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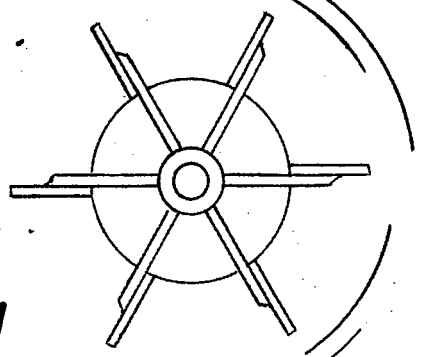

Seed Processing and Handling

Seed Technology Laboratory
Mississippi State University
State College, Mississippi

SEED PROCESSING
and
HANDLING

63

Edited by

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FOREWORD

In 1954 the Mississippi Agricultural Experiment Station published Bulletin 520 "SEED PROCESSING EQUIPMENT". This bulletin was - so far as we know - the first comprehensive consideration of modern seed processing equipment, principles, and procedures, in this country. Twelve thousand copies were printed (in two printings) and distributed to people from throughout the U.S.A. and over 40 foreign countries. In tribute to the pioneering effort represented by Bulletin 520, its cover design has been used on the cover of the present handbook.

Seed processing was not a new field in 1954. It had long been an important segment of the commercial seed industry. What was new was a developing interest and competence in the field by agronomists and agricultural engineers at one of the Land Grant Universities.

Before 1950, seed processing was largely a skilled craft passed on from craftsman to apprentice. The procedures and techniques used were almost completely locked within the experiences of the seed processing craftsmen in the various seed companies. Indeed, many of the techniques and procedures were treated as "trade secrets" and, consequently, were not readily communicated or transmitted to others.

Seed processing is - at its best - still a skilled craft. But it is an open craft and most of its "secrets" have become public knowledge. A substantial body of written and illustrated material on equipment, principles, and techniques has been developed and is available. Without this "body of knowledge" the present handbook would not have been possible.

Annually since 1951, the Mississippi Seed Technology Laboratory, in cooperation with the manufacturers of seed processing and handling equipment have given a SHORT COURSE FOR SEEDSMEN. And since 1958, much of the material presented at the Short Course has been published in an annual Proceedings. Although originally published primarily to record the transactions of the Short Course, the Proceedings have become "reference books" on seed processing and various other aspects of seed technology. They have been so widely distributed around the world that supplies of most issues have been exhausted.

The Proceedings have served well as reference works on seed processing and handling; yet, there was still a need for a comphrensive treatment of these subjects - a treatment that would bring together in one manual or handbook, pertinent information scattered through the various Proceedings and the developing literature on seed processing.

It was with this need in mind that the present handbook was developed. Various members of the staff of the Seed Technology Laboratory wrote the several sections. Some served as editors. All have drawn heavily on the material presented by the many speakers during fifteen Short Courses for Seedsmen.

The Seed Technology Laboratory is grateful to the authors of articles that first appeared in the Proceedings, the manufacturers of seed processing and handling equipment, and Jesse Harmond and his associates (USDA), for their assistance and cooperation during the preparation of this handbook.

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Introduction and Principles of Seed Processing

