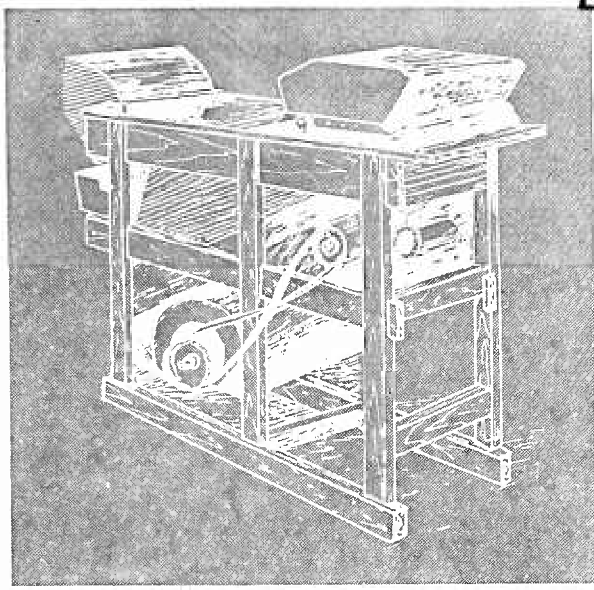

SEED CLEANING AND HANDLING

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Growth Through Agricultural Progress

PREFACE

Seed processing is an integral part of the large agricultural industry, which has the important task of feeding and clothing the expanding world population. This handbook has been prepared as a guide in the selection, operation, and arrangement of seed-cleaning equipment best suited for particular processing needs. Various types of seed cleaners are described, principles of separation for both commercial and experimental equipment are discussed, and typical process flow charts are presented for several seed crops.

Related factors, which are not discussed but which are important in any consideration of efficient seed production, include improved seed varieties, good cultural practices, and effective seed-harvesting techniques.

It is not the intent that this publication shall replace manufacturers' instruction manuals or the knowledge and experience of operators, but rather supplement them.

Acknowledgment is made to the manufacturers of seed-processing and handling equipment whose literature and diagrams formed the basis for some of the material presented here; to seed processors who gave time and assistance in taking photographs of commercial equipment; and to Mr. Hilmer E. Carlson, Agricultural Engineering Department, Oregon State College, for diagrams and sketches.

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SEED CLEANING AND HANDLING

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The annual production of grass and legume seed in the United States is valued at more than $200 million, and imports represent another $15 million. Agriculture constitutes the largest single industry in the world, and many American manufacturers depend upon seed and its products as a source of basic raw material.

To obtain high-quality seed that will increase farm production and provide uniform raw material for industry, efficient seed-cleaning practices are necessary. Even though many types of machines are used for special seed separations, it is estimated that at least 50 percent of good seed is lost in cleaning and handling because it is damaged, or not sufficiently cleaned to meet quality standards set by State seed laws, or certification requirements.

To assist in reducing these gigantic losses, seed-cleaning research is being conducted jointly at Oregon State College, Corvallis, Oreg., by the Small Seed Harvesting and Processing Section of the Agricultural Engineering Research Division, Agricultural Research Service, U.S. Department of Agriculture, and the Oregon Agricultural Experiment Station.

Attempts are being made to reduce seed losses by developing methods and equipment to improve efficiency in handling, treating, and separating crop seeds from weeds and inert matter.

Seed separation is accomplished by the use of special equipment that utilizes differences in physical characteristics of various components in the mixtures. The chief characteristics by which separations are made are size, shape, density, surface texture, color, and electrical properties.

Seed-machinery manufacturers have done an outstanding job in developing separation equipment. Some of the present machines make extraordinary separations of small crop and weed seeds; however, the entire seed-cleaning problem is very complex, and much improvement is still needed in methods and equipment to reduce the heavy seed losses.

There are many types of seed-cleaning machines, such as air-screen cleaners, specific gravity separators, pneumatic separators, velvet rolls, spirals, indent cylinders, indent discs, magnetic separators, electronic separators, debearders, and others. One machine basic to all seed-cleaning plants, from the small farm operation to the largest commercial plant, is the air-screen cleaner. Virtually all other separators are finishing machines, and follow the air-screen unit in the processing line.

The choice of machines used in a seed-processing line depends primarily on the crop being cleaned, the presence of other crop and weed seeds, and the quantity of each in the mixture. Seed is of little value unless it reaches the farmer in a viable condition, essentially free of noxious weeds, and at a price he can afford to pay. The degree to which this can be accomplished is related to the equipment used, its arrangement in the processing plant, and the knowledge and skill of the man operating the cleaning machine.

SEED-CLEANING EQUIPMENT

AIR-SCREEN SEED CLEANER

The air-screen cleaner is the basic machine in a seed-cleaning plant. It makes seed separations mainly on the basis of three physical properties—size, shape, and density.

There are many makes, sizes, and models of air-screen cleaners ranging from the small, one-fan, single-screen machine to the large, multiple-fan, six- or eight-screen machine with several air columns. Screens are manufactured with many sizes and shapes of openings. There are more than 200 screen types available, and with a four-screen machine, more than 30 thousand screen combinations are possible.

The typical air-screen cleaner now found in a farm seed-cleaning plant is a four-screen machine located beneath a seed hopper, as shown in figures 1 and 2. Seed flows by gravity from the hopper

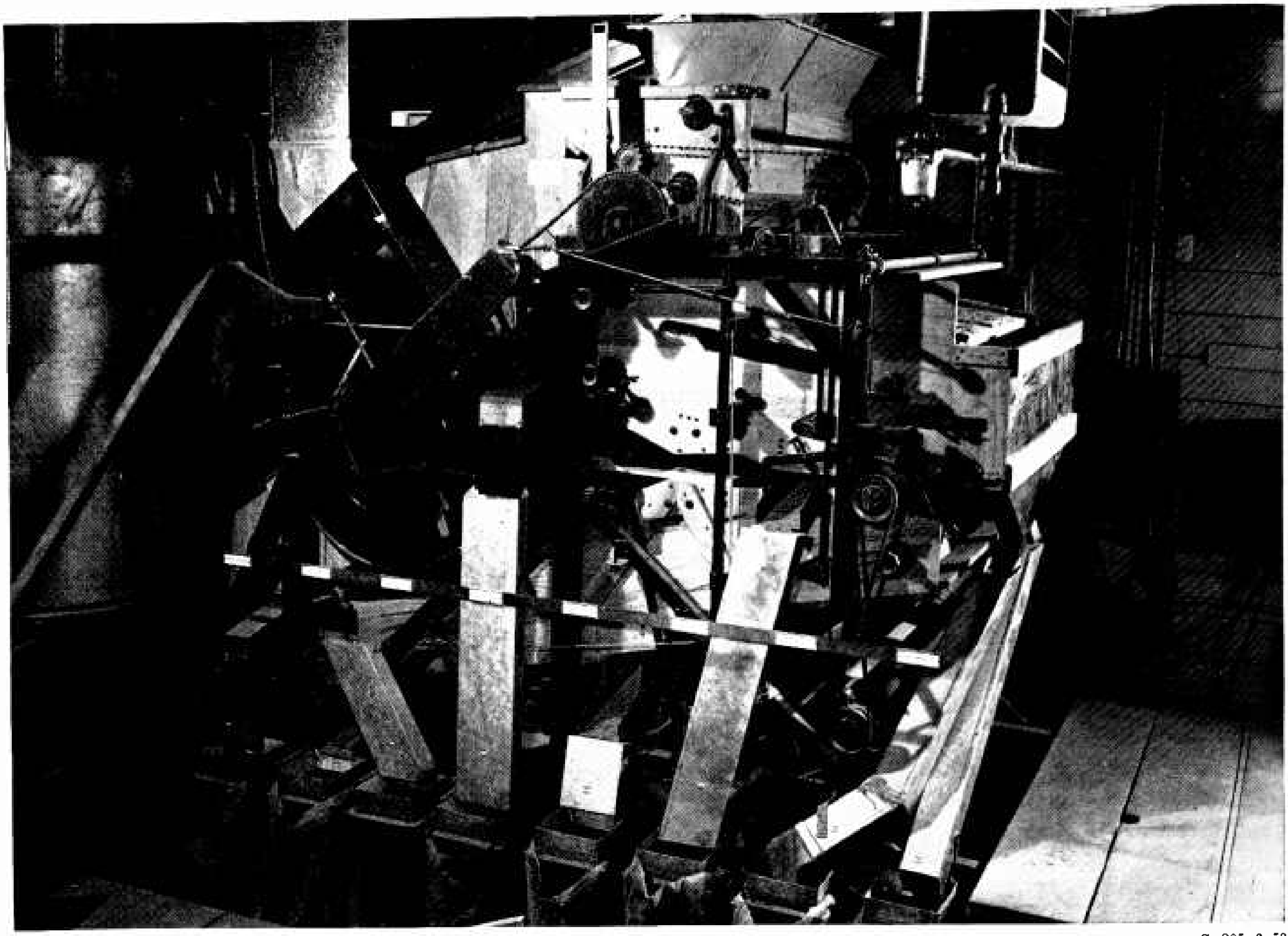

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FIGURE 1.—Air-screen seed cleaner.

into a feeder that meters the seed mixture into an air stream, which removes light, chaffy material so that the remaining seed can be distributed uniformly over the top screen. The top screen scalps or removes large material, the second screen grades or sizes the seed, the third screen scalps the seed more closely, and the fourth screen performs a final grading. The finely graded seed is then passed through an air stream, which drops the plump, heavy seed, but lifts and blows light seed and chaff into the trash bin.

Screen Numbering System

The size of a round-hole screen is indicated by the diameter of its perforations. Perforations larger than size 5½ are measured in 64ths of an inch. Therefore, a 1-inch round-hole screen is called a No. 64; a ½-inch screen is a No. 32, et cetera. Screens smaller than 5½/64 are measured in fractions of an inch. The next size smaller than 5½ is a 1/12th; then, in descending order, 1/13th, 1/14th, et cetera.

Oblong-hole screens are measured in the same manner as round-hole screens except that two dimensions must be given. In large oblong-hole or slotted screens the hole width is indicated in 64ths of an inch; for example, 11 x ¾ means an opening 11/64ths of an inch wide and ¾ths of an inch long. In slotted screens smaller than 5½/64 x ¾ width is generally indicated in fractions of an inch; for example, 1/12 x ½. There are some exceptions to this latter designation in that such sizes as 5/64 x ¾, 47/8/64 x ¾, 3/64 x 5/16, and others, use the large-screen numbering system with hole widths indicated in 64ths of an inch. In all cases, the final number is the length of slot.

Wire-mesh screens are designated according to the number of openings per inch in each direction. A 10 x 10 screen has ten openings per inch across, and ten openings per inch down the screen. The size 6 x 22 has twenty-two openings per inch across the screen, and six openings per inch down the screen. Such screens as 6 x 22 have openings which are rectangular in shape, and are the wire-

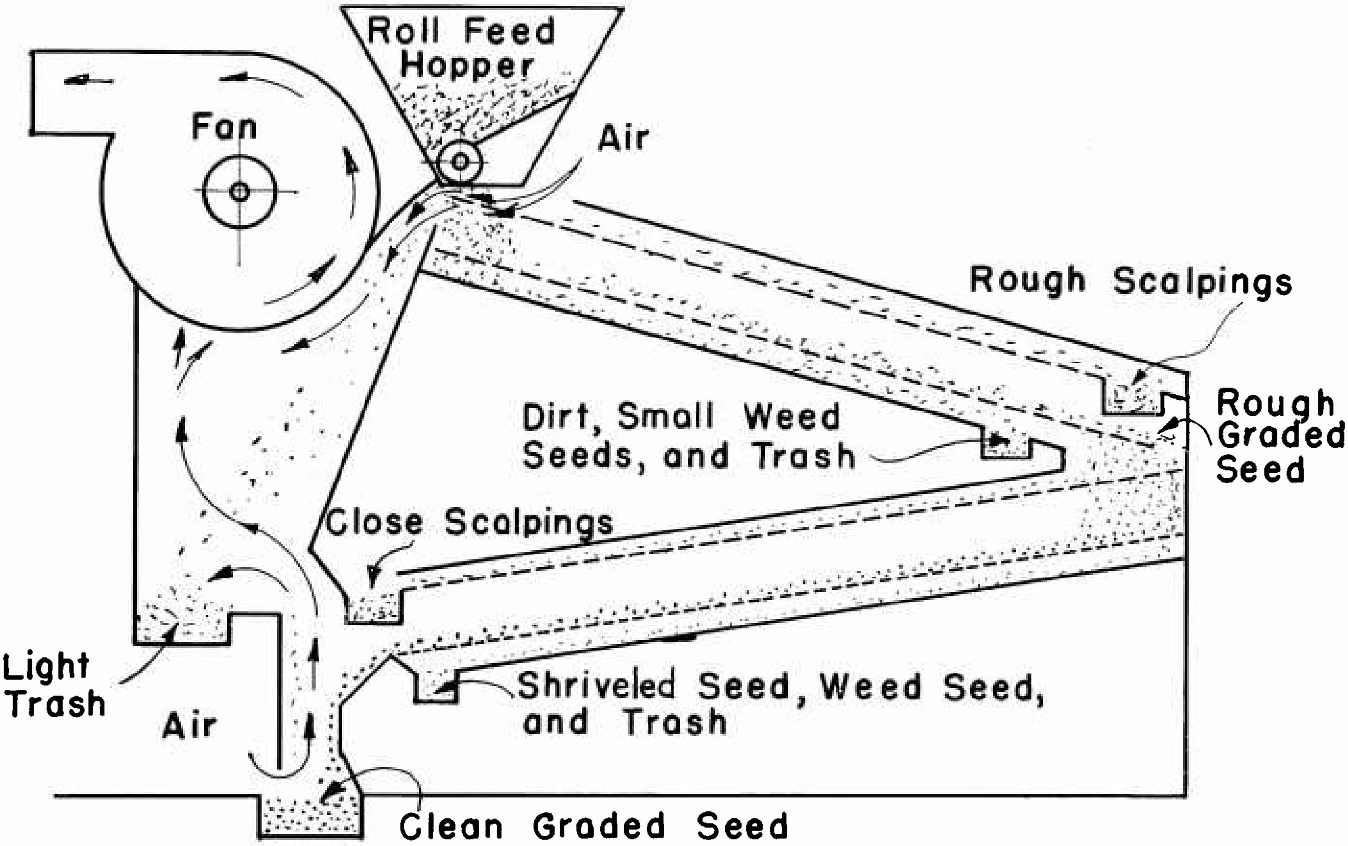

FIGURE 2.—Schematic view of air-screen seed cleaner.

mesh equivalents of oblong-perforated or slotted screens.

Triangular screens may be measured in two ways. The system most commonly used in the seed industry indicates length of each side of the triangle in 64ths of an inch. The sides of the hole in a No. 11 triangular screen are $^{11}/_{64}$ths of an inch long. Another system used by perforators is to designate the triangle as the diameter of the largest circle that can be inscribed in the triangle.

Table 1 shows manufacturers' screens in sizes and shapes commonly stocked.

Selecting Screens

The two basic screens for cleaning round-shaped seed are a round-hole top screen and a slotted bottom screen. The round-hole top screen should be selected so as to drop the round seed through the smallest hole possible, and retain anything larger. The seed drops through the top screen onto the slotted bottom screen, which takes advantage of seed shape and retains the round, good seed while dropping broken crop seed and many weed seed.

The basic screens for cleaning elongated seed (oats, fescues) are a slotted top screen and a slotted bottom screen. In special separations it may be necessary to pass such seed through round-hole top screens or over some screen other than a slotted bottom screen, but generally, slotted top and bottom screens are used.

The basic screens for lens-shaped seed (lentils, flax, and Korean lespedeza) are usually a slotted top screen and a round-hole bottom screen. These shapes allow the best cleaning possible when a machine is equipped with only one top and one bottom screen. The lens-shaped seeds tend to turn on edge and drop through a slotted top screen but lie flat and travel over a large round-hole bottom screen, which will pass most other crop and weed seeds.

Since most air-screen cleaners have more than two screens, the general rule is to equip the cleaner with oblong- and round-hole top screens, and oblong- and round-, square-, or triangular-hole bottom screens. With few exceptions, this system assures the most thorough seed separation.

TABLE 1.—*Sizes and shapes of screens commonly stocked by manufacturers*

PERFORATED METAL SHEET									WIRE CLOTH			
Round holes			Oblong holes		Triangles	Oblong cross slot	Round hole half sizes	Oblong half sizes	Square openings	Oblong openings		
Fractions	64ths		Fractions	64ths	64ths	Finished screens made only in "9" and "8" model widths. Sheet sizes 26" x 41½" and 26" x 53¼"						
									3 x 3	2 x 8	4 x 15	6 x 14
									4 x 4	2 x 9	4 x 16	6 x 15
									5 x 5	2 x 10	4 x 18	6 x 16
1/25	6	24	1/24 x ½	4⅞ x ¾	5	6 x ¾	5½	7½ x ¾	7 x 7	2 x 11	4 x 19	6 x 18
1/24	7	25	1/22 x ½	5 x ¾	8	7 x ¾	6½	8½ x ¾	8 x 8	2 x 12	4 x 20	6 x 19
1/23	8	26	3/64 x 5/16	5½ x ¾	9	8 x ¾	7¼	9½ x ¾	9 x 9	3 x 14	4 x 22	6 x 20
1/22	9	27	1/20 x ½	6 x ¾	10	9 x ¾	7½	10½ x ¾	10 x 10	3 x 16	4 x 24	6 x 21
1/21	10	28	1/18 x ¼	6½ x ¾	11	10 x ¾	8½	11½ x ¾	12 x 12	3 x 16 sp.	4 x 24 sp.	6 x 22
1/20	11	29	1/18 x ½	7 x ¾		11 x ¾	9½	12½ x ¾	14 x 14	3 x 17 sp.	4 x 26	6 x 23
1/19	12	30	1/18 x ¾	8 x ¾–D		12 x ¾	10½	13½ x ¾	15 x 15	3 x 20	4 x 28	6 x 24
1/18	13	31	1/16 x ¼–A	9 x ¾		13 x ¾	11½	14½ x ¾	16 x 16	3 x 21	4 x 30	6 x 25
1/17	14	32	1/16 x ½	10 x ¾–E		14 x ¾	12½		17 x 17		4 x 32	6 x 26
1/16	15	34	1/15 x ½	11 x ¾–F		15 x ¾	13½		18 x 18		4 x 34	6 x 28
1/15	16	36	1/14 x ¼–B	12 x ¾–G		16 x ¾	14½		20 x 20		4 x 36	6 x 30
1/14	17	38	1/14 x ½	13 x ¾–H		18 x ¾	15½		22 x 22			6 x 32
1/13	18	40	1/13 x ½	14 x ¾–I		10½ x ¾	16½		24 x 24			6 x 34
1/12	19	42	1/12 x ½–C	15 x ¾–J		11½ x ¾	17½		26 x 26			6 x 36
	20	44		16 x ¾–K		12½ x ¾	18½		28 x 28			6 x 38
	21	48	1/22 x ½ diag.	17 x ¾			19½		30 x 30			6 x 40
	22	56		18 x ¾			20½		32 x 32			6 x 42
	23	64		19 x ¾			21½		34 x 34			6 x 50
		72		20 x ¾			22½		36 x 36			6 x 60
		80		21 x ¾					38 x 38			
				22 x ¾					40 x 40			18 x 20
				24 x ¾–L					45 x 45			20 x 22
				32 x 1					50 x 50			
									60 x 60			

One of the lens-shaped seeds commonly cleaned with an oblong-perforated top screen and a round-hole bottom screen is flax. This slick, shiny seed must turn on edge to drop through the oblong holes. If the top screen is a perforated-metal type, some of the seeds will slide over the screen without turning on edge, thus reducing capacities. When a wire-mesh screen with rectangular openings is used in place of the oblong-perforated screen, much greater capacities can be achieved for two reasons: The roughness of the wire surface encourages the flax to turn on edge more readily and drop through the openings, and the wire mesh presents many more openings per square inch of screen area.

