# BULK HANDLING OF GRAIN IN THE UNITED STATES OF AMERICA



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# I INTRODUCTION

In July and August 1951 a Mission from this country visited the United States to study the methods used for storing, drying and marketing grain. In its Report* the Mission drew special attention to the American methods of handling grain in bulk and to the use of standard rather than specialized equipment and vehicles for this purpose. The general adoption of these methods to move grain in bulk from the field to the ultimate user in an area where farms are comparable in size and output to the smaller farms in the United Kingdom was of particular interest to the Mission. In view of the saving in labour which is effected as well as the reduction in transport costs and the avoidance of the use of sacks the Mission felt that there is great scope for improvement in the efficiency of our handling methods by the further development, no doubt gradually, of the bulk handling of grain at each stage of distribution. The Mission recommended that an illustrated leaflet should be prepared on bulk handling methods in the United States.

This booklet has been prepared by the members of the Mission to show some of the American techniques and types of equipment which may have an application in this country. No one set of machinery or equipment can solve all the many handling problems which arise in the distribution of grain, and the methods best suited to meet the problems of the individual trades and industries concerned must be determined by the firms themselves in planning modifications of their premises and equipment. In particular, some of the American methods described in this booklet would need to be modified to meet the wetter harvesting conditions often experienced in the United Kingdom. It was not within the province of the Mission to assemble full technical details of American equipment nor would this have been possible in the time available.

The authors recognize that there are already in this country a number of farmers, merchants and processors who are adopting bulk handling methods in order to improve the efficiency of their operations. Others are thinking of doing so, but a major deterrent has been the idea that specialized equipment is necessary. It is hoped that this booklet will stimulate interest in what has already been accomplished in this country and provide at least some information on the methods evolved in the United States to utilize standard equipment for bulk handling.

* "Grain Storage, Drying and Marketing in the United States of America." H.M.S.O. 1952, price 1s. 6d.

# II BULK VEHICLES

In America any type of vehicle that has a bottom and four sides is regarded as being capable of carting bulk grain. Improvisation, particularly on farms, is widespread. Large holes through which grain might fall are stopped up with wood, fibre-board, plywood, steel sheet or any other similar material that may be to hand, while small holes through which grain could filter are covered with paper, hessian, rag, or anything of that kind. These remarks apply equally to the small vehicle, transporting grain from the combine to the farm store, as to the rail box-car, transporting 40 or 50 tons of bulk grain from the growing area to the port or mill. Specialized tipping vehicles or hopper-bottomed vehicles are rarely seen, but portable or fixed apparatus is common at unloading points, enabling one end of a vehicle to be lifted, and thus transforming any standard vehicle into a tipper.

Vehicles and containers may vary in size and may be classified roughly as follows:

(a) *Trailers*. These may be 2- or 4-wheeled vehicles, of any size, upon which is mounted a box capable of holding grain.

(b) *Standard Motor Lorry*. Of any size from the small 10-cwt. light utility truck to the largest 6- or 8-wheeled articulated vehicle.

(c) *Tipping Lorries*.

(d) *Grain Carts* (for rice).

(e) *Rail Box-cars*.

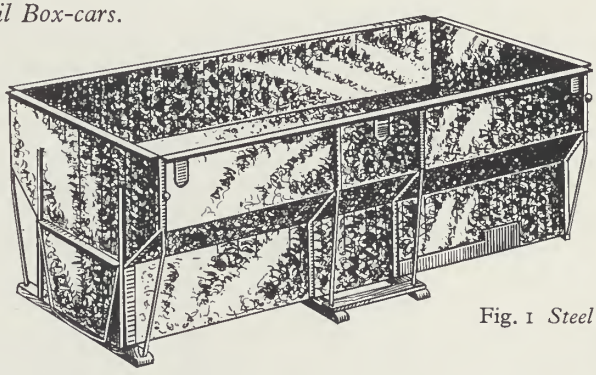

Fig. 1 *Steel flarebox*

**(a) TRAILERS** are most commonly seen on farms. (The containers are made of anything convenient.) Their capacity varies from half a ton up to 2 tons, or more. They are drawn by a truck, jeep, motor-car or other similar vehicle. The wheel track is usually quite narrow so that the trailer can pass through farm gates, store-house doors, and other narrow entrances. The top of the container is often flared outwards to gain capacity. A reasonably cheap standard container, for mounting on any suitable chassis, is shown in Fig. 1. Trailers with such containers

are used for carting anything on the farm. The only special fitting for grain is usually a slide in the back that can be opened to let the grain run out. Boxes of wood or metal for placing on a platform trailer (or on a lorry) are sometimes seen, but the box and the platform vehicle must be suited to each other to avoid grain leakage.

