Seed Treating Equipment

Section J
Figure J. Germination of treated and untreated seed.
The application of seed treatment materials is a very specialized operation and is usually the last step in processing of seed. A discussion of all seed treatment processes, the basis of selecting treatment materials, and characteristics of treatment materials are beyond the scope of this manual. However, the equipment and devices used to treat seeds in the plant are classified as processing equipment and they are considered below.

Seed treatment materials are applied as dusts, slurries (a mixture of a wettable powder in water) or liquids. The equipment used to apply chemicals, in any form, to seed are classed as seed treaters and can be divided into two broad categories — commercial treaters and farm treaters.

Commercial Treaters

Many seed treaters are available that can apply a small amount of chemical and spread it uniformly over the surface of each seed. These vary in size and capacity from large commercial treaters to small ones suitable for farm use.

Slurry Treaters

Slurry treaters became commercially available toward the end of World War II following the development of the slurry treatment principle. This principle involves suspension of wettable powder treatment material in water. The treatment material applied as a slurry is accurately metered through a simple mechanism composed of a slurry cup and seed dump pan. The cup introduces a given amount of slurry with each dump of seed into a mixing chamber where they are blended. Slurry treaters are adaptable to all types of seed and rates of treating with capacities up to 600 bushels per hour. The small amount of moisture added to the seed, 1/2 to 1% of the weight of the seed, does not affect seed in storage since the moisture is added to the seed surface and is soon lost.

While operation of slurry treaters is relatively simple, the various operational procedures must be thoroughly understood.

(1) The metering principle is the same in direct, ready-mix or fully automatic treaters, i.e., the introduction of a fixed amount of slurry to a given weight of seed.
Figure J1. Schematic diagram of a slurry seed treater.
(2) To obtain a given dump weight, slurry treaters are equipped with a seed gate that controls seed flow to the dump pan. With the proper seed gate setting, a constant dump weight for a given seed can be obtained.

(3) The amount of treatment material applied is adjusted by the slurry concentration and the size of the slurry cup or bucket. As the dump pan fills, a point is reached where it over-balances the counter weight and dumps into the mixing chamber. This brings the alternate weighing pan in position to receive the inflow of seed and activates a mechanism to add a cup of slurry to the mixing chamber. Thus, one cup of slurry is added with each dump of seed.

(4) The mixing chamber is fitted with an auger type agitator that mixes and moves seed to the bagging end of the chamber. The auger may be of several types - curved paddles, curved rods, or nylon brushes. The nylon brush auger is used for thin-coated seeds or seeds that have a tendency to mechanical injury, such as beans and corn. Further modifications to minimize seed injury can be made, such as rubber-coating the weighing pan and sides of the mixing chamber at the end where seed are dumped. The speed of the auger is important because at slow speeds more uniform distribution is obtained. Rate of seed movement can be modified by changing the pitch of the mixing paddles.

Slurry tanks have 15 to 35 gallon capacities depending upon the size of the treater. They are equipped with agitators that mix the slurry in the tank and keep it suspended during operation. It is important that the powder be thoroughly suspended in water before treating. If the treater has been idle for any period of time, sediment in the bottom of the slurry cups must be cleaned out.

Further, the proper size slurry cup must be used. Early "Gustafson" machines were equipped with an endless chain, mounting either 23 cc. cups or 46 cc. cups. Later machines have a single chain of cups with ports and rubber plugs for 15 cc., 23 cc., and 46 cc. quantities. With all plugs out, the cups deliver 15 cc. of slurry, with the bottom port plugged, they deliver 23 cc. of slurry, etc. Some users prefer to mix the slurry in an auxiliary tank and then transfer to the slurry chamber as needed.

Direct Treaters

Direct treaters are the most recent development and include the "Panogen" and "Mist-O-Matic" treaters. These two were initially
Seed delivery to scale hopper for accurate measurement of acid.

Treatment metering cup.

Overflow liquid is returned to drum by return hose.

Liquid is delivered to pump by gravity feed.

Connection for fume exhaust.

Seed flows through distributing fingers which apply the liquid.

Rotating drum tumbles seed to obtain coverage.

Adjustable shutters provide automatic clean-out.

Seed enters discharge housing through center opening in rotating drum. It then falls through bagger into bags.

Pump forces liquid to treater reservoir through connecting hose.

Figure J2. Diagram of Panogen seed treater used to apply liquid seed treatment materials.
Figure J3. Diagram of a Mist-O-Matic seed treater used to apply liquid seed treatment materials as a mist.
designed to apply undiluted liquid treatment. Instead of applying 23 cc.
of material per 10 pounds of wheat, as in slurry treaters, they apply 14
to 21 cc. (1/2 to 3/4 ounces) per bushel of wheat. This small quantity
of material is suitable only with liquid materials which are somewhat
volatile and do not require complete, uniform coverage for effective
action. Later modifications of treaters include dual tanks that permit
simultaneous addition of a fungicide and an insecticide, and adaptations
for the application of slurries. The metering device in both the "Panogen"
and "Mist-O-Matic" treater is similar to that of the slurry treater, since
it is attained through synchronization of a treatment cup and seed dump.
Otherwise, they differ decidedly from the slurry treater and from each
other. Both of these direct treaters have an adjustable dump pan counter
weight to adjust the weight of the seed dump. This is not practical
with slurry treaters.

The first direct treater was the Panogen type treater. Operation
is relatively simple. A small treatment cup, operating from a rocker
arm directly off the seed dump pan and out of a small reservoir, meters
one cup of treatment with each dump of the seed pan. Fungicide flows
through a tube to the head of the revolving-drum seed mixing chamber.
It flows in with seed from the dumping pan and is distributed over the
seed by the rubbing action of the seed passing through the revolving
drum. The automatic feature is obtained with a small electric pump fit-
ted with tubes to the product container and the treatment reservoir to
permit continuous treatment. The desired treating rate is obtained by the
size of the treatment cup and adjusting the seed dump weight. Treat-
ment cup sizes are designated by treating rate in ounces and not by actual
size, e.g., the 3/4 ounce cup applies 3/4 ounce (22.5 cc) of treatment
per bushel with six dumps per bushel. Actual size of this cup is
approximately 3.75 cc. There are several sizes of treaters and a modi-
fied treater (auger forced seed feed) is also available for cotton.