Some seed shapes fall between the classifications of round, elongated, or lenslike. For example, Sudan grass seed is not exactly round, nor is it an elongated seed. Consequently, when screens are selected for such seed, the choice depends upon what must be removed from the specific mixture. Generally, when cleaning Sudan grass seed in a multiple-screen unit, the top screens will be a round-hole and an oblong, and the bottom screens will be a round-hole and an oblong.

Special Separations

After seeds have been screened to the same size, further separations are made on the basis of shape differences. One of the earliest-used screens for special separations is the "dock" screen, size 3/64 x 5/16, especially devised for separating dock, mustard, ragweed, and other plump or round weed seed from thinner clover seed.

Bottom screens with triangular openings are being used for separating wild buckwheat and field bindweed from small grains, and dock and sorrel from fescue. Triangular-shaped weed seed can be dropped through these openings, while the longer crop seed will "float" over them.

Triangular holes are preferred to round holes in bottom screens when elongated crop seed is being cleaned because the openings do not become plugged with seed as quickly as in round-hole screens. Elongated seed sometimes wedge so tightly in round holes that screen-cleaning brushes will not sweep the openings clean, and the bottom screens become matted and useless. Screens with triangular openings do not mat or plug as readily, and screen-cleaning brushes can keep the holes open. For this reason, bottom screens with triangular holes are sometimes used for making separations of round seed from elongated seed, such as mustard from oats.

A 6 x 15 wire-mesh bottom screen will separate burclover from subterranean clover even though both crops have been screened to the same size with a round-hole screen. The subterranean clover is round and will not go through the narrow slot, while the thin burclover will.

Percentage of Open Area

In selecting screens, another point to be considered is the percentage of open area. A good screen must have openings as close together as possible without impairing the structural strength of the material. Wire-mesh screens have more openings per square inch than perforated-metal screens. For this reason, they are excellent bottom screens for small seeds, and they permit a more accurate high-capacity screening than is possible with perforated-metal screens. Comparing a perforated-metal screen to an equivalent wire-mesh screen, the perforated screen has only a fraction of the total number of openings per square inch that are available in the wire-mesh screen, and consequently would reduce capacity if used.

Another reason that wire-mesh screens serve better as bottom screens is that their surfaces are rough and seeds passing over them are caused to turn, tumble, and present all sides to the openings. As a result, if the seeds are small enough in one dimension, they have every chance to drop through. Perforated-metal screens have smooth surfaces and seeds may lie flat and "float" over the openings.

Bottom screens may take advantage of this floatation. In this case, it is desirable for the good seed to lie flat and float over the perforations rather than turn on edge and drop through the screen along with the weed seed.

Length of Slot

Slotted screens are perforated in different lengths because there is a need for longer and shorter slots. The sizes $\frac{1}{14}$ x $\frac{1}{2}$ and $\frac{1}{14}$ x $\frac{1}{4}$ illustrate these special needs. Seed processors need the $\frac{1}{2}$-inch length to drop hulled oats when they are cleaning seed oats. Cleaners of market grain do not want to drop the hulled oats but should drop the small weed seed, and thus require the shorter $\frac{1}{14}$ x $\frac{1}{4}$ slot. Processors of Korean and Kobe lespedeza find that the $\frac{1}{18}$ x $\frac{1}{4}$ slot is fine for Korean but a longer slot, size $\frac{1}{18}$ x $\frac{1}{2}$ or $\frac{1}{18}$ x $\frac{3}{4}$, is needed for Kobe, which is a flatter, wider seed, and will not pass rapidly enough through the $\frac{1}{18}$ x $\frac{1}{4}$ slot. For the same reason, a $\frac{3}{4}$-inch long slot is good in a bottom screen for cleaning seed wheat because it effectively drops wild oats, quackgrass, or cheat, without losing any more good wheat than would be dropped with a shorter slot.

The length of slot should be carefully considered when selecting a slotted screen. For a top screen, the slot must be long enough to pass good seed freely and give adequate capacity. In a bottom screen, the slot should be long enough to give weed seed every chance to engage the perforation and drop through, yet not long enough to allow excessive loss of crop seed.

Screen Dams

Screen dams are objects fastened to a screen to make it sift more completely than normal. They are used for very close and accurate separations of small round seed. For example, dodder can be removed from Korean lespedeza with a $\frac{1}{16}$ round-hole bottom screen equipped with dams. Operators of flat-screen corn graders frequently use dams on all screens to insure maximum accuracy of grade. Dams may be constructed of any material, but commonly are strips of wood lath about $\frac{1}{4}$-inch high and 2 inches wide. When fastened over the cross braces of the screen with nails or screws, the dams interrupt the smooth flow of seeds down the screen, causing them to stop momentarily and be thoroughly sifted. This provides ample opportunity for all seeds to contact the perforations and to drop through the screen if size and shape of the openings permit.

Screen dams are effective in separating ryegrass seed and flax seed. When this mixture is passed over a $\frac{1}{12}$ round-hole screen with dams, the seed flow across the screen is retarded and seeds collect behind the dams. As the ryegrass attempts to work its way over the dam, it approaches an upright position and the oscillation of the screen causes the seed to pass through the screen endwise, making the separation.

When screen dams are used on round-hole bottom screens, the accuracy of sifting is increased so that a heavier layer of seed may be carried on the screen, with a resultant increase in capacity.

Except when a screen is being used for grading, dams are generally used only on bottom screens. Ordinarily, top screens drop their good seed quickly enough, and dams on a top screen would cause some weed seeds that normally flow over the screen to stand on end and drop through with good seed.

A device that can be used to improve the separating action of a top screen is a piece of oilcloth lying flat on the screen with the slick side down. The seed mixture flows between the cloth and the screen, and the weight of the cloth tends to keep long pieces of straw and stems flat on the screen so that they do not stand on end and pass through the openings with good seed.

It is good practice to blank off the lower section of a top screen. Once the point where all of the good seeds have dropped through has been determined, the screen, from that point to its discharge edge, can be blanked off with paper, plastic, or other suitable material. Any foreign material that has passed over the first section of open perforations will then flow onto the blanked-off portion and have no further chance to stand on end and pass through with the good product.

Adjustments

Feed rate can be adjusted by increasing and decreasing the speed of the metering roller, or by varying the opening of the metering gate located in the bottom of the feed hopper. The feed rate should be regulated to keep the final grading screen about seven-eighths full. It is better to have a small section of the screen uncovered part of the time than to flood the screen occasionally.

Airflow is usually regulated by means of baffles in the air ducts. The top air is adjusted to blow out light chaffy material and dust. The bottom air is regulated to a higher blast than the top air so that it will blow out light seed and heavier trash.

Oscillation of the screens is controlled by means of variable-speed pulleys and should be adjusted to keep the seed action "alive" over the screen. The greater the oscillation, the faster the seed movement over the screens. If this movement is too fast, the seeds hop across the screen and will not be separated properly. If it is too slow, the seeds have a tendency to glide across the screen with the larger material and not sift through.

The pitch can be adjusted for each screen individually. The steeper the screen, the faster will be the flow of seed across it, and the more likely a long seed is to stand on end and go through. The more the tilt, the smaller the size of the particle that will pass through the screen. The smaller the pitch angle, the longer the material takes to pass over the screen. This gives more time and a better chance for seed to line up with a hole and pass through the screen, as well as the best chance for a long seed to stay in the horizontal position and slide over the screen in lieu of through it.

Screen Attachments

Most air-screen cleaners are equipped with traveling brushes beneath the screens that move from side to side sweeping lodged seed from the openings. The two materials used for brush bristles are hair and nylon. It is the general opinion that nylon, although more expensive initially, will last considerably longer, and do a more effective job of dislodging seed than the hair bristles, which tend to be limber.

Mechanical hammers or bumpers are sometimes used to assist brushes in dislodging seed by striking the screen periodically at top center, bouncing seed free of the openings.

Clod-crushing rolls are another air-screen attachment. These usually consist of two spring-loaded, rubber-covered rolls mounted so that material passing through the first grading screen is fed between the rolls where dirt clods are crushed without damaging seed. The second, or fine-grading, screen drops the crushed dirt and retains the seed.

After seed is cleaned on the air-screen machine, it is inspected to determine whether or not it needs further processing, and if so, what special machine or machines will be required to make the specific separations.

If further cleaning is required, it is done by taking advantage of some other difference in physical makeup of the seeds, such as length, surface texture, electrical property, or specific gravity. The characteristic differences will dictate the special equipment to be used in further processing.

The many types of machines used to make these special separations will be discussed in following sections.

SPECIFIC GRAVITY SEPARATOR

The specific gravity separator classifies material according to density or specific gravity. This unit was originally developed by the mineral industry to separate ore from clay or dirt and to grade ore in mining districts. The gravity separator, as it is commonly called, has been adapted by the seed industry for the grading of seed and the separating of seed and inert matter. (See figure 3.)

There are three cardinal rules that apply to gravity separation:

1. Particles of the same size but different densities can be separated.
2. Different-size particles of the same density can be separated.
3. A mixture of particles of different sizes and densities cannot be separated.

Component parts of the gravity separator are an air-blast fan, an air-equalizing chamber, a perforated deck, a variable-speed eccentric, deck rocker arms, a feeding or metering device, a deck end-raise adjustment, and a deck side-tilt adjustment. The end-raise adjustment varies the inclination of the discharge edge. The side-tilt adjusts the deck so that the back is higher than the front. One end of the deck is the discharge edge and the sides are the banking rails.

A mixture to be separated is metered at a uniform rate to the back of the deck. The slant of the deck and its oscillating motion move the seed over the deck. Air forced through the porous deck from the equalizing chamber forms thousands of small jets which cause the material to stratify into layers of different densities in much the same manner as water stratifies ground cork and sand. Cork floats on the surface of water, and sand will form a layer on the bottom. In the air-stratified material, the light material floats and the heavy material is in contact with the deck, as shown in figure 4. The oscillating motion of the deck "walks" the heavy material uphill nearly parallel to the discharge edge, and the air "floats" the light material downhill. As the material travels from the feed point on the deck to the discharge edge, a gradation of material takes place ranging from

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FIGURE 3.—Specific gravity separator.

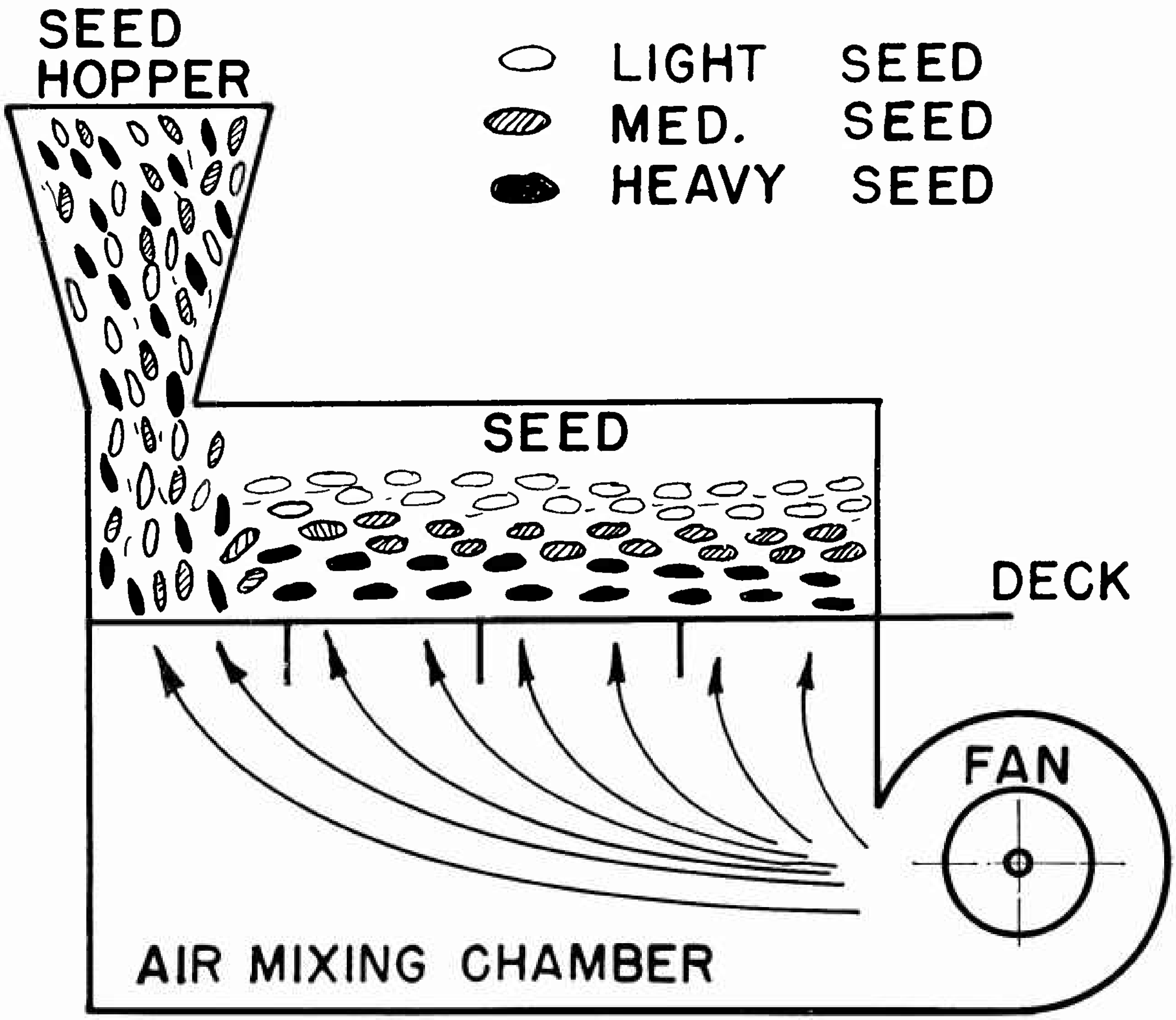


FIGURE 4.—Section view of specific gravity separator.

light material on the lower side of the deck to heavy material on the upper side. By means of movable splitters, the discharge can be divided into any number of density fractions.

When a sized mixture of dirt, wild geranium, crimson clover, and gravel is passed over the gravity separator, the geranium and weevil-eaten crimson clover will be discharged at the low side of the deck, the rocks and heavy dirt clods at the upper side, and the good crimson clover in the middle. This separation is shown in figure 3.

The Deck

The deck can be called the "heart" of the gravity machine. Deck covering plays an important role. Separation efficiency is dependent on air movement through the deck, and inclination and movement of the deck. About three or four types of deck coverings are needed to handle seed crops ranging in size from small grasses to beans.

The main job of the deck covering is to help stratify seed material above the deck, yet adequately restrict air flow to build up static pressure within the air-chamber and insure uniform air distribution. A closely woven covering gives best results for small seed, while a coarser weave is required for large seed. Linen, plastic, and wire coverings have been satisfactorily used. It is imperative that the deck covering be made from material that will stand abrasion and is free of lint, which would collect dust particles and clog openings, thus preventing uniform air distribution.

Adjustments

Feed-rate adjustment.—The rate of material entering the gravity deck is important and greatly affects operation efficiency. Optimum rates vary according to the difference in density or specific gravity of the mixture components. The greater the difference, the more rapid will be the travel of light material to the low side of the deck and the subsequent reporting of heavy material to the high rail. Greater feed rates are then possible with this type of mixture. Conversely, when separating a mixture with small differences in specific gravity, seed-travel toward the sides is not as pronounced, and feed rate must be reduced.

Insufficient feed rate causes seed to travel across the deck in a thin bed, and portions of the deck will be blank. For satisfactory separations, the deck surface should be covered at all times. An excess rate of feed will "rush" the procedure, and too many good seeds will be discharged with the middlings or rejects.

Air adjustment.—The air stream through the porous deck prevents light seed from touching the deck while it "floats" to the low side. The air is regulated to permit heavy seed to contact the oscillating deck. The sideways motion of this deck imparts an uphill direction to the seed.

A common error in adjustment is an oversupply of air through the deck. If this is the case, the intense air stream acts as a mixing agent rather than a separating means, and formation of horizontal layers or strata does not take place. The basic principle of successful gravity operation consists of stratifying the particles into layers of different densities through the use of air, and separating the layers by a combination of eccentric motion and inclination of the deck. These actions take place in two zones on the deck—the stratifying area, and the separating area.

The size of the stratifying area at the rear of the deck depends on existing differences in specific gravity of the seed particles. The greater the difference in specific gravity, the smaller will be the area required for stratification. Seed particle motion in the stratifying area can be considered essentially vertical, and results in a stratified seed mass, with light material "floating" on top and heavy material partially suspended just above the deck surface.

The remaining portion of the deck is the separating area. Here, motion of the seed particles is confined generally to certain layers, the direction of motion being essentially horizontal. The lifting action of the air stream still must be maintained at a degree sufficient to retain the formerly established stratification. However, as the seed particles proceed on their journey to the front, or discharge edge, of the machine, the stratification becomes less pronounced. Movement of the lighter particles to the low side of the deck and heavier particles to the high side begins to appear. The separation becomes complete when the vertical stratification has dissipated and given way to a horizontal gradation of material as it flows off the deck.

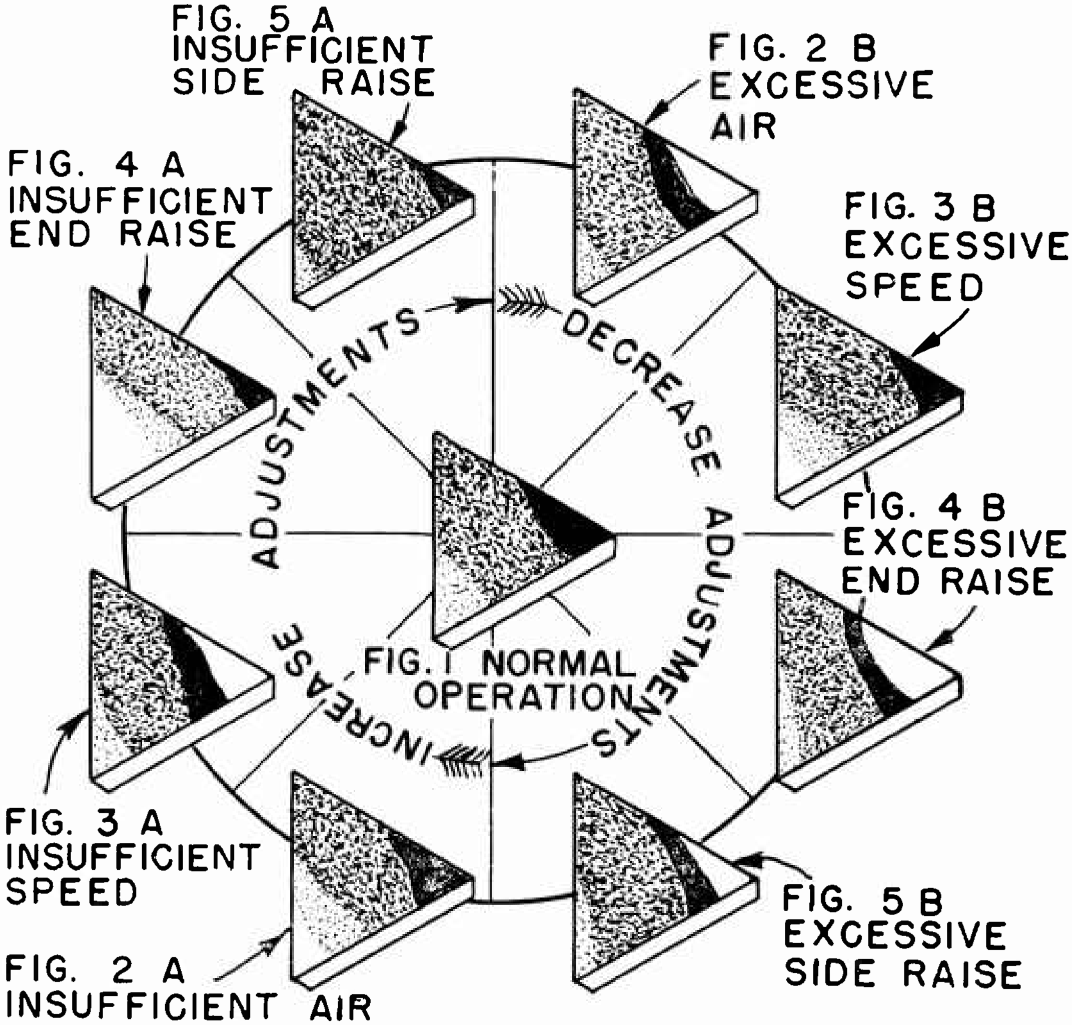
Excessive air rate tends to shift the seed material on the deck to the low rail and produce uncovered areas at the upper rail. Insufficient air rate shifts the seed material to the high rail with uncovered areas appearing at the lower rail. Satisfactory operation requires uniform coverage of the deck at all times.