**(b) STANDARD LORRIES.** These vary from light utility lorries, holding little over half a ton of grain, to large 20-ton lorries which are less common. In general these vehicles are the property of the farmer, and are used for every kind of purpose besides delivering bulk grain. Speaking generally, every farmer has one, and normally delivers his own grain to a local store (elevator) not more than 5 to 10 miles away from his farm. The local elevators seen by the Mission are all equipped with lifting gear to raise the front wheels of such vehicles. Normally this lifting gear is suitable for vehicles up to 6 or 8 tons capacity. The larger vehicles are only used for transport to larger installations suitably equipped to deal with them. Many smaller vehicles have improvised additions to the sides to increase the carting capacity, and appeared in effect to be loaded beyond the rated capacity. Where discharge takes place at the farm store, mechanical devices to tip the vehicles are not so common, and in those cases the grain is often shovelled out with shovels made of aluminium alloy, whose lightness affords a great saving in labour.

**(c) TIPPING LORRIES** are admirably suited for dealing with bulk grain, but are not commonly employed because American farmers have not much other use for tipping gear. They can be used to the best advantage only if the receiving pit is sufficiently large to hold the complete load. Some of these tipping lorries are designed with funnel-shaped discharges to minimize spilling.

**(d) GRAIN CARTS** (*for rice*). Rice-fields are flooded to within two weeks of harvesting and the land is often unsuitable for large trucks. Special grain carts were therefore designed to transfer rice in bulk from the combine either to the farmer's store or to large bulk lorries for transportation to the rice warehouse or mill. These carts are solidly constructed of steel and fitted with rubber tyres. The hopper shape of their containers, together with the built-in auger driven by a power take-off from the towing tractor, gives a speedy and entirely mechanical discharge to the bulk lorry. The smallest size carries the equivalent of two combine tanks.

Farms where grain carts are used are devoted almost wholly to rice production and livestock, justifying the use of this single-purpose tool. On the typical mixed farm, where land is solid enough to take normal vehicles, limited use of grain carts may not justify the cost of purchase.

Plate 1
*Rail box-car*

**(e) RAIL BOX-CARS** (*see Plate* 1). Country elevators, easily accessible from farms, are the first stage in the journey towards the mills of most of the marketed grain. From the elevators practically all grain travels by rail in box-cars. In the cars the grain is enclosed, and is loaded and unloaded through the sliding doors in the centre of the two sides. Box-cars are very large compared with our rolling-stock; their normal capacity is 40 tons, but some range up to 70 tons. These wagons are standard freight cars, used for many kinds of goods. Before the grain is loaded the car is lined wherever necessary with paper, cardboard, hessian or some other suitable material to prevent leakage. Wooden bulkheads (as shown in the illustration) are nailed across inside the doorways to hold up the grain. The usefulness of a vehicle which can take almost any type of freight without difficulty is held to outweigh the disadvantage of its lack of gravity discharge for grain handling. Loading, almost invariably by gravity, does not present much difficulty. Special discharge equipment will be mentioned later. Box-cars are usually fully loaded with the rated weight of grain when the grain is from 4 ft. to 5 ft. deep. The space at the top is not wasted, as it permits access for sampling, etc., and also gives the grain a better opportunity to breathe.

# III PORTABLE AND FIXED CONVEYORS, ELEVATORS, ETC.

Many different kinds of equipment are used in bulk handling of grain from the field to its final destination. Much storage on and off the farm is in lines or clusters of individual bins, often of corrugated steel or aluminium. For filling and emptying these bins, portable conveyors and elevators are more convenient than fixed conveying plant. Small and mobile units are also invaluable where loading or unloading is necessary at various stages *en route*.

**(a) USES OF PORTABLE CONVEYORS ON FARMS.** Plate 2 illustrates the use of portable conveyor/elevators to turn grain. The grain is drawn from one silo, passed over a simple screen and elevated to another silo. A flarebox is used here as a hopper for feeding the elevator. The small power units attached to each auger and the pneumatic wheels for shifting are worth noting. This illustration shows one of the many Federal Government stores, and although the silos are larger than those on farms, it is typical of the layout now being developed on many farms. This type of conveyor may be used for loading lorries from ground level as well as for filling, emptying or turning the bins. Augers can only handle certain commodities, but a flat-troughed elevator, such as the chain and flight elevator, can lift such things as baled grass and straw.