Section A

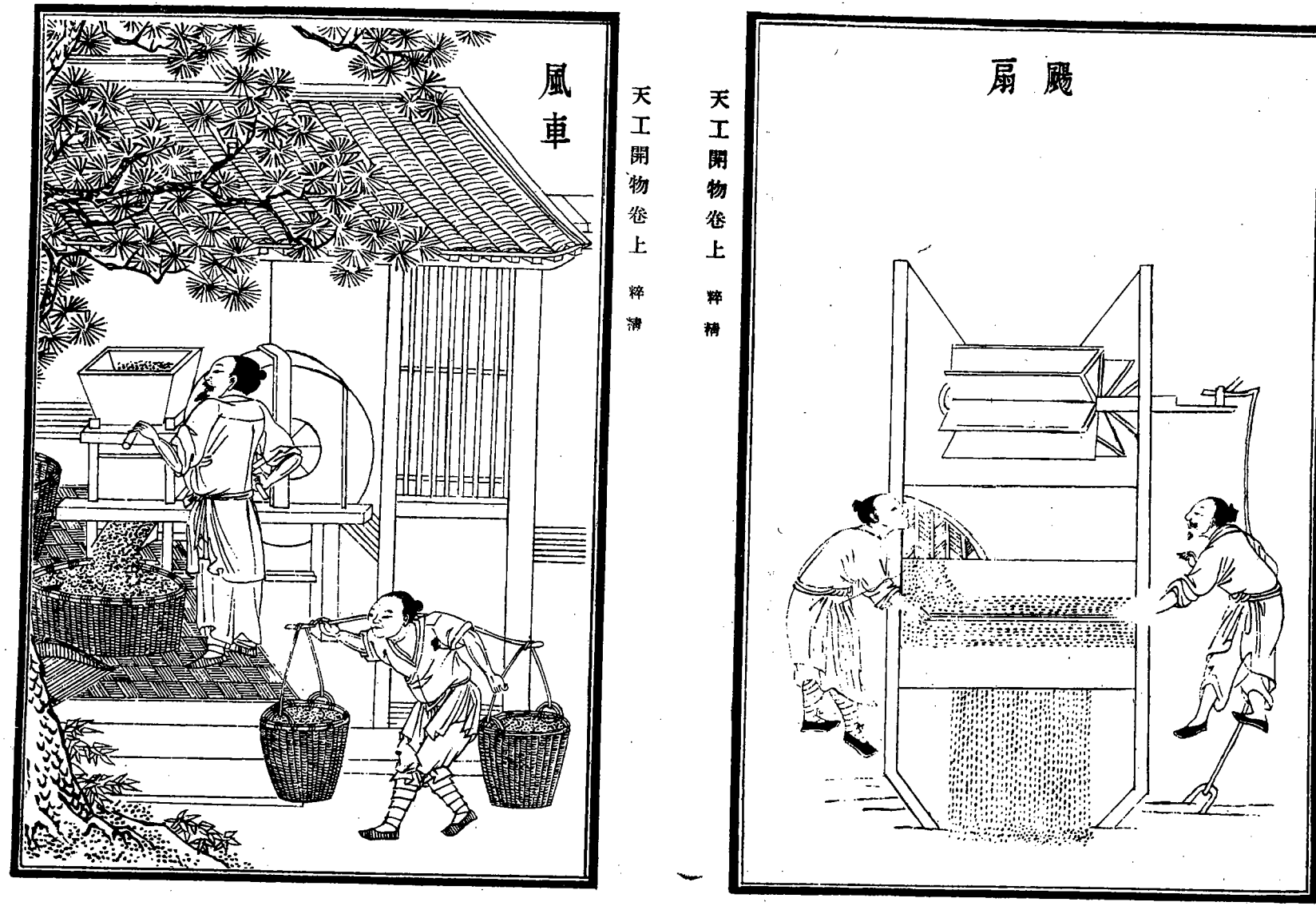


Figure A. Cleaning seed in China during the 17th century.

Introduction

New and improved crop varieties become an important agricultural input only when seed of such varieties are available to farmers varietally pure, in a viable condition, free of contaminating weed seed and in adequate quantities at the right place and time. Seed processing is an integral part of the technology involved in transforming the genetic engineering of the plant breeder and geneticist into improved seed. In its broadest sense, seed processing encompasses all the steps involved in the preparation of harvested seed for marketing - handling, shelling, preconditioning, drying, cleaning, size-grading, upgrading, treating and packaging. In common use, however, the term seed processing refers only to the preconditioning, cleaning, size grading and upgrading of seed. This restricted "definition" of seed processing was adopted in this handbook with some expansion of it to incorporate basic considerations of seed handling and treatment.

Seed growers and producers are dependent on the seed processor for preparation of their seed for market. The quality of the final product, regardless of its inherent capacity to produce, is directly related to the processor's ability to remove contaminants and low quality seed, to properly size-grade for precision planting, to treat the seed effectively, and to prevent mechanical mixtures of the seed with those of other varieties or hybrids. In turn, the processor's ability to render these services efficiently and effectively, is greatly affected by the types of processing and handling equipment available to him, their arrangement within the plant, his skill in operating them, and his knowledge of seed characteristics and how they relate to processing.

Think of seed processing and you think of equipment and machinery, conveyors and structures. For it is inconceivable that quality seed of improved varieties and hybrids could be made available in the quantities required by farmers without a high degree of mechanization of the many steps involved in the processing and preparation of seed. Thus, seed processing involves more mechanical skills and engineering principles than are involved in other areas of seed technology.

A variety of contaminants must be removed from raw seed - particularly seed harvested by a combine - to make it ready for marketing and planting (see chart). Contaminants such as inert material and off-size seed are not, in themselves, harmful but they do greatly influence seed flowability and plantability, incidence of insect infestations, and contribute to storage problems. Other contaminants such as weed seed and seed of other crops and varieties can seriously affect production of crops if they are not removed.

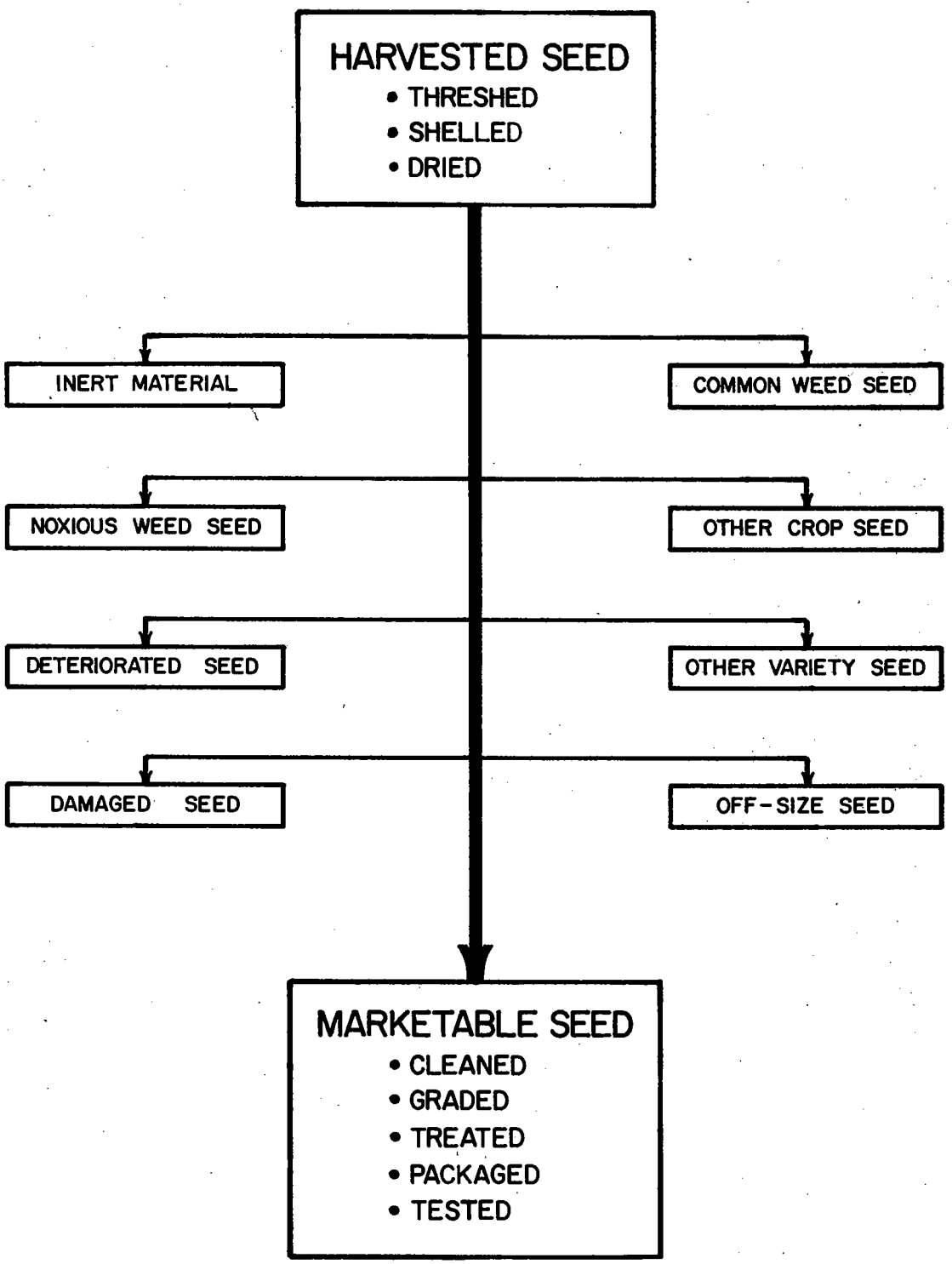


Figure A 1. Flow chart illustrating types of material that are removed from seed during processing.