Side-tilt adjustment of the deck.—The side-tilt adjustment (back to front) depends upon the area required for stratifying. The greater the difference in specific gravity of the seed components, the smaller will be the required stratification area, and the steeper may be the side tilt of the deck. Conversely, a flatter tilt is required for seed mixtures having more similar specific gravities. Capacity of the gravity machine is directly related to the side tilt; therefore, the most efficient operation involves the maximum side-tilt setting that still gives the mixture enough time on the deck to become separated.

End-raise adjustment of the deck.—Increasing the end-raise inclination of the discharge edge causes more material to flow toward the low side of the discharge edge, and flattening the raise moves material to the high side. The maximum slope of the discharge edge is usually about 6° from horizontal, but a 2° slope is most common for the average seed mixture.

Eccentric thrust adjustment.—Heavier materials of the seed mixture are forced to travel uphill due to motion induced by the eccentrics. This uphill travel is caused by the inclination of the toggles supporting the deck, which are activated by the eccentric thrust. The deck is given a horizontal motion as well as an upward and downward motion, which moves seed in the direction of the deck travel. The deck surface then drops from the seed bed and again contacts it on the next forward stroke. Heavy seed particles "hop" across the surface of the deck at a rate governed by the various machine adjustments. The faster the motion, the faster the movement of material across the deck to the upper side. Slowing the motion tends to shift seed toward the low side of the deck.

All five of these machine adjustments are of critical importance and closely interrelated. They must be blended properly to obtain efficient operation of a gravity separator. Figure 5 illustrates typical deck patterns for normal operation and for unbalanced conditions resulting from faulty adjustments.



A. START THE SEPARATION AND WAIT FOR THE MATERIAL TO DEFINE A CONSTANT PATTERN OF DISTRIBUTION.

B. COMPARE EACH PATTERN OF MATERIAL DISTRIBUTION WITH FIG. I FOR IDEAL OR OPTIMUM ADJUSTMENTS.

C. CORRECT ERRORS OF ADJUSTMENT IN THE FOLLOWING ORDER.

1. AIR ADJUSTMENT FIG. 2 A OR 2 B
2. ECCENTRIC SPEED FIG. 3A OR 3B
3. END RAISE SLOPE FIG. 4A OR 4B
4. SIDE RAISE SLOPE FIG. 5A OR 5B

FIGURE 5.—Check chart for adjustment of specific gravity separator.

Seeds of the same width or thickness can be separated on the basis of length differences. Length separators are of two general types—the indent disc and the indent cylinder—but both use the principle of lifting short seeds from a mixture with a given pocket, or indentation, which is too shallow to accommodate long seeds.

The indent disc separator consists of a series of indented discs which revolve together on a horizontal shaft. Each disc contains numerous undercut recesses on each face (see figure 6). As the discs revolve, the recessed pockets lift out the short seeds and reject the longer seeds; for example, vetch can be lifted, leaving oats, ryegrass, and other elongated seeds; and crimson clover can be lifted, leaving ryegrass and fescue seeds.

Normally, when several sizes of contaminants are to be removed, the discs are located so that disc-pocket size increases progressively from intake to discharge end of the machine. Small seeds are removed first, the larger seeds being lifted as the seed mass moves toward the discharge point. When there is only one separation to be made, many discs of the same size and shape are incorporated in a machine, or several machines, to increase capacity. (See figures 6 and 7.)

Seed Travel

Seed travel from intake end of the machine to discharge end is provided by vanes attached to spokes of the discs. The removable vanes operate like a screw conveyor to move the seed mass slowly through open portions of the discs. In addition to conveying, this operation brings the seed mass in contact with each disc and facilitates separation. The vanes and spokes also agitate the seed mixture, thus minimizing stratification.

The housing of the machine closely fits the rims of the revolving discs, but there is sufficient clearance to prevent the crushing of seed. This favors seed travel through the center and open portions of the discs.

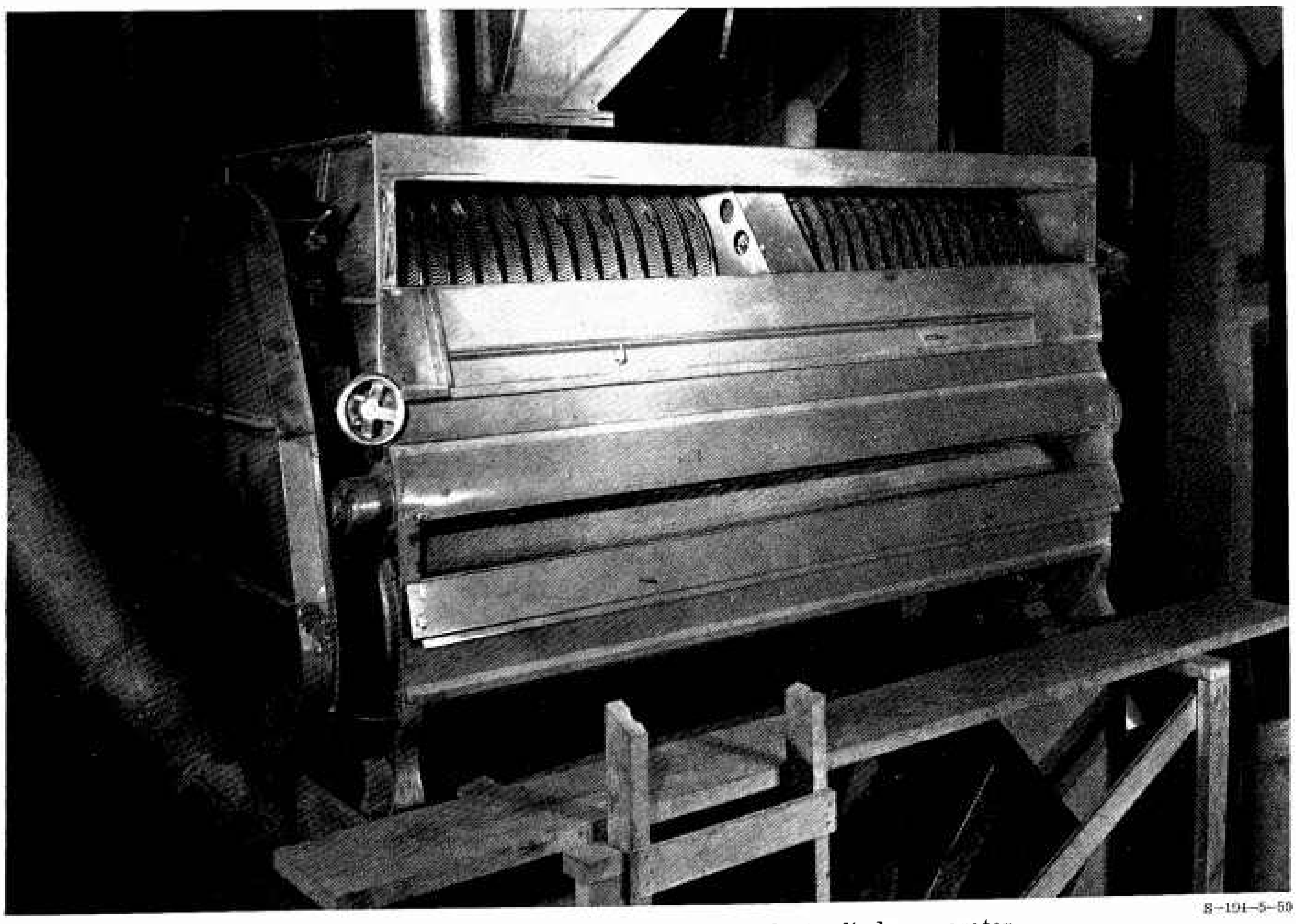


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FIGURE 6.—Indent disc separator above an indent cylinder separator.

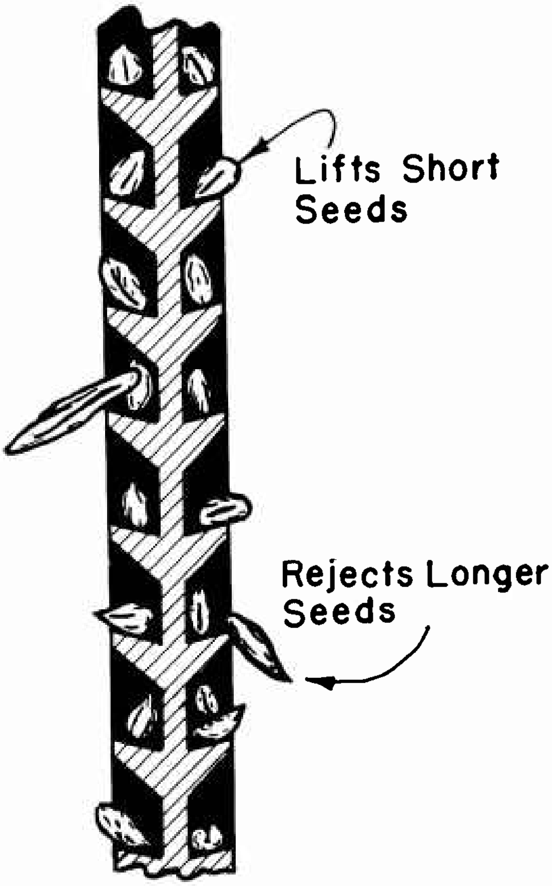

FIGURE 7.—Cross-section view of an indent disc separator.

Disc Pocket Design

The disc pocket functions like an elevator bucket. As the disc passes through the reservoir of seed at the bottom of the machine, short seed will be held in the pocket by a combination of centrifugal force and capacity of the seed to become seated on the pocket bottom. Whether a seed is lifted or rejected depends upon its length and position of center of gravity. If the center of gravity extends beyond the pocket lip, the seed is rejected. Seed is discharged from the pocket in the same manner that an elevator bucket relieves its load.

Disc pockets are made in two basic shapes, and each shape is available in a number of sizes. Pocket size is indicated by its width in millimeters, measured radially from the center of the disc. Length or height of the pocket is essentially the same as the width. Depth is usually one-half the width. The undercut part of the pocket is referred to as the bottom.

The "R" pocket.—This pocket or indent derives its name from "rice." It was designed to remove broken rice grains from whole grains. The lifting edge is flat, while the leading edge is round. Pocket design is such that it will reject round seeds, but will lift out cross-broken grain or elongated seeds on the flat surface.

The "V" pocket.—This pocket derives its name from "vetch," and is designed to remove round-shaped seeds. The pocket has a round lifting edge. "V" pockets tend to reject tubular, or elongated seeds, as they have no flat surface to bear on. These seeds tip out of the pockets as the disc revolves.

Both the "V" and "R" pockets are made only in the smaller sizes, usually 2½ mm. to 6 mm. These discs are designed primarily for removing small materials from a mixture, such as dodder, dock, sorrel, or plantain from fescues and ryegrass. Both types of pockets are designed to give the maximum contact surface according to the shape of the material being lifted. The letters "V" and "R" are always followed by a number, which indicates the size in millimeters. For example, an R5 pocket has a flat lifting edge and a radial width of 5 mm.

Other designations.—Some discs are made with pockets designated solely by letter. They carry no numeral to indicate width, and usually are made in sizes exceeding ¼ inch in radial width. Normally, these pockets are square-faced and are used in specialized separations or splittings.

Operation

Disc rotational velocity.—The rotating speed of the discs should be held nearly constant since variations of only a few r.p.m. affect the efficiency of disc operation. Too great a velocity prevents the material from becoming seated in the pocket bottom, or prevents the discs from discharging seed properly. Low velocity may not provide sufficient centrifugal force to hold seed in the pocket.

Disc-pocket size.—Whether the disc separator operates with all discs of the same size pocket, or with a combination of pocket sizes and types, depends upon how closely the seed mixture has been graded. In a combination type of arrangement, the discs are grouped into sections, with the smaller-sized pocket discs installed near the seed intake. In this arrangement, material both shorter and longer than seed being cleaned can be removed. The selection of "V" pockets, "R" pockets, or a combination of both, depends upon the shape characteristics of the seed, and the grading desired.

Reject and re-run.—Flexibility of operation can be achieved by provision for re-run or removal of such fractions as may be desired.

Seed travel adjustment.—Conveyor vanes may be removed or added as desired to move the seed mass through the machine at a rate giving best separation. Capacity and efficiency of separation are determined by the ratio of the number of small particles to be removed to the number of pocket recesses needed to remove the material. The travel speed of the seed mass may be controlled accordingly. Raising the tailings gate tends to keep the seed in the machine longer, and gives the discs more time to clean the seed thoroughly.

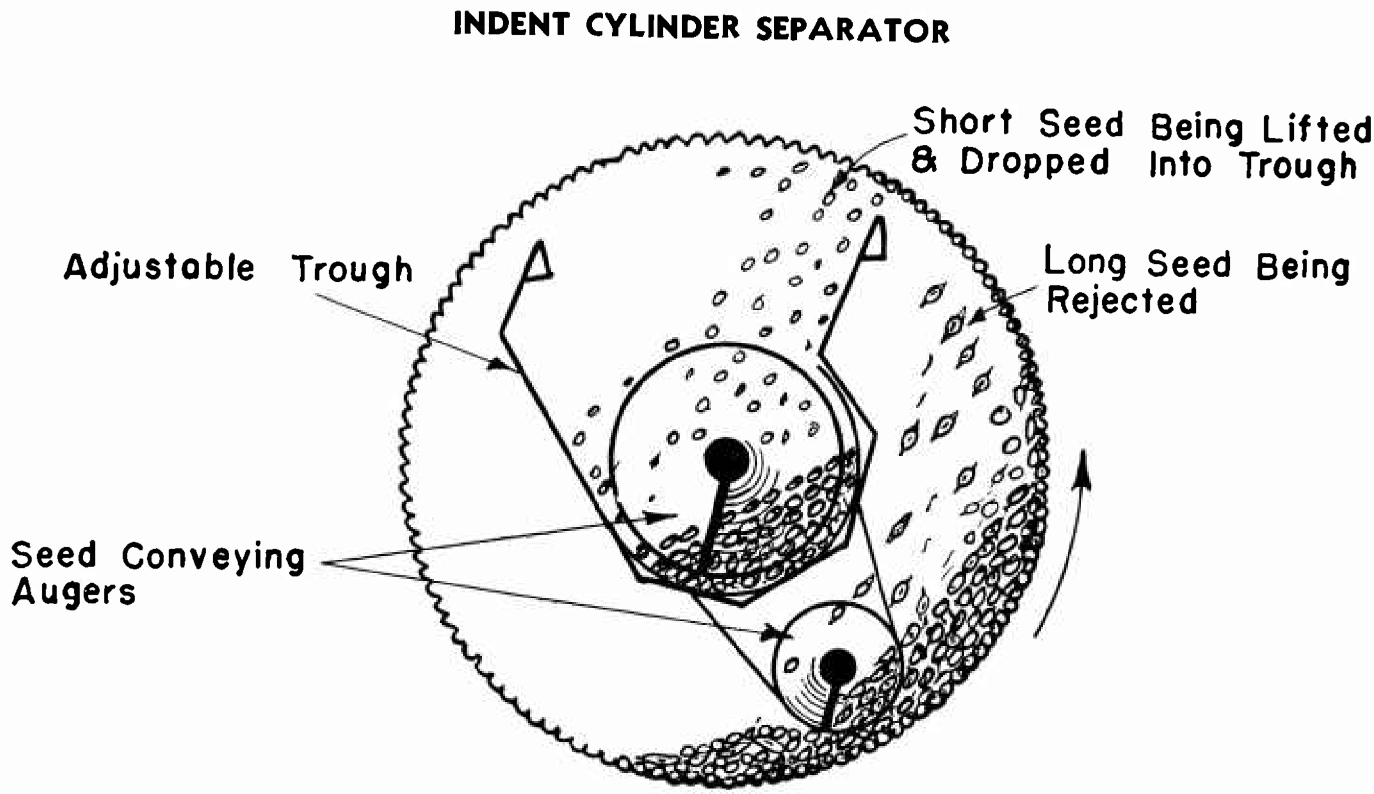

FIGURE 8.—Cross-section view of an indent cylinder separator.

Indent cylinders perform separations on the same basis as the disc separator. Both use centrifugal force and length differences to lift material from a seed mass, making a length-sizing separation; for example, sloughgrass can be lifted, rejecting meadow foxtail.

The indent-cylinder separator, as shown in figure 6, page 11, consists of a rotating, horizontal cylinder and a movable, horizontal separating trough. The inside surface of the cylinder has small, closely spaced, semi-spherical indentations. In operation, the seed mass to be separated lies on the bottom of the cylinder. As the cylinder rotates on its axis, the short seeds in the mass are lifted from the mixture by the numerous indents. At some point before reaching the top of the rotation, the seeds drop from the indents and are received by an adjustable trough. See figure 8.

Indent Pocket Design

Shapes.—Various shapes of indents have been tested. The shapes of bottoms and sides, the slope angle of the sides, and the indent depth in relation to width provide a wide range of separation characteristics. For example, an indent with cone-shaped sides was best for the removal of seeds which would not roll readily. A cylinder having spherical-shaped indents drawn slightly shallower than their diameter was better for removal of round seeds, such as crimson clover or soybeans.

Indents with straight, vertical sides were best for lifting, but were limited in flexibility of operation.

It is not practical to install more than one size or shape of indent in any one cylinder. Nor is it practical for the operator to change indent cylinders to take out each shape or size of seed separately. A compromise in pocket design was reached where side slope, depth, width, and shape provided the best results for the most seeds normally encountered. Indent size is indicated by numerical notation, the number indicating indent size in 64ths of an inch. For example, a No. 4 indent cylinder has pockets 4/64ths of an inch in diameter.

Selecting the indent.—Good selection involves the use of the smallest size indent that will satisfactorily lift all material to be removed. The combination of centrifugal force and indent size lifts short particles and carries them the highest out of the main seed mass. Next to fall from the indent are intermediate-size seeds. The longest seeds fall free of the indent only a short distance above the seed mass, or are not lifted at all.

Some materials are too large to lift, and may roll along the bottom of the cylinder causing a stratification of the seed mass. To prevent this stratification, screw conveyors or similar devices are located inside the separator to agitate the seed. This also tends to level the seed mass in the machine and prevent build-up at the feed end. Too much build-up would let material fall into the separating trough without having been lifted by the indents.

At the feed end of the cylinder there are many undersize particles in the seed mass. These quickly find their way into indent pockets and are lifted out singly and by multiples. As these sizes are depleted and the mass works toward the center of the cylinder, the intermediate-size material is removed. At the tail end of the machine, the final and closest grading by the indent is accomplished. The cylinder is set on a slight incline so that material flows by gravity from the feed end to the discharge end of the machine.

Operation

The indent cylinder lifts particles from the seed mass by a combination of centrifugal force and the retention of material in the indent. This unit shows its greatest efficiency when lifting material that weighs in excess of 45 pounds per bushel. For this reason, the cylinder is more practical with small grains and legumes than it is with grasses. Unlike the disc separator, seed coat texture, density, and moisture content of the seed do affect separation in an indent cylinder. Friction of the seed slipping out of the indent affects the distance it will travel in the pocket before being dropped. Hence, a rough or wet seed will be lifted and carried from the seed mass more readily than a slick, dry one. The following two adjustments, together with the variations in physical properties of seed, provide a wide range of separation response in this machine.

Speed of cylinder.—A seed is held in the indent recess by centrifugal force sufficient to lift it from the seed mass and to retain it until some determined point of the travel arc is reached. Adjustment for cylinder speed is therefore provided on this machine. Speed should not be increased beyond the amount required to carry the seed to a point directly over the cylinder axis. Speeds in excess of this amount will not allow the seed to drop from the indent. On the other hand, speed must be great enough to lift seed from the mass. Between these two extremes, maximum separation efficiency can be obtained.