Plate 2 *Portable conveyor/elevator*

**(b) TYPES OF DRIVE.** The type of drive is determined by the facilities at the farm. Plate 3 shows a power take-off from the tractor on one farm. In this case an auger is in use for lifting maize into a silo. The farmer in question is a large producer of seeds. If current is available, motors are attached to the conveyors, but petrol engines are perhaps the most convenient because they allow mobility of the machine.

**(c) TYPES OF CONVEYORS.**

**(i) Augers** (*see Plate* 3). Designs are similar to those used in Great Britain, but there is a wide range of sizes. Rated capacities range from 25 tons to 60 tons per hour. It must, however, be appreciated that in the United States cereals are harvested in a drier condition than here, and that with dry grain the capacity of auger conveyors is both greater and closer to rated capacity.

Features of a typical light auger are as follows:

Capacity: up to 1,400 bushels (about 35 tons) per hour.

Drive: operates with either a $7\frac{1}{2}$ h.p. petrol engine or a 5 h.p. electric motor.

Powered from the centre by transmission similar to a lorry or tractor.

Motor has belt clutch and automatic tension adjustment.

Long V-belts and drives eliminated.

Delivery end free from gears, belts or other interfering parts.

Gathering auger available for easy attachment to main loader to gather grain to loading end and reduce shovelling.

Flexible tube delivers grain remote from loader.

Loader easily elevated to maximum height on track-mounted rollers with sturdy windlass. Available in 22-, 30- and 38-ft. lengths with 5-in. auger in 6-in. tube.

Dismountable grain hopper.

A larger auger would handle up to 60 tons of grain per hour, delivering 42 ft. away and 27 ft. high. This would house a 9-in. screw in a 10-in. tube and a 13 h.p. air-cooled engine would be necessary.

**(ii) Dragline Elevators** (*see Plate* 4). This conveyor is not unlike an auger to look at, in that the grain is conveyed in a steel welded double-compartment tubular casing. However, instead of a continuous worm, grain is moved by rounded motor flights, each attached centrally to a continuous steel link chain. Sprockets are fitted at the boot and head of the conveyor so that the chain of flights after pushing the grain the length of the casing returns in the compartment above the conveyor (this may be contrasted with other equipment working with a

Plate 3 *Steel bins and portable auger*

Plate 4 *Dragline conveyor/elevator*

continuous chain and band which is generally arranged for underneath return journeys). The design of the flights (*see Fig.* 2) is said to prevent them from tipping and permitting the grain to run back. At no point does the chain come into contact with the elevator casing, and as it returns over the sprockets instead of underneath, grinding and crushing of the grain is lessened.

This elevator is supplied mounted to take an engine or tractor power, and take-off may be utilized. The whole apparatus is mounted on wheels and towing by tractor is easy. A hand winch provides simple lifting, and in addition a receiving hopper above a worm may be installed. This hopper can be swung up on its hinged connection out of the way when not wanted, or when the machine is being shifted. The smaller-sized 22-ft. elevator will lift grain nearly 17 feet, and the 30-ft. elevator lifts it 21 feet above ground level. The capacity of the machine depends upon the speed at which it is driven, the power available, and the condition of the grain. This type of conveyor will move from 20 to 35 tons per hour. Power units can vary from 5 h.p. to $7\frac{1}{2}$ h.p., as running speed is low (95 to 105 r.p.m. on the boot shaft).

**(iii) Chain and Flight Elevators.** These too are of many makes and capacities, and in principle consist of a flat trough along which grain is drawn by metal or rubber flights attached to chains (*see Plate* 5). This type is mobile and easy to draw by tractor and to manœuvre into position. Setting is simple, as a fitted hand crank raises or lowers the


Plate 5 *Chain and flight elevator*

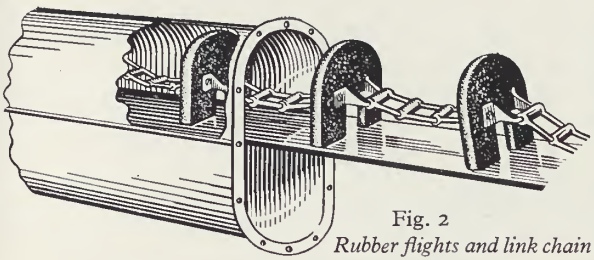

Fig. 2
*Rubber flights and link chain of dragline elevator*

elevator. These elevators can handle maize cobs, shelled maize, cereals, baled hay, or ensilage crops. They are of sturdy construction and can be considered as heavy-duty elevators of high capacity, with the following features:

Elevator length: from 26 ft. to 50 ft.

