this occasion. From him there is no appeal; and in obedience to his ruling of the law, I will occupy your time for a short period this evening, regretting, however, in addressing you, that pressing duties have kept me from doing more than throwing together a few hasty thoughts.

In the first place, I very sincerely thank you for elevating me to so honourable a position as that of your President, and for lessening the responsibility of my office, and adding to its dignity, by associating with me as Vice-Presidents, so excellent a natural philosopher as Mr Elliot, and so skilful an engineer as Mr Leslie. It is a great satisfaction to me also to know that the editorship of your transactions is in the hands of so rarely accomplished a physicist as Mr Sang, on whose cordial co-operation in forwarding the interests of this Society I know I can fully count, and from whose experience I shall always be glad to learn. With those gentlemen; with my able predecessor in office, and the other members of the council to aid me; with our faithful treasurer to change his usually benignant look into the sternest frown, if I should propose to waste the money of the Society; and with our secretary, a host in himself, whom I regard not merely from his official position, but in virtue of his personal merits, equivalent to our Lord Chancellor, and as such adviser of my presidential majesty;—with Mr Tod to keep me from erring, I trust that I shall not altogether fail to do justice to my appointment

The Royal Scottish Society of Arts has long reached a place in public estimation which renders it needless for me to commend it to general notice. Its meeting-place is Edinburgh, but it is the Scottish, not the Edinburgh Society of Arts, and it has always, I believe, acted faithfully up to its title, and encouraged the cultivation of the arts not only in every part of Scotland, but beyond our seas. Our Transactions and Prize-Lists from year to year never fail to exhibit in large number the names of strangers to the Scottish capital. We often cross the Border to do honour to skilful Englishmen; we are always ready to foster Irish art; our Colonies have the same claim upon our sympathies as our mother country, and we give letters of naturalization to every foreigner who cares to come before us.

It is little perhaps that we can do, but we have done that little cheerfully and freely; and I refer to this cosmopolitan spirit which I believe has always characterized us, not because it has done an immense deal for the world, but because it has done a great deal for ourselves. It has kept us from that restricted view of our claims and vocation, which has paralyzed other Societies possessed of as much intrinsic talent and energy as our own, and has saved us from continually pacing round one narrow circle, and attempting to reap fresh harvests from a solitary exhausted stubble-field.

A Society like this is one of the educational institutions of the country, and in some important respects is all the more one, that it is essentially a voluntary self-ruling brotherhood. Such brotherhoods can flourish only in free countries, long civilized and enlightened; and Societies like our own scarcely exist except among the Anglo-Saxon nations, and flourish nowhere as they do among ourselves. The continental Scientific Societies are Academies resembling more our Colleges than bodies like this. They do excellent work in their way, but that way is unlike, and often the very opposite of ours.

In constitution this Society is a republic, and as such removed from the autocratic sympathies which dominate elsewhere in Europe; yet this republic exhibits many of the best features of a constitutional monarchy, and unless I am greatly mistaken, Societies like our own do not take the prominent place in America which they do in this country.

I am not going to trouble you with speculations on the relative merits of political constitutions, but it is not out of place to notice here, that on the Continent, submission in social arrangements to the will of the *majority* has never been practically learned unless in a few countries, either by princes or people. A *minority* rules, and, in conformity with this principle of government, the learned Societies, even when free to adopt a republican constitution, adopt one far removed from a democratic system, and concentrate the powers of the Society in the hands of a few.

In America, on the other hand, the majority rules politically in all things, and the wishes of the minority go for little or nothing. The business of a minority there is as fast as possible to convert itself into a majority; for as a minority it is a powerless nothing. Among our Transatlantic Brothers, accordingly, and I may add, Sisters, Associations spring up and thrive, which with us no majority could call into being, or sustain in existence.

In our own country, to a greater extent than in any other, the endeavour is made to respect the rights alike of the majority and minority of its thoughtful subjects, and our Society has more largely than most caught and reflected this happy characteristic of the British people.

That in a voluntary association of earnest, intelligent men, the majority should decide, where there is a difference of opinion, is a principle which we, as a people, not only acknowledge as just in the abstract, but from boyhood have been practised in obeying. That we do not, however, blindly hold that the voice of the multitude is the voice of God, we show, by varying the number of the decisive majority we bow to, according to the difficulty, or importance of the case under discussion, and by sometimes preferring silent, sometimes open voting.

Yet how strong our recognition of the equal intellectual capacity and judgment of the mass of our neighbours is, is proved by our every day submitting the destinies of the nation, in both Houses of Parliament, to the mercy of an individual vote; and in this part of the empire we do not hesitate, in our Courts of Law, to doom an accused party to death, if but seven of the twelve jurymen pronounce him guilty of a capital crime.

Nevertheless, we make large provision for a doubting, dissenting, or dissatisfied minority controlling a triumphant majority, and do not dispense justice anywhere by simply counting heads. The very fact that we are so often content with a vague show of hands, without formal numeration of them, which might seem at first sight to imply the idolatrous worship of a majority, is, in truth, in many cases a deferential recognition of the rights of a minority, which is not provoked by the tabulation of columns of figures, whilst an opportunity for appeal is offered to it.

And, surely, this respect of the minority is just. The Giver of all good gifts dispenses his gifts unequally. Sodom was not the only city which could not be saved for want of ten righteous men. The Wise men, the Brave men, the Good men—in a word, the Manly men, have always been in a minority in this world, and are often in the minority of our voting assemblies. We should try, at least, to secure for them utterance. For the tyranny of a mob is as evil a thing as the tyranny of a despot; both are at best only better than anarchy; and the happiest social communities will ever be those which are most successful in bringing into equipoise the conflicting rights and unequal endowments of majorities and minorities.

This Society has endeavoured with no mean success to do so in carrying out its fundamental idea. Whosoever brings a communication before us submits it to the judgment of the entire Society; and it is not merely the right, but the duty, of every member to give expression, whether by deliberate utterance or significant silence, to his estimate of the value of the work submitted to our notice. In truth, the highest compliment which we can pay to those who contribute to our instruction, is to treat their communications as worthy of criticism; and for my own part I sincerely wish that this Society would abandon its kindly-intentioned practice of giving votes of thanks to communications which are listened to with indifference by those who are present. A hollow compliment, or vapid eulogy, is a poor substitute for a candid criticism; and communications which cannot endure the latter should not be received, or should be simply dismissed in decorous silence.

But we must acknowledge that, in the open arena of a free society, the merits of communications cannot be nicely weighed and adjusted. Ours is a public market; our weights are just, and our steelyard true, but we weigh only to ounces; and it so happens that the most valuable of the commodities which appear in our bazaar require to be estimated at least by "scruples," often by grains, sometimes by fractions of them.

Wisely, therefore, has this Society, after hearing in open court the opinion of every member who has been pleased to express an opinion on the matters brought before it, submitted each important communication to the review of a small committee, chosen by desire and consent of the majority, from that minority of members who are supposed to be most conversant with the special subject submitted to them.

This minority of members, seldom exceeding three, reports to the majority its decision; but with that majority rests the approval or disapproval of the judgment laid before them; so that the whole Society consents to every approved report, and by so doing thanks and acknowledges the services of the minority.

Farther, all those offsprings of thought which are thus a second time considered by us, as certainly destined to grow to maturity, are subjected once a year to an Eclectic Prize Committee, which winnows again from the chaff the grain twice winnowed before.

We thus, I think, do all that can be done to secure justice in our judgments on individual merit; and if it is ever wrongly appraised, the fault lies with the particular appraisers and their approvers, not with the system under which both act. Men are often better, still more often worse, than their creed; and we may rise above, or fall below our secular confession of faith, and yet agree in thinking it an excellent and sufficient symbol of union.

We agree, then, with the famous republics of history, in making Liberty and Fraternity fundamental principles of our association; but we do not assign the same importance to Equality. In one respect we are all equal; in another we are not.

I would compare this Society to a crystal, not pervaded in all parts to the same extent by the same forces, but nevertheless resulting from the union of an indefinite number of particles, each intrinsically possessed of the same powers. Take, for example, one of the many-sided obelisks of quartz which spring from the granite cliffs of our Highland hills. Each crystal, in itself a beautiful unity, rises like a cathedral spire, and terminates in a transparent needle pointing skyward. It has six, or twelve, or more, prominent faces turned to as many points of the compass, and reflects light equally from all. The particle of quartz at the apex of the crystal, which represents myself, your president, is physically and chemically in all respects identical with the less prominent, but still striking, particles which, like your vice-presidents, secretary, treasurer, and editor, mark its salient angles; and that crowning, terminal crystal-atom, and these adorning and supporting crystal-particles, are the same in all their individual endowments as the hidden molecules within the mass, and the obscure particles buried in the matrix out of which the crystal springs. Crush the crystal to fragments, or reduce it to powder, and you will find no physical difference between one particle and another: subject it to analysis, and the same identity will manifest itself. The crystalline forces have lifted one particle to the apex, and have projected others to the attractive angles, and built up the faces, and filled up the interstices with the remainder; but all the particles have been consenting parties to this arrangement, and none has surrendered any of its intrinsic powers in accepting the place which it fills. Yet, equal and similar though they are in essence, their functions are very different as they occur in the crystal. A ray of sunshine sent through it in one direction passes on unchanged, and leaves it only "to fade into the light of common day." A ray sent in another direction is altogether altered in properties, and emerges refracted doubly, and enabled by the polarity which has been conferred upon it to reveal the inner structure of transparent bodies as unaltered light cannot do, and to make them shine with the most gorgeous colours. Yet the quartz-particles which have polarized the light, and brought into play its hidden powers, have done so simply from their place in the crystal, not from their possession of properties different from those particles which could not polarize a ray. And so, whilst here we are all equal, and I ask nothing for myself individually, I ask all that is due to me as your president, that the influence belonging to my office may be exercised without let or hindrance for our common good; that along with my fellow office-bearers I may, like the particles around each axis of a quartz or Iceland spar crystal, double in brightness each single ray of knowledge which you transmit, and invest it with added powers. To effect this much is the duty of the occupant of this chair; and were it as perfectly filled by its fittest occupant, as every crystalline interstice is filled by the very particle most suitable to fill it, I would not utter one word on this matter; but as I am but a dim and dusky nebulous atom, at best to be compared to a particle of "smoky" quartz, I plead for my chair, as distinguished from myself, that when I try to hold the balance even between majorities and minorities, and mayhap offend both, you may impute the offence to unwise zeal or mistaken judgment, or to aught else but arrogance or indifference to you.

We meet here, then, to discuss as equals all that is brought before us. Our intention is, that no one shall address us who counts it a condescension to appear in this arena. Our desire still more is, that no one shall doubt that there is no respect of persons amongst us, and that whosoever brings an approved communication here, whether member or not member, is regarded as our benefactor, and will be met at least half-way by our earnest desire to show that we appreciate his services.

And from the intercommunion of gifted men, which societies like this (and none more than it) secure, the good that flows is, I believe, incalculable. The general proposition is so undeniable, that I will only refer to one particular exemplification of its truth.

Since the printing press was invented, literary men and printers (including among the latter publishers) have stood in a peculiarly fraternal relation towards each other. The Great Thinker whose thoughts could not reach the world, shaped them into words, and submitted them to the printer. He gave them wings, which, though but of paper, have secured an earthly immortality to ideas, which otherwise would not have risen above the gulf of oblivion. Very pleasant are the memories which haunt us, of author and printer consulting together concerning the paragraphs and sentences, the spelling and punctuation, the syllables and commas, which should fully embody the thoughts of the one, and do justice to the work of the other.

There is a similar bond, which I do not remember to have seen recognised, between the scientific man and the instrument-maker. As the printer to the author, so is the instrument-maker to the philosopher. In both cases we have the deviser possessed of an idea, which he cannot himself realize, and the realizer who clothes his idea for him, and makes it as it were a living thing.

There are memories as pleasant of the scientific man and the instrument-maker, as of the literary man and the printer. But without dwelling on these, which your time forbids, I would refer to this one point common to both fraternities, namely, that each of the pairs of twins profits by the alliance. Our great printers have been in effect great authors; our great authors have compelled the press to obey them like a mirror reflecting their very thoughts; and it would be in vain to separate, in the vast literature of our day, what of its greatness and goodness (not to speak of its littleness and worthlessness) is due to the author, what to the printer. And so also is it with students of physical science and instrument-makers, but with this great difference, that the scientific man is much more frequently the constructor as well as the deviser of a machine, than the literary man is the realizer to the world of his ideas. Nevertheless, although there are amongst us instrument-makers who might justly claim rank with men of science, and scientific men who would make their fortunes if they turned instrument-makers; still, in these days of division of labour, the deviser and the constructor must, to a great extent, remain apart, and suffer by their separation.

One great good end which is secured by a Society like this is, to bring such thinkers and workers together, so that the former may not become idle dreamers or barren projectors, or the latter mere money-coining engines or living machines. The great achievements of physical science have been secured only by the intelligent co-operation of both; and they have often changed places: for, to take but one example, if James Watt sat at the feet of Joseph Black to learn the doctrine of Latent Heat, Joseph Black sat at the feet of James Watt to study the construction of the steam-engine.

Nor is it merely that theoretical men may be taught here to respect Practice, and practical men to respect Theory, that I have thus spoken. The existence of such a Society as this implies that they hope to profit in this respect by meeting together; but in truth, although the fact is often forgotten, theoretical men are as likely to gain here by being taught not to over-estimate practice, and practical men by being taught not to over-estimate theory.

It is not more natural to us to exaggerate the value of what we are skilled in executing, than it is to exaggerate the value of what altogether exceeds our skill to produce it. Hence sagacious practical men are often far more concerned about some petty theory which they have devised, than about the machine whose perfection is owing to their having unconsciously followed a very different formula; and theoretical men, instead of thinking out an idea, which, in the hands of others, will yield manifold machines, are found wasting their time in constructing some wretched model which refuses to work, but is nevertheless complacently exhibited to skilled artificers (whose gravity it sorely tries), as a perfect instrument from which they may learn much. This Society can safely engage to cure both maladies. It has always numbered a host of theorists and a host of practisers among its members; and he whose distemper is not assuaged by the one class is sure to have it cured by the other.

Those are general remarks. I will conclude with two special ones. It is one of the excellent principles of this Society to regard this chair not as an honorary sinecure, in which its President shall sit like some pensioned Indian prince and do nothing. You expect your President to make the year of his reign memorable for the number and excellence of the communications brought before you during its currency, through his personal exertions and instrumentality. My predecessors in this chair have set me an example in this respect, which I cannot hope to do more than equal; but I shall do my best to come up to the high standard which they have accustomed you to regard as the true one. I can do this, however, only by the kindly co-operation of all interested in the objects of this Society, and I appeal to such to bring before us as many communications as possible. Secondly: You purposely select your Presidents from different professions in turn, so as to secure a freshness from the individuality and special pursuits of each.

It is several years, I think, since a chemist filled your chair, and you will naturally expect me to give a prominence to chemical arts; but my doings as a chemist are now to a great extent merged in the wider duties of Director of the Industrial Museum of Scotland, and it is in that capacity that I shall seek to serve you.

But for the labours of the sister Society in London, and its august President, the Prince Consort, we should never have had either the first or second Crystal Palace, the New York or Paris Exhibition, or the Industrial Museum of Scotland. This Society exerted itself energetically, along with other public bodies, in procuring the foundation of that Museum, and I need not spend words in urging that the Scottish Society of Arts and the Scottish Museum of Arts cannot be indifferent to each other. As yet the Museum is only in embryo, and it must be much more indebted for a long season to you, than you will be to it. But by and by it will be otherwise, and I hope that will begin at least to appear even this winter.

The Industrial Museum will be a threefold teacher of the community. In the first place, it will, as a silent preceptor, simply present to the senses of all who visit it the objects which it contains, and leave them to speak for themselves.