Adjustment of separating trough.—The edge of the separating trough can be set at any position giving best separation. Trough position for any given seed mixture will be dictated by the speed of the cylinder, indent size and shape, and level of the seed mass. Combination of these variables gives considerable flexibility in operation.

Methods of Use

Single unit.—The cylinder separator is most commonly used as a single unit in seed processing.

Multiple units.—A useful multiple-cylinder unit can be arranged wherein the cylinders are grouped vertically, with the top cylinder having a middle-size indent. Liftings of the top cylinder are sent to a lower cylinder provided with a small indent. Tailings of the top cylinder are sent to another lower cylinder fitted with the largest size indent. The top cylinder acts as a "splitter," and the final separations of each fraction are made in the two bottom cylinders.

Combination.—The indent cylinder also can be employed as one component of a single assembly offering several mediums of seed processing. For example, equipment is manufactured which provides for scalping, aspiration, disc separation, and cylinder separation, all in one machine.

Many different types of air separators are manufactured for seed processing. Some are called aspirators and others, pneumatic separators, but all use the movement of air to divide materials according to their terminal velocities. Terminal velocity refers to the air velocity required to suspend particles in a confined, rising air current, and takes into account such characteristics as shape, surface texture, and specific gravity, all of which affect a particle's resistance to air flow.

The primary difference in the two types of separators is the location of the air source. In the aspirator, a fan is placed at the discharge where it induces a vacuum so that atmospheric pressure can force air through the separator. In the pneumatic unit, the fan is at the intake where it creates a pressure greater than atmospheric, which again forces air through the separator.

In both cases, air velocity through the machines can be adjusted by regulating the fan air intake. All products with a terminal velocity less than the air velocity through the units will be lifted. Material with a higher terminal velocity will fall against the air flow.

There are several forms of aspirators. Figure 9 is a cross-section view of a scalping aspirator. A seed mixture is fed from the hopper "A" to the rotating scalping screen "C," which allows seed to pass to the aspirating chamber "E." Sticks, straw, leaves, and other large roughage components are carried over the revolving screen into section "B." With a suction or negative pressure at "H," air passes through the aspirating chamber "E" at a velocity slightly below the terminal velocity of the heavy, plump seed. Shriveled or weevil-eaten seeds, light trash, and weed seeds are lifted and deposited in chamber "F," and the conveying air escapes through chamber "H." Heavy, plump seeds fall through the incoming air and out the inlet to a conveyor or receiving bin. The air velocity, through the aspirator, is controlled by regulating bypass air through "M" with adjustable gate "O."

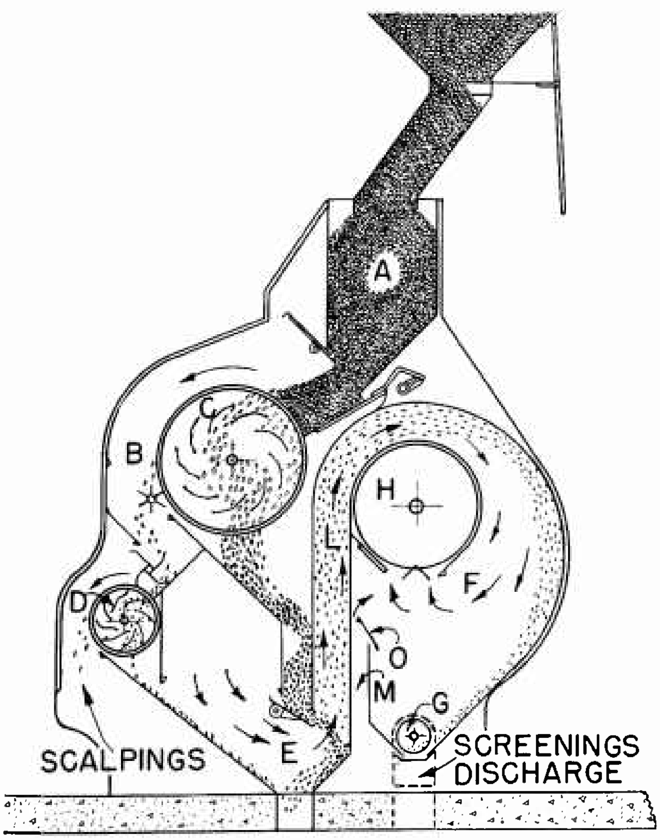

Figure 10 is a cross-section view of a fractionating aspirator. When seed is metered into the air column "B," the heavy seed falls against the air flow and out the air inlet, whereas the lighter seed, shriveled seed, weed seed, grass seed, and chaff are lifted. By adjusting the movable air vane in column "C," the air velocity can be decreased to drop out any components traveling below their terminal velocities. Column "D" will receive the heavier liftings, which are usually good seed but not of the highest quality. Column "E" will catch salvage grass seed, broken seed, or light and unusable seed. The light chaff, dust, rodent filth, and other extremely light material will be delivered to the "F" chamber.

The total air volume flowing through the system, and therefore the air velocity at "B," is regulated by the air-control damper in the fan discharge pipe and by a variable-speed electric motor driving the fan. This separating unit can provide graded fractions in a continuous operation.

Figure 11 is a cross-section view of a pneumatic separator. When seed enters the feed chute, the light seed, splits, broken seed, chaff, and straw

FIGURE 9.—Scalping aspirator, cross-section view. A, Feed hopper; B, section into which large trash is thrown off as it passes over the revolving scalping screen; C, rotating scalping screen; D, reclaimer for any seed that may have passed over the scalping screen; E, aspirating chamber; F, area into which shriveled or weevil-eaten seeds, light trash, and weed seeds are conveyed with the exhausting air; G, discharge valve; H, suction or negative pressure chamber through which conveying air escapes; L, same as F except that air velocity is higher in L; M, chamber where bypass air enters; O, adjustable gate.

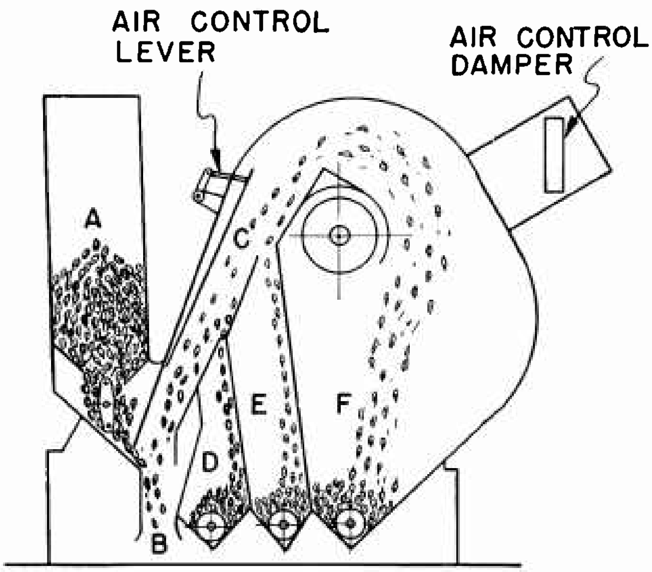

FIGURE 10.—Fractionating aspirator, cross-section view. A, Feed hopper; B, air column through which heavy seeds fall against the air flow; C, column into which lighter seeds and chaff are lifted; D, column which receives the heavier liftings; E, column which catches salvage grass seed, broken seed, or light and unusable seed; F, column into which extremely light waste materials are delivered.

are lifted by the air flow up through the column and are deflected by an inverted cone to a discharge pan. Heavy seed falls against the air flow until it is diverted by an inclined screen to the heavy seed outlet. With adequate air control, many precise separations can be made with pneumatic separators, such as lifting meadow foxtail and rejecting Alta fescue, cheat, and light material.

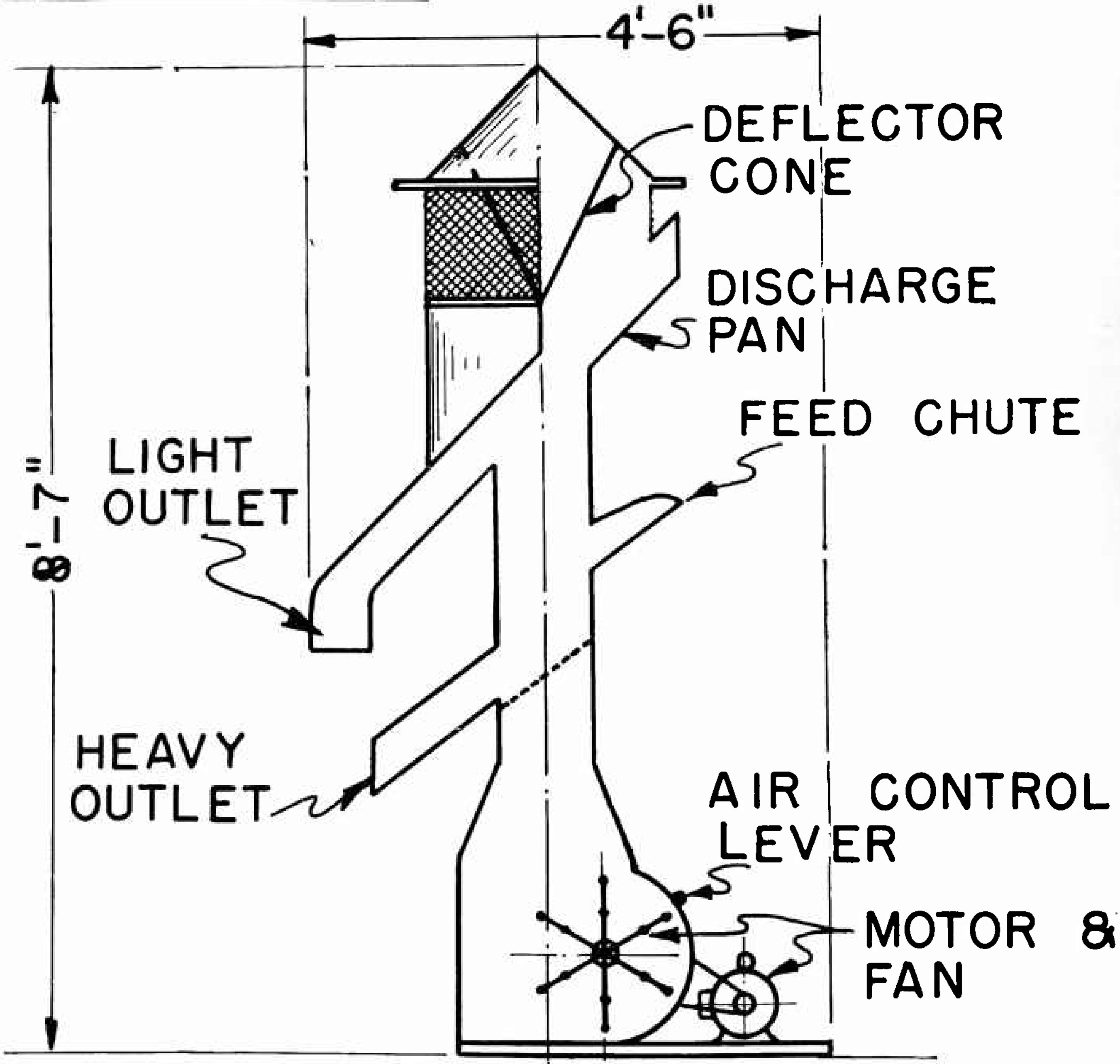

FIGURE 11.—Pneumatic separator, cross-section view.

VELVET ROLL SEED SEPARATOR

The velvet roll separator is a special seed-cleaning machine that divides material by differences in surface texture and shape. It consists primarily of two velvet-covered rollers placed side by side in contact with one another, and set at an angle. The rolls, when viewed from the top, rotate outwardly in opposite directions, and have an adjustable shield above them.

Figures 12 and 13 show, respectively, a velvet roll separator and the basic principle of operation. A seed mixture to be separated is fed onto the rolls at the upper end so that seed travels down the incline formed by the rolls. Rough-coated seeds, sharp-pointed seeds, and broken seeds catch in the velvet and are thrown against the shield, which deflects them back to the roll. They bounce back and forth in this manner until they are worked over the roll and out of the mixture. Smooth-coated seeds slide down the incline and are discharged from the lower end of the rollers. The separation is a graduated one with rougher seed being thrown out first; then a progressive reduction in roughness of throw-out material takes place as seeds approach the discharge or lower end of the rollers.

The velvet roll machine, like other seed-cleaning equipment, needs balancing adjustments to give best performance. The speed of the rolls, angle of incline, clearance between shield and rolls, and rate of feed are all adjusted according to the particular seed mixture requirements. The clearance between rollers and shield should be great enough so that seed can turn freely without touching both shield and roller at the same time, but small enough so that rough-surfaced seeds will be thrown repeatedly against the shield as the seed comes in contact with the roller. If the clearance is too great, many rough seeds will spin and slide back between the rollers into the smooth-seed stream. When the clearance is too little, smooth seed will be pressed against the roller and rolled out with the rough-surfaced seed.

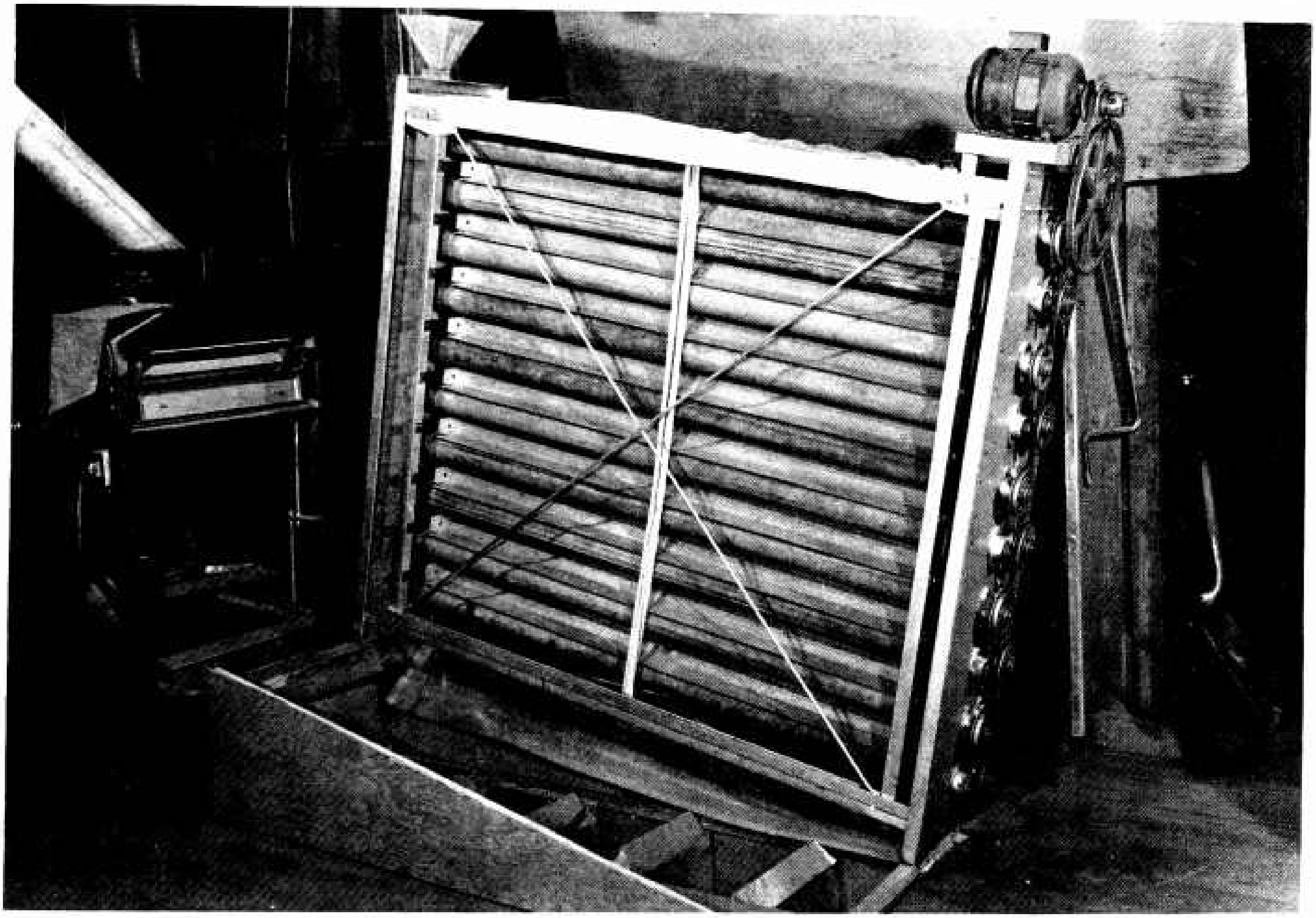

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FIGURE 12.—Velvet roll seed separator.

The rate of feed is important on a velvet roll machine. If too great, many seeds will not come in contact with the rollers, and therefore will not have the chance to be separated. The rate of feed and angle of incline of the rollers can be increased as the differences in surface texture of the seeds in a mixture increase, and vice versa. The speed of the rolls is another important factor, and should be adjusted as required to make the separation. The faster the roll speed, the greater the "throw-out." If too much good seed is being thrown out, the roll speed should be decreased. When too much rough seed is discharged with the clean seed, the roll speed should be increased.

Since the effects of machine adjustments are sometimes difficult to see, the following practice is recommended in adjusting the velvet roll separator. Make only one change at a time; operate the machine 5 minutes after each change, and then observe the results. If rough-coated seed is found in the smooth-seed discharge, the rolls are running too slow, or the machine is being fed too heavily. If too much smooth seed is being thrown out with the rough seed, the rolls are running too fast.

The velvet-roll machine is simple, and once set in operation, can run continuously with little attention. It is used to finish many seed separations where capacity requirements are not too high. The name "dodder mill" is sometimes assigned to this unit as it is used to remove rough-coated dodder weed seed from smooth legume seed. Other common separations are dirt clods from beans, timothy from alsike clover, unhulled from hulled lespedeza, and many rough weed seeds from smooth crop seeds.

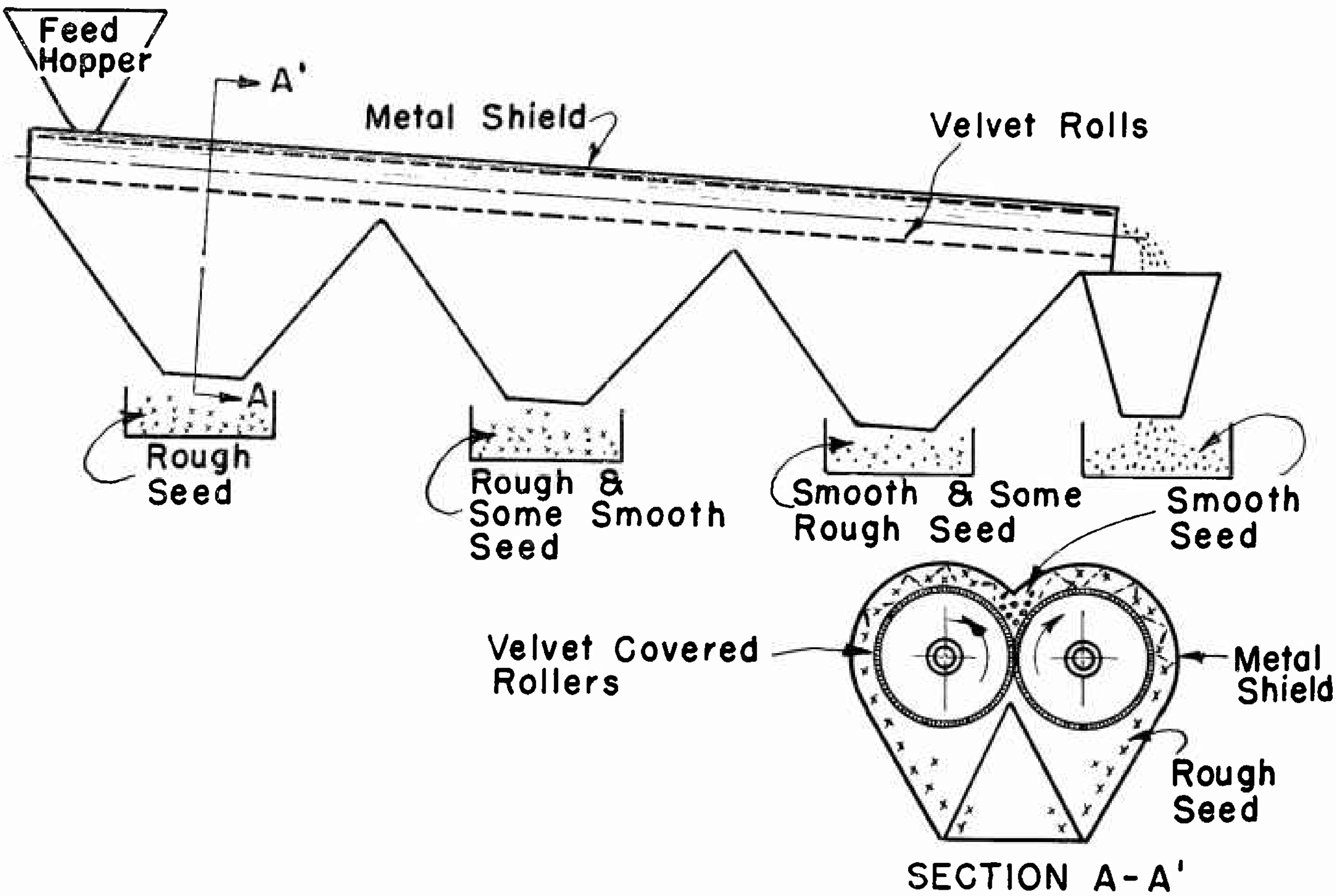

FIGURE 13.—Side and cross-section views of velvet roll separator.