Size of upper trough: 7 in. $\times 15\frac{1}{2}$ in.

Size of flight (steel): 3 in. $\times 14\frac{3}{4}$ in.

Steel chain for flights.

Drives: air-cooled petrol engine (3 h.p. to 6 h.p.) or electric motor (1 h.p. or 3 h.p.) or power take-off.

Many types of feeding accessories are available, the commonest being shown in the illustration—the boxed-in conveyor, which may be hinged up out of the way when not in use. The illustration also shows a simple type of vehicle hoist.

Rates of movement vary with the size of the machine and the crop. Although statistics are not available, as a guide the largest lorry may be discharged and lifted to store in from 3 to 10 minutes.

Chain and flight conveyors are much liked because the risk of damage to the commodity moved is slight.

**(iv) Pneumatic Conveying.** Owing to the comparatively high capital cost and expensive operation very few pneumatic conveyors are seen. Air is used for loading rail box-cars when gravity is insufficient.

At the Rice Experimental Station at Crowley, Louisiana, a mobile pneumatic elevator (*see Fig.* 3) had just been received for trial. This is complete as a unit and is mounted with its petrol engine on a chassis for towing to wherever it is needed. Details are as follows:

Total distance of transfer can exceed 100 ft.

Grain can be elevated 50 ft.

Capacity over 17 tons per hour.

Powered by 30 h.p. air-cooled engine, or 25 h.p. electric motor, or by farm tractor belt pulley.

Fully portable and a one-man operation.

Fig. 3 *Mobile pneumatic elevator*

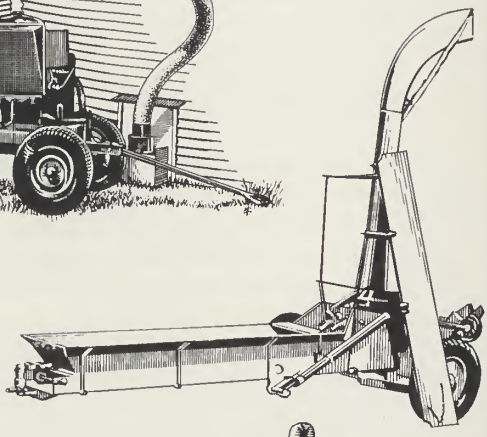

Fig. 4 *Mobile blower*

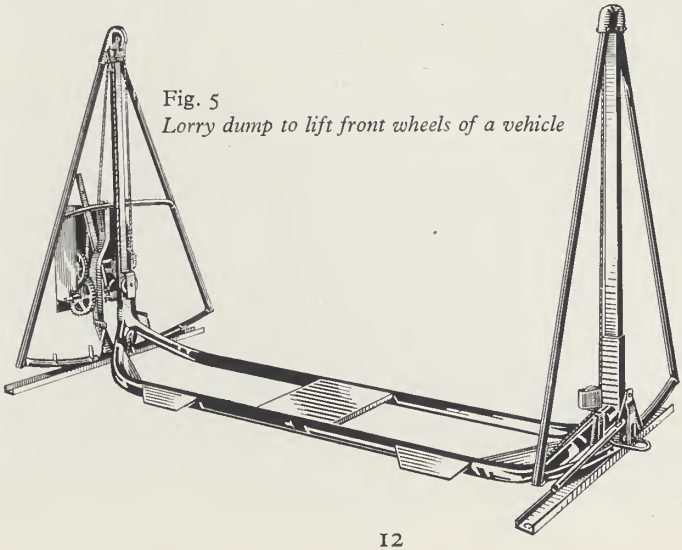

Fig. 5
*Lorry dump to lift front wheels of a vehicle*

A very useful pneumatic tool was seen at a small country elevator (co-operative). This was a mobile blower for loading rail box-cars from lorries (*see Fig.* 4). Grain from the lorry is emptied into the hoppered worm conveyor and is then blown up and into the box-car. The four vanes of this particular blower were made of rubber.