The "Mist-O-Matic" treater applies treatment as a mist directly
to the seed. The metering operation of the treatment cups and seed
dump is similar to that of the "Panogen" treater. Cup sizes are designated
by the number of cc.'s they actually deliver, e.g., 2 1/2, 5, 10 and 15.
The treater is equipped with a large treatment tank, a pump, and a return
that maintains the level in the small reservoir from which the treatment
cups are fed. After metering, the treatment material flows to a rapidly-
revolving fluted disc mounted under a seed spreading cone. The disc
breaks drops of the treatment into a fine mist and sprays it outward to
cut seed falling over the cone through the treating chamber. Just below
the seed dump are two adjustable retarders designed to give a continuous
flow of seed over the cone between seed dumps. This is important since
there is a continuous misting of material from the revolving disc.
Quantities as small as 1/4 ounce per bushel may be applied with good
seed coverage. The desired treating rate is obtained through selection
of treatment cup size and proper adjustment of the seed dump weight.
Figure J4. Gustafson Mist-O-Matic seed treater, Model M100.
Figure J5. On-the-farm rotary seed treater used to apply seed treatment materials.
Figure J6. The application of seed treatment during conveying of seed.

Figure J7. A small cement mixer can be used as a seed treater.
Farm Treaters

Several methods are used for seed treatment on the farm. Some of the following methods will give fairly satisfactory results, but do not permit exact control of treating rates, and some seed will receive more treatment than others. Chemicals that injure seed in overdoses should be used with caution.

**Homemade drum mixer:** A simple mixer can be made by running a pipe through a drum at an angle. The drum is then mounted on two sawhorses. The seed and treatment are placed in the drum and it is rotated slowly until all seed are covered.

**Grain auger:** Liquid materials can be dripped onto the seed as they enter a grain auger or screw conveyor. By the time the seed have left the auger, the liquid is spread well over most seed. Dust and slurry materials may also be applied in this manner, but with more difficulty.

**Shovel:** Seed are spread on a clean, dry surface, 4 to 6 inches in depth. The proper amount of treatment is diluted with water and sprinkled evenly over the seed. Mixing is accomplished with a shovel or scoop by turning the seed at least 20 times.

Installation

All seed should be cleaned before being treated, so the seed treater is the last machine through which the seed pass before bagging. In most seed processing plants the treater is permanently installed above the bagging bin.

Seed treaters are relatively light-weight when empty (300–600 pounds) and produce little vibration in operation. The weight of some treaters is nearly doubled when the storage tank is filled. A small surge bin should be located above the treater to avoid premature force-tripping of the weighing pan. The treater should be level when in operation. When installed permanently, provision should be made for bypassing seed which need no treatment.

During the treating season the reserve tank will need refilling, sometimes daily. The treater should be located so that additional materials can be pumped or poured into the treater without difficulty. Floor level reserve tanks equipped with electric or manual pumps are available. If the seed treatment material is mixed with water, a source of clean, filtered water must be readily available.
In some plants it is convenient to have one treater mounted on an angle iron frame with rollers. The treater can then be rolled from place to place as required in the processing operations. In such cases, a bagging attachment is usually fastened to the treater. Seed are bagged as they come from the treater.

Summary

Seed treatment materials are applied on dusts, slurries or liquids. Several commercial machines have been designed to apply accurately measured quantities of treatment material - slurries or liquid - to a given weight of seed.

Seed treatment is usually the last step in processing and is done just before bagging.
Figure J8. Treating rice seed in Taiwan. Treatment material is poured into a barrel while the seed are being stirred.
Elevating
and
Conveying Equipment

Section K
Figure K. Bag conveyor used in stacking seed.
SEED CONVEYORS

Efficient movement of seed into, through and away from the processing plant is a vital but often neglected part of seed processing. Proper placement of correct seed conveying equipment in the plant can increase processing efficiency, reduce seed damage, and minimize contamination.

The conveyor selected for any step in the seed processing line should: (1) minimize damage to the seed, (2) have adequate capacity to serve the processing or storage equipment without reducing their efficiency, and (3) be self-cleaning or easily cleaned.

During processing it may be necessary to move seeds vertically, horizontally, or on an inclined plane. Seed conveyors are available to meet all these requirements, but no single conveyor successfully performs all functions. Conveyors can be classified as: (1) bucket elevators, (2) belt conveyors, (3) vibrating conveyors, (4) pneumatic conveyors, (5) screw conveyors, (6) chain conveyors, and (7) lift trucks. All are available in various sizes and capacities.

Bucket Elevators

A bucket elevator consists of an endless belt or chain with evenly spaced buckets that run in a vertical or near vertical direction over top and bottom pulleys or sprockets. The top pulley or sprocket is powered and drives the belt or chains. The top or discharge portion of the elevator is usually called the head, while the lower or feed end is called the boot. The assembly is usually enclosed in a steel or wood casing called the legs. The elevating leg (up-leg) and the return leg (down-leg) may be enclosed in the same or separate housings. Feeding of the elevator is accomplished through a hopper device on the up-leg or down-leg or between two lower pulleys depending on the type of elevator.

Bucket elevators are widely used in seed processing plants. They are quiet, efficient, long-lasting and have minimum maintenance requirements. The chief disadvantages of some designs are that excessive belt speed may cause damage to seed during feeding or discharge, and the enclosed units may be difficult to clean.

Based upon the method of discharge, bucket elevators may be classified into four types.

Centrifugal Discharge

The centrifugal discharge elevator is the type most commonly
used by the U.S. seed industry. Discharge from the buckets depends upon both centrifugal force and gravity. The shape of the bucket, the speed and radius of the head pulley, and the position of the discharge chute must be in proper relationship for efficient operation. When this type of elevator is operated slower or faster than the speed for which it is designed, some seeds fall back into the down-leg. Operation of the centrifugal discharge elevator at high speeds to increase capacity results in a high discharge velocity that may cause considerable injury to delicate or fragile seed.

If the boot pulley is smaller than the head pulley, the elevator should be fed on the up-leg above the center line of the boot pulley, because there is no centrifugal force on portions of the belt not in contact with the pulley. Feeding into the down-leg tends to decrease capacity and increase seed damage.

Bucket shapes vary but rounded or flat bottom buckets are generally preferred. Although buckets are ordinarily constructed of steel, plastic and fiberglass buckets are also available. Bucket spacing depends upon their size, shape, belt speed, and pulley diameter.

Positive Discharge

Buckets on a positive or perfect discharge elevator are normally mounted on a pair of chains. They move slowly and are designed so that the seed drops by gravity from each bucket into a chute positioned to accept the discharge. In some units seed is scooped from the boot, while in others seed is fed directly into the buckets. This elevator is most useful when handling seeds which are light, fragile or which do not otherwise discharge readily from a centrifugal elevator.