Secondly, it will supply the text on which the Director of the Industrial Museum, as Professor of Technology, and others, will discourse. Thirdly, and assuredly not least important, it will gather together those objects and instruments of the useful arts, which this Society is specially concerned in studying, and will afford the means of these being continually submitted at your meetings to the critical discussion of your members.

A Silent Museum may teach much; a Museum expounded by its Director and others will teach more; but a Museum criticised will teach most of all, especially to those who are already adepts, and conversant with the practice of the various arts.

I trust that the Society will be largely a gainer by the Museum, and that the Museum will not less be a gainer by the Society. But remembering the sacred caution, "Let not him that girdeth on his harness boast himself as he that putteth it off," I will avoid boasting, and be content to promise to do my best.

Professor More moved that the thanks of the Members of the Society be given to the President for his able and eloquent address, which motion was carried by acclamation.

2. Description of a new Air-Pump of extreme nicety of construction, producing an almost perfect vacuum. By Mr James Laing, Draughtsman, Dundee.

The Air-Pump was exhibited in action. (3691.)

In this Air-Pump the Cylinder lies horizontally, and there are two solid Pistons working through stuffing-boxes at each end. These solid Pistons alternately cover the air passages, and thus supersede the use of separate valves, except the exit valves; and when once set in motion, they create a vacuum on each side of them, into which the air from the receiver rushes until exhausted. Motion is given by a handle and fly-wheel, and the Pistons are moved and regulated by curves upon the horizontal toothed wheel.

Various experiments were shown calculated to exhibit the powers of the instrument; and after an animated discussion, in which Messrs Elliott (V.-P.), Sang, Adie, and Swan took part, the Communication was referred to a Committee.

3. Description of the Naturalist's Dredge and Mariner's Trawl Net. By Mr Henry Dempster, Kinghorn.

A Model was exhibited. (3688.)

Some other Communications had to be postponed from want of time.

The following Donations were laid on the Table, viz. :—

1. Researches on Colour-Blindness, with a Supplement on the Danger attending the present System of Railway and Marine Coloured Signals. By George Wilson, M.D., F.R.S.E., Regius Professor of Technology in the University of Edinburgh, and Director of the Industrial Museum of Scotland. (Edinburgh, 1855), 8vo, pp. 180. Dedicated to the Society. Presented by the Author. (3685.)

2. Catalogue Officiel de l'Exposition des produits de l'Industrie de toutes les Nations, 1855. Publié par ordre de la Commission Impériale, 2d Edit., Paris, 1855. 8vo, pp. 544, with two separate Plans of the Palais and Annexe. Purchased for the Society. (3674-1-2.)

3. Proceedings of the Institution of Mechanical Engineers of Birmingham, 25th April 1855. Presented by the Institution. (3666.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The Fellows received two Copies of Form of Application for Admission, to be filled up by any of their friends who might desire to join the Society.

10*th December* 1855.—Professor George Wilson, M.D., F.R.S.E., President, in the Chair. The following Communications were made:—

1. Description of an improved Bunsen's Lamp, dispensing with the use of wire gauze. By Robert Ferguson, Ph.D. (3692.)

In introducing the lamp, which was exhibited in action, the paper referred to the inventor, Professor Bunsen of Heidelberg, and to the modifications of it which the author had made. These were intended to increase the convenience and power of the lamp. The principle on which the lamp is constructed is, that air mingled with coal-gas before combustion causes the flame of the latter to be smokeless. The lamp itself consists of a metal sole, and has a gas jet in it communicating with a supply pipe. Over the jet is a narrow tube for mingling the gas with the air, which enters by holes in the tube near the jet; the mixture burns blue and smokeless above. The greater part of the paper was taken up in showing the flame did not descend the tube and burn at the jet below, and concluded by referring to its heating power, and to several applications of it to lighting, and to the illustration, by interesting experiments, of several chemical phenomena, which the author had made. A discussion followed, in which the President, Messrs Swan, Sang, and Landale, took part; and the communication was referred to a Committee.

2. Notice of an improved Construction of a Standard Weight. By Edward Sang, Esq., F.R.S.E. (3698.)

Mr Sang exhibited a standard pound-weight, which he had constructed some twenty years ago. It consisted of a quantity of mercury contained in a strong glass ball, the neck of which was closed by fusion. The advantages of this kind of standard were stated to be, *density, hardness, and resistance to chemical change.* But the most important quality which it was said to possess is this, that any wear caused by frequent use, or any wilful reduction in its weight, must be accompanied by a change in its specific gravity; and that thus a comparison of its specific gravity at any time with its original specific gravity would afford data from which to compute the loss of weight. After some discussion, in which Messrs Elliot, V.P., Swan, Bryson, and Sang took part, the communication was referred to a Committee.

3. Description of an improved method of Slicing fossils for Microscopic Investigation. By Alexander Bryson, Esq., F.S.A. Scot., F.R.P.S. The apparatus was exhibited. (3672.)

Mr Bryson described the various methods hitherto in use for slitting stones, and stated that in Edinburgh the first specimens were prepared, by which the microscope revealed hitherto unknown facts regarding fossil phytology. He described his self-acting method of slitting specimens, and a new *pneumatic chuck*, by which the specimen to be operated on is held in its position by atmospheric pressure, instead of cement. Referred to a Committee.

Some other communications were postponed.

The following Donations were laid on the Table, viz.:

1. From the Smithsonian Institution, Washington, U.S., viz.—
   (1.) Smithsonian Contributions to Knowledge, Vol. VII. 4to. 1855.

(2.) Eighth Annual Report of Board of Regents of said Institution for 1853.
(3.) Ninth do. for 1854.
(4.) Smithsonian Report on the construction of Catalogues of Libraries, and of a General Catalogue. By Charles C. Jewett. 2d edit., 8vo. Washington, 1853. (3675-3678.) Pp. 96.

2. From the Patent Office of the United States of America, viz. :—
(1.) Patent Office Report. Part 2d, 1853. Agricultural.
(2.) Patent Office Report, Vol I., 1854. Mechanical, (3679-3680.)

3. Proceedings of the Institution of Mechanical Engineers of Birmingham, 25th July 1855. Presented by the Institution. (3680.)

Thanks were voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidates were elected as Ordinary Fellows, viz. :—

1. John Dalgleish, junior, assistant to the Professor of Music, University.
2. James Robertson, druggist, 35 George Street.
3. Dr James Scott, deputy-inspector of Hospitals and Fleets, 6 Argyll Square.
4. Professor C. Piazzi Smyth, 1 Hillside Crescent.

III. In terms of Law XX, the Treasurer's Books were laid on the Table, and a Committee appointed to audit the same, and to report thereon, and generally on the state of the Funds of the Society.

14*th January* 1856.—James Elliot, Esq., V.P., in the Chair. The following Communications were made :—

1. On a peculiar Mechanical Imitation of Electro-Magnetic Rotation. By James Elliot, Esq., V.P., teacher of mathematics. Illustrated by experiments. (3703.)

In this communication the author first describes the singular phenomena of electro-magnetic revolution, first discovered by Professor Faraday, viz., that each pole of a magnet has a tendency to revolve round an electric current, that the two poles tend to revolve in opposite directions, and that the directions of rotation of each are changed by a change in the direction of the current. He then proceeds to show the difficulty of forming any hypothesis regarding the way in which such revolutions can arise by any known mode of operation common to other departments of physics. The first difficulty arises from the fact that the electric current is wholly confined to the conducting wire, while its magnetic effects are external to it. This difficulty the author endeavours to show, by reference to other phenomena, and by direct experiment, is not insuperable. But supposing it to be overcome, another more formidable meets us. How can a current in a rectilineal direction produce a revolution in a plane perpendicular to that direction without the agency of rigid mechanism? The only known case resembling it is that of a current of fluid directed upon oblique vanes, free to move only in a plane perpendicular to the direction of the current; but to render the cases strictly parallel, he shows that such a peculiar molecular structure would be necessary in the magnet, and such an incessant change in the position of its atoms during the revolution as to render the hypothesis of any similarity of cause too complicated to be admissible. The author then, after discussing the possibility of several hypothetical modes of operation, proceeded to show experimentally, that if a magnet be made to rotate on its axis, resting on a fixed point coincident with its centre of gravity, and if, while so rotating, its pole be brought near either pole of a fixed magnet, the rotating magnet revolves round the fixed magnet, the direction of revolution varying with the relative positions of the poles. When the adjacent poles are of the same name, the direction of the revolution is the same as that of the rotation; but when the adjacent poles are of different names, the direction of revolution is contrary to that of rotation. We have thus a motion precisely resembling electro-magnetic revolution, produced on a well-known physical principle. How far there may be any similarity in their causes remains for consideration. Referred to a Committee.

2. Notice regarding Mr Robert H. Bow's paper on "New Designs for Iron roofs of Great clear Span." By Robert Mallet, Esq., C.E., M.I.C.E., Hon. F.R.S.S.A., Delville, Glasnevin, County Dublin. With a tracing. (3684.)

Mr Mallet referred, in a highly complimentary manner, to Mr Bow's paper, but begged permission to correct the statement that the designs were new, as he himself had made extensive use of such roofs; that they had been previously proposed by Mr Adams, of London, and at a still earlier date were known in France.

3. On the subject of Mr Mallet's letter, with results of some further investigations. By R. H. Bow, Esq., C.E. (3700.)

Mr Bow stated that he was not aware of the existence of roofs similar to those proposed by himself, until after the reading of his paper to the Society; that, however, he never took much credit for the mere designs, but put the chief value upon the investigations, which proved the superiority of these over the form of roof most frequently employed for railway stations. He considered Mr Mallet's letter as very valuable, as giving the history of the leading form of the designs, and thought the extensive adoption of this class of roofs reflected the greatest credit upon Mr Mallet. Mr Bow gave results of some further investigations, and stated that these had pointed out to himself the erroneousness of an impression he had entertained, viz., that the designs were peculiarly suited for *great spans* only, or where many supported points were desirable for the rafters; whereas it was now proved that these roofs were pre-eminently suitable for *all* spans. After some discussion, in which the Society considered the correspondence between Messrs Mallet and Bow highly creditable to both of these gentlemen, from the good spirit shown in it, and a willingness to do each other justice, the papers were referred to the Publication Committee.

4. Suggestions for increasing the Speed of Steam-Boats. By Robert Aytoun, Esq., W.S. (3707.)

Mr Aytoun stated that the well-known proposition in hydraulics, *that the power required to impel a boat increases as the square of the velocity*, has exercised a pernicious influence over the minds of ship-builders, in making them look upon it as hopeless to attempt any great increase of speed, which was to be attended by such enormous increase of power. This proposition, by showing the impossibility of greatly increasing speed with any of the known forms of boats, by giving them increased power, clearly indicated that the path of improvement, if any, must lie in new forms, calculated to take advantage of the new power of the marine steam-engine. It at once occurred to the author that, by elongating the bow of the vessel, that water which our present steamboats dash aside from their path with great force and velocity, and the rapid removal of which absorbs the whole power of the engine, might be laid aside comparatively slowly and gently, like the sod from a Scotch plough, however great the speed of the vessel. A diagram was here shown, exhibiting three steamboats, whose midship sections were all equal, but the length of whose bows were respectively 1, 2, and 3. It was pointed out that, when No. 2 had twice the speed of No. 1, it dashed aside the water in its path with no greater velocity than did No. 1. and therefore did not require more steam-power, though proceeding at double speed. That, when No. 3 had thrice the speed of No. 1, it dashed aside the water in its path with no greater velocity than did No. 1, and therefore did not require more steam-power, though proceeding at three times the speed. It thus appeared that the well-known proposition above referred to, which has so long paralyzed the efforts of ship-builders, must now give place to the more hopeful one, namely, *that the resistance to the motion of boats may be made the same for all velocities, by suiting the form of the boat to the velocity required of it.* A similar proposition, in regard to railways, was early made by Mr Maclaren, with the happiest results, at a time when eight or ten miles an hour was the greatest speed they were thought capable of achieving. The author stated that it was to be hoped that our enterprising ship-builders would not be slow in realizing the same speed in steamboats which the railway engineers have done on the rail, and that by the elaboration of the self-same proposition, namely, *that the resistance to motion may be made the same for all velocities.* A considerable advance in speed has been attained of late years by *fining the lines* of steamboats, by cutting them in two, and inserting an addition to their length amidships, or by increasing their original length, though this last is often marred by a proportionately increased breadth of beam. These were all steps in the right direction, and tend to support the principle just stated; but nothing short of an attempt to reach thirty or forty miles an hour will satisfy the occasion. Mr Sang, Mr Elliot, and Mr Swan discussed the subject of the paper at some length; and while they admitted, as mathematicians, the correctness of the principle advanced by Mr Aytoun, as applied to one part only of the resistance, considered that that gentleman had not given sufficient weight to other sources of resistance to the motion of boats, such as friction, which would become very formidable when boats of the great length which he advocated were urged to extreme speed. Referred to a Committee.

5. Mr Sang exhibited and orally described, on behalf of Mr Waterston, 56 Hanover Street, a Prussian-Slate Globe for Class demonstrations in Geography, Astronomy, and Trigonometry, constructed on Mr Sang's suggestion. Thanks voted. (3706.)

The following Donations were laid on the Table, viz.:—

1. Unsafe Ship-building, a National Sin. In reply to a despatch of His Grace the Duke of Newcastle upon the unsafe transmission of emigrants. By James Ballingall, Surveyor of Shipping and Hon. Secretary to the Port-Philip Immigration and Anti-Shipwreck Society. 1st and 2d edits. Melbourne, 1855. Presented by the Author. (3682-1-2.)

2. Journal of the Society of Arts of London, Vol. III. 1854-5. Presented by the Society. (3687.)

3. List of Premiums awarded by the Council of the Institution of Civil Engineers, London, Session 1854-55; and List of Subjects for Communications for the following Session (1855). Presented by the Institution. (3696.)

4. On the Composition of Bread. By Douglas Maclagan, M.D., F.R.S.E. (1855). Presented by the author. (3697.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidate was elected an Ordinary Fellow, viz.:

George H. Slight, engineer, 34 Leith Walk.

III. The Report of the Auditing Committee on the Treasurer's Books and on the Funds of the Society was read,—Mr Horne, Convener. The President granted discharge to the Treasurer. The Society then adjourned.

28th January 1856.—Professor George Wilson, M.D., President, in the Chair. The following Communications were made:—

1. On the application of the Altitude and Azimuth Circle to Stereometric Surveying. By Edward Sang, Esq., F.R.S.E. (3689.)

After adverting to the many advantages which the altitude and azimuth circle possesses over the theodolite as a surveying instrument, Mr Sang described the peculiar process, which formed the subject of his paper, to consist in observing, along with the bearing of a tall signal staff, the nadir distances of two marks made near the two extremities of the staff: the data thus obtained furnish the means of readily computing the place of the signal-staff upon the plan, and also its altitude above the sea or above any known level. A discussion followed, in which Messrs Elliot, Gardner, Landale, Sutter, and T. Stevenson took part; after which the Communication was referred to a Committee.

2. On an Isolating Atmospheric Gaswork Condenser. By Mr John Young, engineer and manager of the gasworks, Dalkeith. A working model and illustrative drawings were exhibited. (3711.)