## IV UNLOADING, WEIGHING AND SAMPLING DEVICES

Wherever possible loading and unloading of vehicles is effected by gravity. Although some of the machinery required to achieve this end is very expensive, the outlay is thought to be well worth while.

**(i) Rocker Type Dump** (*see Fig.* 5). A lorry dump is a device to lift front wheels of a vehicle. This particular one is suitable for lifting small vehicles and is normally intended for farm use. When a load is being emptied the front wheels of the lorry or flarebox are placed in the cradle and lifted to allow the contents to flow out at the rear. The dump is portable and can stand on any hard base to empty the contents of the lorry where they are required. The farm type may be driven by tractor take-off or a small motor or engine may be fitted. Details are:

Maximum lift: 3,500 lb.

Width of wagon handled, 9 ft.

Power required when operated independently, $\frac{3}{4}$ h.p. electric motor, or $1\frac{1}{2}$ h.p. petrol engine.

Total weight of machine, 575 lb.

**(ii) Overhead Lorry Hoist.** As with (i), this appliance raises the front wheels of the laden vehicle to give gravity discharge into a receiving hopper (*see Fig.* 6). This is designed for heavier loads than the dump.

Floor boards in the cradle ensure a smooth approach and exit of the lorries. Hoists may be equipped with 3, 5 or 7 h.p. motors. A 3 h.p. motor will raise the front end of the lorry and 30,000-lb. loads 5 feet in 25 seconds; higher powered motors work correspondingly faster. When facilities (inside or on the outside of premises) are lacking for installing this type of hoist, steel framework is used. Slide rails for adjusting the distance of the cradle from the intake pit are needed when a number of vehicles of different dimensions are expected to be received.

**(iii) Hydraulic Platform Lifts.** For the speedy discharge of very large lorries, the bigger terminal elevators favour hinged ramps using hydraulic jacks. The lorries are held to these tilts so that when the

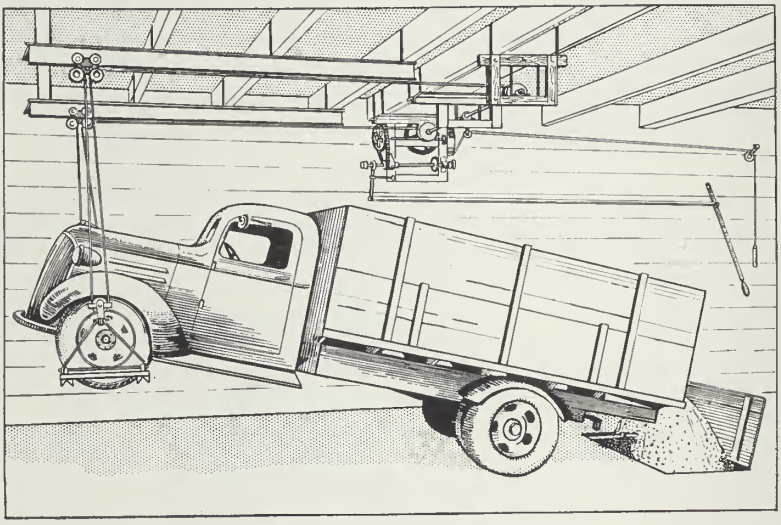

Fig. 6 *Overhead lorry hoist*

front rises the grain will run into the intake hopper. Strong grilles of tubular steel cover hoppers so that vehicles can traverse them.

**(iv) Power Shovels.** Rail box-cars are very large wagons with central doors. There are two ways in which millers and other users unload these: (a) by power shovels, and (b) by mechanical dumpers [*see* (v)]. At nearly all installations the power shovel is used. In essence this consists of a friction hoist drum mounted on a convenient spot near the unloading point. The ropes from this drum are led into the truck, where they are attached to a board or scoop about 3 feet square. In the simplest form the arrangement is such that when the drum is engaged against the friction drive, the scoop is pulled towards the truck door, bringing with it a large quantity of grain that falls out of the doorway and into the receiving hopper. The scoop is then manhandled back to the far end of the truck, and the hoist drum operated again so that the scoop brings a further load out of the doorway. An advance type of this apparatus was seen in which the hoist drum was reversible. For reverse movement direction the rope is led through a pulley so that the scoop is pulled back mechanically into the far corner of the truck. The controls of this apparatus are usually operated by a man standing in the truck doorway. The final cleaning of the truck involves a fair amount of hand sweeping and shovelling. The chief merit of this method of unloading rail trucks lies in the comparatively low capital cost as compared with the expensive apparatus installed at elevators and mills of very large capacity.