Continuous Bucket

The continuous bucket elevator is composed of a continuous chain of buckets mounted as close together as possible. During discharge the seed flow over the specially-shaped bottom of the preceding bucket. Because of a greater number of cups, high capacity can be attained with slow belt speeds.

Internal Discharge

This is a continuous-bucket type elevator in which filling and discharge of the buckets takes place inside the bucket line rather than outside as with other types. The buckets are designed and positioned so that they overlap and can be continuously fed from a hopper in the bottom section of the elevator. The conveyor may consist of one to several sections each with separate feed and discharge devices. Thus,
Figure K4. Diagram of an outside discharge, continuous bucket elevator.

Figure K5. Diagram of internal discharge, continuous bucket elevator.
several different seed streams can be handled at the same time. Filling and discharge may be accomplished from either or both sides of the elevator, simultaneously.

Several types are available, but the type with two boot and two head shafts mounted in an open frame is most popular because of its gentleness in handling seed and ease of cleaning. Since the seed is fed into the slowly-moving buckets, no boot is needed. This eliminates seed damage caused by buckets moving through the seed mass. Also, seed are not crushed between the chain and sprocket, and they fall only the depth of the bucket during feeding and discharge. Lubrication of the chains with graphite rather than grease prevents adherence of seed to the chains and makes the elevator practically self-cleaning. A minor disadvantage of this elevator is its requirement for greater floor space. Processing plants handling easily damaged seed should consider this elevator.

**Belt Conveyors**

A belt conveyor is an endless belt operating between two pulleys with idlers to support the belt and its load. It is mechanically efficient, especially with anti-friction idlers, has a low power requirement, is dependable, and will handle practically any type of material. With proper belt size and idlers, the same unit can handle precleaned seed, cleaned seed and even bagged seed. It can be self-cleaning but as usually installed in seed plants, it is not. Operated at low speeds, the conveyor can be used as a picking and sorting belt. The initial cost of a heavy duty high capacity installation is rather high. On the other hand, many small units employed in seed plants are relative inexpensive.

Essential parts of a belt conveyor are the belt, the drive, and the driven pulleys, tension adjustment mechanism, idlers, and loading and discharging devices.

The belt must be flexible enough to conform to the shape of the pulleys and idlers, yet strong enough to carry the load, and wide enough to deliver the desired capacity.

The drive should be at the discharge end of the belt, and diameter of the drive pulley must be large enough to provide adequate contact with the belt. An idler can increase the wrap contact of the belt with the drive pulley. The take-up or tension adjustment may be by manual or automatic screws on either the foot pulley or on the idling pulley.

In simple installations consisting of short conveyors with narrow belts, the load-carrying portion of the belt may be supported by a smooth
wood or steel surface. However, for installations involving heavy loads or long distances, the belt should be supported by anti-friction idlers. When the belt itself is troughed by conforming to the shape of the load-carrying idlers, the width and cross-section shape of the trough determine the load that can be placed upon the belt. Because of the cost of anti-friction idlers and the narrowness of the belts, most belt conveyors used for seed are supported by the floor of a flat-bottomed trough with vertical or angled sides. While the belt is self-cleaning, the trough often is not. Belt elevators may operate on an inclined plane of up to 15°. If the belt is equipped with flights, the angle may be increased.

Material may be discharged over the end of the belt, or along the sides by using diagonal scrapers or by tilting the belt. The most satisfactory way to empty a troughed belt is with a tripping mechanism consisting of two idler pulleys that divert the belt into the shape of an S. The material is discharged over the top pulley into a side chute. Trippers are usually mounted on tracks so that they can be moved to any place along the length of the belt.

An interesting variation of the belt conveyor is the zippered belt. The edges of the belt are equipped with notches much like those on the common zipper. After filling, the belt edges are attached together so
Figure K7. Conveyor belts with "trippers" or unloading devices installed over holding bins in a seed plant.
that the belt with its load is shaped like a hose. Although in industrial use, few are used in seed processing plants.

**Vibrating Conveyors**

Vibrating conveyors or shakers move material through a metal trough at horizontal or near horizontal angles. The trough is mounted on rigid inclined toggles and is usually driven by a consistent-stroke eccentric drive. The horizontal motion resulting from the eccentric is transformed into an upward and forward pitching action by the inclination of the toggles. Seed fed into the trough move up and forward with each vibration. The result is a series of rapid pitching actions which produce a total net movement of the seed toward the discharge end of the trough. Short feeding-type conveyors are sometimes powered by an electromagnet that can produce differing rates of vibration to change the rate of feed. Most often used in industry to convey hot, abrasive, fine, dusty, lumpy, or stringy materials, these vibrating conveyors handle free flowing seed materials equally well. In a seed cleaning plant they are often used to convey seed for short horizontal distances, as from beneath a cleaner to an elevator leg on the same level, or to feed some machine uniformly. A well-built unit of this type is sturdy and compact, completely self-cleaning and easily inspected. Perhaps its chief limitation is that it must be mounted on a firm foundation.
Figure K9. Diagrammatic sketch illustrating the flexibility of an air-lift elevator.
Pneumatic Conveyors

Pneumatic conveyors move granular materials through a closed duct system by air. They are characterized by low upkeep since they have few mechanical parts. They are also flexible, since the conveying pipes may be placed in any position and may be branched. Pneumatic conveyors are also practically self-cleaning. Disadvantages include high power requirements and possible damage to conveyed materials. Three basic systems are used to convey a variety of materials:

1. High pressure systems which employ low-volume, high pressure air.
2. Low pressure systems using high-velocity, low pressure air in which centrifugal fans are commonly employed.
3. Vacuum systems which operate below atmospheric pressure.

The high pressure system is the most efficient of the three, but seed handling by this method is still in the experimental stage. The low-pressure system does not deliver sufficient force to convey many types of seeds. The vacuum systems, commonly termed "air-lifts", are widely used in certain areas, notable in Western United States, for conveying of seed.

An air-lift elevator consists of a feed hopper, conveying pipe, suction fan, receiver, or cyclone to settle or drop seed from the air stream, exhaust line, and an air-lock to discharge seed from the cyclone without losing vacuum.

In operation, seed or grain fed into the moving air stream in the vacuum line are lifted to the conical receiver, where it settles out because of a decrease in air velocity. They then pass through the rotary air-lock while the air discharges directly from the fan. Baffles and a discharge line larger than the intake line prevent seed from blowing out the discharge pipe.