The author stated, that in gasworks only one condenser is required, if working efficiently, as no chemical agent has to be employed in its interior, its action entirely depending upon the amount of heat abstracted from the gas while passing along its series of pipes. This cooling influence reduces the tarry and other vapours, carried mechanically along with the gas, leaving them as a deposit either of tar or salts of ammonia, in the interior of the tubes of the condenser. During winter frosts, the action of the condenser is most efficient, but then the liability to stoppage is also greatest, so great that, in metropolitan gasworks, two, three, or four sets of condensers have to be maintained, and so connected by valves that, when one set becomes choked, another can be employed, setting aside those that are stopped to be cleaned out. But in country gasworks, where no such thing as a second set of condensers exists, this source of annoyance is very great, and is much increased when a stoppage occurs at night, which frequently happens. In the old form of condensers, the necessity of stopping the flow of gas is not the only inconvenience—the awkwardness of having so many cap-plates to unscrew; so many lute-joints to remake; the dropping and misplacing of cap-plates, bolts, and nuts; and the dangerous position of the workman, generally on the top of a ladder, are also serious inconveniences. The author then described his improved condenser, in which cap-plates, bolts, nuts, and screws are altogether done away, and their place supplied by having the pipes straight, and open at top, protruding through a shallow cistern of water, whereby, and by means of moveable boxes, embracing the mouths of two pipes, and dipping into the water, and forming water-joints, any two neighbouring pipes can be connected together, and any number thrown out of work till it be ascertained where the obstruction lies, while the flow of gas to the lamps is never for a moment interrupted. The author explained his invention by excellent drawings, which he very clearly described; and he also showed its operation by a working model. After some discussion, in which Messrs Landale, Elliot, Sang, Black, and the President took part, commendatory of the beauty and efficiency of the invention, and the reading of complimentary letters from the manager of the Musselburgh gasworks, where it has been used efficiently for two years, and from Mr Russell of Elmfield Foundry, Dalkeith, who made and fitted it up from the author's drawings and specifications, the Communication was referred to a Committee.

3. Description and Drawing of an Instrument to be used in the construction of Artificial Teeth—as a guide to their correct length and projection. By John Smith, M.D., surgeon-dentist, Edinburgh. The instrument was exhibited. (3705.)

This instrument consists of a metal stand, having attached a square pillar, graduated into tenths of an inch, and upon which a frame, containing a plate of ground glass, slides. The outline of a set of artificial teeth is to be traced upon the plate of ground glass from a pattern placed upon the stand of the instrument, and under the glass; while the required length of the teeth is indicated by the height at which the sliding frame rests on the graduated pillar. Much time and trouble were said to be saved by this instrument, both to the patient and the dentist, as the dimensions, &c., of the future set of teeth are capable of being obtained at the very first visit, and the work finished from these measurements without the necessity of any further attendance. Referred to a Committee.

4. A new Gas-Stove for Churches, Chambers, &c., where no flues can be obtained. By James Gall junior, Esq., sculptor, Edinburgh. The stove was exhibited in action. (3710.)

The peculiarity of this stove consists in having a comparatively low temperature spread over a large surface, by means of a very small consumption of gas. The heat is communicated to the room by radiation, instead of being poured upwards to the ceiling in a column of hot air.

A discussion took place, in which the President, Messrs Elliot, Sang, Landale, and Black took part.

The following Donations were laid on the Table, viz:—

Presented by Charles Cowan, Esq., M.P., various returns and reports to the House of Commons, on the following subjects:—(3686-1-28) viz.

1–7. Explosions and Accidents in Coal Mines. 1853 and 1854.

8–12. Warming, Ventilation, and Lighting of the House. 1852 and 1854.

13–22. Relative to the Sea, Harbours of Refuge, Shipwrecks by Lightning—Hydrographical Survey and Observations—Screw Squadron—Life Raft. 1852, 1853, and 1854.

23. Accumulation of Mud in the Thames. 1854.

24. Metropolis Water and Water-Works. 1854.

25. Redl's Cone Telegraph. 1854.

26. New Standards of Length and Weight. 1854.

27. Corn-Grinding Machinery. 1853.

20. Public Works (India). 1854.

Thanks voted to the Donor.

PRIVATE BUSINESS.

The Minutes of last Meeting were read and approved of.
The Society then adjourned.

11*th February* 1856.—Professor George Wilson, President, in the Chair. The following Communications were made.

1. Description and Drawing, &c., of direct-acting Steam-Engines, adapted for heavy Pumping, as lately introduced in Scotland by David Landale, Esq., Mining-Engineer. (3717.)

This paper was illustrated with numerous drawings, showing the progressive improvements on the three-valved or single-actine enging, as left us by Watt, up to the present day. The Cornish engine was described, and the interior arrangement of pumps, as wrought by it in a deep shaft, illustrated by a section. Of the new direct-acting engines, six were mentioned as erected and working since 1852, and other three large ones, for 110 and 160 fathom pits, as now being made by Neilson & Company, Glasgow; while the engineers in Lancashire had made about as many in the same period, but of the non-condensing kind, while the direct-acting engines were slowly making their way against strong prejudice, because of their cheap first cost, which is only *one-half* of that of a beam-engine of the same power. There were two kinds of the new engine described, both condensing high-pressure and expansive; one with a 40-inch cylinder and 12-feet stroke, which was simply a Cornish engine turned upside down, the cylinder resting on a strong sole-plate over the mouth of the shaft, and the piston-rod attached directly to the forcing set pump-rods. The air-pump was small in diameter, with the same length of stroke as the engine, thus doing away with the ponderous beam, parallel motion, and heavy masonry of the cylinder pedestal, lever wall, and engine-house, and obtaining any desirable length of stroke by merely adding to the length of the cylinder and piston-rod, thereby increasing the efficiency of the pumps, and making smaller ones do the same work. The second kind of engine was also inverted over the shaft, and secured and attached to its work in precisely the same way. It also uses high-pressure steam expansively; but its peculiarity consists in there being a constant vacuum above the piston, both during the descent and ascent of the load. During a portion of the descent the piston is nearly *in equilibrio*, having a vacuum on both sides; that under being a partial, and the one above being about $12\frac{1}{2}$ lb. per square inch, or the common condenser vacuum. As the piston and load continue to descend against this vacuum, a self-acting valve shuts towards the piston, and a full vacuum (showing 15 lbs. per square inch on the gauge) is acquired by the time the piston has got to the lower end of the cylinder, thus giving a tension or extra pressure, equal to 4 tons on the 70-inch cylinder, at the moment when it is most required to overcome the *vis inertia*. The steam-valve is then opened, and high steam admitted for the up-stroke. There are only two double-beat valves worked by the engine. The vacuum valve is self-acting, oblong, and hinged, working on the upper port of the cylinder; and the machine does its work admirably. It was explained that many attempts had been made to use direct-acting pumping-engines from an early date without success. The ingenious Symington erected a large one at Dysart colliery as early as 1810 or 1812. It worked with low steam and no expansion, and raised its water by two columns of 17-inch common lifting-pumps, until 1849, when higher steam was used expansively, and a forcing set applied for the upper column of pumps, the lower one being still a lifting pump. The vacuum-valve was also introduced above, and the result is that this same old engine, made by Symington, now works pumps $23\frac{1}{2}$ inches diameter, or almost twice the area, and doing twice the work with the same consumpt of fuel; and, from being the most troublesome engine in the district, has now become the safest and easiest kept in repair. The vacuum-valve is the invention of a working engineer named Mackenzie, since dead. Mr Landale only claimed the merit of its after-introduction in these new engines, for which engines he claimed a saving of first cost equal to one-half—greater simplicity and less tear and wear, facility of getting a long stroke at an inconsiderable cost, and consequently smaller size of pumps.

An animated discussion followed, in which half-a-dozen gentlemen took part, all but one being in favour of the new arrangement, giving the preference to the two-valved engine.

Mr Neilson, of Hyde Park Foundry, Glasgow, rose and expressed himself strongly in favour of these engines, although there was less profit on their manufacture than the beam-engine. He enlarged upon the saving in the pit-work, and the advantage of the long stroke, by fewer openings and shuttings of the clacks being required, and concluded by expressing his belief that a 20-feet stroke would yet be attained.

Mr Cadell, of Grange Colliery, Bo'ness, next spoke, and while he gave Mr Landale every credit for the ingenuity of this application of a pumping engine, and for the paper just read, and admitted the great saving in the first cost, yet he could not agree with him as to all the advantages to be derived, while he saw several drawbacks which he would endeavour to point out. The first was, the placing of a cylinder of such a size over a pit-mouth was inconvenient, and prevented the proper application of the crab-rope to the pump-rods in cases of repair. The second was, that the piston and piston-rod were added to the weight of the pit-work, whereas in the old way, when hung on the opposite side of the beam, they acted as a balance to the pump-rods. A long stroke could be got in the old way by a longer beam, and the two-valved nozzles with the vacuum-valve (of which he highly approved) could be applied to the beam-engine.

Mr Edward Sang, F.R.S.E., after asking some questions about the vacuum valve, and the kind of foundation for the building on the pit-mouth, concluded by repelling some of Mr Cadell's objections, and eulogizing the direct-acting-engines.

Mr Black, architect, saw no difficulty in getting a foundation ; it would be as easy for the direct-acting-engines as the beam-engine.

Mr Elliot also spoke in favour of the direct-engine, and particularly the perfect vacuum obtained above the piston, at the proper time for the up-stroke ; but he would advise Scotch engineers never to rest until they obtained the same *duty* as the Cornish engineers had done.

Mr Gourlay, one of the makers of these engines, concurred in every word that had fallen from Mr Landale and others in favour of the direct-acting-engines, and saw nothing in Mr Cadell's objections. All he saw wrong with the engine was, there is too little work on them, too little iron and brass, and they are too easily made to afford so much profit to the maker.

Mr Sinclair also spoke in favour of the direct-engines, and moved a vote of thanks to the author of the paper.

Mr Landale, in reply, said, with regard to the long-stroke, the old Dysart engine had a 6-feet stroke; he had begun with 9 feet, and in the last engine had arrived at 12 feet, and he might come to 15, but there were practical difficulties in the shaft which, he feared, would preclude a 20-feet stroke. He could assure his friend, Mr Cadell, there was no real inconvenience found in practice by the half of the cylinder covering the end of the pit. There was a manhole in the cylinder bottom through which all the upper dry rods were let down, and, after being once in their place, he did not expect their renewal during a whole lease ; that with the lower pumps and rods several hundred feet down there was no real difficulty in the rope being 3 feet off the plumb for the short period it was required. Then, as to the objection of the piston and rod being on the wrong end of the cylinder, Mr Landale reminded Mr Cadell that with forcing pumps, in many cases, it was not so, but that weights had to be applied to the pump end of the beam ; and as to getting as long a stroke with a beam, that involved a vast expense. The Balgonie engine, for instance, with an $8\frac{1}{2}$-feet stroke in the shaft, had a beam 28 feet long and 14 tons weight; such a beam for a 12 feet stroke would need to be 38 feet long, and the additional weight and building to carry it were evils of no small magnitude, which it was the object of the direct-engine to avoid. He agreed with Mr Cadell that the two-valved nozzles, and the vacuum valve, could be applied to the beam-engine as well as the direct-acting one. As to Mr Elliot's observation about the inferior "*duty*" done by Scotch engines, he begged to remark, that with the direct-engine, all the Cornish improvements in casings, clothings, and boiler could be applied to it exactly as to the Cornish engines, and he had not the least doubt, that as large a "*duty*" could be got here as in Cornwall (quality of coal considered). But, at most collieries, where the small coal is mixed with shale and dirt, the Cornish boiler is inapplicable, and, as that rubbish must be burned, and costs only from 1s. 6d. to 2s. 6d. per ton, parties will not go to the expense of steam-jackets and clothing of pipes and boilers, as they do in Cornwall, where coal is seven times the price.

Mr Landale stated that some of his direct-acting-engines were now about to be constructed by makers who had formerly opposed their introduction, and that they had been made at a cost (including foundations) of L.1720, as compared with the old engines of L.3500, the engines being of equal power.

The Communication was then referred to a Committee to report.

2. On a Dissected Electro-Magnetic Coil-Machine, on the principle of the Medical Shock Machine. By Mr William Hart, philosophical instrument maker, Young Street. Communicated by the President. The machine was exhibited in action. (3715.)

Thanks voted.

Several other Communications were postponed for want of time.

The following Donations were laid on the table, viz:.—

1. Catalogue of Select Examples of Ivory Carvings from 2d to 6th centuries, preserved in various public and private collections in England and other countries, casts of which may be obtained from the Arundel Society,—classified in Schools and Periods. By Edmund Oldfield, M.A., Assistant in the Department of Antiquities, British Museum. Presented by the Council of the Arundel Society, 24 Old Bond Street, London. (3693.)

2. On Caries of the Teeth, and the Cure of Toothache without extraction. By Donaldson Mackenzie, surgeon-dentist, 21 Saville Row (London, 1855). Presented by the Author. (3694.)

3. The Assurance Magazine, No. XXI. in continuation. (3671.)

4. The Assurance Magazine, Vol. VI. Part II. Jan. 1856. Presented by the Institute of Actuaries of London. (3709.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidate was elected an Ordinary Fellow, viz.:—

William Lees, A.M., Lecturer, School of Arts.

The Society then adjourned.

25th February 1856.—Professor George Wilson, M.D., President, in the Chair. The following Comunications were made:—

1. On the Adaptation of the Micrometer to the Levelling Telescope. By Edward Sang, Esq., F.R.S.E. (3690.)

The improvement described in this communication consists in moving the field-bar of the telescope by means of a micrometer screw. The divisions of the level scale are made to correspond with those of the micrometer, so that, when the telescope is slightly out of position, the error can be corrected on the micrometer. In this way the very tedious operation of bringing a delicate level to its zero is avoided. By placing two wires at a proper distance from each other, a means is obtained of correcting directly for the curvature of the earth. But the chief facility is this, that when the utmost degree of precision is wanted, the wire is brought to the divisions on the staff; and the place at which the horizontal line cuts it obtained by computation.

After a discussion, in which the President, Messrs Adie, Leslie, V.P., D. Stevenson, Mr Elliot, V.P., and Mr Sang, took part, the Communication was referred to a Committee.

2. Description and Drawing of a Rifle-Barrel, with Screw of irregular pitch, and of various forms of Bullets. By Mr Peter K. Hunter, draughtsman, Cowlairs Station, Glasgow. (3699.)

It was stated that this rifle may be made either oval or grooved. The principal difference from the ordinary rifle is, that the screw is *irregularly* pitched, commencing at the breech with a pitch of about five feet, and getting gradually quicker until it reaches the muzzle at a pitch of about two feet. By this method it is intended to impart *gradually* the rotatory motion to the bullet, and prevent its riding over the screw thread and the dangerous consequences in firing the Lancaster guns. The author also described a form of sight different from any in use; and also a form of bullet for firing with plain bored barrels.

It was stated by Mr Mortimer, that he believed that the irregularity in the pitch of the groove was included in Lancaster's patent.

Referred to a Committee.

3. Description and Sketch of a new mode of Steamboat Propulsion. By Mr Peter K. Hunter, draughtsman, Cowlairs Station, Glasgow. (3695.)

The air is to be forced towards the stern of the vessel by a blowing cylinder, and the blast orifice is under the water. The blast orifice is near the centre of the ship, on both sides of the keel, and kept as far below the surface of the water as the ship's draught will admit, and slightly inclined downwards, whereby, in the author's opinion, a resisting medium of 1 lb.

per square inch of orifice would be obtainable for every two feet it is below the surface.

It was stated by a member that this suggestion proceeds on a fallacy, viz., that more power would be obtained by the blast under water, than if it were above water, and that, though the vessel in both cases would be propelled, it would be with a great loss of steam power.

Referred to a Committee.

4. Letter to the Secretary on the subject whether Lightning Rods should terminate in a Point or Ball. By J. Stewart Hepburn, Esq., of Colquhalzie. (3712.)