Seeds are processed to remove contaminants, to size-grade for plantability, to upgrade quality through removal of damaged or deteriorated seed, and to apply seed treatment materials. The demands of the seed producer and seed consumer require that these four objectives be achieved effectively, efficiently and with minimal damage to the seed.

A variety of equipment is available for processing seed. They range from the simple winnowing tray - still used in many areas of the world - to complex and highly sophisticated equipment such as the electric sorting machine. Although variable in type and design, all seed processing equipment have one thing in common: the separations they effect are based on differences in physical properties among desirable material (good seed) and undesirable material (contaminants). Some machines separate good seed from contaminants on the basis of differences in several physical properties. More often, however, satisfactory removal of contaminating material from seed requires that they be processed in a specific sequence through several machines - each machine removing a certain portion of the contaminating material.

The choice of a machine or sequence of machines for processing seed depends on the kind of seed being processed, the nature and kinds of contaminants (weed seed, other crop seed, inert matter, etc.), the quantity of each in the raw seed, and the quality standards that must be met. Thus, the processor must be as familiar with seed standards and seed characteristics as he is with processing equipment.

This handbook was prepared as an introduction to seed processing and handling. Various types of equipment are considered. The main features and component parts, principles of separation, uses, and operational procedures are discussed for each machine. Throughout the handbook - and specifically in one section - an attempt was made to emphasize the concept of the "processing line", that is, the combination, proper sequence and arrangement of machines, conveyors, and procedures required for processing and handling of seed. For some kinds of seed, a simple processing line consisting of one machine coupled with handling and bagging equipment is entirely adequate. In the case of other kinds of seed, complex processing lines consisting of several machines arranged in sequence and matched for capacity, many surge and holding bins, and several types of elevators and conveyors are often required for complete processing. A processing line should never be static. Flexibility is necessary so that the line can be tailored and organized to handle each seed kind and each lot within a kind in the most efficient manner. Considerable attention and thought should be given, therefore, to the spatial arrangement and layout of equipment, bins, and conveyors within the seed plant.

The arrangement of material in this handbook is progressive like a processing line. The first section is a sort of over-view of the entire spectrum of seed processing equipment and procedures with emphasis on fundamental concepts and principles. The next several sections deal with equipment and procedures basic to all kinds of seed. Then the highly specialized machines needed for some kinds of seed are discussed. Accessory equipment and seed plant layout and design are considered in the last sections.

It was stated earlier that this handbook is intended to serve as an introduction to seed processing and handling. That is all that it can be, for seed processing is a craft, an applied science, and - at its best - an art. The development of operational skills and expertise can only be attained through experience and constant study.

PRINCIPLES OF SEED PROCESSING

The modern seed processor is basically interested in five things: (1) Complete separation - removal of all contaminating or undesirable material from the seed; (2) Minimum seed loss - some good seed are removed along with contaminants in almost every processing operation, but this loss must be kept at a minimum; (3) Upgrading quality - improvement of seed quality not only through removal of contaminating seed, but also removal of rotten, cracked, broken, insect damaged or otherwise injured or low quality crop seed; (4) Efficiency - the highest capacity consistent with effectiveness of separation, and (5) Minimum labor requirement - labor is a direct operating cost and cannot be recovered.

Steps in Processing

Seed processing operations can be broken down into several definite steps that follow in a specific sequence. The first step is RECEIVING - seed arrive at the processing plant in bags, pallet boxes, or in bulk. From the receiving station the seed go into bulk STORAGE to be held for later processing, or directly into the processing line for cleaning.

The next step in seed processing is CONDITIONING AND PRE-CLEANING. This includes removal of appendages, large pieces of trash, debearding to remove awns, or hulling the seed.

The first actual cleaning and/or upgrading step is BASIC CLEANING. The air-screen machine is probably the most common basic cleaner. It makes size separations and aspirates the seed. Seed lots may come from the field in good condition with few contaminating seeds and require cleaning only on the air-screen machine. Most often, however, it is necessary to send the seed through one or more special SEPARATING OR UPGRADING machines to remove a specific contaminant. These special machines separate crop and weed seed by differences in their specific physical characteristics. For effective and efficient separation, the crop seed must differ from the weed seed sufficiently in some characteristic so that the machine can differentiate between each crop and weed seed.

When all possible inert material and weed or other crop seed have been removed, the seed are ready for BAGGING. Sometimes a fungicide or insecticide TREATMENT is applied before they are bagged. The seed may then be shipped directly to other seed companies, or held in STORAGE until they are needed.