Screw Conveyors

The screw or auger conveyor is one of the oldest and simplest methods of moving bulk materials. It is a helix formed from a flat steel strip and mounted on a pipe or shaft with supporting brackets and bearings. This screw may operate in a U-shaped trough for horizontal conveying, or through cylindrical tubes or casings when materials are moved vertically or on an inclined plane. The screw conveyor is simply
constructed, inexpensive, and since it can be used in any position, is easily adaptable to congested areas in the plant.

Because of friction among seeds during conveying and the possibility of seed cracking from dented casings or improper clearance between screw and casing, screw conveyors are not generally recommended for easily-damaged seeds. They are also difficult to clean. Short sections of screw conveyors are commonly and satisfactorily used for cereal and grass seed.

Chain Conveyors

Chain conveyors are made in a variety of types for a variety of purposes. They are slow-moving conveyors, often characterized by high power requirements. The drag or scraper conveyor is a common type. Depending upon the use made of the conveyor, drags of varying shapes are mounted between one or two chains driven over end sprockets. The most common seed conveyor of this type is the outside portable elevator used for handling ear corn. The conveyor may operate horizontally or on a maximum inclined plane of about 45°. Increased capacity of such a conveyor should be accomplished by larger flights rather than by increased speed.
Figure K11. Drag-chain conveyor.
Lift Trucks

Lift trucks have several advantages. Well-constructed and planned tote boxes serve both as conveyors and as storage units. A lift truck is especially useful where a larger number of lots are handled on relatively few processing machines. Tote boxes equipped with movable tops provide excellent temporary storage bins before processing. They can substitute for a large number of permanent bins and eliminate the need for handling uncleaned seed in bags. With proper pallets, the same lift truck that carries the boxes can also transport and stack bagged seed.

Lift trucks are ideal for processing a large number of lots in which positive identity is imperative. They offer many advantages in cleanliness, maintenance of seed purity, damage-free handling, and flexibility. With perforated bottoms in the boxes and a properly-designed drying set-up, seed can be dried in the boxes. The original cost is high but the system pays off in the long run.

Selection of Conveyors

Selection of the proper conveyors for receiving seed in the plant,
moving seed from dryers, shellers and one processing machine to another, and finally moving sacked seed into storage has an important influence on the efficiency of processing operations.

Conveyors should be selected on basis of kinds of seeds handled, direction and length of conveying, capacity of equipment from which or to which seed are conveyed, and ease of clean-up. Generally, one should strive to eliminate as much manual handling as possible. In sizeable operations, dependance on manual handling, limits capacity and efficiency of the various processing steps.

As already indicated, an important consideration in selecting conveying equipment is capacity. Conveying equipment should have a greater capacity than the equipment to or from which it will convey seed. Matching conveyor capacity to equipment capacity requires careful study.

First, the maximum capacity of the items of equipment served by the conveyor must be determined and then a conveyor capacity selected somewhat above this maximum level. Conveyors with inadequate capacity decrease efficiency and sometimes effectiveness of the various steps in processing.

A frequent omission in many seed plant designs are methods for disposal of rejects or waste products. In smaller operations, rejects and waste products can be bagged and hand loaded onto trucks for dumping. For larger operations, however, this method may not be satisfactory, particularly when rejects or waste materials are produced in rather high volumes. Cobs, shells, refuse from high capacity scalpers, etc., can rapidly accumulate and create troublesome conditions unless some means for moving them away from the machines are provided. Generally, this is done by screws, vibrating conveyors, and blowers.

Summary

Several types of conveyors are available for moving seed into, through, or away from the processing plant in vertical, horizontal or inclined directions. Selection of conveyors that have adequate capacity, do little damage to seed, and are easy to clean can have an important influence on processing effectiveness and efficiency.

Selection of conveying equipment is an essential feature of seed plant design. It is the conveyors that move the seed to and from every step in the processing operation.
Figure K13. Elevator heads and spouting in a seed processing plant.
Accessory Equipment

Section L
LETS CLEAN UP

Figure L. Thorough clean-up is necessary to prevent mechanical mixtures of varieties.
ACCESSORY EQUIPMENT

Equipment such as scales, bag closers, blowers and vacuum cleaners are essential for the efficient operation of a seed processing plant. The arrangement, number and capacity of these machines must complement the other processing equipment. Fortunately, there are many manufacturers of these kinds of equipment, each offering models of varying capacity. This discussion is limited to the general types of scales, bag closers, blowers and vacuum cleaners used in the seed processing industry.

SCALES

Seed are weighed twice in most processing operations. The first weighing is usually in bulk as seed are received by the processor. This requires scales with the capacity to weigh from a few hundred to many thousand pounds, according to the normal method and volume of delivery by seed growers. The second weighing is made on processed seeds. This requires scales which weigh a few grams, a few pounds, or up to one or two hundred pounds, depending upon the size of the seed package. Scales of proper capacity and accuracy can add to processing efficiency, when they are located at both ends of the processing line.

The following is a brief description of the general characteristics of various types of scales used in the processing plant.

Platform Scales

Drive-on platform scales are used primarily for weighing heavy loads of incoming seeds received on trucks, trailers or wagons. Seed normally received in bags, pallet boxes or similar containers can be handled by lift trucks, hand trucks or by hand, when a platform scale is available. Since these scales are a major investment and are permanent installations, considerable thought and planning should go into selecting type, capacity, and location of the scale.

Most processing plants also use at least one small portable platform scale. This scale is particularly useful for weighing small lots of seed, chemicals used in treaters, partially-filled containers, and other materials weighing up to 200-300 pounds.

Bagging Scales

Capacity and efficiency of the bagging scale should equal or exceed the capacity of the processing equipment it serves when this equipment is operating at maximum capacity.
Bagging scales are classified as manual, semi-automatic, or automatic.

**Manual:** This type scale, usually a portable platform, is considered inefficient for volume weighing operations because of a high labor requirement and relatively low capacity, in terms of bags filled per minute. With this scale, bags are filled to approximate weight, placed on the scale and then "even-weighed" with a hand scoop. These scales are useful when (a) weighing bags of non-free-flowing seeds, (b) a bagging bin is not available, or (c) labor costs are minimal.