The Secretary read a letter from Mr Stewart Hepburn in reference to the discussion which took place last session on the subject of lightning conductors, in which he mentioned the common experiment where two conductors, one terminating in a point, the other in a ball or disc, were presented together to a charged battery. The discharge took place by the *pointed* conductor; not, however, at once by a *flash*, but by a *continuous stream*; showing, as he conceived, that the pointed wire, being only capable of drawing off an electric charge gradually, was inapplicable to the protection of buildings, where it had to deal with atmospheric electricity darting in mass through the air from a distant cloud. And he ventured to suggest the possibility of bringing it to the test of experiment, by fixing to a large building two conductors, one pointed, the other with a ball, each being made to pass through a metallic case containing a charge of gunpowder, with a break within the charge to cause a spark. When a thunder-storm passed over the building, the explosion of one or other of the charged cases (whether heard or not) would show which of the conductors was best adapted for conveying the flash to the earth.

The thanks of the meeting were voted to Mr Stewart Hepburn for this Communication; but the subject having been so recently discussed, the meeting did not feel inclined to renew the discussion.

5. Patented Improvements for Heating Bakers' Ovens. By Mr Alexander Hendry, Port-Glasgow. A model and drawings were exhibited and described. (3718.)

The mode of heating patented by Mr Hendry is by a series of pipes through which the heat passes from the furnace to the flue. These pipes rest upon bars of iron, about fifteen inches from the sole of the oven, and heat the oven thoroughly, the sole as well as the roof, and the heat is capable of being easier kept up than by the common method. He stated that there was a great saving in fuel, as, in place of good coal or wood, common dross can be used with good effect. Two such ovens when placed side by side can be heated by the same furnace. Mr Hendry exhibited specimens of bread baked by his new mode of heating, showing that the sole of the oven was sufficiently heated—the bottom of the bread being equally if not better done than the top. He also stated that his method was much more cleanly, there being no fire introduced into the oven and no smoke.

Thanks voted.

The following Reports of Committees were read and approved, viz.:—

6. On Mr Sang's proposed Improved Construction of a Standard Weight. Mr Elliot, Convener. (3698.)

7. On Mr James Laing's New Air-Pump. Mr Sang, Convener. (3691.)
8. On Mr A. Bryson's Pneumatic Chuck for Preparing Fossils for the Microscope. Professor Gregory, Convener. (3672.)

The following Donations were laid on the table, viz. :—

1. The Tricolor Code of Metallic Signals, or Nautical Alphabet. By Alfred Wilkinson. Published by Mrs Jane Taylor, 104 Minories, London, 1855. 12mo, pp. 8. Presented by the Author. (3704.)
2. Remarks on Floating and Fixed Lighthouses. By David Stevenson, Esq., F.R.S.E., M. Inst. C.E., January 1856. 8vo, pp. 8. Presented by the Author. (3714.)
3. Proceedings of the Institution of Mechanical Engineers, Birmingham, October 24, 1855. Presented by the Institution. (3716.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidates were elected Ordinary Fellows, viz. :—

1. Auckland Campbell Geddes, C.E., 1 Erskine Place.
2. William Irving, Assist. Loco. Supt. Scottish Central Railway, Perth.

The Society then adjourned.

10*th March* 1856.—Professor George Wilson, M.D., President, in the Chair. The following Communications were made :—

1. Railway Signals and their suggested improvements. By Mr Thomas Sturrock, brassfounder, Thomson's Place, Leith. A model and three drawings were exhibited. (3721.)

Mr Sturrock stated that, by a very simple contrivance, he has united all the movements of the day-signal with the night signal ; done away with the third colour, or green light, by a combination of red and white only ; and by easy application of the lenses, superseded the three-lensed lamp now in use, and rendered the signal at once simple and intelligible. He stated that his improvement consists principally in the arrangement of the blades or arms having the lenses attached, and fixed lanterns behind the arm ; that it is equally applicable to the locomotive engine and the tail-van of a train, thus rendering communication more efficient than at present. He also suggested improvements on the present mode of flag and hand-lamp signalling.

A discussion ensued, in which Mr Bouch, C.E., Colonel Moodie, the President, Mr Elliot, V.P., Mr Sang, and the Secretary, took part. Mr Bouch considered Mr Sturrock's suggestion good for the night-signals, but that it was no improvement on day-signals, which should always be distinguished by *form* as well as *colour*. Mr Bouch also strongly advocated the point that railway signals should always give *positive* and not merely negative information. They should leave nothing to be inferred by the engine-driver.

Referred to a Committee.

2. On a correct and cheap Assay Balance. By Robert Aytoun, Esq., W.S. The balance was exhibited. (3722.)

In this balance, as the author stated, one end of the beam is loaded with a permanent weight, while from the other end is suspended a pair of pans, one below the other. Before using the balance, it is necessary to ascertain the counterpoise or weight required to counterbalance the permanent weight on the loaded arm. For this purpose weights are to be put into one of the pans until the equilibrium be established. The greatest care must be bestowed upon this process, as the correctness of all subsequent weighings depends upon it. The weights composing the counterpoise are put into a box, and the instrument is now ready for use. The substance to be weighed is to be placed in one of the pans, and weights taken from the box are to be put into the other, till the equilibrium be established. The weights *which remain in the box* give the weight of the substance. The weight thus determined is totally free from the numerous errors which occur in the ordinary process of weighing, where the substance and corresponding weights are suspended from the opposite arms of a balance. A second improvement was stated to be gained in this balance by the use of needle-points instead of knife-edges. By this substitution great delicacy is obtained, and means of immediate repair are placed within the reach of the operator.

A discussion took place, in which Mr Adie, Dr Stark, and Mr Sang took part, in which the remarks were laudatory of Mr Aytoun's method. Mr Sang said that he knew a gentleman of the name of Whelpdale, about eighteen years ago, who invented a nearly similar balance, but as it was never made public, this did not detract from Mr Aytoun's merit as an inventor.

Referred to a Committee.

3. Notice of the Niagara Suspension Bridge, designed by Mr Roebling, C.E.; and of another Railway Suspension Bridge over the Kentucky River, on the Lexington and Dansville Railway, of 1200 feet span, and 300 feet high above the river—also designed by Mr Roebling—with a tracing of Plan and Section of Truss. Communicated by Thomas C. Gregory, Esq., C.E., F.R.S.S.A., Great Western Railway, Windsor, Canada West. (3708.)

Thanks voted.

The following Reports of Committees were read and approved, viz.:—

4. On Mr Aytoun's suggestions for increasing the Speed of Steamboats. Mr Elliot, Convener. (3707.)

5. On Mr E. Sang's application of the Altitude and Azimuth Circle to Stereometric Surveying. Mr Elliot, Convener. (3689.)

The following Donation was laid on the table, viz:—

Introductory lecture on the Harmony of Theory and Practice in Mechanics, delivered to the class of Civil Engineering and Mechanics in the

University of Glasgow, 3d January 1856. By W. J. Macquorn Rankine, Esq., C.E., F.R.SS. L. & E., Regius Professor. (3719.)

Thanks voted to the Donor.

Purchased—The Year Book of Facts, 1856.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The following Candidates were elected Ordinary Fellows, viz.:—

George Waterston jun., stationer, 56 North Hanover Street.
John Tod, engineer, 29 Leith Walk.
William Hurst, engineer, 12 West Brighton Crescent, Portobello.

The Society then adjourned.

24*th March* 1856.—James Elliot, Esq., Vice-President, in the Chair. The following Communications were made, viz.:—

1. Remarks on the Gyroscope in reference to his "Suggestion of a new experiment whereby the Rotation of the Earth may be Demonstrated," read before the Royal Scottish Society of Arts, 9th March 1836. By Edward Sang, Esq., F.R.S.E. The Precession Instrument given to Professor Playfair by M. Arago about 1817 was exhibited. (3723.)

The object of these remarks was formally to draw the attention of the Society to the fact that the experiment made by M. Foucault before the meeting of the British Association at Liverpool had been contrived and explained by Mr Sang eighteen years before, and that the Society itself had awarded to him a special vote of thanks for the communication. Mr Sang placed on the table a gyroscope which had been presented, about the years 1816-1817, by M. Arago to Professor Playfair; and he read *verbatim* the paper which, twenty years ago, he had read before the Society, and in which an investigation of the conditions of the experiment was given. The matter is recorded in the "Edinburgh New Philosophical Journal" for April to October 1836, p. 164, and for October 1836 to April 1837, p. 210. He stated that he had no wish to detract from the merits of M. Foucault in regard to this experiment; his interest rather lay in having these merits exalted; his object was simply to assert his priority.

Professor C. Piazzi Smyth, Astronomer-Royal for Scotland, being called up by the Chairman, said that he had been very much gratified by the opportunity which he had just had of hearing an account of Mr Sang's early experiments from his own lips. He trusted that some early and efficient means of publication would be adopted to do proper justice, though even at the eleventh hour and the twentieth year, to the original genius of our able member. "The phenomena of rotatory dynamics are," he said, "amongst the most interesting of mechanical effects, but so difficult to inquire into, that it is not to be wondered at that they are still far from being generally understood or appreciated. The first celebrated application of these laws was made by Newton in his explanation of the *precession of the equinoxes*, and nothing which has been done since can compare with that mighty problem. In a practical way many little instruments have been invented from time to time, on the Continent and in this country, to show that *precessional* movement; but they were all mere pretty little toys, capable—as, indeed, almost everything that can turn is—of showing the manner in which precession is brought about, but nothing further. And little advance was made in the matter until soon after 1820, when Troughton produced his celebrated 'top,' and exhibited the properties residing in free rotation in a far more striking manner than had ever been seen before. For, by his method of adjusting the centre of gravity to the centre of motion, and by the immense amount of mechanical energy which he accumulated by wheelwork and threw into the spinning of his top, he brought about that that body, which, when at rest, would have wabbled on its supporting pin at the slightest touch, like a delicately-poised compass-needle—would now acquire such a wondrous faculty of keeping its own place in spite of disturbing forces, that, though hammered on one side with the fist, it would not sensibly yield, but appeared as if nailed to a fixed support. This property, as residing in a spinning body, was shown by M. Foucault, at the Liverpool meeting of the British Association, and every one clapped their hands, and declared it quite new; and, as I have personally experienced, one can hardly now bring forward, either in this country or in France, any scientific apparatus, including rotatory motion, in any shape or for any purpose, without being told that 'it is *precisely* Foucault's apparatus,' or 'that it is *only* his apparatus,' *i. e.*, only a theft from him, and nothing more. No one seemed to think of Troughton, or knew that the same property has been annually exhibited in the Natural Philosophy Class-room of the Edinburgh University for 20 years past at least. But the main credit given to Foucault was undoubtedly his using the above peculiar energy to show the rotation of the earth; and this *application* has obtained as much popular celebrity as Newton's solution of the great problem of precession—obtained it, be it observed, for M. Foucault, who, we now find, was preceded in that very thing by Mr Sang some eighteen years. Mr Sang struck out the original idea, tested its truth in practice, and described to this Society a more perfect form of the apparatus, by which, as he demonstrated, the rotation of the earth could be shown in a clear and undeniable manner. In fact, Mr Sang did everything that ought to have been done, or could have been done, by the man of science; and the only part he left undone was the part of the moneyed man, viz., ordering the construction of the more perfect apparatus with the best workmanship in the finer metals. When, therefore, we find, that on Foucault taking up the subject eighteen years after, he was assisted precisely at the point where Mr Sang stopped, by the funds of Imperial France, it is evident that if, in this most popular problem of the exhibition of the earth's rotation by rotatory dynamics, Great Britain has lost the first place, it is not from her scientific sons being deficient in genius, in originality, or in invention."

After some remarks by Mr Elliot, V.P., and Mr Sang, the Communication was remitted to a committee.

2. Some account of Artistic Lithography. By Mr Alexander Macpherson, 12 Royal Exchange, Edinburgh. Illustrative specimens were exhibited. (3732.)

Some account of artistic lithography was then given by Mr Alexander Macpherson, 12 Royal Exchange. Lithography was invented by Alois Senefelder, the son of a poor actor in Munich, towards the close of last century. It was first introduced into this country, under the name of polyautography, about the year 1804; but it was not until the late Mr Rudolph Ackermann published the translation of Senefelder's celebrated treatise, some fifteen years later, that the business became domesticated in this country. It now supports more artists and artisans than all other branches of the reproductive arts put together. Artistic lithography, as distinguished from commercial lithography, was properly divided into three branches—1st, chalk drawing; 2d, chalk and tint drawing; and, 3d, chromo-lithography—of which divisions a description was given, and specimens exhibited. The philosophy of the art consisted of two principles—a physical and a chemical principle. The first was the repulsion of water and grease; the second, the reaction of nitric acid on the carbonate of lime. As to its artistic value, it was in many respects superior to line or mezzotint engraving. Specimens were exhibited after Harding and Louis Haghe, who were the great apostles of their respective schools. Several fruit pieces after Lance, by Messrs Hauhart, were described as the best productions we possessed in chromo-lithography. The French and Germans excelled us in laborious manipulation, but they were far behind us in breadth, freedom of touch, and natural effect. This might in part be accounted for by the Government patronage on the one hand, and by the voice of popular appreciation on the other, the last being the only recognition of artistic merit in our country.

Referred to a Committee.

3. Description and Drawing of a Railway Lighthouse Signal. By Andrew Carrick, Esq., 14 Holmhead Street, Glasgow. (3713.)

This invention consists of an iron column, sixteen feet high, being set up at certain points along the line. A light is reflected from a circular opening near the top, and every passing engine sets wheels in motion, by which the light is alternately obscured and brightened very rapidly during ten minutes. The object is to warn the conductor of a train that should he observe the light disturbed as above, he must be cautious in proceeding, as another train is only a short way ahead of him on the same rails.

Referred to a Committee.

4. Report of a Committee on Dr John Smith's Instrument to be used in the Construction of Artificial Teeth as a guide to their correct length and projection (Dr Newbigging, Convener), was read and approved of. (3705.)

The following Donations were laid on the table, viz.:—

1. The Journal of the Society of Arts, &c., London. Vol. III., for 1855. Presented by the Society. (3725.)

2. The Civil Engineers' and Architects' Journal, Vol. XVIII., for 1855. Presented by Mr Laxton. (3726.)

3. The Artisan, Vol. XIII., for 1855. Presented by the Proprietors. (3727.)

4. The Practical Mechanics' Journal, Vol. VIII., for 1855. Presented by Mr Johnson. (3729.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved of.

II. The following Candidate was balloted for and elected an Ordinary Fellow, viz.:—

Alexander Henry, gunmaker, 10 South St Andrew Street.

III. The Fellows received the printed Annual Abstract of the Revenue and Expenditure of the Society for Session 1854–55, and State of the Funds.

The Society then adjourned.

14*th April* 1856.—James Elliot, Esq., Vice-President, in the Chair.

The following Communications were made:—

1. On the Angular Movements of Ships—the Measurement of the Amount—and the Elimination of their Effects in certain cases. By Professor C. Piazzi Smyth, F.R.S.E., Astronomer-Royal for Scotland. Illustrated by Working Models. (3733.)

These angular movements were resolved into three varieties—viz., rolling, pitching, and yawing; or two deviations *from* the horizontal plane, and one deviation *in* the same; and were described as being those which most rendered astronomical observation difficult at sea, and in some cases impossible. To obtain numerical particulars of the amount and nature of such movements, the author had invented, and now exhibited, two new species of ship-clinometers; one of them based on the principle of a level with an *infinitely small* bubble; and the other, on the persistence of a free axis of rotation. The freedom of both these instruments from the errors of most ship-clinometers was demonstrated before the Society. To eliminate the effects of such angular movements of ships, was a second part of the paper; and by employing a *balanced* frame and one or more axes of free rotation, the author had contrived to keep small tables perfectly uninfluenced by any angular motion of ships, even by their most violent lurches. He had as yet only tried apparatus large enough to carry the astronomical instrument, but he exhibited models of others, calculated, by their principles of arrangement as well as by their size, to carry the observer also; and, amongst other methods of producing the necessary speed of rotation, he had devised a new form of driver, by which water or steam might produce in the first mover the highest velocity required, without the intervention of wheelwork. He then described the practical points necessary to be attended to, in order to bring out in the utmost force the peculiar qualities of a *free* axis of rotation; and concluded by illustrating with the apparatus on the table the true and the erroneous principles of philosophising; and gave some curious applications to moral as well as natural philosophy.