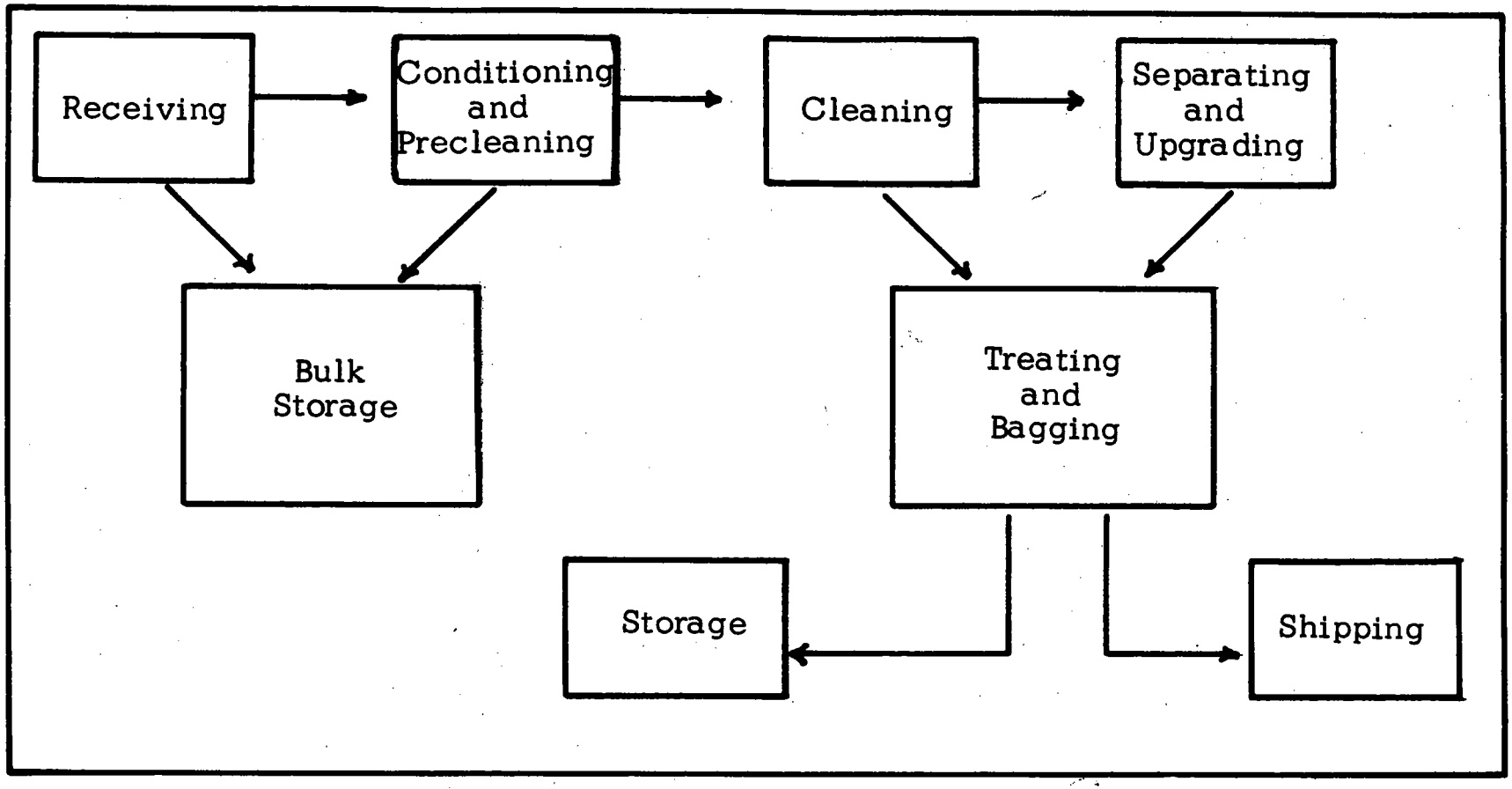


Figure A2. Basic flow diagram showing essential steps in seed processing.

Basis of Separations

Seed processing is based on differences in physical properties between the desirable seed and the contaminating weed or other crop seed. Seed that do not differ in some physical characteristic cannot be separated. If a difference exists between the seeds and a machine is available which can differentiate between them in a consistent manner, they can be separated. Seed processors can choose from a wide selection of machines that differentiate between seeds differing in SIZE, LENGTH, SHAPE, WEIGHT, SURFACE TEXTURE, COLOR, AFFINITY FOR LIQUIDS, or CONDUCTIVITY.

A single machine cannot separate seeds that differ in all these characteristics. In most instances a different machine must be used to make separations based on each of these characteristics.

Size

Size is the most common difference among seeds, and between seed and undesirable material. Size separations are basic to seed processing. The air-screen machine - the basic seed cleaner - uses a series of perforated sheet metal or woven wire screens to separate seed of different sizes. One or more air blast separations remove light material. In a typical air-screen machine, the seed mixture drops through an air blast onto several screens, and then through a second or even a third air blast where remaining light material is removed.

The first screen has perforations large enough to allow the crop seed to drop through. Larger undesirable material does not drop through the openings, and rides over the screen and out a separate discharge spout. The crop seed then fall onto a second screen which has openings smaller in size than the crop seed. As the seed pass over this screen, all seed, seed pieces, or inert material smaller than the good crop seed drop through the screen openings into a discharge spout. Good seed ride over this screen, and may pass onto additional screens for finer and closer size separations, or be moved to other machines, or bagged.

Two types of screen sizings are made: (1) SCALPING, in which good seed drop through the screen openings while larger material is carried over the screen into a separate spout, and (2) GRADING, in which the good seed ride over the screen while smaller particles drop through the screen openings. A series of scalping and grading operations remove all material larger or smaller than the crop seed. The paramount feature of the air-screen machine is the wide range of available screens - over 200 different sizes and shapes of perforations. Seed processors must