**Semi-automatic:** This is the most widely used scale in the seed industry. The scale is attached to the bottom of a bagging bin, and the bag is clamped to the bottom of the scale. The desired weight is set on the scale by the operator. The feed gate is opened manually and may be closed either manually or automatically when the proper weight is attained. The scales have a capacity of four to eight 100-pound bags per minute, depending on seed being packaged and the skill of the operators.

When selecting a scale of this type, the circumference and composition of the bags or containers must be considered. The orifice of the bag clamp must be smaller than the open end of the bag; however, too small an orifice and clamp will result in seed spilling around the
edge of the bag. The bag clamps hold materials of specific finish and thickness; therefore, the composition of the bagging material (i.e., jute, cloth, plastic, paper) should be stated when ordering the scale.

**Automatic:** Scales of this type are used primarily in the small package (vegetable and lawn seed) segment of the seed industry and in some of the more modern field seed processing plants. The entire weighing and filling process is done automatically. Installation is similar to the semi-automatic bagger. Some completely automated systems pick up the empty bag, place it on the bagger, fill the bag and release the filled bag which then moves by conveyor to a bag closer.

Regardless of the type of scales used, they should be checked regularly to determine their accuracy, particularly if they are portable. Frequent and careful cleaning of the weighing mechanism will decrease the number of inaccurate weighings and extend the life of the scale.

**BAG CLOSERS**

Field seed packaged in burlap, cloth, or paper bags are normally closed by industrial sewing machines. Seed packed in plastic bags are closed with a heat sealer. Boxes of seed are closed by tape or glue.
Figure L.3. Portable bag closer.
Figure L4. Use of semi-automatic bagging scale and portable bag closer in seed processing plant.
Thus, the first consideration in selecting a package closer is the packaging material used. It is also necessary to know the hourly capacity, package size and weight, type of closure needed, and the flow pattern in which the closing machine is to operate.

Sewing machines used by the seed industry are available with closing capacities ranging from 60 to 500 standard 100-pound bags per hour. Generally, price and size of the sewing unit increases as the capacity increases. The package size has a direct effect on the sewing machine capacity; the weight of the package is important only when considering the use of a bag conveyor.

The two types of sewn closures used on most packages are plain-sewed and tape-bound. The plain-sewed is the most widely used for fabric, paper-lined fabric, and paper bags. It can also be used with multiwall paper bags but some difficulty in tearing of the bag may be encountered, particularly with machines adjusted to close other types of packages. The tape-bound closure is more and more frequently used for multiwall bags. The tape usually adds to sales appeal and eliminates most of the problems associated with plain-sewed closures on multiwall bags.

Depending upon the capacity of the processing plant, the number of processing lines, and the location of bagging and closure installations, a portable or stationary installation of the sewing equipment may be best. Portable machines are widely used because of their light weight and flexibility. Such machines require little installation, support or plant space. A suspension unit, however, will prevent a great deal of damage caused by careless handling. Models are available which operate either electrically or by air power. They weigh from 10 to 22 pounds.

A suspension unit allows using the "heavy-duty" two-thread sewing machine. Because of its weight, this machine is not considered portable, although it can be moved readily from one suspension unit to another. Such machines are mechanically more complex, but frequently have greater capacity and durability than the smaller machines.

Both portable and "heavy-duty" sewing units may be mounted on permanent stands with a conveyor belt, scales, or other accessory equipment. Thus, it is possible to reduce bagging, weighing and closing to a one-man operation. The use of such accessory equipment may be justified by the volume of packages handled, labor expense and other plant facilities.
Figure L5. Portable bag closer attached to a bag conveyor.
Figure L6. Automatic bagging scale with bag closer and bag conveyor.
Figure L7. Heavy duty vacuum cleaner and high velocity air blower.

BLOWERS AND VACUUM CLEANERS

"Clean-up" is a debit cost item in all seed processing plants; therefore, the job must be done quickly but thoroughly. To aid in this task, most seed processors use both an air blower and a vacuum system.

Seeds and trash lying on inaccessible floor areas around processing equipment can quickly be blown by a guided air stream into another area for easy pick-up. Both the fan type portable blower and air compressor with long hoses work satisfactorily. The blowing unit should have a small (less than 2" diameter) orifice, be easily handled, and have a high air velocity at the orifice so the air stream can be controlled.

Blowing is not a satisfactory method for cleaning the interior of most seed processing equipment, dump pits, elevator "boots" in pits or cleaning floors. Some type of vacuum cleaner is essential for thorough clean-up. Because vacuums pick up the undesirable material, they clean areas more effectively than the blower which tends to scatter material. Some models can also be used to pick up water which accumulates in floor recesses. Only the heavy-duty industrial vacuums are recommended for general use.
Both the portable tank-type and the more permanent central vacuum systems should be considered. In general, the portable cleaner offers greater versatility, requires no assigned floor space, no special installation, and the motor unit on some models can be removed and used as a blower. The relatively new central vacuum systems usually have greater capacity, require only the movement of the suction hose, can be used for dust or screening evacuation at the same time vacuuming is being done, and usually have a larger capacity settling tank. A large variety of attachments are available for both types of vacuums.

Figure I.8. Small surge bin used as a hopper for a gravity table. The bin was made from a steel barrel.
BINS

Bulk storage bins of concrete, steel, or wood are common to the grain trade, and are also used in the seed industry for bulk seed storage. The only difference in bulk grain bins and bulk seed storage bins is the need for smooth inside surfaces in the seed bin. A smooth inner surface offers fewer places where seed can lodge, and is easier to clean out when changing seed lots or cleaning certified seed.

Surge or holding bins mounted above processing machines are used in practically every seed processing installation. A holding bin above the first cleaner will automatically feed seed into the cleaner hopper and free the man who would otherwise spend his time feeding seed into the cleaner. Another advantage of surge bins is that many cleaners normally used in sequence do not operate at the same capacity. Without surge bins, all cleaners must be slowed down to the capacity of the slowest machine. Many cleaners do not separate seeds effectively when they are operated below normal capacity.

Bins mounted in the cleaning line between the various cleaners will absorb differences in capacity and allow each machine to operate at its most effective capacity.

Surge and holding bins are generally constructed from reinforced sheet steel. Reinforcing is mounted on the outside to avoid ledges within the bin where seed may lodge. Wood hoppers should be lined with sheet metal to insure smooth inner surfaces.