Mr Elliot (V.P.) congratulated the members on the value of the communication which had just been laid before them by Professor Smyth. He said that he had often listened with pleasure to the detail of ingenious inventions such as those in which our age abounds, but he had never enjoyed a greater treat in that way than on the present occasion. The apparatus before them displayed unusually happy applications of the principles of mechanical science, a singular felicity of ingenious resources, and exquisite workmanship. We here beheld a good specimen of the intimate connection which subsists between theory and practice. The doctrines of rotatory motion, which were at first regarded as mere subjects of theoretical investigation and wrapped up in mathematical formulæ, and subsequently brought out to illustrate natural phenomena, were now being turned into purposes of refined practical utility. He was glad to see so numerous an assembly on an evening in which the attraction on the opposite side of the street was so powerful; but if the audience were of his mind they were well repaid. At the previous meeting of the Society, a complaint was made that science did not receive, in this country, that amount of patronage from Government which was conferred upon it on the Continent; but he thought that science was making such advances that it might aspire to patronize royalty itself. If Her Majesty had occasion to take a voyage in rough weather, she could not have a greater favour conferred upon her than a seat mounted as Professor Symth had described, unmoved by the agitation of the waves, and in perfect repose amidst the fury of the tempest.

Mr Sang said that, in his opinion, Professor Smyth had hardly done justice to himself, or to the importance of the objects sought to be accomplished. Astronomical observations at sea are exceedingly difficult, and yet are essential to the navigation of a ship. Thus after a long storm the altitudes of two stars, well taken, may enable the mariner to compute his latitude and longitude without dependence upon his dead reckoning. In long voyages the rates even of the best chronometers have to be checked, and this can only be done by reference to lunar distances, or to the eclipses of Jupiter's moons. Now, a telescope mounted on one of Professor Smyth's frames, without the observer needing to accompany it, would remain sufficiently well-directed to the planet to permit the observation of an eclipse. And, again, a far less degree of steadiness than that which the Professor aims at would enable the seaman to take his lunar distance with almost as much precision as we can do on shore. There can be no doubt, then, that the introduction of such apparatus would be attended with most useful results: it would mark a new era in the practice of Nautical Astronomy.

Professor Smyth's Communication was then referred to a Committee.

2. Proposal of Experiments to determine the Molecular Changes which take place on Glass. By Edward Sang, Esq., F.R.S.E. (3734.)

In this paper, Mr Sang drew the attention of the Society to the hypothetical nature of the objections which the committee had urged against his standard weight (a glass ball containing mercury), and proposed that the Society should institute a set of annual weighings, for the purpose of ascertaining if any and what changes time may induce on the bulks of glass balls.

After some remarks by Mr Elliot, V.P., and Mr Sheriff Cay, Mr Sang's paper was referred to a Committee to consider and report whether the

Society should undertake such a set of experiments as would require to be carried on for a series of years.

3. On a Method of Preventing the Bursting or Straining of Water-cocks during frost. By Mr Alexander Cleugh, Rawcliffe, Yorkshire. Specimens were exhibited. (3724.)

In this paper Mr Cleugh gave the results of his experience of his invention, which, he stated, had not failed during the past winter. His method is to cast the plugs hollow, and to fill the space above the water-way with vulcanized India-rubber, as shown in the specimen exhibited, the elasticity of which allowed the water to expand in freezing, and thereby saved the cocks. He stated that he had taken out the plugs when the water in them was frozen, but never found one broken or strained in which this packing was placed; while the others, if frozen, were either broken or strained, so that part of the water escaped, and when the ice melted these cocks leaked, and generally had to be rebored, and have new plugs made for them.

After some remarks by Mr Sang and Mr Melville, the latter of whom stated that, from experience, he considered that a hole in the pail, so as to allow the water in the water-way to escape when the cock was shut, is fully a better preventative from bursting, the Communication was referred to a Committee.

4. Report of Committee appointed to collect information as to the Effects of the late Hurricane upon Tall Chimneys, &c. (Mr Bow, Convener), with Drawings. (3742.)

The chimneys affected by the hurricane of 7th February 1856, and of which particulars were given, were those at St Rollox, Glasgow, 330 feet high above ground; Dalry, Edinburgh, 180 feet; Innerleithen, 110 feet; and shorter ones at Portobello, Musselburgh, Dalkeith, Lingerwood, near Dalkeith, Arniston, and Leith. The report was confined to recording the simple facts of each case; any theoretical opinions upon the stability or mode of failure of tall chimneys that may have come before the Committee, Mr Bow stated, would be duly noticed in a subsequent communication to be made on these subjects by the Convener.

The thanks of the Committee and of the Society were given to the gentlemen who had kindly assisted in the work of collecting information—among others, to the Messrs Tennant & Company, Glasgow, Mr Robert Gill, Innerleithen, and in particular, to Mr John Young, manager of the Dalkeith Gasworks. The thanks of the Society were also voted to the Committee, and especially to Mr Bow, the Convener, for his exertions in obtaining and in illustrating and tabulating the information obtained.

The following Reports of Committees were read and approved, viz.:—

5. On Mr Peter K. Hunter's mode of Steamboat Propulsion. Mr Aytoun, Convener. (3695.)

6. On Mr Peter Hunter's Rifle Barrel and Balls. Mr Alex. Kirkwood, Convener. (3699.)

7. On Mr Gall's Gas-Stove without Flues. Mr P. Stevenson, Convener. (3710.)

8. On Mr D. Landale's Direct-Acting Pumping Engines, as lately introduced in Scotland. Mr Leslie, V.P., Convener. (3717.)

The following Donation was laid on the table, viz. :—

Railway Machinery,—a Treatise on the Mechanical Engineering of Railways, embracing the principles and construction of Rolling and Fixed Plant, illustrated by Plates, &c. By Daniel Kinnear Clark, Esq., C.E. Vol. I. Text; Vol. II. Plates. Fol. Glasgow, 1855. Presented by the Author. (3729–1–2.)

Thanks voted to the Donor.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. A List of Prize Subjects for Session 1856-7, prepared by the Council, was approved of, and ordered to be printed and advertised as usual.

The Society then adjourned.

28*th April* 1856.—James Elliot, Esq., Vice-President, in the Chair.

Before commencing the business in the programme, Mr William Swan, F.R.S.E., read the following letter addressed by him to the Secretary :—" Having felt much interest in the claims of Mr Edward Sang, as the original proposer of the method of exhibiting the diurnal motion of the earth, by the persistence of the plane of rotation of a freely suspended and rapidly revolving wheel, I have great pleasure in being able to give my testimony in his favour.

" In 1836 when Mr Sang read his paper entitled ' Suggestions of a new Experiment which would demonstrate the Rotation of the Earth,' I was not a member of the Royal Scottish Society of Arts, having then scarcely completed my 17th year. I was however, present at the meeting of the Society on the 9th March, for the purpose of hearing my cousin, David Stevenson, read his observations on the Dublin and Kingston Railway.

" I have a very distinct recollection of seeing Mr Sang spin a sort of top, a polished brass sphere or spheroid, hung in something like the gimbals of a ship's compass. And that he thus proposed not to *illustrate but actually to prove the fact that the earth revolved.*

"Although I was not then able fully to comprehend the theoretical grounds of Mr Sang's proposal, this constitutes no reason why my evidence should not be received as to matters of fact, about which my recollection is perfectly distinct, namely, that he proposed to *demonstrate experimentally the rotation of the earth, and that for that purpose he put a mass of metal in rapid rotation.*

" These facts were probably all the more strongly impressed on my memory from the surprise I well remember to have felt at the long time the revolving body continued in motion after being 'spun,' a feeling again recalled to my mind some years afterwards on seeing Troughton's top at the Natural Philosophy Class at College.

"While I heartily concur in the justly merited tribute of praise which has been awarded to M. Foucault, I am anxious to see justice done to the prior claims of Mr Sang; and if my humble testimony can add the slightest weight to the evidence existing in his favour, it will afford me the most sincere pleasure. I remain," &c.

Mr Alexander Bryson then rose, and stated that he also had been present at the meeting referred to by Mr Swan, and had witnessed the experiment of the rapidly revolving spheroid exhibited by Mr Sang on that occasion.

The meeting ordered the letter to be recorded in the minutes.

The following Communications were made :—

1. On a Method of producing an intense Lime Light by the Bunsen Lamp, without risk of Explosion. By Alexander Bryson, Esq., F.S.A. Scotland. (3735.) The lime light was exhibited.

The apparatus consists of a Bunsen lamp with the addition of an interior tube flattened at the top for the emission of the oxygen. This inner tube is carried up nearly to the top of the Bunsen lamp, and the two gases (oxygen and hydrogen) are mingled at the point of ignition on a flat disc of lime. The frequent explosions which render the lime light so troublesome are thus avoided, and it burns with all the steadiness of a moderator lamp. When the gases are used in proper proportions, the light was stated to be very intense.

After some remarks by Messrs Sang, Thomas Stevenson, Fyfe, Swan, Gardner, and the Secretary, the Communication was referred to a Committee.

2. Dr Fyfe presented to the Society specimens of Torbane Coal, and of the products of Distillation of Coal. (3738.)

After making a few observations on the composition of coal, Dr Fyfe presented to the Museum of the Society specimens of the products of its distillation, to which he had referred in the paper read in 1854, such as tar liquor, ammonia-water, naphtha, naphthaline, paraffine, paraffine oil, &c. Specimens of the same substances, procured from Torbane coal, were also presented, along with specimens of the different cannel-coals of Scotland, accompanied with a statement of their composition, pointing out the percentage of volatile matter and of coke afforded by each, and the quantity of fixed carbon and of earthy matter in each of the cokes. Dr Fyfe also exhibited some specimens of Torbane coal containing fossil remains, some of which were large and entire. The composition of the coals containing these, and which was marked on each specimen, Dr Fyfe stated he had found to be the same as that of the other pieces of Torbane coal which he had analysed and laid before the Society in 1854, with only one exception. In it, the composition more nearly resembled that of common cannel. A piece of the trunk of a tree, of about a foot in diameter, found imbedded in Torbane coal, was also exhibited and presented to the Museum. The composition of this tree was also the same as that of the other specimens containing the fossil remains, with the exception of the bark, in which the percentage of volatile matter and of coke was nearly alike, while the earthy matter was small as compared with that generally existing in Torbane coal. The coke of the bark also resembled that got from English caking coal; the pieces, when taken from the vessel in which they were heated, being joined together, whereas those from the Torbane coal were always separate.

On the motion of Professor More, seconded by Mr Bryson, the thanks of the Society were unanimously voted to Professor Fyfe for his valuable and interesting Donation, which were given to him from the Chair.

3. Remarks on the present Patent Laws, and the manner in which they are administered. By the Rev. James Brodie, A.M., Monimail, Fife. (3739.)

Mr Brodie, in this paper on the British Patent Laws, showed that the expense imposed on inventors is most oppressive, amounting to at least £200 for every complete patent for fourteen years. He also showed the absurdity of some of the regulations of the Patent Law Commissioners, and the call that there was for an inquiry into the whole subject; the encouragement given to inventors abroad, while they are oppressed in Britain, having lowered us in the rank of producers, and enabled other nations to excel us in those manufactures in which we formerly stood pre-eminent. He also showed the injurious effects which the systematic oppression of talent and ingenuity produced on the social and moral condition of our more intelligent artisans, who finding property protected and honoured, while inventive talent is repressed, feel themselves to be injured, and naturally become discontented. To this cause he attributed in no small degree the chartism and infidelity which prevail among our manufacturing classes.

Thanks voted. Referred to the Council to petition Parliament, if thought proper, either for a committee to investigate, or at least for a reduction of the fees and stamp-duties.

4. Some observations on his Patented Holding-Instruments, such as Vices, Pincers, Pliers, Tongs, Rope-Holders, &c. By the same. Specimens were exhibited. (3740.)

Mr Brodie made some remarks on the principles on which the action of holding instruments, such as vices, pincers, pliers, and tongs, depends, to which subject his attention had been turned while endeavouring to construct an instrument by which seamen might be enabled to grasp a rope and hold on by it, even when the hand was benumbed with cold. The instruments were exhibited, and the ingenuity of their construction called forth the approbation of the Meeting.

Thanks voted.

5. Description and Drawings of a Simple Apparatus for Boring Cheeks of Cranes, and other similar purposes. By Mr George H. Slight, engineer, 34 Leith Walk. (3730.)

The author stated that this apparatus was constructed, and principally used for boring the cheeks of Henderson's patent Kerrick cranes, and consists of two parts, one stationary, fitted up immediately within the outer wall of a workshop, with toothed gearing, driving pulleys, and clutches, for driving a spindle in either direction, or disengaging it. This spindle extends through the outer wall, and has on its outer end a fixed fork or double driver. The other part of the apparatus is attached to the stem of the crane to be bored, and consists of two light angle iron frames, fixed temporarily by being jammed against the sides of the crane stem by two bolts. In each of these frames a round cast-iron bush is supported by set screws and hung in the same manner as a ship's compass, so that it is capable of adjustment in any direction, and has the power of adjusting itself to the direction of the boring bar which it supports. The boring bar is turned parallel throughout, and has on one end a fork, to connect it with the one on the driving spindle, and attached by a pin which allows it to move sideways and adjust itself to the driver, thereby almost entirely removing bending strain from the boring bar. Cutters are fixed in mortices in the bar, and the bar is moved sideways in either direction by a screw working in a spherical nut, which allows a certain amount of obliquity between the direction of the bar and the screw. The crane stem, while being bored, is simply blocked up to bring the bar nearly in a line with the driving spindle, a considerable deviation being allowable without any serious risk of lateral strain to the bar. Different sizes of boring bars and supporting bushes are employed, the same frames answering for all.

Referred to a Committee.

6. A new and improved Swey or Swing, for raising and lowering Culinary vessels on a Kitchen Range. By Mr John Johnstone, smith, Hamilton. Communicated by Mr James Gray, 85 George Street. A model was exhibited. (3731.)

In this swey the lever for raising or lowering the culinary vessels is adjusted to any height by a screw which raises or lowers a nut sliding in a groove. It was stated to be much safer than the usual method of a pin and a series of holes.

Referred to a Committee.

7. Chattaway's Patent Central Buffing and Drawing Apparatus for Railway Rolling Stock was described by Mr E. D. Chattaway, Meadowbank House, Edinburgh. A full-sized model was exhibited. (3737.)

The patentee stated that in this contrivance the buffer and draw-hook are combined in one piece or arrangement, and the buffer-head, instead of being a plain circular disc, is made of an irregular form, the lower part being curvilinear, whilst the upper part is a long narrow projection. The inner side of this projection is shaped to act as a draw-hook, for the reception of the coupling-link of the adjoining carriage, which, being made wide for the purpose, works upon it as upon an ordinary draw-hook. The draw and buffer rod is made with a screw-thread near its end, just within the buffer-head, and carries an adjustable nut and collar apparatus with projecting arms, carrying a wide coupling-link. In this way the coupling can be drawn hard up or slackened off, as occasion may require. Instead of adopting the screwed spindle and collar arrangement for tightening up the coupling, the nut may be dispensed with and the rod left plain, or the collar working loose upon it, and carrying a pin connected to it by a chain, such chain being for insertion in vertical holes bored through the rod. There is an average saving of 40 per cent. in cost and 60 per cent. in weight with this coupling apparatus, as compared with the various systems at present in use, with much less injury to the carriage-frames, from the patent buffer being in the centre.

Thanks voted.