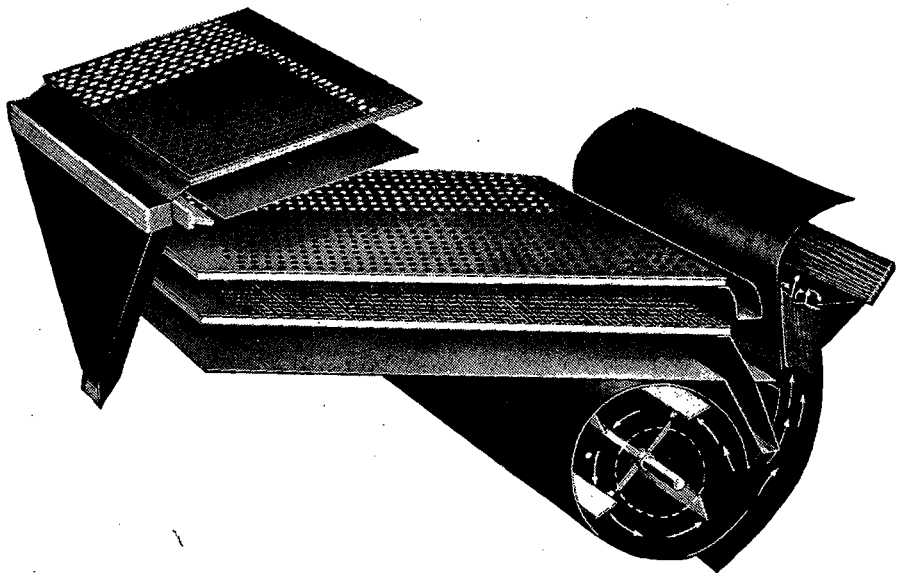


Figure A3. Section view of screens and air system in an air-screen cleaner.

know the characteristics of crop seed and material to be removed, how to operate the machine, and have available all scalping and grading screens needed to remove undesirable material from the crop.

Width and Thickness

Width and thickness are special size dimensions used in operations such as sizing hybrid seed corn into specific widths and thicknesses for space-planting. Several seed seprations are also made by width or thickness sizing. Width or thickness separations are made by turning the seed on edge or standing it on end to present its width or thickness dimension to perforations of specific size. If the seed is less than the selected width or thickness, it will drop through the perforation; if it is greater than the selected width or thickness, it will not go through, and will be discharged into a different spout. A thickness separation is made by cylindrical or flat screens which have slotted perforations in the bottom of recessed grooves. The shoulders of the groove turn the seed on edge before it reaches the slotted perforation. Thin seed fall through, while thick seed are rejected and go out a separate discharge spout.

Width separations are made by round-hole perforations at the bottom of indents or cup-like depressions in cylindrical or flat screens.

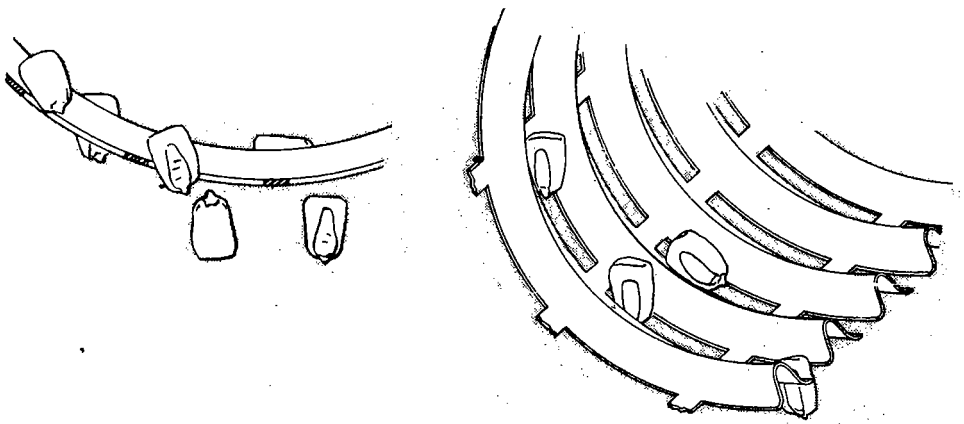


Figure A4. Diagram of thickness separation of corn seed using a screen with slotted openings.

Shoulders of the indent tilt the seed on end and present its width dimension to the perforation. If the seed is narrow, it drops through the perforation; if it is wider than the perforation, it is rejected. A series of width and thickness separations can be combined in a single machine to produce several different width and thickness sizes in the same operation. For example, corn seed can be sized into different flat and round sizes.

Length

Length differences are common among crop seed and weed seed, and are frequently used to upgrade and improve quality. Both the indented cylinder and the disc separator make length separations. The indented cylinder separator consists principally of a long round cylinder whose inner surface has thousands of small indents of a precise size. Inside the cylinder are other parts that help make the separation, including an auger to keep the seed mass level, a lifting trough to catch seeds, and an auger to remove lifted seed from the trough. Seed are fed into the cylinder as it turns. The seed mass turns as the cylinder revolves so that each seed has an opportunity to fit into one of the indents and be lifted. The relationship of seed length and center of gravity to the depth or size of the indent determines whether the seed will be lifted. Long seed do not fit completely into the indent, so they do not remain

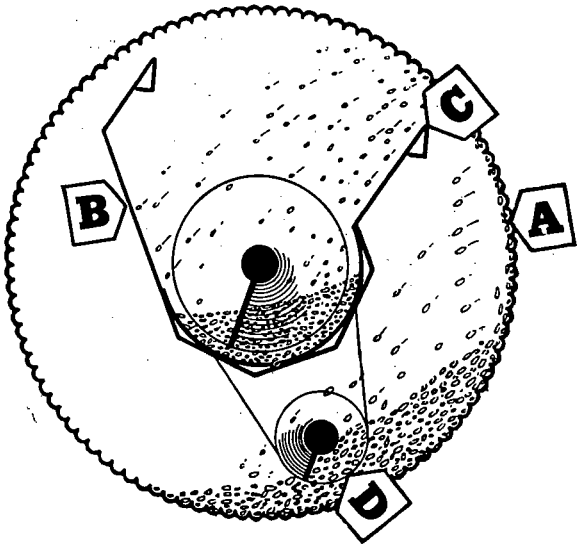


Figure A5. Cross-section of a length separator. A, the cylinder wall with indents stamped into it; B, the adjustable trough catching short lifted seed; C, the separating edge of the adjustable trough; and, D, the auger conveyor in the bottom of the cylinder that conveys long rejected material out of the cylinder.

in the indents long enough to be lifted as the cylinder revolves. Seeds intermediate in length are lifted slightly above the edge of the seed mass by the indents. Shorter seed are lifted higher up the arc of the cylinder's rotation, and are dropped into the lifting trough and go out a separate spout. Thus, length of seeds determines their fit in the indents, and how high they are lifted.