Bin Size

To determine the best surge bin size, the processor should answer these questions about his particular installation:

A. What size bin is needed for a certain machine?

1. Bins should always be as large as possible to reduce the number of times they must be refilled. If the cleaner empties its bin every 20 minutes, a man must fill the bin three times an hour. If 15 minutes are required to fill the bin, one man must spend 45 minutes of each operating hour to fill this one bin. Usually, he will spend the rest of the hour moving seed to the elevator, so one worker is tied down by this operation. As a general rule, the bin should not require filling more often than once every one or two hours.
2. "Surge" bins between machines in the cleaning line: If the second cleaner in the line has a capacity of 60 bushels per hour while the first cleaner feeds 75 bushels per hour to it, the bin for the second cleaner should be large enough to handle the difference in capacities. EACH MACHINE SHOULD BE RUN AT THE CAPACITY WHICH GIVES IT THE GREATEST EFFICIENCY, BOTH FOR CAPACITY AND FOR THOROUGH CLEANING. Power requirements are not greatly different whether the machine is operated at full or at half capacity. Some cleaners will not give the same cleaning results when run at a fraction of their normal capacity.

If cleaners in the same cleaning line vary too widely in operating capacities, smaller machines should be replaced with larger models. If this is not possible, two of the low-capacity machines should be installed side-by-side to handle seed from the larger machine.

B. How long will it take the machine to empty the bin?

1. If the machine is operating at a capacity of 120 bushels per hour (two bushels per minute) and the bin holds 144 bushels,

\[
\frac{144}{2} = 72 \text{ minutes required for the machine to empty the bin.}
\]

The easiest way to determine operating capacity of a machine on a given lot is to check the time required to clean the known amount of seed in the bin of known capacity.

C. How long will it take to fill a bin?

1. If the cleaner is not running:

If the bin holds 144 bushels, and is fed by an elevator with a capacity of 700 bushels per hour, or 11.67 bushels per minute:

\[
\text{Divide capacity of the bin by amount of seed delivered by the elevator in one minute.}
\]

\[
\frac{144 \text{ bushel capacity}}{11.67 \text{ bushels per minute}} = 12.3 \text{ minutes required to fill the bin}
\]

2. If the cleaner is running:

Subtract the bushels of seed taken out of the bin by the cleaner in one minute from the bushels of seed delivered to the bin in one minute by the elevator; i.e., if the elevator delivers 11.67 bushels per minute and the cleaner
takes out 2 bushels per minute, the gain is 9.67 bushels per minute.

Divide capacity of the bin by the difference computed above, as:

\[
\frac{144}{9.67} = 14.9 \text{ minutes required to fill the bin when the cleaner is taking out 2 bushels per minute.}
\]

Estimating Capacity of Bins

A. Round Bin or Tank

1. Area of a circle = \(\pi r^2\)

2. Volume = area x height \((\pi r^2 x h)\)

3. Divide volume in cubic feet by 1.25 to obtain capacity in bushels.

4. Example:

A round tank 12 feet high and 14 feet in diameter.
Volume = \(3.14 \times 72 \times 12 = 1846.3\) cubic feet
Capacity in bushels = \(\frac{1846.3}{1.25} = 1,477\) bushels.

B. Cone or base of a tank-type bin

1. Volume of the cone = \(\frac{\text{area of base (circle) x height}}{3}\)

2. Example:

Cone 14 feet across the base and 7 feet in height.
Area of base = \(3.14 \times 72 = 153.86\)
Volume = \(\frac{153.86 \times 7}{3} = 358.82\) cubic feet
Capacity in bushels = \(\frac{358.8}{1.25} = 287\) bushels

C. Capacity of rectangular or square bins

1. Volume = width x length x height
2. Example:

The rectangular section of a bin is 4 feet wide, 4 feet long, and 8 feet high.
Volume = 4 x 4 x 8 = 128 cubic feet capacity
128 ÷ 1.25 = 102.4 bushels capacity.

D. Pyramidal bins and pyramidal bases of bins

1. Volume = \text{width x length x height} \div 3

2. Pyramidal bins usually do not come to a point; they are "cut off" at the base to fit the seed intake of a machine. To compute the volume of either a pyramid or a cone when the base has been cut off:

(a) Figure total volume of the entire bin as if the point were extended all the way down.
(b) Compute the volume of the missing point and subtract from the bin total.

Example:

Pyramidal base of the bin in C above is 4 feet wide, 4 feet long, and slopes down 2 feet at a 45° angle to an opening 6" x 6":

(1) The volume of the uninterrupted pyramid would be:

\[
\frac{4 \times 4 \times 2}{3} = 10.7 \text{ cubic feet}
\]

(2) The volume of the point cut off below the 6" x 6" opening would be:

\[
\frac{0.5 \times 0.5 \times 0.25}{3} = 0.6 \text{ cubic feet}
\]

(3) Actual capacity of the pyramidal base is:

10.7 cubic feet - 0.6 cubic feet = 10.1 cubic feet

10.1 \div 1.25' = 8.1 bushel capacity
E. Example of a round bin with a cone-shaped bottom:

Use the tank computed in A above, and add the capacity of the cone computed in B above:

\[
\begin{align*}
1,477 \text{ bushels capacity of the tank} \hfill \\
287 \text{ bushels capacity of the cone} \hfill \\
1,764 \text{ bushels total capacity}
\end{align*}
\]

F. Example of a flat-sided rectangular bin with a pyramidal bottom sloping in to fit the hopper of a cleaner:

1. The rectangular part of the bin (C above) contains 102.4 bu.

2. The pyramidal base of the bin (D above) contains 8.1 bu.

3. Total capacity is:

\[
\begin{align*}
102.4 \text{ bu.} \hfill \\
8.1 \text{ bu.} \hfill \\
110.5 \text{ bu. total capacity}
\end{align*}
\]

Summary

Bins of several types are used in the seed industry. Bulk storage bins of concrete, steel, or wood are used for bulk seed storage. Surge or holding bins are used between machines in the processing line to allow the machines to operate at normal capacity.
Figure L 9. Hopper bottoms of large holding bins. The bins empty onto conveyor belt. Note vacuum cleaner near spout used to remove dust as bin is emptied.
Design and Layout of Processing Plant

Section M
Figure M. Scale model of multi-story seed processing plant constructed by students in Seed Technology Laboratory.
Decreasing profit margins are forcing progressive seedsmen to cut operating costs and increase efficiency at every opportunity. One of the most effective means of increasing both capacity and efficiency is through improved layout of equipment. Effective layout arrangement places all machines in proper sequence so that the right process is done at the right time, with a minimum of handling cost, and at the most efficient capacity.