The following Reports of Committees were read and approved:—

8. On Mr Aytoun's Assay Balance. Mr Adie, Convener (3722). A

balance on this principle, made by Adie, was exhibited, capable of weighing up to 1000 grains, and turning with one-hundredth of a grain.

9. On Mr Sang's remarks on the Gyroscope, in reference to his former paper, No. 355, suggesting an experiment which would show the rotation of the earth. Professor Kelland, Convener. (3723.)

The following Donations were laid on the table:—

1. Proceedings of the Institution of Mechanical Engineers, Birmingham. December 19, 1855. Presented by the Institution. (3736.)

2. The Assurance Magazine and Journal of the Institute of Actuaries. No. XXIII. Vol. VI. Part III. Presented by the Institute. (3741.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. It was stated that a copy of the List of Prize Subjects for Session 1856-7 had been sent to the Fellows, and more might be had for distribution on application to the Secretary. The Fellows were requested to make the list known in their several localities.

III. In terms of Law XX., the Treasurer laid on the table a list of those Ordinary Fellows who are in arrear of their annual contributions.

The Society then adjourned.

The Society held an Extraordinary Meeting on Monday, 14th July 1856;—Professor George Wilson, M.D., F.R.S.E., President, in the Chair.

The President reported from the Council the generous foundation of a Biennial Prize or Medal of Ten Sovereigns, by General Sir Thomas Makdougall Brisbane, Baronet, G.C.B., G.C.H., &c. &c., of Brisbane and Makerstoun.

On the motion of Richard Hunter, Esq., the thanks of the Society were unanimously voted to Sir Thomas for his munificent gift; and on the motion of the Secretary, a cast from Mr Gall's bust of Sir Thomas was ordered by the Society.

The following Communications were made:—

1. On the Manufacture of Ropes and Paper from the Stem of the Hollyhock. By Mr James Niven, gardener to William Stirling, Esq. of Keir. Communicated by the President. Specimens in illustration were exhibited. (3753.)

This invention relates to the application or employment and use of the common garden hollyhock, or the *Althea rosea* of Linnæus, and other plants in the natural family *Malvaceæ*, in the manufacture or production of the pulpy material or fibre from which paper is to be made, as well as in the manufacture or production of fibrous material for textile purposes. In the adaptation of these plants, or their varieties, they may be used either in a green or dried state. They are prepared by being broken up by any of the ordinary means hitherto used for the disintegration of vegetable fibres, the whole being suited, after disintegration, for the production of pulp for the manufacture of paper. Its adaptation as a substitute for rags and other materials now used will be easily demonstrated.

(1.) Because of the bulk of pure available fibre it produces, the stems attaining the height of from eight to ten feet even under ordinary cultivation, the only loss in weight being in the separation of the mucilaginous matter which they contain.

(2.) Because of the permanency of the crop, and the tendency of the root to stool like the willow, thereby producing with its age a greater number of stems, the strength of which may be easily upheld by the application of portable or liquid manures.

When the crop requires renewal, the roots, which contain a large amount of farina, should be bruised in the manner of making starch from the potato, and the fibre left is at once suited for the fabrication of a quality of paper even stronger than that which can be produced from the stems, the farina being also available either as a substitute for starch or food for animals. It is also known that the hollyhock contains a large amount of colouring matter, which, being little inferior to indigo, might also be extracted, and thus the whole plant appropriated to useful purposes. Its suitability for the manufacture of rope is alone sufficient to cause it to be extensively cultivated, an acre of plants, when established, producing from three to five tons of available fibre for this purpose. The average quantity of fibre suited for the paper manufacture per imperial acre will be about 15 tons. This arises from the inner boon of the stem being pulped down with the outer fibre.

Thanks voted to Mr Niven, and also to the President, in communicating and exhibiting the specimens.

2. On the Swedish Safety Lucifer-match. Communicated by the President. The match was exhibited. (3754.)

The safety lucifer-match is the invention of Lundstrom, a Swede, who has a large match manufactory at Jonkoping, in Sweden, where some hundreds of workmen are employed, and eight or more millions of matches are produced daily. They are about to be introduced into this country by the firm of Bryant and May, London, who are the largest importers of German and Swedish lucifers in the kingdom. A patent has been taken out in their name for the sale in England of the Swedish match. Its peculiarity consists in the division of the combustible ingredients of the lucifer between the match and the friction-paper. In the ordinary lucifer, the phosphorus, sulphur, and chlorate of potash or nitre, are all together on the match, which ignites when rubbed against any rough surface. In the Swedish matches these materials are so divided that the phosphorus, which is employed solely in the amorphous (slightly combustible) form, is placed on the sand-paper, whilst the sulphur and a minimum amount of chlorate, or nitrate of potash, is placed on the match. In virtue of this arrangement, it is only when the phosphorized sand-paper and the sulphurized match come in contact with each other that ignition occurs. Neither match nor sand-paper singly takes fire by moderate friction against a rough surface. The matches are thus much less liable to cause accident by casual ignition than the ordinary ones; and the recent edict by the Spanish government against the employment of lucifers by the peasantry of the forest districts in dry weather (which will certainly be evaded), would be needless, if the Swedish matches were in general use. If they fully answer the announcements of the inventor (and it is due to him to acknowledge that they excited great interest at the Exhibition in Paris last summer), they will soon displace the common lucifer, in virtue alike of their manufacture being much less injurious to the health of the workmen who make them, and to the property of those who use them.

Thanks voted to the President for this Communication.

3. Description of an Apparatus for seeing through Tubular Drains from the Surface of the Street. By James Leslie, Esq., C.E., Vice-President, Royal Scottish Society of Arts. A model and drawings were exhibited. (3748.)

The apparatus exhibited, which may be considered as a model on half the scale which it would be expedient to adopt in practice, is for the purpose of affording the means of seeing from the surface of the street through underground tubular drains which are too small for a person to pass through, and thereby enabling the observer, without his requiring to go down into any underground chamber, by looking towards a lamp or candle lowered down to another point in the line of drain, to see whether there be any sediment or other obstruction in the portion of the drain between him and the light. This is effected by looking down, with the help of a telescope of small power, to a mirror set at an angle of 45°, in the lower end of a light metal tube, say six inches diameter, and lowered down from the surface of the street to the axis of the drain-pipe, through a fixed vertical pipe or eye, a light being lowered down another and similar vertical pipe, whereof there must necessarily be one at every bend or change of gradient in the drain.

Referred to a Committee.

4. Suggestion for the introduction of the Parisian *Crochet* for the use of Street Porters. By Colonel Graham Graham of Jarbruck, Moniaive. (3702.)

This was a suggestion for the introduction, for the use of street porters, of what in Paris is called a *crochet*, a very simple and cheap contrivance (as one can be constructed for 2s. 6d. to 5s.), curved on the back, which has the effect of throwing the load off the spine, and causes it to rest on the limbs, thus enabling the porter to travel much more comfortably, even under a greater load than that usually carried in this country. Mr Sang remarked that a somewhat similar machine, of even simpler construction, was in daily use in Constantinople; and that it was astonishing how great a load a Turkish porter can carry, the pressure being entirely thrown upon the limbs, and not on the spine.

Thanks voted to Colonel Graham.

5. Descriptions and Sketches of Three American *Registered* Kitchen Ranges or Cooking Stoves. By Mr James Smith, 85 Union Street, Glasgow. A model and some of the stoves were exhibited. (3746.)

The advantages of these stoves, or portable ranges, were stated to be their peculiarly compact formation, affording, at a comparatively small cost, nearly every opportunity for all the varieties of cooking possessed by the most expensive and complicated ranges, insuring also a very small consumpt of fuel, with cleanliness and saving of labour to the cook. The heat from the small fire in the front part of the stove is made to pass under various boilers and pots, and then, by a peculiarly simple arrangement of the flues, to pass round and uniformly heat the oven, which occupies the body of the stove, before passing off up the vent. They are made of cast-iron, the fireplace lined with fire-clay, are handsome in design, and are furnished with all the necessary cooking utensils for family use, and require no fitting or building in.

Thanks voted.

6. Notice of the American Apple-Parer. By James Alexander, Esq., late of Frederick Street, now of Toronto, Canada, The machine was exhibited in operation. (3744.)

This very ingenious and simple machine (of about 9 by 5 inches in size) excited much interest, from the efficiency and celerity of its operation. It pares an apple or any other body of about the same size, adapting itself to all sizes from about one to three inches, in an incredibly short time, and does it so regularly that the paring comes off in one long stripe. It is said that, by this little machine, the movements of which are very beautiful, though all the wheel-work is of unfiled cast-iron, one pound of apples can be pared during the time that a nimble-handed person can pare half-a-pound with the knife in the usual way, and much better. It also takes out the core after the apple is pared.—The Secretary noticed that he had seen these machines lately in the shops for sale, under an English patent.

Thanks voted to Mr Alexander.

7. The President then laid before the Society several specimens of coloured compressed vegetable fibre resembling papier-maché, made by Mr R. Endall, Kilmichael, Glen Urquhart. (3756.)

The fibre employed is obtained from some of the most familiar plants, consolidated by pressure, and dyed. The specimens shown were in the form of small slabs, varnished on the surface and slightly polished. They resembled in appearance ornamental woods or coloured marbles, and excited much interest. Mr Endall is in humble circumstances, and in indifferent health. His invention is well worth the notice of manufacturers of papier-maché, ornamental furniture, book-boards, &c.

Thanks voted to Mr Endall, and to the President for exhibiting the specimens.

The following Reports of Committees were read and approved of, viz. :—

8. On Dr Ferguson's Bunsen Lamp. Professor George Wilson, *P.*, Convener. (3692.)

9. On Young's Gaswork Condenser. Ditto, Convener. (3711.)

10. On Sturrock's Railway Signals. Ditto, Convener. (3721.)

11. On Carrick's Railway Lighthouse Signal. Ditto, Convener. (3713.)

12. On Elliot's Imitation of Electro-Magnetic Rotation. Mr Swan, Convener. (3703.)

13. On Johnston's Kitchen-Grate Swey. Mr Steele, Convener. (3731.)

14. On Mr George Slight's Apparatus for Boring the Cheeks of Cranes. Mr Aytoun, Convener. (3730.)

15. On Mr Alexander Cleugh's method of Preventing Water-Cocks from Bursting during Frost. Mr A. Kirkwood, Convener. (3724.)

16. On Mr Sang's proposal of a Committee to determine the Molecular Changes in Glass. Professor C. Piazzi Smyth, Convener. (3734.)

17. On Dr Stark's Paper on Writing Inks. Dr Douglas Maclagan, Convener. (3626.)

The following Reports not being lodged, were ordered, when lodged, to be sent direct to the Prize Committee :—

18. On Sang's Application of the Micrometer to the Levelling Telescope. Mr Swan, Convener. (3696.)

19. On Professor C. Piazzi Smyth's method of giving Stability to Astronomical Instruments at Sea. Ditto, Convener. (3733.)

20. On Macpherson's Paper on Artistic Lithography. Mr Leith, Convener. (3732.)

The following Donations were laid on the Table, viz. :—

1. Second Annual Report of the Directors of the Association for Promoting Improvements in the Dwellings and Domestic Condition of Agricultural Labourers in Scotland, with Supplementary Report containing Woodcuts and Plans. By William Fowler, Architect to the Association. (Edin. 1856.) Pp. 40. Presented by the Association. (3743.)

2. Three Sheets of Designs for such Cottages, with Specifications. Presented by the same. (3752–1–2–3.)

3. The 11th, 12th, 13th, 14th, and 15th Annual Reports and Transactions of the Royal Society for the Promotion and Improvement of Growth of Flax in Ireland—for years ending October 1851 to October 1855. Presented by the Society. (3749–1–5.)

4. Journal of the Geological Society of Dublin. Vol. VII. Parts I. and II. (1855-56.) Dublin, 1856. Presented by the Society. (3747–1–2.)

5. Description, with Illustrations, of the Improvements in Propelling and Navigating Steam-Vessels, Invented and Patented by J. & M. W. Ruthven, engineers, Edinburgh. Presented by the Patentees. (3750.)

6. Proceedings of the Institution of Mechanical Engineers, Birmingham, 30th January 1856. Presented by the Institution. (3751.)

7. Observations on the Flow of Water through Pipes, Conduits, and Orifices. By James Leslie, Esq., M. Inst. C.E. (London, 1855.) 8vo, pp. 47. Presented by the Author. (3755.)

Thanks voted to the Donors.

PRIVATE BUSINESS.

I. The Minutes of last Meeting were read and approved.

II. The Society appointed the Prize Committee to award the Prizes for Session 1855–56, viz. :—

Professor George Wilson, M.D., President.
Professor Gregory.
William Swan, Esq.
Patrick Newbigging, M.D.
Peter Stevenson, Esq.
Alexander Kirkwood, Esq.
Robert M. Bow, Esq., C.E.
John Adie, Esq.
Rev. Professor Kelland.
Samuel Leith, Esq.
Wilkinson Steele, Esq.
James Tod, Secretary, Convener *ex officio.*

The Society then adjourned till next Session.

APPENDIX (T).

LIST OF PRIZE SUBJECTS FOR SESSION 1856-57.

THE ROYAL SCOTTISH SOCIETY OF ARTS proposes to award Prizes of different values, of Thirty Sovereigns and under, in Gold or Silver Medals, Silver Plate, or Money, for approved Communications *primarily* submitted to the Society, relative to Inventions, Discoveries, and Improvements in the *Mechanical* and *Chemical* Arts in general, and in their relation to the Fine Arts, and also to means by which the *Natural Productions* of the Country may be made more available; and, in particular, to such as—but not limited to—the following, viz. :—

I. INVENTIONS, DISCOVERIES, or IMPROVEMENTS in the Useful Arts.

1. *Mechanical Arts.*

INVENTIONS or IMPROVEMENTS in the construction of Fire-Proof Buildings,—in applying Glass to new and useful purposes,—in methods of uniting the Joints of Glass or Earthenware Water-Pipes, without employing White Lead or other poisonous substance,—in Sewerage,—in Economical Appliances for increasing the Sanitary Condition of Towns,—in constructing Economical and Salubrious Dwellings for the Working-Classes, —in Extinguishing Fires,—in Locks,—in Tools, Implements, and Apparatus for the various Trades,—in Bricks,—in Cements and Mortars,—in Machines for Planing Wood,—in Printing Machines, Cases, and Rollers,—in Stereotyping,—in Cranes,—in the Machinery for Collieries, &c.,—in preserving Timber and Metals in Marine Works,—in Locomotive, Stationary, and Marine Engines,—in Screw Propellers,—in Railways, Plant, and Signals,—in Machines for Cutting, Dressing, and Boring Stone,—in Optical Apparatus,—in Steel or other Metallic Pens,—in Electro-Magnetic or other new or improved Motive Power,—in the construction of Cameras and other Apparatus used in Photography, &c. &c.

2. *Chemical Arts.*

Inventions or Improvements in methods of rendering the Electric Light available in practice, particularly in the Illumination of Mines, &c. &c.,—in new and useful applications of Gutta Percha and Vulcanized India Rubber, or similar Gums,—in substitutes for, or improvements upon, the process of Vulcanizing India Rubber,—in Dyes, and in their economical extraction from Dye Woods, &c.,—in Paints,—in Paper,—in Glass,—in Writing Inks,—in the Manufacture of Hats.

3. *Relative to the Fine Arts.*

Inventions or Improvements in Photographic processes, and their application to taking Microscopic objects and machinery,—in Electrotype processes,—in Die-sinking,—in methods of illustrating Books to be printed with the letterpress,—in Paper Hangings,—in Articles of Porcelain, Common Clay, or Metal,—in Glass Staining,—in Engraving on Stone,—in Chromatic Lithography.