SPIRAL SEPARATOR

The spiral separator classifies seed according to shape, density, and ability to roll. It is a simple machine with no moving parts, and requires very little floor space. Once it is placed under a storage bin and the feed rate is regulated, the spiral will operate continuously with little or no attention. Some separations can be made with this unit that are not possible with air-screen machines, length separators, and other seed cleaners.

Basically, this separator consists of one or more sheet-metal flights wound on a central tube in the form of a spiral. The unit resembles an open screw conveyor standing in a vertical position. (See figure 14.)

In operation, a seed mixture is introduced at the top of the inner spiral. Round seeds roll down the inclined flight while irregularly shaped seeds tend to slide. The faster the seed travels down the flight, the larger the arc of travel becomes because of centrifugal force. The round seeds, having greater velocity, make a wider circle than the irregularly shaped seeds, and the original mixture can then be divided into fractions by splitters (dividing boards) at the bottom or discharge end of the flight.

Spiral separators sometimes have multiple flights arranged in order of increasing size, with each flight having a separate discharge chute. Seeds that roll well because of their density and roundness travel downward in a spiral path of increasing diameter. These seeds will flow over the edge of one flight to another until they reach one of sufficient diameter to coincide with the seed-travel path. Such a separator, with flights of several widths, will produce gradations of a seed mixture ranging from flat seeds at the small-diameter, inner flight to high-density, round seeds on the outer flight.

The spiral is used to separate round seeds, such as rape, vetch, and soybeans, from irregularly shaped seeds like wheat, oats, and ryegrass. It can also separate whole vetch seed from broken vetch, and crimson clover from rape or mustard seed. Large seeds require a different size of flight from that of small seeds; therefore, several spiral designs may be needed to process a range of seed sizes.

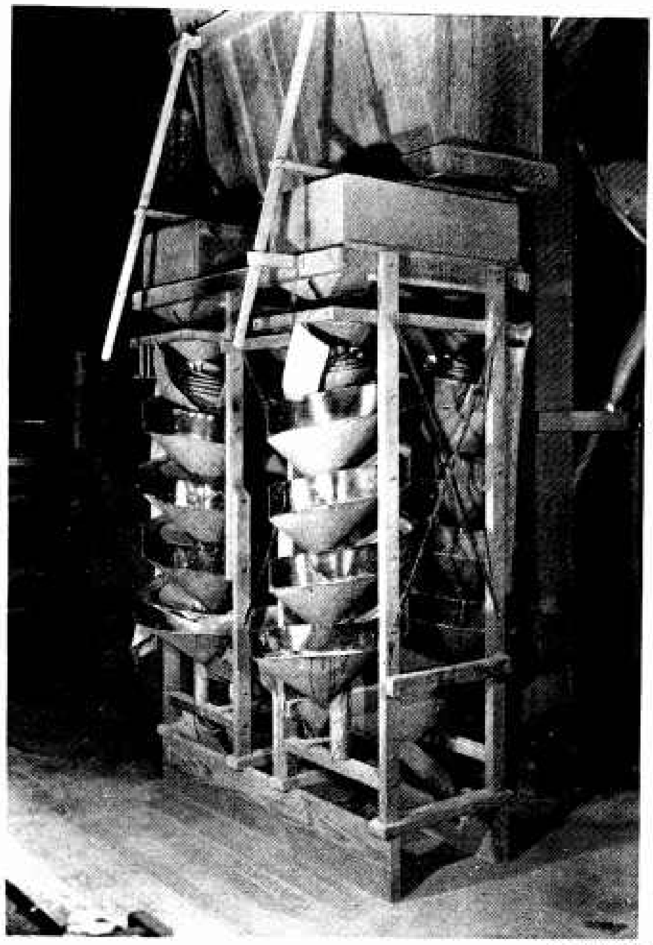

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FIGURE 14.—Spiral separator.

The chief disadvantages of the spiral are lack of flexibility in adjustment, and a relatively low capacity, which may range from 200 to 700 pounds an hour, depending upon the seed being separated.

INCLINED DRAPER SEPARATOR

The inclined draper separates seeds on the basis of a difference in ability to roll or slide down an inclined surface. The rolling or sliding characteristics of seeds are governed by their shape and seed-coat texture.

A seed mixture to be separated is metered from a hopper to the center of an inclined draper belt traveling in an uphill direction, as shown in figure 15. Round or smooth seeds, like vetch, will roll and slide down the draper faster than the draper is traveling up the incline. In contrast, flat, rough, or elongated seeds, like oats, will be carried to the top of the incline, thereby making the separation. The seeds dropping off the draper at its lower end are gathered in one chute, and the seeds reaching the upper end are dropped into a second chute.

To gain capacity in commercial operation, multiple draper belts can be used in a single machine.

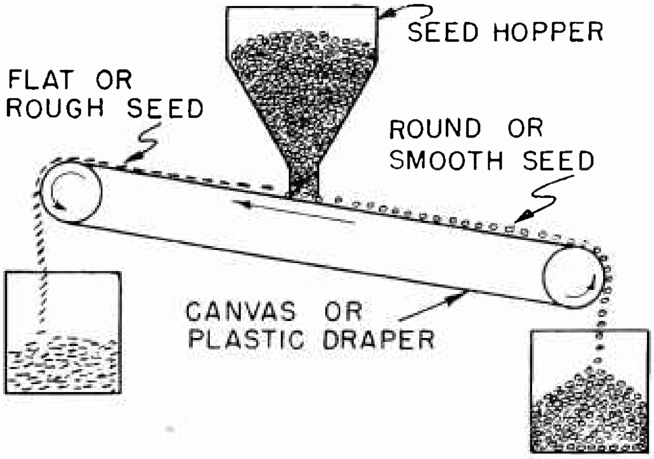

FIGURE 15.—Inclined draper seed separator, section view.

(See figure 16.) The rate of feed to the draper may be varied. The rate should be slow enough to allow each seed to act individually and not be hindered from rolling or sliding by those that are stationary. Also, it should not be forced to move by those that are traveling.

The angle of incline may be varied to match the rolling or sliding characteristics of the seed mixture. The speed of the draper may be varied to simulate a shorter or longer length of incline, and belts with different degrees of roughness may be used as the draper. A relatively rough canvas belt may be employed when rolling tendencies are predominant in seed of the lower fraction, while a smooth plastic belt is more useful if a sliding action is wanted for the lower fraction. In many cases, the smooth belt can do all that a canvas belt does, and in addition, can provide a means of making a more precise separation.

In adjusting the machine to perform a given separation, start with a very low rate of feed, a slow draper speed, and a flat draper slope. Increase the angle of slope until none of the rolling or sliding fraction of the mixture is being carried to the top. Increase the draper speed until none of the flat or elongated seed is falling off the lower end. Increase the rate of feed until it becomes obvious that quantity is interfering with individual seed action and changing previously set conditions; then reduce the feed rate a small amount. Typical separations made by the inclined draper are crimson clover from grass seed, vetch from oats, and other spherical seed from flat, rough, or elongated seed.

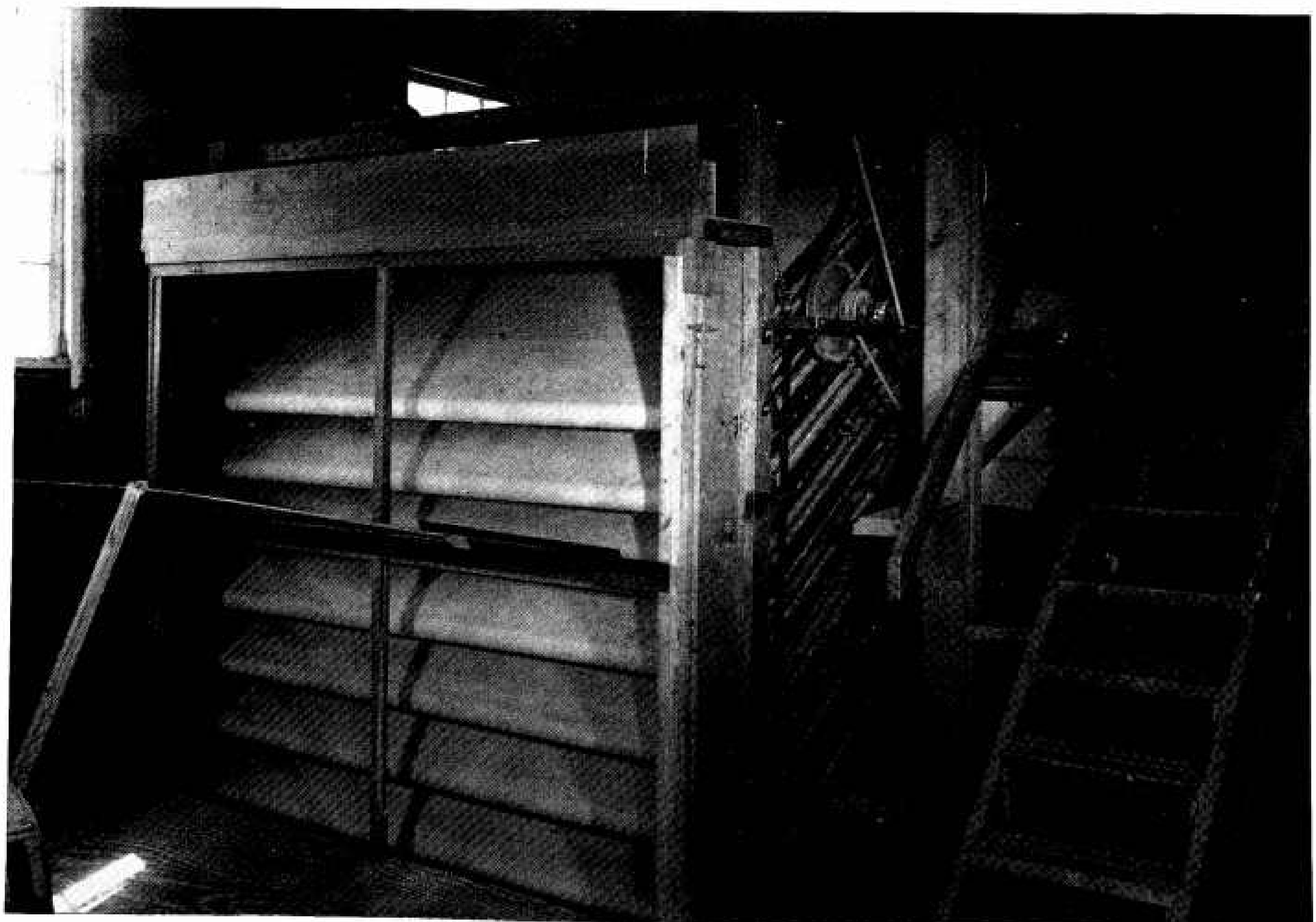

FIGURE 16.—Commercial inclined draper, equipped with multiple draper belts.

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HORIZONTAL DISC SEED SEPARATOR

The horizontal disc separator (fig. 17) is a special machine designed to divide seeds by difference in ability to roll or slide when subjected to centrifugal force. Physical factors affecting this separation are shape, density, and surface texture of the seeds. This unit is considered a finishing machine, and is used to salvage rejected seed from other cleaning equipment. It will separate dodder from alfalfa, curly dock from red clover, and other mixtures where one seed has a greater tendency to roll or slide than another.

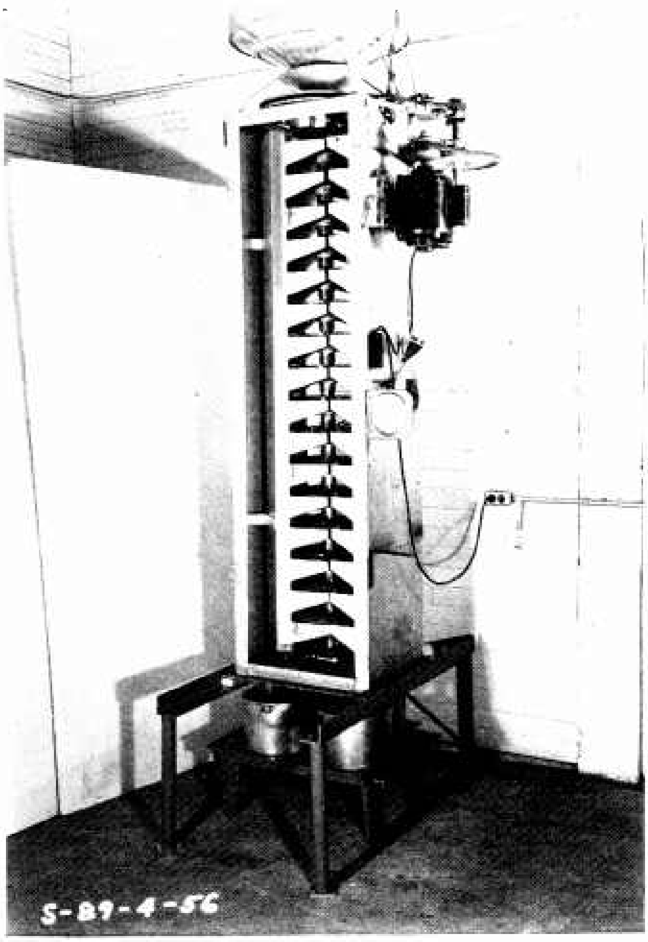

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FIGURE 17.—Horizontal disc seed separator.

The separation made by the horizontal disc is similar to that made with a spiral, but is more selective since the disc machine has a variable speed control which can change the proportions of a seed mixture retained or rejected.

The discs are mounted at regular space intervals, one above another, on a hollow vertical shaft. The seed mixture is fed from a hopper into the top of the hollow shaft which meters seed to each disc through variable orifices. A plastic fence with two adjustable outlets confines seed in the center of the disc, discharging two single seed rows, spaced 180° apart, to the outer portion of the disc, as shown in figure. 18. Centrifugal force causes the round seeds to roll off, while irregularly shaped seeds remain on the disc and are raked off at each half-rotation, resulting in four separations per disc. The outer area of each disc is banked like a highway curve to offset, partially, the increased rolling tendency due to increased centrifugal force that is present as a seed moves away from the center of disc rotation.

The 16-disc machine pictured in figure 17 has a capacity ranging from 300 to 500 pounds per hour, depending upon the seed being cleaned.

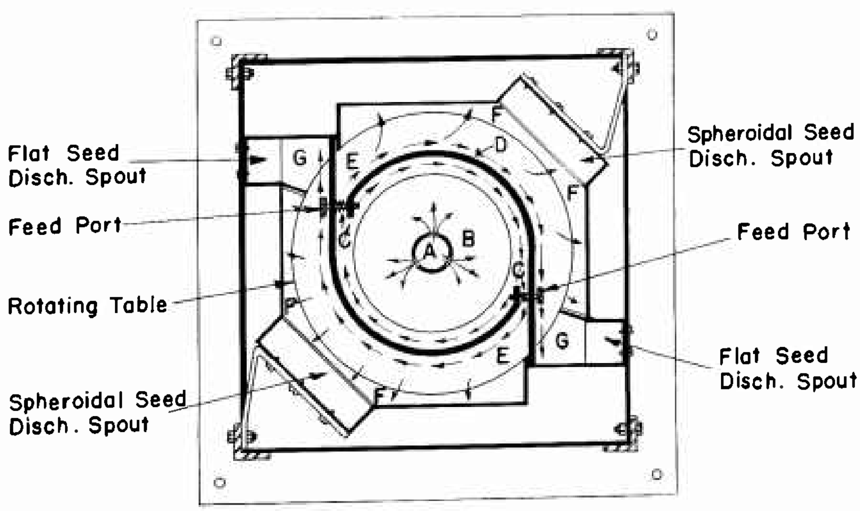

FIGURE 18.—Cross section of horizontal disc separator. A, Hollow vertical shaft which meters seed to the discs; B, inner portion of disc; C, adjustable outlets; D, plastic fence; E, outer area of disc; F, discharge for round seed; G, discharge for flat seed.

Electronic seed cleaners take advantage of differences in electrical characteristics of seed to make many separations that cannot be made with conventional seed-cleaning equipment. The degree of separation possible depends upon the relative abilities of seeds in a mixture to conduct electricity or to hold a surface charge.

Electronic, or electrostatic, separations have been practiced for many years in the mineral industries, but the principle has been applied to seed separation only recently in a few commercial installations. Some of the separations that have been reported are watercress seed from rice, ergot from bentgrass, and Johnson grass from sesame.

It has long been known that substances can be "electrified" or charged with static electricity. For example, a comb which has been passed through hair is capable of attracting lightweight objects such as bits of paper. This attraction takes place because the electric charge on the comb is now different from that on the paper. In an electronic separator, seeds are given a surface charge of static electricity by passing them through a high-voltage electrical field. Some seeds lose their charge faster than others, depending upon their conducting properties. The charged seeds tend to move toward an electrode of opposite polarity. The seeds that hold a charge best are attracted most strongly to the electrode; thus, a separation of seed can be made.

In the general arrangement of an electronic seed separator, a hopper feeds the mixture to a belt or cylinder, which discharges the seed into a high-voltage field. A suitable power unit and electrode assembly can provide field strengths up to 45,000 volts, DC. As the seeds pass through the field, they are attracted or repelled according to the charge they possess, and this charge determines the path that will be taken as the seeds fall from the belt or cylinder. Dividers in the drop path can be positioned to collect any fraction of the distribution desired. Figure 19 is a schematic sketch of an electrostatic separator.