Background Study

Unless there is complete satisfaction with profits and efficiency under present operations, it would be advantageous to make a careful study of the seed flow through the plant. Is capacity sufficient? Are the machines operated at maximum efficiency? Is there a bottleneck in either cleaning or handling? Is there an operation that requires constant supervision? Improvements in layout can increase capacity and lower handling costs.

Before a new plant is built, layout should be carefully planned to insure that seed receive the necessary processing in the proper sequence, that there are no bottlenecks, and that operating costs are kept to an absolute minimum. Proper layout planning combined with automated control systems and up-to-date seed handling methods can greatly reduce the processor's costs.

The keys to efficient plant layout are a thorough knowledge of what needs to be done and sound planning.

First, the general sequence of processes involved between the time the seed enter the processing plant and the time they are cleaned, packaged, and ready for shipment must be charted. A breakdown of these steps is shown in an accompanying illustration. The seed are RECEIVED into the processing plant before any cleaning begins. They may be held in STORAGE until cleaned, or sent directly into the cleaning line.

The first phase of processing is CONDITIONING AND PRE-CLEANING. This involves removing awns or hulls, breading up clusters, scalping off large trash, and other operations which improve the condition and flowability of the seed. Such machines as debearders, hullers, and scalpers are used.

The next step is BASIC CLEANING. Here material larger and smaller than good seed are removed and the seed are generally sized
and cleaned. The air-screen machine is most often used for this basic operation.

Sometimes seed can be brought up to required purity by basic cleaning. More often, additional SEPARATING AND UPGRADING must be done, using machines which separate seed that differ in a narrower spectrum of physical properties. Velvet roll mills, gravity separators, magnetic separators, and others are used to remove specific contaminants and improve seed quality.

After purity requirements have been met, the seed may be TREATED before they are BAGGED or packaged. The seed are then ready for STORAGE or SHIPPING.

The layout planner must have an intimate knowledge of the seed he processes, its physical characteristics, the weed seed and contaminants in it and the machines needed to bring the seed up to acceptable marketing standards. These differ with different crop seeds, so different processing machines are needed. Sometimes seed conditions will require a different sequence of processing.

Analysis of Operations

General flow patterns used to process different types of crop seeds are shown in accompanying illustrations. These general flow patterns do not represent any single processing plant; they are composites prepared from the flow plans of many plants. The machines and the sequence that are used to process a given crop seed are shown. Depending on a given processor's situation and conditions, a particular machine shown in the diagrams may not be needed, or a different machine may be required to remove a particular contaminant.

Processing Sequence

After the machines needed are identified, the proper processing sequences and capacities must be determined. Sequence is an important factor in processing efficiency. Some machines will make precise separations only after the seeds have been properly precleaned, while others will perform better after the seeds have been through other machines. For example, the gravity separator will separate seeds of the same size but of different specific gravities according to their specific gravity. When the seeds are of similar specific gravities but differ in size, it will separate them according to size. When the seeds vary both in size and specific gravity, a precise separation cannot be made. For precise separations, seed must be closely sized before they go onto the gravity separator.
The location of the roll mill is another example of efficiency gained by layout planning. Alfalfa seed processors have found that gravity separation of seed ahead of the dodder roll mill removes sand and reduces excessive wear of the roll fabric. The amount of material going onto the roll mill is also reduced, so capacity is increased.

Matching Capacity

Equipment size or capacity must be carefully planned to prevent bottlenecks. A machine that can handle only 100 bushels an hour, for example, would not fit into a cleaning line with other machines that can operate efficiently at 200 bushels an hour. When the overall operating capacity needs have been determined, all machines must be able to handle that capacity with some reserve capacity for problem lots. Surge bins can handle slight variations in individual machine capacities. But, when differences are great, either larger models or more than one machine installed in parallel flow must be used to maintain uninterrupted flow.

Conveying

Elevators and conveyors are important equipment in the seed plant. Their selection and installation is as vital to efficiency as any machine. They must be able to handle the capacity needed in a particular spot, and they must be carefully adapted to the seed handled. For example, elevators handling chaffy grass seed must move the seed without bridging or plugging. Elevators moving beans and peas must not cause mechanical injury.

Types of Layouts

When the type and size of conveying equipment are selected, the actual plant layout planning can begin. There are three main types of processing plant layouts: multi-story, single level, and combination.

Multi-story

The multi-story plant has been a long-time favorite. In this system, seed are carried by elevators to the top floor and emptied into large bins. Cleaning machines are then arranged in vertical series on lower floors. Seed flow from one machine down into the next by gravity.

Single Level

Many plants are built today with all cleaning machines mounted on a single level, or on platforms on the same floor. In the single-story plant, seed are moved from one machine to the next by elevators.
placed between the machines. More outlay for elevating equipment is needed, since a separate elevator must feed each machine. But, supporters of this design are quick to point out that building costs are much lower, and smaller less expensive elevators are used. A great advantage of the single-level system is that one man can supervise the processing line without running up and down stairs. He can maintain closer supervision of all operations, and produce cleaner seed at a higher capacity.

Combined Design

Many seedsmen find that a compromise between the single and the multi-story system fits their needs best. New automation and remote control systems fit either layout, and result in large gains in efficiency.

Planning

After the proper machines, elevators, capacities, cleaning sequences, and layout design have been selected, detailed layout planning can begin. Careful layout planning can identify and remedy bottlenecks and trouble spots before the plant is built, and thus prevent later trouble.

As the layout or design develops, it should be drawn on paper. A good method is to draw lines of flow first, and then convert these flow lines to machine lines. After appropriate revisions, detailed drawings can be made to show exact locations of equipment and distances. Scale drawings are the most widely used method of layout planning. Scale models and scale templates are also very effective, but are more expensive.

Layout planning today is a science in itself, and is a valuable tool of process industries from seed processing to automobile manufacturing. Improvements are frequently reported in journals serving the process industries. Equipment representatives are often trained in plant layout, and the seedsman planning a new plant should take full advantage of their special knowledge.
Figure M1. General flow diagram for seed processing plant.
Figure M4. Cotton Seed (Acid Delinted) Flow Diagram
Figure M5. Hybrid Corn Seed Flow Diagram
Figure M6. Pea & Bean Seed Flow Diagram

Figure M7. Grass Seed Flow Diagram
Figure M8. Small Grain Seed Flow Diagram
Figure M9. Sorghum Seed Flow Diagram

Figure M10. Soybean Seed Flow Diagram
Figure M11. Flow diagram showing steps in the cleaning of wheat, barley, oats and vetch, grass and legume seed.
Figure M12. Floor plan for seed processing plant.