The disc separator also separates seeds differing in length. The discs are cast iron wheels with many small undercut pockets cast into both faces. As the disc turns through a mass of seed, each seed has a chance to seat in a pocket. If the seed is long, it will fall out; if it is short, it will seat inside the pocket and be lifted out of the seed mass. Lifted seed are carried up and dropped into a separate discharge spout. Various pockets shapes are available. Square-shaped pockets separate different crop seeds; pockets with rounded lifting edges lift round seed, and pockets with flat lifting edges lift flat-sided or rectangular seed.

The complete disc separator consists of a revolving shaft with many discs mounted on it. Seed enter the machine at one end, move through the center of the discs, and come in contact with the pockets on the side of each disc. These pockets either reject or lift out seed as the mass moves through the machine. By using a series of discs of different pocket sizes on the same shaft, several length grades can be made in one machine.

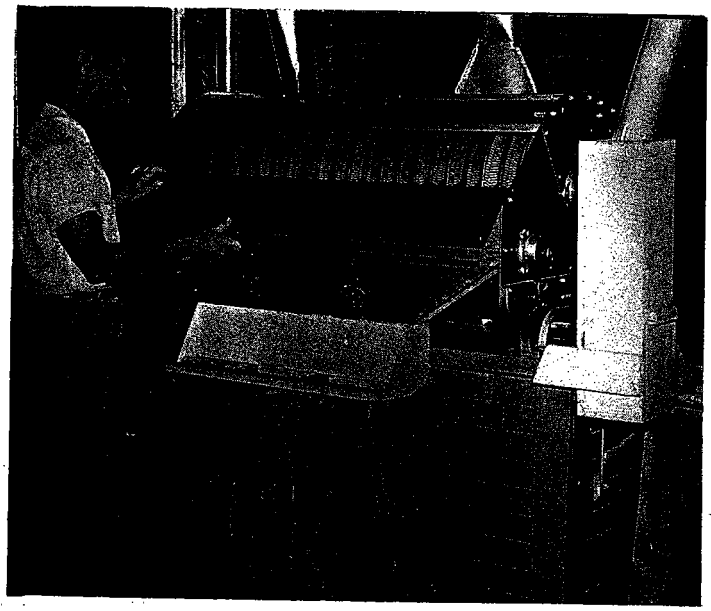


Figure A6. Disc separator used to separate seed on basis of differences in length.

Shape

Shape varies widely among seeds. The separations made by the air-screen machine are often related to differences in shape, especially when triangular-hole screens are used. The indented cylinder and the disc separator take advantage of shape differences, particularly when they are a function of length. There is a machine, however, designed especially to separate round from flattened seed - the spiral separator.

The spiral separator consists mainly of a simple vertical series of spiraled flights. A mixture of flat and round seed is fed onto the inner spiral at the top of the machine. (As seed move down the spirals under the influence of gravity, the velocity of the round free-rolling seed increases to the point where they roll over the inclined edge of the inner flight of spirals, into an outer flight. This outer flight discharges into a separate spout. Flattened or irregular-shaped seed slide down rather than roll down the spiral and do not attain sufficient velocity to roll over the edge of the flight and continue down the flight to the discharge spout. Thus, flat and round seed are separated in the spiral separator by differences in roundness or their ability to roll.

Surface Texture

Relative roughness or smoothness of the seed coat - surface

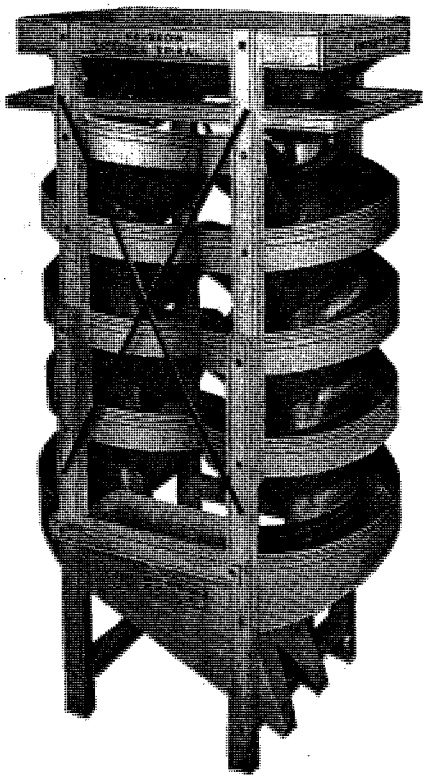


Figure A7. Krussow double spiral separator.

texture - is a common difference between seeds. The roll or dodder mill, the draper belt, the magnetic separator, the buckhorn machine, and vibrator separator all effect separations of seeds differing in surface texture.

The basic unit of the roll mill consists of two long cylinder-like rollers, covered with a velvet or flannel material, and positioned side by side so that they touch along their entire length forming a trough above and between the rollers. The long axis of the paired rolls is slightly inclined. The mixture of smooth and rough seed is fed into the trough formed by the rolls at the high end. As the rolls revolve in opposite directions up and out from the trough center, rough seeds are caught by the nap of the velvet or flannel fabric covering the rollers, and are thrown up against the bottom of a curved shield mounted just above the rollers. A seed thrown against the shield strikes it at an angle, and rebounds back to the roller at an opposite angle, thus striking the roll at a higher position than that from which it started. It is then thrown back against the shield. This ricocheting action continues until the rough seed is carried over the edge of the rolls and falls into a separate discharge spout.

The surfaces of smooth seed do not catch in the nap of the roll fabric, so they slide down the rollers until they reach the lower end and are discharged. The long axis of the rolls usually feeds three bins with discharge spouts. Near the upper end only rough seed, such as

Figure A8. Roll mill used to separate rough seed from smooth seed.

dodder removed from alfalfa, are thrown over by the rolls. As the seeds move down the rolls, rough seeds are still being thrown over, but an increasing percentage of smooth seed will be caught and thrown over. At the lower end of the rolls only smooth seed, such as alfalfa, remain and are sent out the smooth seed spout. Thus, seed discharged at the upper end are all rough, while those discharged at the lower end are all smooth. There are, however, intermediate or middling fractions consisting of varying proportions of rough and smooth seed.