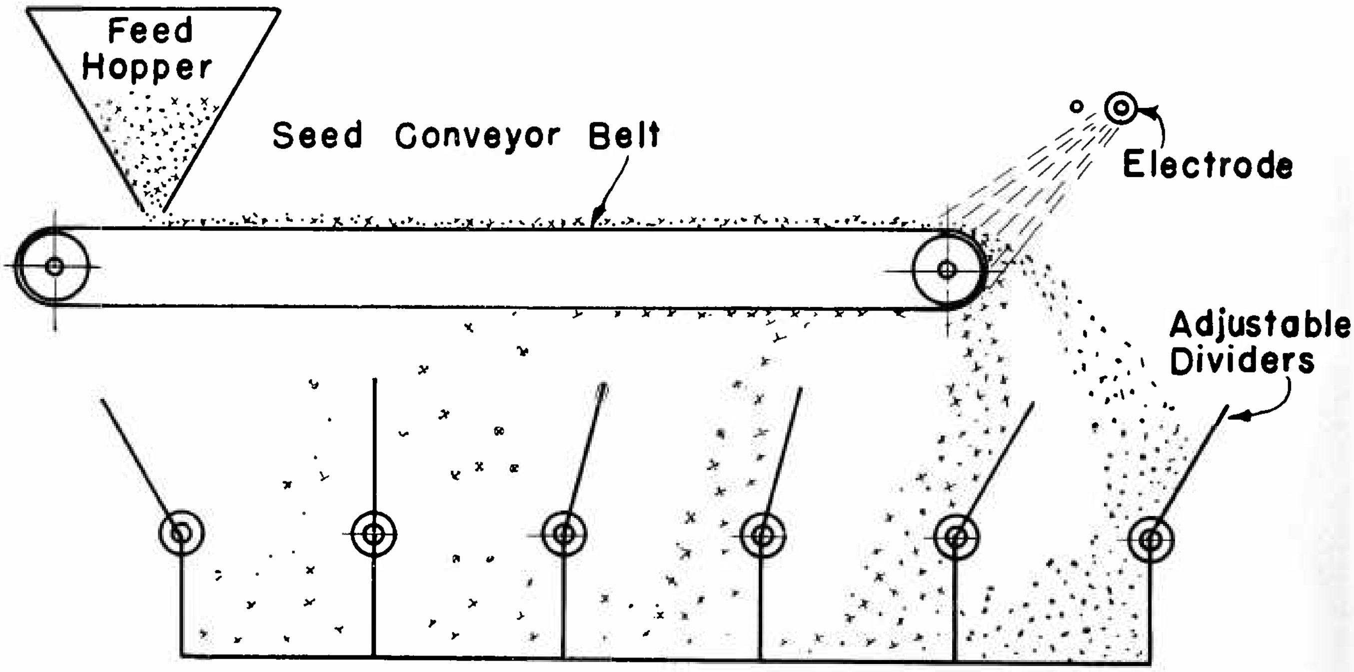

FIGURE 19.—Schematic drawing of an electronic seed separator.

Three different field conditions can be provided according to the position of the high-voltage electrode. One is a static or non-discharging field, which produces a "lifting" effect where seeds of a particular charge are attracted to an electrode of opposite polarity. This is a direct example of the phenomenon of static electricity, and little or no current flow takes place. Another is a discharging field, which produces a "pinning" effect. Seeds passing through this field receive a spray charge of electricity from the electrode, which causes some seeds to be repelled from the electrode and pinned to a grounded belt or roller. A combination lifting and pinning effect is also possible.

The proper field conditions for a given separation depend upon the seed mixture, and are best determined by experiment.

Encouraging results have been shown by a separator developed at Oregon State College through the cooperation of the Agricultural Engineering Research Division of the U. S. Department of Agriculture, and the Agricultural Engineering Department, Oregon State College. Preliminary research has been conducted with this

However, changes in moisture content can be compensated for, to some degree, by proper adjustment of voltage, field condition, and other machine pink and cornflower) was successfully removed from Alta fescue and ryegrass. Also, curly dock was separated effectively from red clover.

To determine the effects of high-voltage exposure upon germination, extensive tests were conducted with common ryegrass. After repeated exposure to 25,000 volts, seed lots were germinated

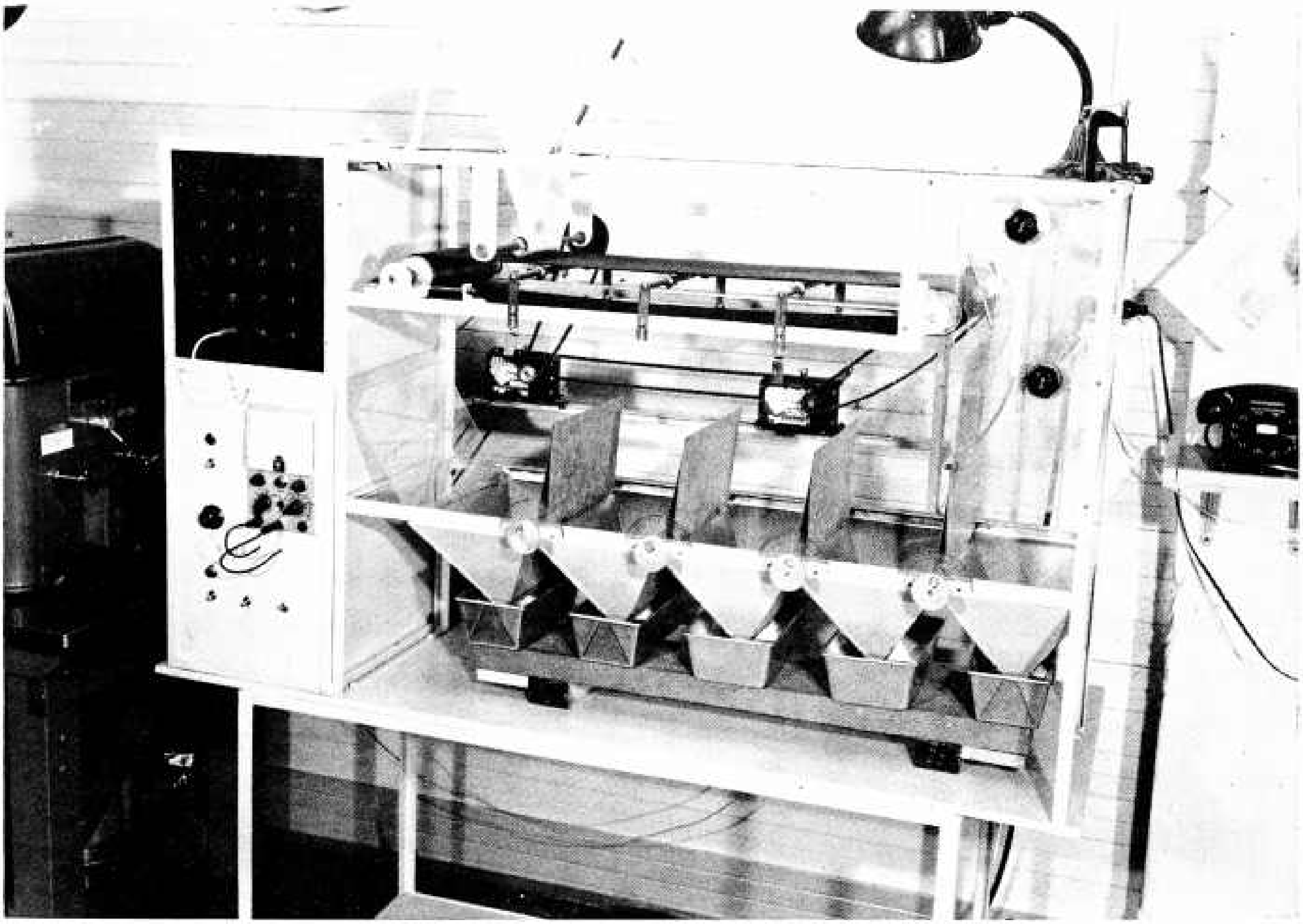

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FIGURE 20.—Electronic seed separator developed cooperatively at Oregon State College.

unit, shown in figure 20, to determine what seed mixtures could be separated, the effects of seed moisture content on separating efficiency, and the influence of high-voltage exposure upon the germination of seed.

Moisture content was found to play an important part in electronic separation of crop seeds, which stems from the fact that a seed's ability to conduct electricity is affected by changes in seed moisture. Changes of 2 to 3 percent in moisture content were great enough to impair separation.

at intervals over a period of 6 months and showed no significant change in germination. Other seeds that showed no change in germination were alsettings. Bachelor's button (also called French falfa, red clover, alsike clover, Alta fescue, and perennial ryegrass. Additional tests were conducted at higher voltages with subterranean clover, ryegrass, and Chewings fescue. After exposure to 44,000 volts, these lots also showed unchanged germination values.

Although electronic separation is not a new development, it is a useful tool when properly adapted to the seed-cleaning industry. Since this separation is not based upon physical differences of seed, it offers the possibility of making separations that are now difficult or impossible with conventional seed-cleaning equipment.

MAGNETIC SEED SEPARATOR

At least six different makes of magnetic separators are used in the seed industry, representing German, English, and United States developments. Some employ permanent magnets and others use electromagnets in their operation. All are considered finishing machines and are becoming increasingly popular as seed standards grow more exacting.

The operating principle is shown in figure 21, which is a section view of a single-drum, magnetic separator. Most magnetic cleaners have two drums in series and subject seed to two magnetic fields, thereby increasing the efficiency of separations.

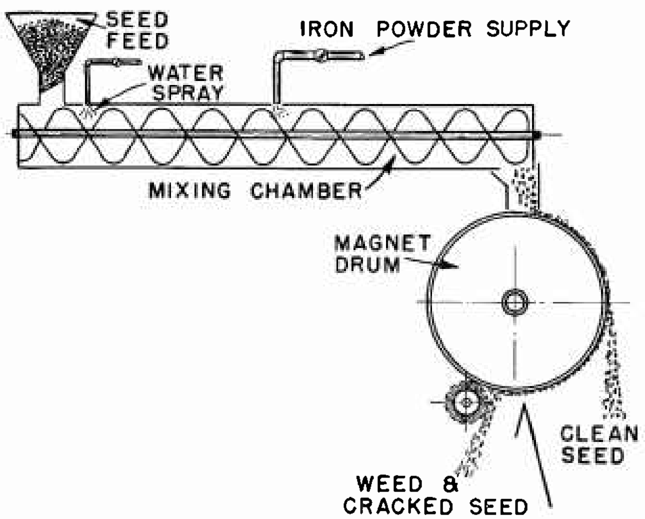

FIGURE 21.—Section view of a single drum, magnetic seed separator.

The seed mixture is fed into a screw conveyor that tumbles and mixes the seed with a proportioned water spray and a finely ground iron powder. The powder will adhere to rough seed coats, cracks in a seed coat, dirt clods, chaff, or seeds with a sticky residue on the surface. The mixture is then discharged from the mixing screw onto the revolving drum, which has a high-intensity magnetic field. The rough-textured or sticky seeds, which are now coated with iron powder, adhere to the magnetic drum until they are removed with a rotary brush. The good seeds, being smoother, are relatively free of powder and are not attracted by the magnetic field. They will fall from the drum in a normal manner thus making the separation.

The magnetic cleaner is excellent for removing rough-coated seeds like dodder, or mucilaginous, coated seeds like buckhorn plantain, from smooth legume or flax seed. Hulled Johnson grass can be removed from alfalfa by using an emulsified oil along with water to help the grass seed pick up and hold the powder.

Capacities of magnetic separators range from 200 to 2,000 pounds of seed per hour, depending upon machine size and the seed being cleaned.

BUCKHORN MACHINE

The buckhorn machine is a special unit designed primarily to remove buckhorn plantain from legume seed, such as crimson clover, alfalfa, and red clover. Normally, the buckhorn plantain and the legume seeds are so similar in size, shape, and weight that many of the buckhorn seeds cannot be removed by the air-screen machine, the gravity separator, or other seed-cleaning equipment.

However, the buckhorn seed has a mucilaginous substance on its surface that becomes sticky when dampened and will pick up finely ground sawdust, thereby forming a larger seed unit with lower density. Since the legume seed is smooth, the sawdust does not adhere to it.

After a seed lot is mixed with a small amount of water and sawdust, as shown in figure 22, the

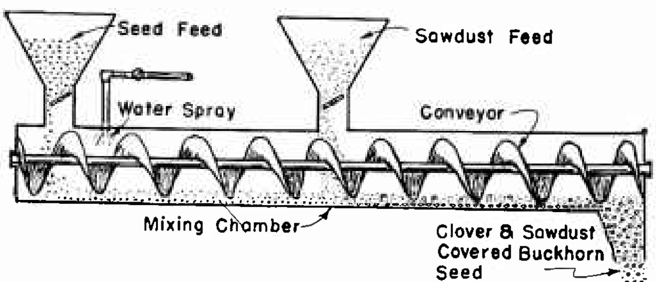

FIGURE 22.—Buckhorn machine, section view.

enlarged buckhorn seeds can be removed with an air-screen cleaner. If small buckhorn seeds drop through the screen along with legume seeds, the gravity machine may be employed to separate these components on the basis of density differences.

TIMOTHY BUMPER MILL

The bumper mill is a special machine developed to remove weed seeds from timothy. It makes separations by exploiting differences in shape, surface texture, and weight of seeds.

The unit consists of two sets of identical, superimposed decks suspended in a rigid frame and connected by a linkage. (See figure 23.) A small electric motor drives a cam that rocks the decks back and forth and bumps them simultaneously against adjustable rubber stops mounted on the rigid frame between the two batteries of decks. All decks of a battery are at the same inclination at any one time, and this inclination within the suspended frame can be varied by adjustment screws. Each deck is divided into 3″ x 9″ plates, and a feeder is positioned to supply seed continuously to each plate.

As the rocking deck battery bumps the rubber cushion, all seeds are given an uphill motion. The plump timothy seed has a tendency to roll downhill between each bumping cycle, and will travel a shorter distance uphill than the irregularly shaped seed. By the time the seeds move from the feed end to the discharge end of the metal plate, the seed types have migrated far enough apart to be discharged into separate spouts.

When this machine is properly adjusted in deck angle, rate of feed, and intensity of stroke, it will separate alsike clover, Canada thistle, sorrel, ryegrass, quackgrass, buckhorn, and other seeds from timothy seed.

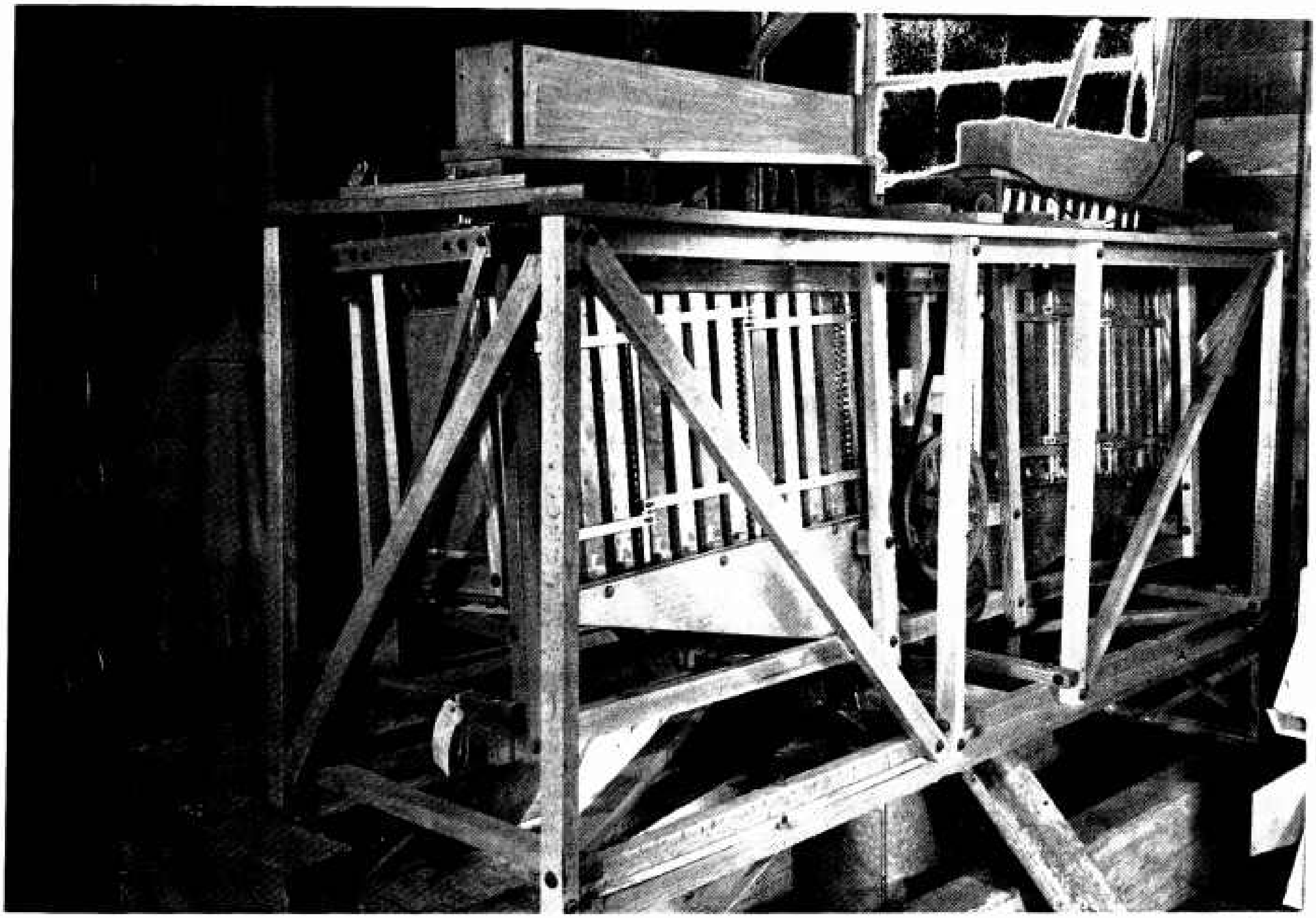

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FIGURE 23.—Timothy bumper mill.

VIBRATOR SEED SEPARATOR

The vibrator separator is a special finishing machine designed to separate seeds by their contrasts in shape and surface texture. Basically, the unit consists of an inclined deck, which is activated by an electromagnetic vibrator, the stroke of which is adjustable. (See figure 24.) The whole assembly can be tilted sideways and forward to provide a wide range of deck inclinations.

FIGURE 24.—Vibrator seed separator.

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Multiple decks may be mounted in a rigid frame so that a single vibrator will power the whole battery. The decks can be of varying textures ranging from smooth metal to rough sandpaper depending upon the seed components being separated, and the vibration intensity can be regulated by means of a rheostat controller in the electrical circuit.

In operation, a seed mixture is introduced near the center of the upper edge of the inclined deck. The action of the vibrator causes flat or rough seeds to climb the incline, while the more spherical seeds travel a shorter distance up the incline or roll to the low side of the deck. The forward deck inclination causes gradually widening bands of different seed fractions to travel over the deck from the feed to the discharge edge, where dividers isolate these fractions.

With the proper deck surface, inclination, and vibration intensity, the vibrator cleaner can make many difficult separations. It will remove curly dock from crimson clover, dogfennel and hedgemustard from timothy, and rippleseed plantain and ergot from bentgrass.

OTHER EQUIPMENT

Special items of equipment are found in seed-processing plants that are not discussed in this handbook. Debearders, for example, remove awns and separate doubles so that seed can be cleaned more effectively. Hullers and scarifiers remove hulls and roughen seed coats to reduce seed loss and hard seed. Other items found useful in seed processing are bagging scales, seed blenders, bag closers, moisture testers, seed samplers, and similar devices.

SEED HANDLING AND TREATING

CONVEYING SYSTEMS

Effective handling of materials is important in the economy of any industry, and seed processing is no exception. Seed lots are transported many times throughout various operations of hauling, cleaning, storing, and shipping, and if care is not exercised, processing efficiency will be reduced by seed damage, contamination, and handling costs.

Generally speaking, seed-conveying methods can be classified in two major divisions—mechanical and pneumatic. Mechanical systems include various types of conveyors, elevators, vibrators, and bulk-handling schemes, while pneumatic systems entail the use of air, and may operate above or below atmospheric pressure.

Mechanical Methods

Belt conveyor.—The belt conveyor is an endless moving belt that can transport material horizontally and at an incline. The belt may be supported by idler rolls, or it may slide in the bottom of an open trough. Little or no seed damage takes place in this type of conveyor, but contamination or intermixing of seed lots is possible when the belt travels in a trough.

Bucket elevator.—The bucket elevator consists of buckets attached to an endless chain or belt which runs along a vertical or steeply inclined path. The system may be enclosed in a single housing called a "leg," or separate housings for the elevator leg and return leg. The buckets load themselves as they pass through a seed hopper or "boot" at the bottom of the run, and, depending upon elevator type, the load is discharged by centrifugal force and/or gravity as the buckets round the top section of the assembly.

The centrifugal-discharge elevator is commonly operated at high speeds to obtain high capacities, and the resultant discharge velocity may cause excessive damage to injury-sensitive seed. Slow-speed, high-capacity units are better for easily damaged or slow-flowing materials. Another limitation of bucket elevators is that they are difficult to clean. Small seeds tend to lodge in hard-to-clean areas throughout the elevator and remain there to contaminate subsequent lots.