Figure M13. Isometric drawing of flow plan illustrated above.
Figure M14. Floor plan of a seed plant drawn to scale. After equipment has been selected and flow lines planned, the layout should be drawn to scale.
Figure M15. Flow diagram for corn grading sequence.
Figure M.16. Large soybean and rice seed processing plant.

Dryer and storage bins are on the left.
AUTOMATION

In recent years automation in industry has come of age. The manufacture of more and more products is being controlled automatically. The thought of automation brings apprehension to some people as they think of elimination of jobs and elation to others when considering the increased production per worker. Let us consider automation and what it can do for us in seed processing.

From the experiences of others using automation techniques one can expect great reduction or elimination of many tedious and repetitious tasks now assigned to men. Manual labor will be almost eliminated and production capacity will go up because every unit will be operating at its maximum efficiency. This automatic control will reduce the number of semi-skilled machine operators but will create a demand for more skilled technicians and managers.

Automation or automatic control is merely an extension of mass production techniques. It is the technique of measuring output of a process and feeding back the information gained to adjust the input. One early example of such a control is the governor for James Watt's steam engine in 1788. A more modern example would be the thermostatic control on a drier in which the temperature of air in the plenum chamber is measured and this information fed back to the thermostat which then opens or closes a valve to regulate the input of fuel to the burners. Engineers call this concept closed loop control.

Using feedback information to correct or adjust is not new, but the many new refinements in instrumentation make its use on a large scale practical. This idea can be expanded from one machine to the entire plant.

Some automatic control devices do not feed back information but use what is called open loop and linear sequence control which is open on both ends. An example of this would be an aeration system that is switched on or off by a humidistat outside the building rather than depending on measurement of conditions inside the bins.

It is necessary to take a systems approach when considering automating processes. Machines involved in a process are interconnected and controlled by the system. Much flexibility can be built into a system so that as processing problems vary some machines can be bypassed or added to the processing sequence.

Truly automated systems depend on feedback information and closed loop control. Anything less is merely remote control.
Figure M17. Closed loop concept of automation.

Tools used in automating grain, seed or feed handling plants are:

1. Bin level controls.
2. Electrically operated gates, valves and distributors.
3. Interlocking wiring.
4. Load limiting devices.
5. Flow indicating devices.
6. Indicating flow diagram at a central control center.

For example, these tools may be applied to a single installation consisting of a driveway dump pit feeding by gravity into an elevator leg equipped with a three-way valve, and spouts to three different bins. The intake on the elevator is equipped with an electrically operated slide gate and is interlocked so it cannot be opened unless the elevator is running. The elevator motor is equipped with a load limiter that controls the opening of the slide gate and causes it to maintain a position that gives maximum feed to the elevator without overloading or underloading. The electrically operated three-way valve on the elevator head directs the flow of seed to one of the three bins. A flow indicating device is installed in each spout and a bin level control is mounted near the top of each bin.

When this system is put in operation the operator at the central control panel starts the elevator. The three-way valve is set to one of the pos-
itions to spout the seed into the desired bin. The slide gate that controls the feed into the elevator is then opened. As the system is put on automatic, the load limiter causes the gate to seed a position that permits flow into the elevator at the maximum rate. The three-way valve directs the grain to the desired bin. The flow-indicating device signals back to the central control center that seed is flowing down the correct spout. When the bin is filled, the bin level control is activated. Its signal immediately causes the slide gate in the elevator to close. When seed has stopped flowing down the elevator spout the flow-indicating device sounds an alarm or causes the three-way valve to switch to an empty bin. After the switch is made the slide gate opens again to the best position and seed flow through the system into the empty bin. This is continued until all bins are full at which time the operator must empty one of the bins before additional seed can be received through the driveway dump pit.

A well designed central control center incorporates all of the electrical controls needed in a large size seed handling plant. Included are the following:

1. Service entrance - terminals are provided for the incoming power line.
2. Main disconnect switch.
3. Power distribution center.
4. Lighting circuit breakers.
5. Circuit breakers for all motors used including double safety lock outs.
6. Meters to measure power consumption.
7. Timed fumigation systems.
8. Starters for all motors.
9. On-off lights for each motor.
10. Push button for each motor.
11. Alarm systems coupled to bin level controls.
12. Flow indicating diagram with selective interlocking. This permits the operator to plan a flow or grain through the system and so interlock the motors operating the conveyors and elevators that they cannot be started out of sequence and will stop the flow instantly when activated by an over-load or a bin level control.
13. Separate amp meters for each motor. Each will have a maximum load position field marked so that the operator can spot an overload or underload condition instantly.
Figure M18. Central control panels in a large seed drying and processing plant.
For complete automation this control center has controls coupled to the selector switches which automatically causes all slide gates, two-way valves, three-way valves and other such distributing units to be activated. Position-indicating lights show the position of each.

Such a control center is intended for installation in a new plant. It incorporates all electrical controls needed to operate the plant. The extra cost of adding the automation equipment is moderate.

Some machines can be individually automated at very moderate costs with a resultant increase in performance. A gravity fed hammer-mill can be equipped with a modulating electrically operated slide gate controlled by a load limiter. The load limiter can be adjusted so that the hammermill operates at maximum load which will cause the slide gate to open to a corresponding point and locate a position which will keep the hammermill running at full capacity. The same system can be used on bucket elevators, debearders, roll mills and other machines where power consumption increases according to increase in rate of feed.

These tools of automation can be assembled to automate almost any installation.
Fred Forsberg and Sons Manufacturing Company, Thief River Falls, Minnesota

A13, B9, E1, E9, E16, G4

Ben Gustafson and Sons Manufacturing Company, Minneapolis, Minnesota

J4

J. W. Hance Manufacturing Company, Westerville, Ohio

B1, C1

Howe Richardson Scale Company, Clifton, New Jersey

L6

S. Howes Company, Silver Creek, New York

C4, L2

Mandrel Industries, Inc., Houston, Texas

A10, H1, H2, H6, H7

J. L. Mitchell Company, Oxnard, California

K5

Oliver Manufacturing Company, Rocky Ford, Colorado

A14, E11, E12, E13, E14, E17, E18, E19, E20

Panogen Division of Morton Chemical Company, Ringwood, Illinois

J6, J7

W. A. Rice Seed Company, Jerseyville, Illinois

F1

Sortex Company of North America, Lowell, Michigan

G2, H, H3, H4, H5