4. *Natural Productions.*

Discovery of Plumbago in the United Kingdom or Colonies, or a good substitute for it, equal to that of Cumberland, and in sufficient quantity to be advantageously quarried,—of Kaolin for Pottery,—of Slate Pencil of good quality,—of Woods suitable for Engraving.

II. Experiments applicable to the Useful Arts.

III. Communications of Processes in the Useful Arts practised in this or other Countries, but not generally known.

IV. Practical Details of Public or other Undertakings of National importance, already executed, but not previously published;—or valuable suggestions for originating such undertakings.

KEITH PRIZE, value Thirty Sovereigns,

For some important "Invention, Improvement, or Discovery, in the Useful Arts, whic shall be primarily submitted to the Society" during the Session.

REID AND AULD PRIZES,

For the First, Second, and Third best Models of "anything new in the Art of Clock or Watch Making, by Journeymen or Master Watch and Clock Makers,"—if these should be considered worthy of Prizes,—the year's Interest of the Reid and Auld Bequest, being about SEVEN GUINEAS, divided among them in such proportions as the Prize Committee shall fix, according to merit.

GENERAL OBSERVATIONS,

AND DIRECTIONS FOR PREPARING AND LODGING COMMUNICATIONS.

Communications lodged *in competition for Prizes* shall not have been Patented, nor have been previously published, nor read before any other Society. Patent articles may, however, be *exhibited* and described.

The Descriptions of the various inventions, &c., must be *full* and *distinct*;—be legibly written on *Foolscap* paper, leaving margins at least one inch and a-half broad, on *both sides of the writing on every page*, so as to allow of their being bound up in volumes; and, when necessary, be accompanied by *Specimens*, *Drawings*, or *Models*. All drawings to be on *Imperial* Drawing Paper, unless a larger sheet be requisite. The Drawings to be in *bold* lines, not less than a quarter of an inch thick, or *strongly coloured*, so as to be easily seen at about the distance of thirty feet when hung up in the Hall of Meeting, and the Letters or Figures of Reference to be at least 1½ inch long. When necessary, smaller and more minutely detailed Drawings should accompany the larger ones, for the use of the Committees, having the same letters or figures of reference.

The Society shall be at liberty to publish in their Transactions copies or abstracts of all Papers submitted to them. All Models, Drawings, &c., for which Prizes shall be given, to be held to be the property of the Society; the Value of the Model, &c., being separately allowed for.

Communications, Models, &c., are to be addressed to the SECRETARY, 55 Great King Street, Edinburgh, Postage or Carriage paid; and they are expected to be lodged *on or before* 1*st November* 1856, in order to insure their being read and reported on during the Session (the ordinary Meetings of which commence in November 1856 and end in April 1857); but *those which cannot be lodged earlier*, will be received up to 1st April 1857;—those lodged after that date may not be read or reported on till the following Session.

By order of the Society,

JAMES TOD, *Secretary*.

EDINBURGH, 14*th April* 1856.

APPENDIX (U).

REPORT

OF

THE COMMITTEE

APPOINTED BY

THE ROYAL SCOTTISH SOCIETY OF ARTS

TO AWARD PRIZES FOR COMMUNICATIONS READ AND EXHIBITED DURING SESSION 1855–56.

Your COMMITTEE having met and carefully considered the various Communications laid before the Society during the Session 1855–56, beg leave to report that they have awarded the following Prizes :—

1. To DAVID LANDALE, Esq., Mining Engineer, Edinburgh,—for his "New and Improved Arrangement of the Direct-Acting Pumping Engine, adapted for deep and heavy Pumping," devised and introduced by him into Scotland, where it is now in most successful operation at various collieries, and is found to be attended with great economy, both in the first cost and working expenses, besides possessing other important advantages; and for his Description and Drawings. Read and exhibited 11th February 1856. (3717.)

   The Brisbane Prize.

2. To Mr JAMES LAING, Draughtsman, 240 Perth Road, Dundee, —for his "New Air-Pump, producing an almost perfect Vacuum,"—with Drawings. Description read, and the Air-Pump exhibited in action, 26th Nov. 1855. (3691.)

   The Society's Silver Medal, value Ten Sovereigns.

3. To Mr JOHN YOUNG, Engineer and Manager of the Gas Works, Dalkeith,—for his "Isolating Gas-Work Condenser—any part of which can be cleaned with safety without stopping the flow of Gas." Description read, and Drawings and Working Model exhibited, 28th January 1856. (3711.)

The Society's Silver Medal, value Ten Sovereigns.

4. To ROBERT AYTOUN, Esq., W.S., Edinburgh,—for his "Cheap and Delicate Assay Balance." Description read, and Model exhibited, 10th March 1856. (3722.)

The Society's Silver Medal, value Five Sovereigns.

5. To Mr GEORGE H. SLIGHT, Engineer, 34 Leith Walk, Edinburgh,—for his "Simple Apparatus for Boring the Cheeks of Cranes, &c." Description read, and Drawings exhibited, 28th April 1856. (3730.)

The Society's Silver Medal, value Five Sovereigns.

6. To ROBERT FERGUSON, Ph.D., Edinburgh,—for his "Improved Bunsen's Lamp, dispensing with the use of Wire Gauze, and found to be of great benefit in the Laboratory." Description read, and the Lamp exhibited in action, 10th December 1855. (3692.)

The Society's Silver Medal.

7. To Mr ALEXANDER BRYSON, F.S.A. Scot., F.R.P.S., Edinburgh,—for his "Improved method of Slicing Fossils for Microscopic Investigation." Description read, and Apparatus exhibited, 10th December 1855. Printed in *Transactions*. (3672.)

The Society's Silver Medal.

8. To JAMES STARK, M.D., F.R.S.E., Edinburgh,—for his Communication "On Writing Inks," and Laborious Experiments. Read, and results exhibited, 12th February 1855. (3626.)

The Society's Silver Medal.

The Committee recommend this Paper to the Publication Committee.

Your Committee recommend, that while the *Thanks* of the Society are justly due to all those gentlemen who have sent Communications, the *Special Thanks* of the Society be given to the following gentlemen, viz. :—

1. To Edward Sang, Esq., F.R.S.E., Teacher of Mathematics, Edinburgh,—

   (1.) For his "Remarks on the Gyroscope" (3723), read 24th March 1856,—in reference to his former Paper (355), entitled "Suggestion of a New Experiment, which would demonstrate the Rotation of the Earth," read before the Society on 9th March 1836. Printed in the *Transactions*.

   (2.) For his communication "On the Application of the Micrometer to the Levelling Telescope." Read 25th February 1856. (3690.)

   Which the Committee recommend to the Publication Committee.

2. To James Elliot, Esq., V.P., R.S.S.A., Teacher of Mathematics, Edinburgh,—for the Ingenious Illustrations exhibited by him in reference to his Communication "On a Peculiar Mechanical Imitation of Electro-Magnetic Rotation." Read and exhibited, 14th January 1856. (3703.)

3. To John Smith, M.D., Surgeon-Dentist, Edinburgh,—for his "Instrument to be used in the Construction of Artificial Teeth, as a guide to their correct length and projection." Description and Drawing read and exhibited 28th January 1856. (3705.)

4. To Robert H. Bow, Esq., C.E., Edinburgh,—for his "Report on the Effects of the Hurricane of February 1856 upon tall Chimneys," &c. Read 14th April 1856. (3742.)

Your Committee may remark, that a communication by James Leslie, Esq., C.E., Vice-President, being a "Description of an Apparatus for seeing through Tubular Drains from the surface of the Street" (3748), was read, and a Model and Drawings exhibited on 14th July last; but the Committee to whom it was referred not having given in their Report, your Committee have not had the Paper and Report before them, and are reluctantly obliged to postpone their award till next Session. The same remarks apply to Mr Macpherson's

Paper on Artistic Lithography (3732), read 24th March 1856, and to Mr DEMPSTER's Trawl Net (3688), read 26th November 1855.

They beg also to state, that a very ingenious and elaborate Paper, by Professor C. PIAZZI SMYTH, F.R.S.E., Astronomer Royal for Scotland, "On the Angular Disturbances of Ships, the Measurement of the Amount, and the Elimination of their Effects" (3733), was read, and Working Models exhibited on 14th April last, and is being printed in the *Transactions*. The Committee, to whom it was referred, have reported that they "regard Professor SMYTH's scheme as quite feasible, and, if brought to a successful issue, as deserving the highest commendation of the Society." Meanwhile, the Report of that Committee being only an *interim* one, your Committee must postpone the further consideration of this communication until Professor SMYTH's Experiments, on the large scale, have been completed and tested, and a final Report be given in; but your Committee would beg leave to second the recommendation in the Interim Report, that Government be asked to make a grant of money to enable Professor SMYTH to experiment, on a suitable scale, with the Apparatus which, if successful, will be of such incalculable advantage to the Navy and Mercantile Marine of all nations.

All which is humbly reported by

JAMES TOD, *Sec.*, *Convener ex officio.*

SOCIETY'S HALL, 51 GEORGE STREET,

Interim,......*24th October* }
Final,.........*13th Dec.* } 1856.

APPENDIX (X).

LIST

OF THE

OFFICE-BEARERS AND FELLOWS

OF THE

ROYAL SCOTTISH SOCIETY OF ARTS.

AS AT 1st NOVEMBER 1856.

THE QUEEN, PATRONESS.

OFFICE-BEARERS FOR SESSION 1855–56.

President,	Professor GEORGE WILSON, M.D., F.R.S.E.
Vice-Presidents,	JAMES LESLIE, Esq., C.E. JAMES ELLIOT, Esq.
Secretary,	JAMES TOD, Esq., F.R.S.E., W.S., 55 Great King St.
Treasurer,	JOHN SCOTT MONCRIEFF, Esq., C.A., 20 India Street.
Editor of Transactions,	EDWARD SANG, Esq., F.R.S.E., 36 George Street.
Curator of Museum,	Mr ALEXANDER JAMIESON.
Medallist,	Mr ALEXANDER KIRKWOOD.
Officer and Collector,	Mr HUGH JOHNSTON.

Ordinary Councillors.

*D. STEVENSON, Esq., F.R.S.E., C.E.
*ROBT. RITCHIE, Esq., C.E., A.I.C.E.
*WILLIAM A. ROBERTS, M.D.
*Rev. PROF. KELLAND, M.A., F.R.S.E.
WILLIAM SWAN, Esq., F.R.S.E.
H. W. NACHOT, Ph. D.
DAVID RHIND, Esq., F.R.S.E.
EDWARD SANG, Esq., F.R.S.E.
WILLIAM A. SMAIL, Esq. R.N.
JAMES STARK, M.D., F.R.S.E.
PATRICK NEWBIGGING, M.D., F.R.S.E.
THOMAS BOUCH, Esq., C.E.

(The four Ordinary Councillors marked * retire by rotation.)

LIST OF THE ORDINARY FELLOWS,

AS AT 1st NOVEMBER 1856.

1822. Abercorn, The Most Noble James Marquis of, K.G.
,, Aberdeen, The Right Hon. George Earl of, K.T.
,, Alison, W. P., M.D., F.R.S.E.
,, Adie, Alexander, F.R.S.E.
1826. Aytoun, Robert, W.S.
1837. Aikman, George, engraver.
,, Alves, H. S., 9 Regent Terrace.
,, Alexander, William, F.R.S.E., W.S.
1838. Adie, John, optician, F.R.S.E.
1841. Anderson, Charles W., merchant.
1843. Anderson, John, Pratis, Fife.
1846. Alexander, James, wine-merchant.
1847. Abbott, Francis, Sec. G. P. O.
1850. Anderson, Thomas, F.R.S.E., Professor of Chemistry, Glasgow.
,, Adie, A. J., F.R.S.E., C.E., Linlithgow.
1851. Archer, William, solicitor, London.
,, Alexander, Wm., M.E., Glasgow.
,, Anderson, William, Islington, London.

1822. Buccleuch and Queensberry, His Grace Walter Duke of, K.G., A.M., F.R.SS. L. & E.
,, Brewster, Principal Sir David, K.H., D.C.L., F.R.SS. L. & E.
,, Bald, Robert, F.R.S.E., Alloa.
1826. Brisbane, Gen. Sir Thomas Makdougall, Bart., G.C.B., President R.S.E.
1830. Bonar, William, F.R.S.E.
,, Brown, Robert, junior, architect.
1832. Black, Alexander, architect.
,, Bryce, David, architect.
835. Borthwick, James, manager N. B. Insurance Company.
,, Berkely, Frederick H.
,, Burn, William, F.R.S.E., architect.
1836. Bryson, Alex., F.S.A. Scot., watchmaker.
,, Ballantyne, James, of Holylee.
1837. Bell, John Beatson, of Glenfarg, W.S.
1838. Beattie, Alexander, Star Hotel.
1838. Blanshard, Major-Gen. Thomas, R.E.
1839. Brown, Thomas, architect.
1840. Brown, James, C.A.
,, Berwick, David, Howard Place.
1844. Bell, J. A., architect.
,, Baillie, William R., W.S.
1846. Buist, George, LL.D., Bombay.
,, Beattie, George, builder.
1847. Bernard, Thomas, brewer.
1848. Brebner, Alan, engineer.
1849. Bouch, Thomas, C.E.
,, Burn, Robert, engineer.
1850. Black, Rev. Archibald P., A.M., London.
,, Blyth, Benjamin Hall, C.E.
,, Bell, Alex. Melville, Prof. of Elocution.
,, Bruce, George Cadell, C.E.
,, Bryden, Adam, bell-hanger.
1851. Bryden, John, bell-hanger.
,, Black, John Trafalgar, Surrey.
1853. Bow, Robert H., C.E.
,, Bell, D. C., Prof. of Elocution, Dublin.
1854. Bertram, William, millwright.

1822. Clerk, Sir George, Bart., F.R.S.E.
1827. Chalmers, Charles, Merchiston.
1832. Craig, Sir William Gibson, of Riccarton, Bart., F.R.S.E.
1834. Campbell, Alexander, brewer.
1836. Cowan, Charles, M.P., Penicuik.
1837. Cowan, Alexander, papermaker.
,, Cooper, Wm., glass-manufac., Canada.
1840. Christie, Robert, accountant.
,, Cormack, David, S.S.C.
,, Carstairs, Drysdale, Liverpool.
1841. Cowan, James, M.D., surgeon R.N.
,, Cameron, Captain Charles.
,, Curriehill, Hon. Lord.
1845. Cay, John, F.R.S.E., advocate.
1846. Callender, John A., C.E., London.
1847. Campbell, John Archibald, F.R.S.E.
,, Cousin, David, architect.
1849. Clark, Thomas, M.D., Whitburn.
1850. Campbell, William, C.E.

1851. Cormack, James, ironmonger.
„ Cunningham, George, C.E.
„ Craigie, Henry, W.S., Falcon Hall, Morningside.
„ Cadell, Henry, M.E., Grange, Bo'ness.
1852. Craig, Archibald R., London.
1854. Currie, Peter, 13 Gayfield Square.

1822. Dunlop, Arch., F.R.S.E.
1838. Dunlop, Andrew, W.S.
1843. Dove, James, engine-maker.
1844. Dickson, James Jobson, C.A.
„ Dunn, Thomas, optician.
1846. Donaldson, J., advocate, Prof. of Theory of Music.
1848. Duff, Rev. Henry, South Leith.
1849. Drury, Rev. Robert, Surrey.
1850. Davison, Samuel D., Leith Eng. Works.
„ Dickson, John, junior, gunmaker.
1851. Duncan, James, M.D.
„ Dawson, Charles, London.
„ Dawson, John, distiller, Linlithgow.
„ Duncan, Jas., M.A., Southampton.
„ Drummond, Geo. A., builder.
1853. Davis, Rev. Nathan, London.
1854. Douglas, Sir Geo. Scott, Bart., Kelso.
„ Dale, Randall P., designer.
„ Dalgleish, John, teacher.
„ Dauglish, John.
1855. Dunn, Thomas, S.S.C.
„ Dalgleish, John, College.