The inclined draper belt also separates flat from round or rough from smooth seed. It is essentially a tilted flat-surfaced, endless belt that moves in an uphill direction. A mixture of rough and smooth seed is fed onto its center. Smooth seed roll or slide relatively easily on the belt, so they slide downhill under the influence of gravity and fall off the low end. Rough seeds do not roll or slide readily on the moving belt, and are carried over the upper end of the belt where they are discharged. Extreme differences in surface texture such as the roughness of dodder and the smoothness of alfalfa are not essential for an effective separation with the draper belt or the roll mill. Sharp edges, sharp points, or projections on many seed are sufficient to permit their separation from smooth seed with the roll mill or the draper belt.

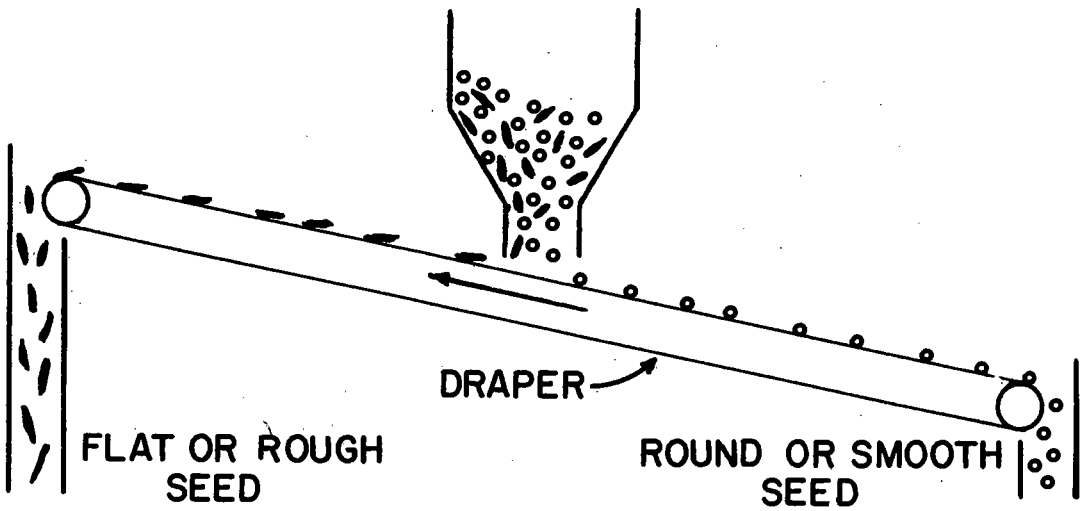


Figure A9. Diagram of an inclined draper belt separator.

Color

Many seeds differ in color or reflectivity. Color separations are used more and more in processing, particularly with the larger crop seeds. Electronic color sorters make color separations. These machines present each seed to electronic sensing devices which compare the seed with an electronic pattern or a given color background. If the seed's color hue or reflectivity is acceptable, it is allowed to continue to a discharge spout. Seeds not in the acceptable range of color hue or reflectivity are divided from the main stream by compressed air or other devices.

One electronic color separator employs a revolving, endless, U-shaped belt to discharge seed on a calculated trajectory through the electronic sensing chamber where photoelectric cells compare each seed with a selected background color. Another color separator picks each seed up on a vacuum ferrule and passes it through a color sensing chamber where photoelectric cells sense its color and either accept or reject it. Color sorters have relatively low capacity, but their versatility makes them unusually valuable for difficult separations on large or valuable seeds.

Affinity for Liquids

Seeds also differ in their affinity for liquids, or the rate at which

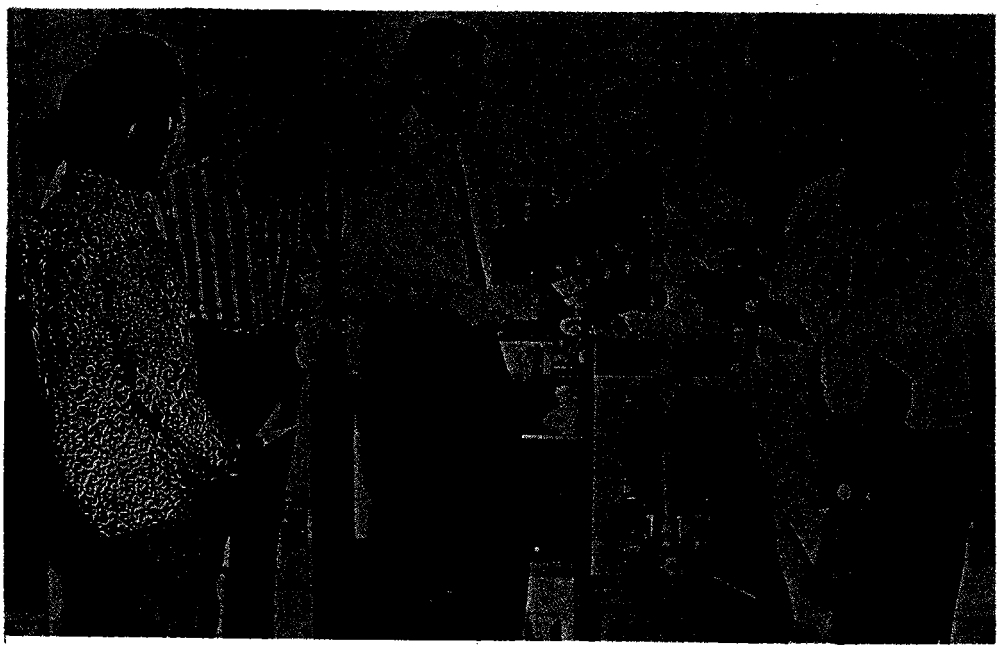


Figure A10. An ESM electric color sorter.

their surface will absorb liquids. The magnetic separator and the buckhorn machine separate seed on the basis of these differences. In the magnetic separator, seed are fed into a mixing chamber where a small amount of water or other liquid is added to the mixture. Some seeds absorb moisture and become damp, while others do not.