A different type of bucket elevator that is becoming increasingly popular in seed handling is a slow-speed, multi-section conveyor, that operates without a filler boot or enclosed housing. In a four-section unit, four kinds of seed can be handled separately in adjacent strands of buckets. Buckets of each section are loaded at the bottom of the run by individual, timed, rotary feeders. The buckets turn upside down as they follow a horizontal path at the top of the conveyor and gently discharge the seed. Because of the open-type construction, any seed that is dislodged from a bucket will fall free of the system. Since there is no boot, housing, or high-speed discharge to be a source of contamination or damage, this elevator is well adapted to handling certified, registered, and other pure seeds.

Screw conveyor.—The screw conveyor usually consists of a long-pitch helix mounted in a U-shaped trough, with or without a cover. As the element rotates, seed fed to it is thrust forward and discharged through openings at the end of the trough. Since this conveyor agitates or tumbles the product handled, it can be used to good advantage as a seed blender in batch and continuous operations. It can also function as a feeding or metering device where fairly accurate control is needed.

Screw conveyors may operate in horizontal, vertical, or inclined paths, but capacity drops as inclination increases. A cylindrical housing surrounding the helix is commonly used when elevating at a steep incline.

This conveyor is simple but seed damage can result from the sliding, squeezing, tumbling movement provided by the screw action. Also, the unit is not self-cleaning. If the seeds being handled are smaller than the clearance between helix and housing, they may remain in the system and contaminate subsequent lots.

Vibrating conveyor.—The vibrating conveyor transports material by "bouncing" it along a metal tray that has a short, reciprocating stroke of high frequency. The tray motion can be accomplished by electromagnetic or mechanical means. No apparent seed damage occurs in this conveyor, and it tends to be self-cleaning. One limitation, however, is that it is restricted to horizontal or near-horizontal transport paths. A special application of this unit is as a metering device where good control of feed rate is necessary.

In electromagnetic units, the conveying tray is pulled down and back sharply by magnetic attraction and then returned up and forward to its original position by springs. This action is modified in some designs so that electromagnets, together with springs, alternately attract and repel the tray to impart the reciprocating motion. As the tray drops backward, the material being conveyed falls perpendicularly to a new position forward in the tray and is then carried up and forward to have the cycle repeated at high speed.

Excellent features of electromagnetic conveyors are convenient control of feed rate and a wide range of conveying capacities in a single unit. The flow rate is simply controlled by a voltage rheostat, which varies the vibration of the tray. Although fairly costly, the electromagnetic unit has several other advantages. There are few moving parts that require maintenance, and power requirements are relatively low.

Another application of this vibration principle in seed handling is the mounting of unit vibrators on bins or hoppers to improve the flow of material that tends to "bridge" or cling to the sides.

When vibrating conveyors achieve their motion mechanically rather than electromagnetically, they are sometimes called reciprocating or oscillating conveyors. There are several methods of obtaining the required movement. In the positive-drive unit the vibrations are produced by an eccentric mounted on a shaft so that its throw causes movement of an attached trough that pivots from special hangars. The geared-weight method uses two unbalanced pulleys mounted in a housing and geared together to revolve toward each other. When the two centers of gravity move in parallel in the same direction, an impulse is communicated to the housing and to the attached conveying trough. Since the impulse will be neutralized when the centers of gravity move in opposite directions, a straight-line vibration may be obtained.

In general, mechanical vibrators can do the same conveying job as electromagnetic units. They show no seed damage, and have good self-cleaning characteristics.

Bulk-handling schemes.—In some cases, seed lots are handled by bulk or unit-load methods. The seed may be transported from field to processing plant in sacks, unit boxes, or as a bulk load in the truck bed. At the plant, the seed is either processed directly or stored in sacks, boxes, or bulk. Sacks can be handled singly by special elevators and conveyors, or in loads stacked on pallets and moved by forklift trucks. Boxes, also, are handled by lift truck, or sometimes with a box elevator which can grasp a large box, elevate it to a point where the load is dumped, and return the box to floor level. Advantages of the box method are reduced labor requirements, less chance of seed contamination, and ease of maintaining seed-lot identity.

In bulk storage, loose seed is delivered to bins by various forms of elevators, conveyors, and pneumatic systems. Scoop attachments fitted on forklift trucks are also used for handling bulk seed in open-end bins.

Pneumatic Methods

Pneumatic systems transport material by air and have the advantages of good clean-out characteristics, flexible horizontal and vertical operation, and mechanical simplicity. In order to transport material in conventional pneumatic conveyors, certain minimum air velocities are required, as shown in the tabulation below. Once this condition is achieved, a rule-of-thumb method for supplying air-volume requirements is to provide 40 cubic feet per minute under average atmospheric conditions for each pound of material to be moved. Limitations of these conveyors are (1) possible damage to the seed because of high velocities, and (2) greater power requirements than in mechanical handling methods.

Vacuum system.—The vacuum system operates below atmospheric pressure and usually includes a conveying pipe, a suction fan, a cyclone or settling chamber to drop seed from the air stream, and an airlock to discharge seed from the cyclone while retaining the vacuum. This system finds considerable use in unloading trucks, freight cars, and ships. Other successful applications are in short runs where seed is conveyed and removed from the system before it reaches a velocity that may be damaging.

Low-pressure system.—Low-pressure systems operate above atmospheric pressure in a range of approximately 10–15 inches of water (about ½ pound per square inch), and require a fan, conveying line, cyclone, and a means of introducing seed into the air stream. Generally speaking, conveyors of this type employ centrifugal fans and conveying lines ranging from 6 inches to 24 inches in diameter. Depending upon actual system pressures, seed can be introduced by injector or auger feeders, or if a better air seal is needed, by using a rotary airlock (also called a star feeder or bucket wheel). The low-pressure and vacuum systems are the most common types of pneumatic conveyors used in seed processing.

Air velocities needed for typical pneumatic conveying of materials at 70° F. and 70 percent relative humidity

Approximate duct velocity in lineal feet per minute	*Material to be conveyed*
2,500	Dry dust and light fluffy seed (bluegrass, meadow foxtail)
3,000	Ryegrass, fescue, and similar grass seed
3,500 to 4,000	Alfalfa, crimson clover
4,000 to 5,000	Heavy oats and cottonseed
5,000 to 6,000	Wheat, corn

Medium-pressure system.—Systems operating at pressures up to about 40 inches of water are classified as medium-pressure conveyors. The greater pressure requirements usually result from longer runs, more elbows, or greater conveying rates. Special centrifugal fans act as the air source, and common conveying pipe sizes are 4 inches to 8 inches in diameter. Rotary airlock units are needed to supply seed to the air stream for this type of conveyor.

High-pressure system.—These systems operate at pressures of about 3 to 15 pounds per square inch, with relatively low air volumes, and generally use small conveying pipe, about 1 to 4 inches in diameter. Positive-displacement air sources are employed in the form of rotary blowers or reciprocating piston pumps. Seed introduction to the high-pressure air stream is accomplished satisfactorily up to about 10 p.s.i. with rotary airlocks, but operation at higher pressures requires special locks or air-sealing mechanisms.

Several characteristics of high-pressure systems in seed conveying are flexibility of small-size pipe runs, high solid-air ratios, and relatively low seed velocity—therefore, low seed damage. Also, with low air volumes, there is little or no dust problem, and cyclones or collectors generally are not needed.

Recent experimental work with high-pressure seed conveying has shown several types of mass-flow patterns, all taking place at low velocities. For example, when crimson clover was transported in a 1½-inch conveying run that included a 30-foot vertical lift, the seed flowed in a dense phase at the bottom of the run, and completely filled the pipe with a continuously moving seed mass. At higher elevations in the lift, the seed movement took place in a fluidized state, and at the top of the run the flow consisted of intermittent surges of seed, discharged at low velocity into an open bin. Conveying capacities ranged from 3,000 to 6,000 pounds per hour.

PROCESSING DIFFICULT-TO-HANDLE SEED

Certain types of seed, particularly native grasses of the Great Plains area, prove very difficult to handle throughout processing and planting operations. In some cases the difficulty is due to seed appendages, such as awns, beards, or fuzz that tend to interlock and cause undesirable clustering. In other seeds, the presence of multiple florets or "doubles" prevents uniform handling and metering. Still another problem is posed by light, chaffy seeds which bridge easily and fail to flow properly from a gravity-fed hopper. Seed characteristics like these make a preconditioning treatment necessary to improve flow properties before such seed can be cleaned and planted with conventional machinery.

Several mechanical units have been investigated as a means of removing awns and appendages. These include the hammer mill, a thresher operating at high speed, a tumbling pebble mill, and a debearding machine. Since all these units employ a vigorous abrading action, care is needed in their operation to insure maximum awn removal with minimum seed damage.

Feed rate, hammer speed, screen selection, and crop condition are all very important in operation of the hammer mill. The screen should have an opening slightly larger than the de-awned seed. If too large a screen is chosen, there will be an excess quantity of inert matter and a high percentage of awns not removed from the seed. If the screen is too small, the seed will show excess damage and the capacity will be decreased. The feed should be regulated so that the mill is approximately full at all times. If the mill is operated only partly full, there will be more seed damage and a higher percentage of awns not removed.

The speed of the hammer mill best suited for pretreating seed for cleaning is about 50 percent of that used in a normal grinding operation; however, this can vary slightly according to individual cases. If the speed of the hammers is too fast, the seed will be mutilated, cracked, or groated. If the speed is too low, awns will not be removed effectively. With a properly adjusted and operated hammer mill, most seed can be conditioned so that an air-screen machine can be used for cleaning. Seeds of the following species have been successfully treated in a hammer mill operation: bluebunch wheatgrass, blue wildrye, Canada wildrye, Siberian wildrye, tall oatgrass, bulbous barley, squirreltail, alfileria, and virgins-bower.

Canada wildrye has also been de-awned in a threshing operation by speeding up the cylinder, setting concaves to a minimum clearance, and reducing the air blast. However, moisture content at time of threshing is quite influential in this process. Another precleaning treatment that is effective in removing seed hairs and fuzz is the tumbling of a seed lot in a container with smooth pebbles. A sample of Merion Kentucky bluegrass, tumbled in this type of unit and then processed in pneumatic and air-screen separators, responded very well and showed improved flow properties.

Debearding machines are also used as preconditioners. There are at least two available types. One is approximately 5 feet in length with a circular cross-section, and has a rotating member with rectangular beater arms set on it at a slight angle. Stationary bars mounted on the sides and protruding toward the center keep the seed mass from rotating with the beaters. The seed is fed at one end and conveyed through the unit by the pitch of the beater arms.

Pressure or density of the seed in the debearder is regulated by a weighted outlet door at the end opposite from the feed, and a variable-speed pulley permits a selection of beater speeds. When these adjustments are set according to the peculiarities of the seed being processed, many of the range grasses can be preconditioned. However, a high beater speed will cause seed damage, and some groating. Too much weight on the outlet door will reduce machine capacity, whereas too little weight will allow seed to escape early and reduce the percentage of seed de-awned.

The second type of debearder is somewhat similar in operation to the unit just discussed, but uses 1½-inch pipe beater arms in place of rectangular bars. The shape of the debearder housing tends to reduce rolling of the seed mass, and de-awning is accomplished by the seeds rubbing against each other. In limited preliminary tests, this type of debearder appears to be doing a more efficient and less damaging job of removing awns and breaking up doubles than either the hammer mill or the debearder discussed previously. Also, it requires less horsepower to operate. However, awns that are not stiff enough to break, but are small and limber, like the awns of black grama, cannot be removed completely by this machine. Even after a lot is processed in debearders, hairlike awns often keep this seed from flowing over screens, and further treatment may be required.

As a unique approach to the problem of awn removal, differential burning has some possibilities. This technique is somewhat similar to flaming grass out of cotton. In a laboratory experiment, the fine awns of black grama seed were burned off by dropping the seed through a blowtorch flame where an instant flashing of awns took place. No scorching of the paperlike lemma and palea was evident, and no increase in seed temperature could be detected by feeling the seed.

Conventional air-screen seed cleaners, with alteration, may satisfactorily handle some of these range grass seeds. To move seed over the screen, it may be necessary to mount the screens on arms so that the cam will give the screen a straw-walker action rather than a straight reciprocating motion all in one plane. To prevent choking or lodging of seed in screen openings, a knocker that periodically taps the screen may be required in addition to traveling brushes on the underside of the screen.

The aspirator cleaner can be used to good advantage both before and after an air-screen cleaning operation. Here, the air adjustment is very accurate and close separations of a mixture may be made. This unit was used to process a sample of meadow foxtail containing sloughgrass, chess, ryegrass, and rattail fescue. On one pass through the aspirator, the meadow foxtail and sloughgrass were lifted and the remainder of the contamination was discharged from the bottom chute. A No. 8 indent cylinder was then used to remove the sloughgrass leaving clean meadow foxtail.

Many schemes have been used to obtain seed flow through planters. Mechanical agitators, brushes to clean the seeder disc, and free-flowing additives, such as sawdust, sand, cracked grain, plastic shavings, and rice hulls have been used. Heavy materials like sand (which is abrasive and should not be used) and cracked grain have a tendency to settle below the light seed, resulting in uneven seeding. Sawdust and rice hulls are better additives, the latter being more desirable. The hulls are light and form a natural pocket to hold the seed. One rule-of-thumb for seeding is to set a planter for 160 pounds of barley per acre. At this setting it will deliver about 16 pounds of rice hulls per acre. The desired amount of seed can then be mixed with the hulls, and the mixture will flow through the planter.

Texas bluegrass is one of the most difficult seeds to process. Its cottonlike appendages interlock the light chaffy seeds so that the seed, entangled stems, and trash are nearly inseparable. Both conventional and special type cleaning equipment were used in attempts to clean this seed, but with little success. The seed was processed until some were groated and would not germinate, but the seed mass still contained tangled stems, leaves, and fuzzy seed.

The need for Texas bluegrass seed to plant in the Great Plains area prompted further effort to condition the seed so that it could be handled and seeded with a mechanical planter. This conditioning was accomplished by spraying the seeds, stems, leaves, and other plant residue with a binder, and compressing the whole mass in an extrusion press. When starch was used as the binder, pellets of seed were extruded that could be seeded with a conventional cotton or corn planter. When Silvicon (a powder fraction of Douglas fir tree bark) was used as a binder, a coarse granule was formed that could be planted with a conventional grain drill. (See figure 25.)

The material presented here represents attempts to process difficult-to-handle seed.

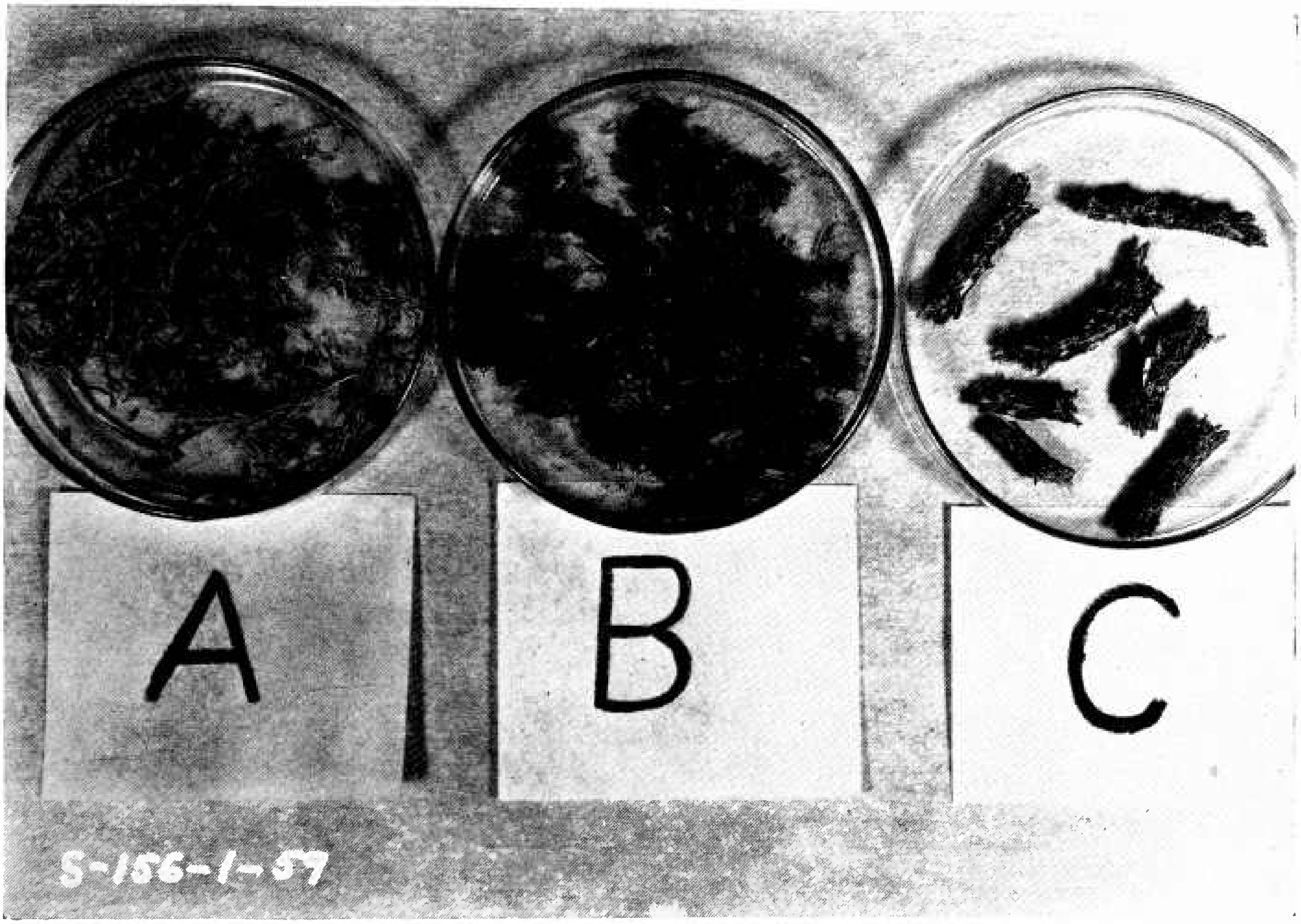

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FIGURE 25.—Texas bluegrass consolidated for planting: A, Original seed mass; B, granular product made with a Silvicon binder; C, dense pellets made with a starch binder.