1828. Ellis, Adam Gib, M.W.S., W.S.
1839. Ellis, Thomas, upholsterer.
1843. Erskine, Daniel, Glasgow.
1853. Elliot, James, teacher of mathematics.

1822. Forbes, George, F.R.S.E.
„ Fyfe, Prof. A., M.D., F.R.S.E., Aberdeen.
1828. Fraser, Robert, Portobello.
1832. Forbes, Prof. J. D., F.R.SS.L. & E.
1838. Fergusson, Lieut.-Col., H.E.I.C.S.
1840. Fleming, Alexander, W.S.
„ Forrester, John, W.S.
1843. Falkner, James P., solicitor, America.
1844. Foulis, Sir Wm. Liston, Bart., Hermiston.
1847. Fullarton, John A., publisher.
1849. Fraser, J. S., engineer, Gt. Western Rail.
1850. Ferguson, William B., C.E., Aberdeen.
„ Falshaw, James, C.E., Perth.
„ Fraser, Alexander, printer.
1851. Forbes, William, London.
1854. Foster, Alex. F., A.M.

1822. Graham, Humphrey, W.S.
1829. Græme, James, W.S., yr of Garvoch.
1832. Gray, James, ironmonger.
1835. Groat, A. G., of Newhall, advocate.
1836. Greig, Thomas (late printer), Elie.
1842. Gillespie, John, W.S.
1844. Girdwood, John, Agric. Eng., London.
„ Gregory, Prof. William, M.D., F.R.S.E.
1848. Gardner, James, Torphichen Street.
1850. Glennie, George, C.E., Melrose.
„ Gowans, James, builder.
„ Gregory, Thomas Currie, C.E., Canada.
„ Gordon, James, jun., W.S.
1851. Gordon, John T., F.R.S.E., Sheriff of Mid-Lothian.
„ Gordon, James Newell, London.
1852. Gilkison, Robert, jun., of Blackburn, merchant, Glasgow.
1853. Graham, Rev. Wm., Newhaven.
1854. Girdwood, Robert, merchant.
1856. Geddes, Auckland, C.E.

1829. Horne, Archibald, of Inverchroskie.
1833. Hamilton, Alex., LL.B., F.R.S.E., W.S.
1834. Hamilton, John, W.S.
„ Horsburgh, Robert, Tongue House.
1835. Hay, James, merchant, Leith.
1836. Haldane, James, brassfounder.
„ Hepburn, J. Stewart, of Colquhalzie.
1837. Hopkirk, J. G., LL.B., W.S.
1838. Hunter, Richard, H.E.I.C.S.
1839. Hill, Lawrence, jun., C.E., Glasgow.
„ Hill, Henry David, W.S.
1840. Harvey, George, R.S.A., histor. painter.
1841. Hope, David T., C.E., Liverpool.
1843. Henry, Jardine, writer.
1845. Hay, David Ramsay, F.R.S.E.
1852. Hunter, David, chemist.
„ Hamilton and Brandon, His Grace William Duke of,
1853. How, And. Peddie, engineer, London.
„ Hosie, James, coalmaster, Bathgate.
„ Hay, Geo. W., of Whiterig, Melrose.
1854. Henderson, Henry, Lasswade.
1855. Hallard, Fred., advocate, sher.-sub., Edinburgh.
„ Hunter, Peter K., Cowlairs.
„ Hart, Wm., phil. inst. maker.
1856. Hurst, Wm., engineer, Portobello.
„ Henry, Alex., gun-maker.

1854. Ivison, Thos. P., C.E.
1856. Irving, Wm., assist. loco. sup., Perth.

1822. Jardine, James, F.R.S.E., C.E.
1840. Johnston, Alex. K., F.R.S.E., geographer to the Queen.
1848. Jefferiss, Robert R., M.D., Dalkeith.
1850. Jardine, William Alexander, C.E.
„ Jopp, Charles, C.E.
„ Johnstone, William, C.E., Glasgow.
1854. Johnston, J. K., teacher of mathematics
„ Jackson, Ed. James, B.A., Oxon.

1822. Keith, James, M.D., F.R.S.E.
1836. Kirkwood, Alexander, *Medallist.*

1839. Kennedy, William, W.S.
1842. Kronheim, Jos. M., London.
1848. Kirkwood, James, goldsmith.
1850. Kelland, Rev. Phil., M.A., F.R.SS.L.&E., Professor of Mathematics.
1851. Kirkwood, Robert, C.E.

1834. Lawrie, William A., W.S.
1836. Lees, George, LL.D., St Andrews.
,, Lawson, Charles, of Borthwick Hall.
1838. Lorimer, George, builder.
1840. Leburn, Thomas, S.S.C.
1842. Leith, Samuel, printseller.
1850. Leslie, James, C.E.
,, Lees, Henry, secretary E. P. & D. Ry.
,, Lessels, John, architect.
1851. Lee, Alexander H., C.E., Calcutta.
,, Lawson, W. J., manager Argus Life Co., London.
1852. Landale, Robert, of Pitmedden.
,, Landale, David, M.E.
,, Lorimer, James, C.E.
1853. Levy, Michael A., 21 Clarendon Crescent.
1854. Livingston, Allan, junior, Portobello.
1856. Lees, William, A.M., Watt Institution.

1822. Maconochie, Alexander, of Meadowbank, F.R.S.E.
,, More, Professor John S., F.R.S.E.
,, Murray, Hon. Lord, F.R.S.E.
1829. Millar, John, C.E., F.R.S.E.
1831. Macdonald, William, of Powderhall.
1836. Milne, James, brassfounder.
,, Mackay, James, goldsmith.
1838. Macgibbon, Charles, builder.
,, Morton, Hugh, engineer.
,, Maclagan, David, M.D., F.R.S.E.
,, Moncrieff, John Scott, C.A., *Treasurer*.
,, Mackenzie, James, W.S.
,, Murdoch, J. B., of Gartincaber, F.R.S.E.
1839. Macbrair, D. J., S.S.C.
,, Maclagan, Douglas, M.D., F.R.S.E.
1840. Murray, James T., W.S.
1841. Maitland, John, C.A.
,, Macpherson, Charles, printer.
1843. Marshall, G. H., jeweller.
,, Melville, John, W.S.
,, Murray, Sir W. K., Bart. of Ochtertyre.
1846. M'Dowall, John, engineer, Johnston.
,, Middleton, Captain J., Waltham Lodge.
,, Mortimer, Thomas E., gunmaker.
1847. Macadam, John, M.D., Melbourne.
1848. Milne, John Kolbe, dressing-case maker
,, Macfarlan, John F., druggist.
,, Mackenzie, Rev. Kenneth, Bo'ness.
,, Mitchell, Graham Alexander, Whitburn.
1850. Mackay, John M., chemist and druggist.
,, Melville, James M., W.S.
,, Martin, George, Glasgow.
1850. Macintosh, James A., wood-engraver.
,, Mackay, Charles, goldsmith.
,, Moffat, William L., architect.
,, Mein, Archd., M.D., surgeon and dentist.
,, Mitchell, John M., merchant, Leith.
,, Marjoribanks, William, merchant.
,, Marshall, William, accountant.
,, Miller, Colin M., M.D.
,, Macpherson, Alexander, lithographer.
,, Macdonald, D., cotton-spinner, Aberdeen.
,, MacGillivray, J., Royal Artil^{y}, Woolwich.
1851. Middleton, J., M.D., Lic.R.C.S.E.
,, Maitland, Sir A. Gibson, Bart.
1852. M'Farlane, Wardlaw, chemist.
,, Moffat, John, C.E., Ardrossan.
,, Morton, John L., 26 Parliament Street, Westminster.
1853. Miller, And. M., merchant.
,, Moodie, Alex. Craig, publisher.
,, Mouat, John, C.E.
1854. Morrison, Adam, S.S.C.
,, Mitchell, Graham, V.S., Melbourne.
1855. Mossman, Adam, jeweller.

1838. Nachot, H.W., Ph.D., teacher of German.
1846. Newlands, James, architect, Liverpool.
1850. Newbigging, Patrick, M.D., F.R.S.E., F.R.C.S.E.

1848. Oliver, Robert S., hatter.
1850. Ogilvie, Archibald, merchant.
1852. Orrock, Jas., surgeon and dentist.

1822. Playfair, W. H., F.R.S.E., architect.
1833. Ponton, Mungo, F.R.S.E., W.S.
1840. Pearson, Charles, C.A.
1842. Pyper, Hamilton, advocate.
,, Paterson, George, of Castle Huntly.
1844. Paterson, John, C.E.
1846. Pattison, Thomas, M.D.
,, Paterson, W., Scot. Cent. Ry. Perth.
1847. Purdie, Thomas, decorator.
1848. Peddie, John D., architect.
1854. Page, David, F.G.S. St Andrews.

1822. Rosebery, The Right Hon. Archibald Earl of, K.T.
1829. Reid, David B., M.D., F.R.S.E., London.
1834. Ritchie, R., C.E., Assoc. Inst. C.E.
1835. Russell, J. Scott, M.A., F.R.SS. L. & E.
,, Ranken, Francis, glass-manufacturer.
1838. Roxburghe, His Grace James H. R., Duke of, K.T.
1839. Russell, Thomas, ironmonger.
1840. Rose, Alexander, lecturer on geology.
1842. Rankine, W. J. Macquorn, F.R.SS. L. & E., Prof. of Civ. Eng., Glasgow.
1843. Rhind, David, F.R.S.E., architect.
,, Roberts, W.A., M.D., dentist & surgeon.
1844. Ronaldson, John, writer.

1846. Robb, Charles, silversmith.
1848. Reid, Robert Little, painter.
1850. Ramsay, Alex., manager Edin. Water Co.
„ Richardson, James, merchant.
„ Richardson, Robert, merchant.
„ Robson, Neil, C.E., Glasgow.
1851. Rogers, James, ironmonger.
„ Ross, William, of Greenside.
1853. Rose, John T., shipbuilder, Leith.
„ Ritchie, And., watchmaker.
1854. Rutherfurd, John, W.S.
„ Robertson, James, C.E., London.
„ Robson, Thomas W. E., teacher.
1855. Robertson, James, druggist.

1828. Sang, Edward, F.R.S.E., *Edit. of Trans.*
1832. Sclater, Robert, die-cutter.
1833. Steele, Wilkinson, merchant.
1835. Steele, Patrick S., merchant.
1838. Stevenson, David, F.R.S.E., C.E.
„ Seeligmann, F.E., London.
1839. Smith, David, F.R.S.E., W.S.
1840. Sprot, Thomas, W.S.
„ Stevenson, Peter, philos. instrum. maker.
1841. Steuart, Robert, of Carfin.
1842. Spence, Charles, S.S.C.
„ Smail, Will. Arch., of Overmains, R.N.
1843. Sanderson, James H., lapidary.
„ Schenck, Frederick, lithographer.
„ Shanks, Thomas, engineer, Johnston.
1846. Swan, Wm., F.R.S.E., teacher of math.
„ Simpson, Prof. J. Y., M.D., F.R.S.E.
„ Seller, William, M.D., F.R.C.P., F.R.S.E.
1847. Steuart, James, W.S.
„ Stevenson, Thomas, F.R.S.E., C.E.
„ Sclanders, Alexander, upholsterer.
1850. Smith, Alexander, C.E., Aberdeen.
„ Swan, Alex., manufacturer, Kirkcaldy.
„ Stewart, James W., C.E.
„ Stark, James, M.D., F.R.C.P., F.R.S.E.
„ Scrymgeour, Henry, upholsterer.
„ Sinclair, Alex., manager Shotts Foundry.
„ Scott, Archibald, architect.
„ Smith, Robert, builder.
„ Sibbald, Thomas, ironmonger.
„ Strachan, Robert, accountant, London.
1851. Smith, R., engineer.
„ Simpson, Geo., Civ. and M.E., Glasgow.
„ Seton, Lt.-Col. R. S., Madras Artillery.
„ Stewart, Robert, of Omoa.
1852. Sutter, Archd., land-surveyor.
1853. Shepperd, Jas., accountant, Portobello.
1853. Smith, William, engineer, Melbourne.
„ Smith Alex. K., C.E., Melbourne.
1854. Stewart, John, 28 Abercromby Place.
„ Small, John, University Library.
„ Shortt, John, M.D., Madras.
„ Syme, Jas. George, advo., 14 Char. Sq.
1855. Scott, Dr James, deputy inspector of Hospitals.
„ Smyth, Professor C. Piazzi, F.R.S.E., Astronomer Royal for Scotland.
1856. Slight, G. H., engineer.

1822. TWEEDDALE, The Most Noble George Marquis of, K.T., F.R.S.E.
1826. Tod, James, F.R.S.E., W.S., *Sec.*
1830. Tod, Henry, W.S.
1836. Traill, Prof. Tho. Stewart, M.D., F.R.S.E.
1839. Thomson, William T., F.R.S.E.
1840. Trevelyan, Sir Walter C., Bart., F.R.S.E.
„ Turnbull, William, acct., Royal Bank.
1846. Trevelyan, Arthur, of Pencaitland.
„ Thornton, Robert, consulting engineer.
1851. Turner, Richard, engineer, Dublin.
„ Tennant, John, St Rollox, Glasgow.
„ Tennant, Charles, St Rollox, Glasgow.
1852. Thomson, Jas. Boyde, M.I.M.E., Glasgow.
1854. Thomson, J. T., F.R.G.S., Singapore.
1856. Tod, John, engineer.

1843. Veitch, John, baker.

1822. Whytock, Richard, merchant.
1836. Wright, Robert, architect.
1838. Wilkie, John, of Foulden.
„ Wilson, Patrick, architect.
1840. Wood, William, surgeon.
„ Watson, Henry George, C.A.
„ Walker, William, surgeon and oculist.
1845. Wilson, Prof. George, M.D., F.R.S.E.
„ Wilson, Prof. Daniel, LL.D., Canada.
1846. Whitelaw, James, watchmaker.
1850. Wright, George, jun., merchant, Leith.
„ Webster, Andrew, S.S.C.
„ Winton, John G., engineer, Newhaven.
1851. Willet, John, C.E., Aberdeen Railway.
1852. Wighton, Rob. K., jeweller.
1856. Waterston, George, jun., stationer.

1848. Young, William D., manuf. ironmonger.
1853. Young, James, chemical manufacturer, Murrayfield.

TOTAL ORDINARY FELLOWS, 379.

The following Ordinary Fellows, included in the foregoing List, are ordered to remain, till they return to Scotland, in the following

SUSPENSE LIST.

1844. William Cooper, glass-manufacturer, late of Picardy Place, Edinburgh, and now in Canada.
„ Joseph M. Kronheim, ornamental designer, London.
1845. Major-General Blanshard, R.E., Mauritius.
1846. George Buist, LL.D., Bombay.
„ Mungo Ponton, F.R.S.E., 11 Lansdowne Place, Clifton.
1849. F. E. Seeligmann, punch-cutter, London.
1851. John S. Fraser, Swindon Station, Great Western Railway.
1852. Thomas C. Gregory, C.E., America.
„ Colin Miller, M.D., late of Edinburgh.
1853. James Newlands, C.E., superintendent of works, Liverpool.
„ David T. Hope, C.E., late of Liverpool.
1854. Dr Daniel Wilson, Professor, Toronto, Canada.
„ J. T. Thomson, C.E., Government Surveyor, Singapore.
„ J. A. Callender, C.E., London.
„ John Macadam, M.D., Surgeon, late of Glasgow, now lecturer on Natural Science Free Seminary, Melbourne, Australia.
1856. James Alexander, wine-merchant, Toronto, Canada.

Total 16.

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END OF VOLUME FOURTH.

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