**(v) Mechanical Box-car Dump.** At very large processors' plant and grain elevators where incoming grain needs to be cleared from box-cars at great speed, mechanical dumpers handling 50 cars a day and costing $100,000 to $200,000 are used. Laden cars are held firmly on a section of the track, which in effect is a huge see-saw. First of all the car is tilted inwards on to a steel "hand" which thrusts inwards the wooden bulkhead standing inside the doors, to allow the grain to run out. The car is tilted towards one end and then see-sawed back towards the other, and in this way emptied of its load. Much excavation is required for such an installation and a substantial building is needed to house it. One man at the controls can cope with incoming grain. The internal facilities must be of sufficient capacity to take the grain away, and only an organization handling vast quantities of grain can justify such heavy plant.

**(vi) Fixed Equipment.** The fixed bucket elevators, worm conveyors, cleaners and dressers seen at the mills and elevators in the United States were generally similar to those in this country. One interesting variation was seen at a farm in Wisconsin. A bucket elevator had been installed for a new store in the course of erection. A central drive-way through the store had been provided for transport, and instead of an excavated pit there was a hinged conveyor which could be lowered for use or pushed up out of the way when not wanted.

**(vii) Weighing Equipment.** Scales similar to those used in Great Britain are installed at elevators for both intake and loading out. Sizes to suit elevators from the smallest to the largest are available. One malting is equipped to weigh over the scale complete car-loads at a tip with a maximum capacity of 150,000 lb. This scale can be used automatically or by manual release.

Weighbridges capable of scaling up to 25 tons at a time are used at many elevators and mills for weighing grain delivered by road. This method assists speedy handling. As soon as the load has been sampled and weighed, the driver receives his gross weight tally. He can then go to the intake pit, dump the grain, and return to the farm.

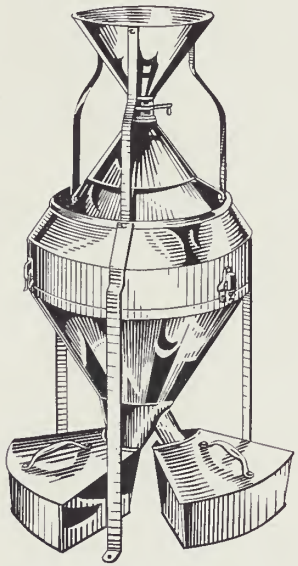

Fig. 7 *Boerner sampler*

**(viii) Sampling Equipment.** Efficient grain marketing and handling depend largely upon true sampling. In the U.S. official standards for all cereals are established and grade assessment is very important. Bulk sampling is made simple by the use of double tube spears. These are of different lengths, but the one most used is the 63-in. Government spear made of brass with a wooden handle. The outside tube is of $1\frac{3}{8}$-in. diameter and has 11 openings down it, the inner tube being partitioned to keep the eleven samples separate until inspection proves the bulk to be consistent.

The technique of sampling is important. The spear is plunged vertically into the grain in a vehicle and withdrawn. The 11 samples representing layers of grain are then emptied on to a suitable table or sometimes on to pieces of canvas. On inspection it is easy to see whether all layers of the grain are the same. This spearing process is repeated five times in the normal lorry load, or truck load, in a regular pattern of positions. The samples from each spearing are laid out alongside the corresponding samples from the earlier spearings. If there are variations, further spearings can be made to establish with great accuracy their volume and extent. Mixing of all samples drawn by the various spearings gives an accurate bulk sample of the whole load.

**(ix) Equipment for Examination of Samples.** Dockage (i.e., foreign material, screenings, etc.) is not paid for, so that accurate analysis of samples is important to the trade. Large concerns and the official grading centres use mechanical extractors, but small elevator operators obtain excellent results with sets of dockage sieves. These sieves fit one into another, with a solid bottom pan, and by shaking a sample is quickly separated from its dockage.

Bushel weight and moisture tests are made. An interesting instrument to ensure a well-mixed sample, and to divide it into smaller and properly representative samples, is the Boerner sampler (*see Fig.* 7). Grain is poured into the top hopper, passes down the sides of a cone, and is cut into 36 separate streams, then alternating into two streams. This divider is an important tool for accurate sampling.

## V ACKNOWLEDGMENTS

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