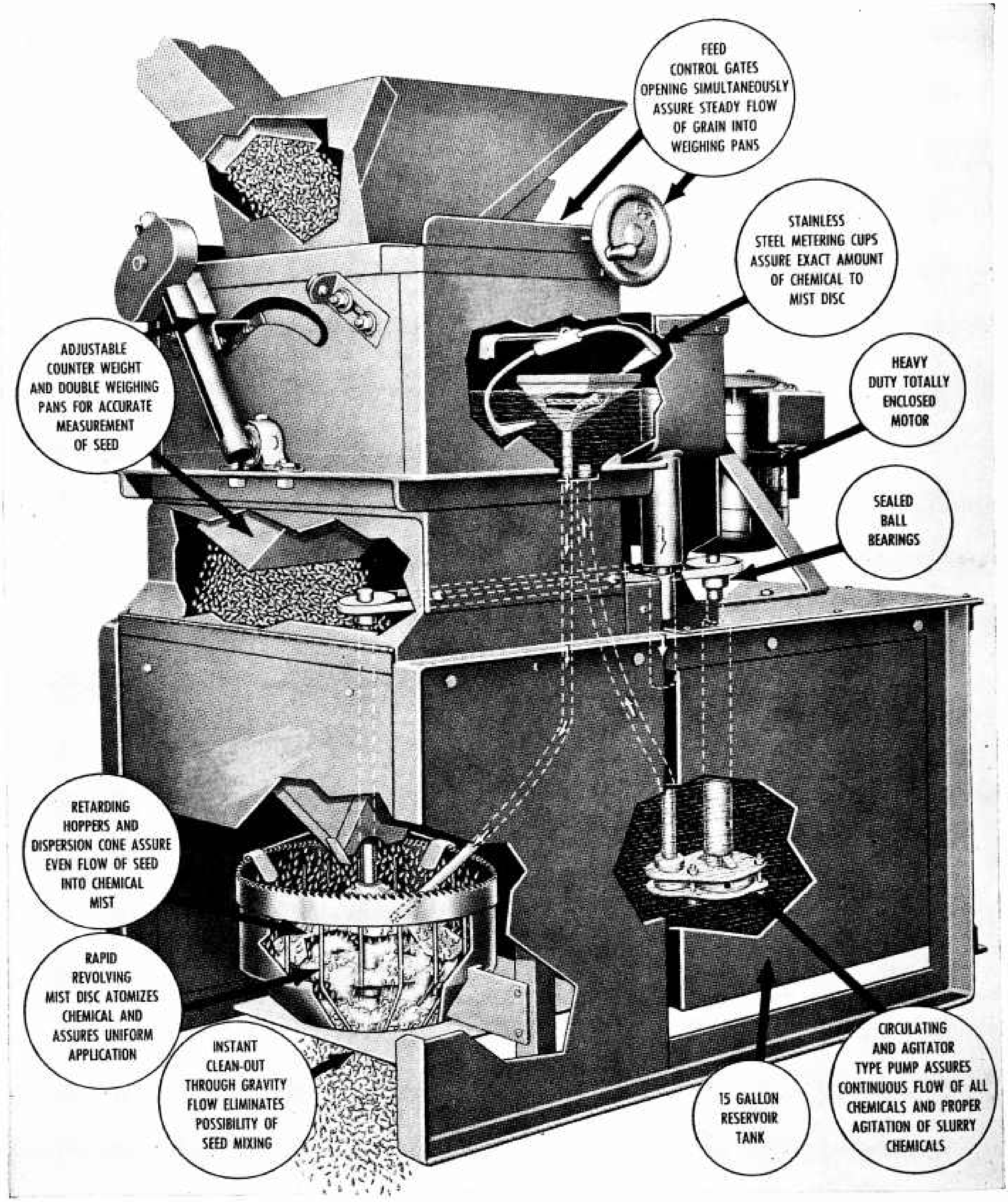

FIGURE 26.—Cut-away of liquid seed treater.

SEED TREATING

The scientist, the farmer, and the seedsman are all becoming more aware of the necessity for treating seed. The use of seed treaters to protect seed from soil- and plant-borne fungi and from insects in the warehouse and the soil has been known to double the field stand in infested areas. The increased production resulting from the use of treated seed is stimulating the use of treating machines in processing plants.

Seed treaters may be divided into three categories: dry-powder applicators, slurry applicators, and liquid applicators. The dry-powder applicators were the first type used. They do a thorough job of coating the seed, but many of these units have been replaced by slurry or liquid types because of the harmful effects of breathing chemical dust, and the difficulty of controlling chemical dosage in the dry-powder units.

The introduction of wettable powders and the development of the slurry treater came next. This was considered a major step forward in seed treating, since it made possible the metering of chemicals needed to treat a given seed quantity, while at the same time confining the chemical to the seed. The slurry is a versatile treater that will handle many different commodities. However, it is not suitable for applying low dosages of the more potent chemicals developed in the past few years. This failing led to the development of the liquid applicator.

The liquid applicator has several advantages. With it, as little as ½ ounce of mercury will treat a bushel of seed without the necessity of adding water, and the treatment can be performed in temperatures as low as $-20°$ F. The seed does not have to be completely covered to give the desired protection. Unfortunately, this technique cannot be used with vegetable or other food-crop seeds. These are still treated by the slurry method.

There are two types of liquid treaters in general use. In one type, a seed mass is tumbled in a rotating drum, and liquid is applied in small drops by a number of fingerlike tubes. The drum is set on an incline so that the seed travels from inlet to discharge as the drum rotates. The other liquid treater consists of a chemical pump and tank, an electrical motor, seed feed control, seed-weighing pan, chemical measuring cups, a seed-dispersion cone, and a rotary disc. (See figure 26.) In this unit, seed is fed to the top of the machine where it is accurately measured in the weighing pan while the chemical is measured in metering cups. The exact proportions of seed and chemical are then dumped simultaneously. The seed falls on a dispersion cone, which spreads it to form a hollow cylinder, the wall thickness of which is equivalent to one layer of seed. The chemical drops on a high-speed revolving disc that breaks up the liquid into a fine, penetrating mist, which sprays the seed from the interior of the cylinder as the seed falls from the dispersion cone into a sacking bin.

This spray treater is satisfactory not only for applying very small amounts of chemical to seed, but can be easily and quickly adapted for treating a wide range of sizes and types of seed.

PLANT LAYOUT

Many factors should be considered in laying out a seed plant. It should be planned so that seed is received, cleaned, and shipped without mixing or damaging the lots, and with a minimum requirement of time, equipment, and personnel. The seed separators, elevating and conveying system, and storage bins should be so arranged that the seed flow can be continuous from the receiving bin to the shipping point, yet flexible enough to bypass a machine or return part of the seed for recleaning, if necessary. An adequate waste-handling system to convey discarded material from various cleaners is essential but sometimes overlooked in seed-processing plans.

Other factors that should be considered in the plant layout are: the kinds of seed to be cleaned and the contaminating crop, weed, and inert matter; the volume of seed to be handled, and the method of handling (bulk or sacks, and if sacks, whether they are to be handled by hand, roller conveyor, or forklift trucks); the conveyor system to be used (pneumatic or mechanical); and the location of receiving and shipping facilities. Also, room should be allowed for future expansion of the seed plant, and possible rearrangement of equipment to accommodate additional machines in the processing line.

About as many different plant layouts can be found as there are seed processing plants. Multistory plants that use enclosed bucket elevators to convey seed to the top floor are the most common, and usually have cleaning machines placed

FIGURE 27.—Exterior view of multi-story processing plant. S–187–5–59

FIGURE 28.—Single-story processing plant, exterior view. S–184–5–59

in a vertical processing line so that the seed flows by gravity from one machine to another on a lower level. This arrangement reduces the number of elevators required to handle the crop but requires a high, reinforced structure to support the heavy machinery on the upper floors. (See figure 27.) Also, workers are needed on each floor to care for and operate the equipment.

Single-story plants, as shown in figure 28, have machinery placed on only one level, and are increasing in number because of the present-day emphasis on varietal purity and the special processing requirements for certain grass, legume, and vegetable seeds. This arrangement requires an elevator for each machine, but has the advantage that one man can supervise the entire processing line from one floor. (See figure 29.) In many cases, the reduced cost of a single-story building compared with the cost of a reinforced, multi-story structure more than offsets the expense of an elevator for each cleaning machine.

The experimental plant at Corvallis, Oreg., set up on a cooperative basis for investigation and demonstration purposes, is a complete single-story seed-cleaning plant. It consists of an air-screen seed cleaner, a gravity separator, an indent disc separator, a velvet roll seed separator, three 30-bushel storage bins, and a self-cleaning, elevating and conveying system. The arrangement provides a flexible operating sequence, and is located in a space 20′ x 30′ x 13′, as shown in figures 30 and 31.

Other plant layouts use a modification of the multi-story and single-story arrangements. For example, seed may be elevated to an overhead storage bin and fed by gravity to an air-screen cleaner located on a balcony. The remaining machines will be placed on the ground floor so that seed from the air-screen cleaner can be spouted to them for finishing operations.

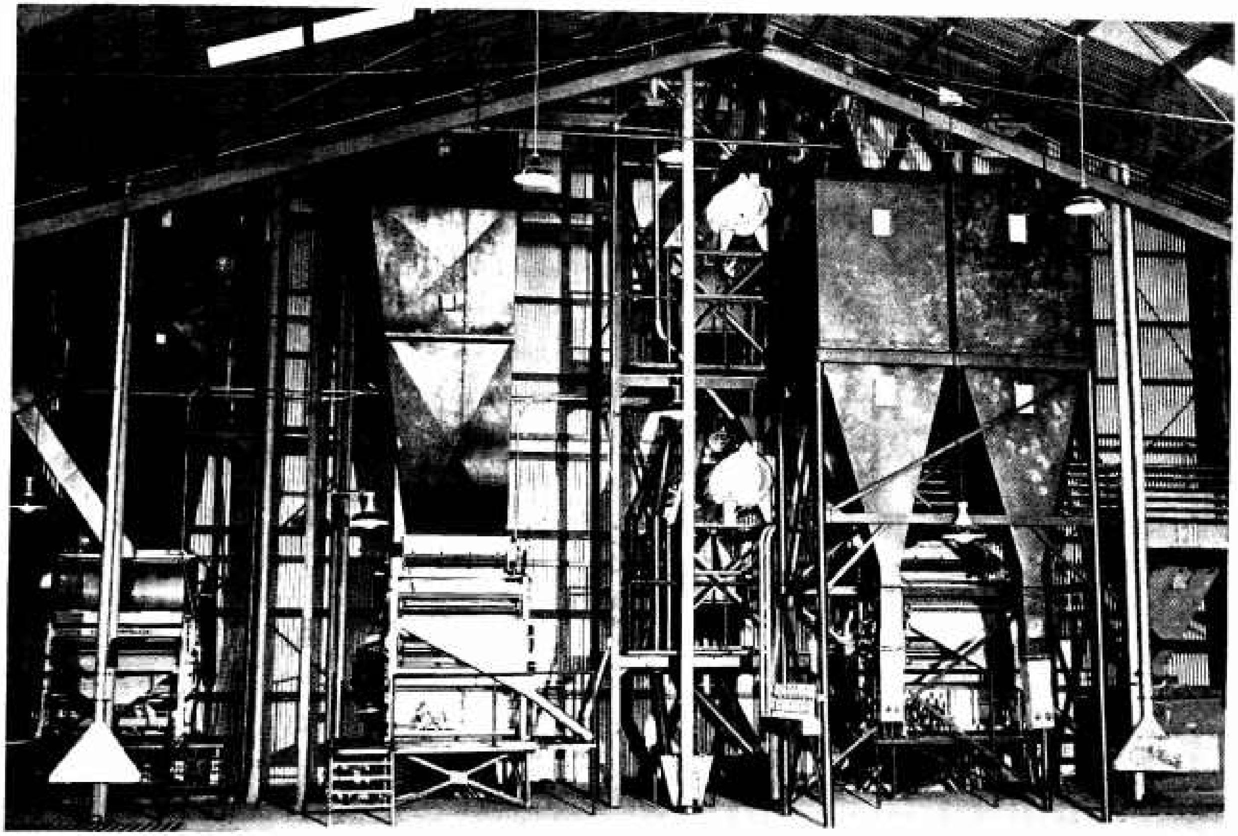

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FIGURE 29.—Single-story processing plant, interior view.

Another plant arrangement that has proven effective is a single-story structure with a high ceiling, a half-balcony, and small pits for airlifts or elevators. In this arrangement, the airlift or elevator discharge can be above the roof and directed to storage bins that feed machines located on the balcony, which require little attention. Examples of these machines are hullers, scarifiers, debearders, indent disc and cylinder separators, and seed treaters, all of which need regulation at the beginning of a seed-lot operation but require few adjustments thereafter. Seed from the balcony machines flows by gravity to air-screen cleaners, gravity separators, and other units located on the ground floor, which require frequent observation and adjustment.

To conserve floor space and minimize the handling of materials, seed-processing machines are sometimes placed one above another, or arranged in series so that the discharge of one unit flows into another unit. Debearders are often found above air-screen cleaners, and indent disc separators are frequently mounted above indent cylinder machines, as shown in figure 6, page 11.

Where a plant operation must be flexible enough to permit processing of grass seed, legume seed, and grain, floor space can be saved by mounting the processing equipment on rollers or mobile frames. Then, depending upon given cleaning requirements, the special machines can be rolled or moved by forklift truck into the processing line, or into storage until needed.

The particular combination of machines forming a seed-processing line will be determined by the seed crops and contaminants being handled. Figure 32 represents the general sequence of operation in cleaning several different crops. Figure 33 is a typical flow diagram for processing bluegrass, and figure 34 is a flow diagram for processing corn.

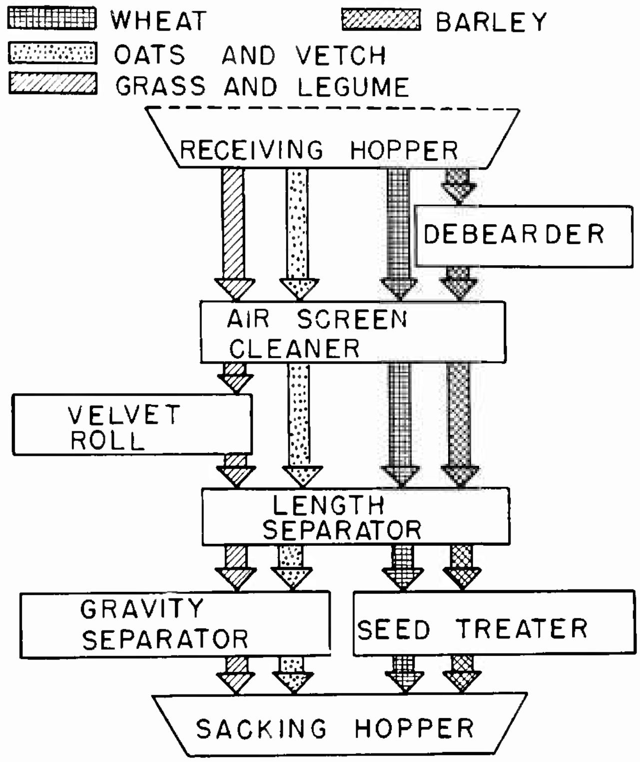

FIGURE 32.—Flow diagram showing steps in the cleaning of wheat, barley, oats and vetch, grass and legume seed.

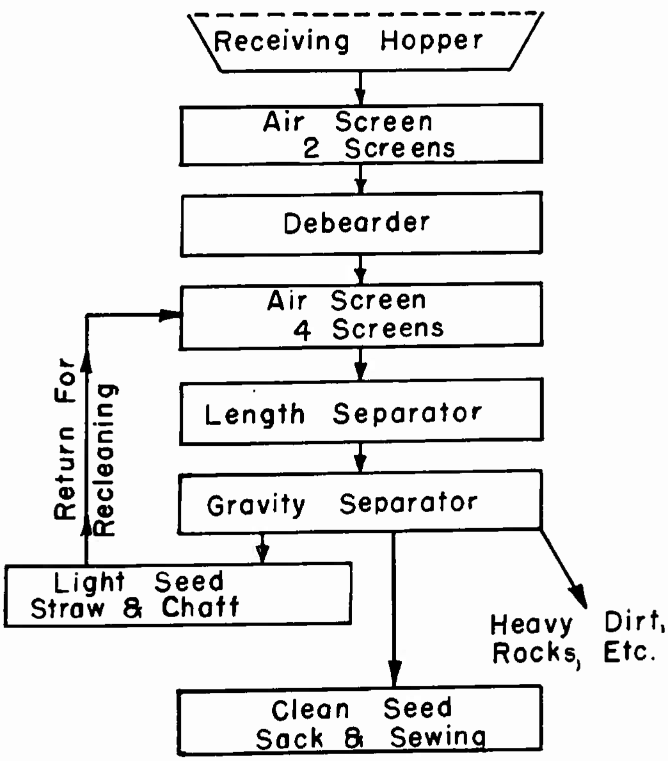

FIGURE 33.—Flow diagram of bluegrass processing.

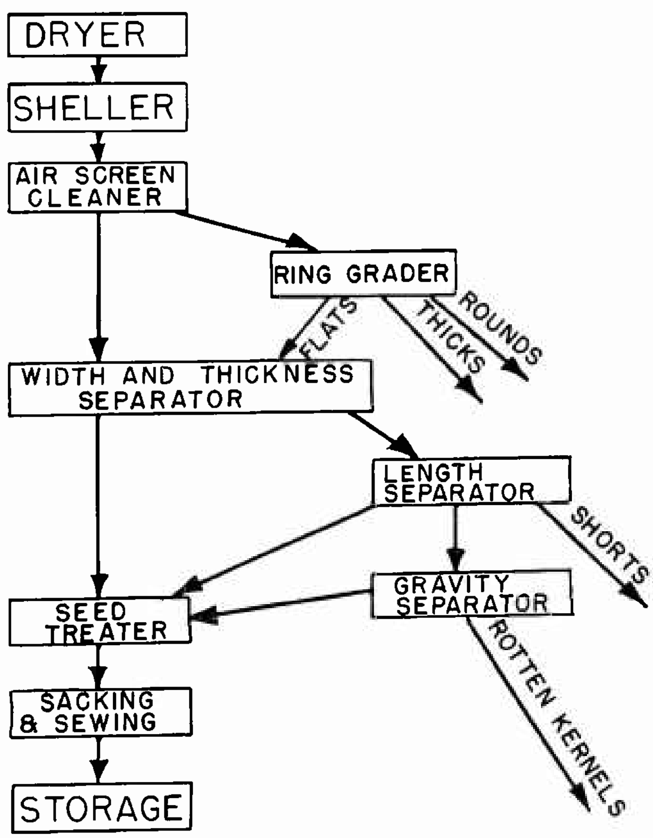

FIGURE 34.—Flow diagram of corn processing.

GLOSSARY

(Names of seeds referred to in this publication)

Common	Botanical
Alfalfa	*Medicago sativa*
Alfileria	*Erodium cicutarium*
Alsike clover	*Trifolium hybridum*
Alta fescue	*Festuca arundinacea*
American sloughgrass	*Beckmannia syzigachne*
Bachelor's button	*Centaurea cyanus*
Barley	*Hordeum* spp.
Beans	*Phaseolus* spp.
Bentgrass	*Agrostis* spp.
Black grama	*Bouteloua eriopoda*
Black bindweed (wild buckwheat)	*Polygonum convolvulus*
Bluebunch wheatgrass	*Agropyron spicatum*
Blue wildrye	*Elymus glaucus*
Buckhorn plantain	*Plantago lanceolata*
Bulbous barley	*Hordeum bulbosum*
Burclover	*Medicago hispida*
Canada thistle	*Cirsium arvense*
Canada wildrye	*Elymus canadensis*
Cheat	*Bromus* spp.
Chess	*Bromus secalinus*
Chewings fescue	*Festuca rubra* var. *commutata*
Clover	*Trifolium* spp.
Corn	*Zea mays*
Crimson clover	*Trifolium incarnatum*
Curly or yellow dock	*Rumex crispus*
Dock	*Rumex* spp.
Dodder	*Cuscuta* spp.
Dogfennel	*Anthemis cotula*
Fescue	*Festuca* spp.
Field bindweed	*Convolvulus arvensis*
Flax	*Linum usitatissimum*
Hedgemustard	*Sisymbrium officinale*
Italian ryegrass	*Lolium multiflorum*
Johnson grass	*Sorghum halepense*
Kobe lespedeza	*Lespedeza striata* 'Kobe'
Korean lespedeza	*Lespedeza stipulacea*
Lentils	*Lens culinaris* (*Ervum lens*)
Merion Kentucky bluegrass	*Poa pratensis*
Meadow foxtail	*Alopecurus pratensis*
Mustard	*Brassica* spp.
Oats	*Avena* spp.
Perennial ryegrass	*Lolium perenne*
Plantain	*Plantago* spp.
Quackgrass	*Agropyron repens*
Ragweed	*Ambrosia* spp.
Rape	*Brassica* spp.
Rattail fescue	*Festuca myuros*
Red clover	*Trifolium pratense*
Rice	*Oryza sativa*
Rippleseed plantain	*Plantago major*
Ryegrass	*Lolium* spp.
Sesame	*Sesamum indicum* (*S. orientale*)
Siberian wildrye	*Elymus sibiricus*
Sorrel	*Rumex* spp.
Soybeans	*Glycine max*
Squirreltail	*Sitanion hystrix*
Subterranean clover	*Trifolium subterraneum*
Sudan grass	*Sorghum sudanense*
Tall oatgrass	*Arrhenatherum elatius*
Texas bluegrass	*Poa arachnifera*
Timothy	*Phleum pratense*
Vetch	*Vicia* spp.
Virgins-bower	*Clematis ligusticifolia*
Watercress	*Rorippa nasturtium-aquaticum* (*Nasturtium officinale*)
Wheat	*Triticum* spp.
Wild geranium (cranesbill)	*Geranium* spp.
Wild oats	*Avena fatua*

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