After each seed has had an opportunity to absorb moisture, finely-ground iron powder is fed into the mixing chamber and blended in so each seed has a chance to come in contact with the iron powder. If the seed surface is moist, the iron powder will stick to the moist seed coat. If the seed surface is not moist, the iron powder will not stick to it. The seed mixture is then passed over a magnetized drum or cylinder. Seeds which retain iron powder are attracted by the magnet, stick to the drum, and are separated from the seed stream. Seeds which do not retain the iron powder do not react to the magnetic field, and are discharged from the machine.

The buckhorn machine operates on a similar principle. It was designed specifically to remove buckhorn plantain from clover seed. The seed mixture is fed into a mixing chamber where moisture is added. After each seed has had an opportunity to absorb moisture, finely-ground hardwood sawdust or bark is introduced into the mixing chamber. When moisture comes into contact with buckhorn seed, a dried material on the seed surface becomes mucilaginous and sticky. This sticky material causes

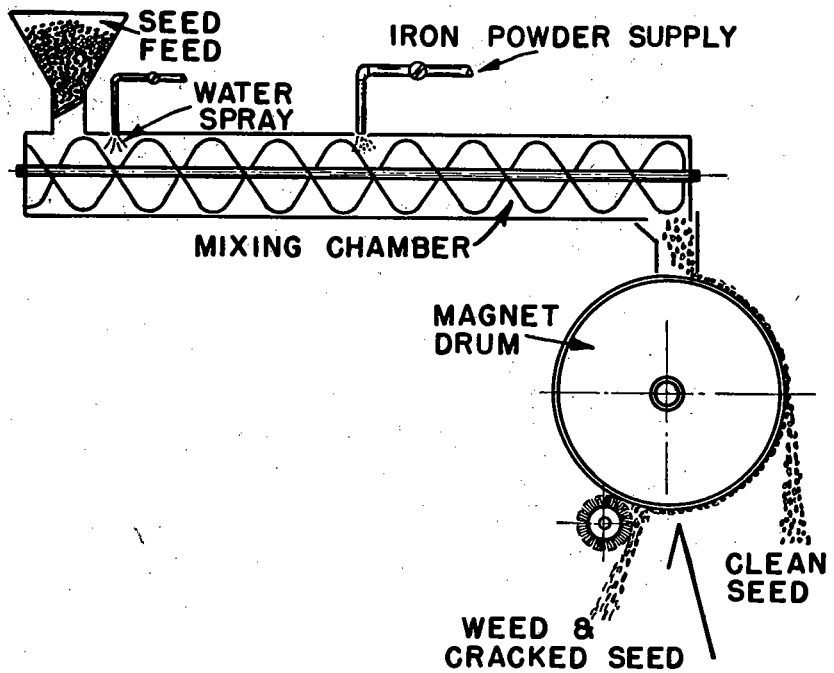


Figure A11. Diagram of a drum-type magnetic seed separator.

the fine sawdust to stick to the seed. Thus, a moistened buckhorn seed ends up in the center of a ball of sawdust, and can be removed by a gravity separator or an air-screen machine.

Weight

Many seeds differ in weight, specific gravity, or relative density. Weight or specific gravity is the effective separation principle in the air-blast separations in air-screen machines. However, the gravity separator, the stoner, the aspirator, and the pneumatic separator are all designed to make specific separations by differences in weight or specific gravity of seed.

The specific gravity separator consists basically of a perforated deck that permits movement of an air stream through it. Seed are fed onto this deck and into the air stream. The air stream is adjusted to lift light seed while heavier seed lie on the deck surface. Then the stratified layers of seed are separated so that light seed go to one discharge spout and heavier seed to to a different spout. This is accomplished by a reciprocating motion through the horizontal axis of the deck. Since the deck surface is mounted at a slight angle, light seed held up by the air will flow downhill and discharge from the low side of the deck. Heavier seed lie in contact with the surface of the deck. As the deck reciprocates, this motion tosses heavy seed in an uphill direction. Each time the deck moves, the seed are worked slightly uphill. This motion continues until heavy seed are carried to the high end of the deck and go out a separate discharge spout.

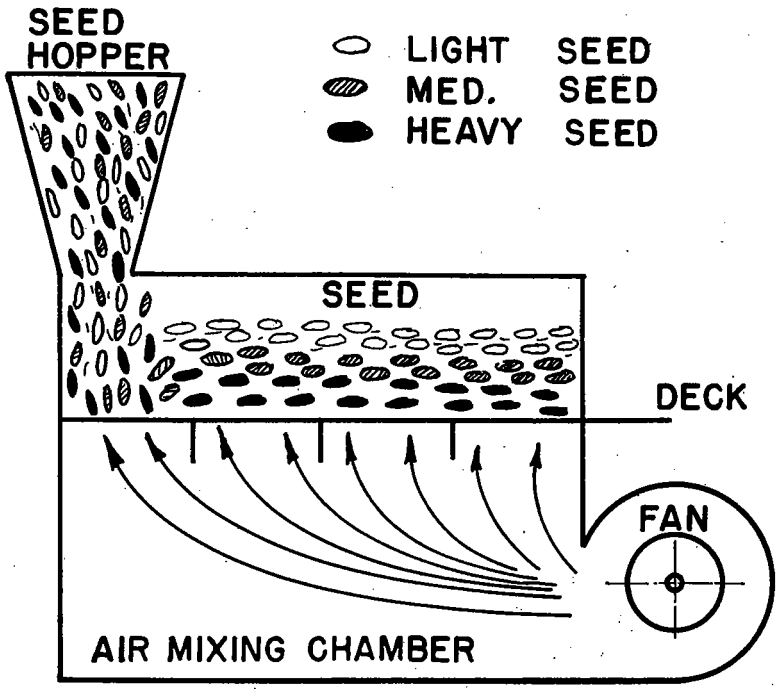


Figure A12. Diagram of air flow through seed on the deck of a specific gravity separator. Seed are stratified into vertical zones by weight.

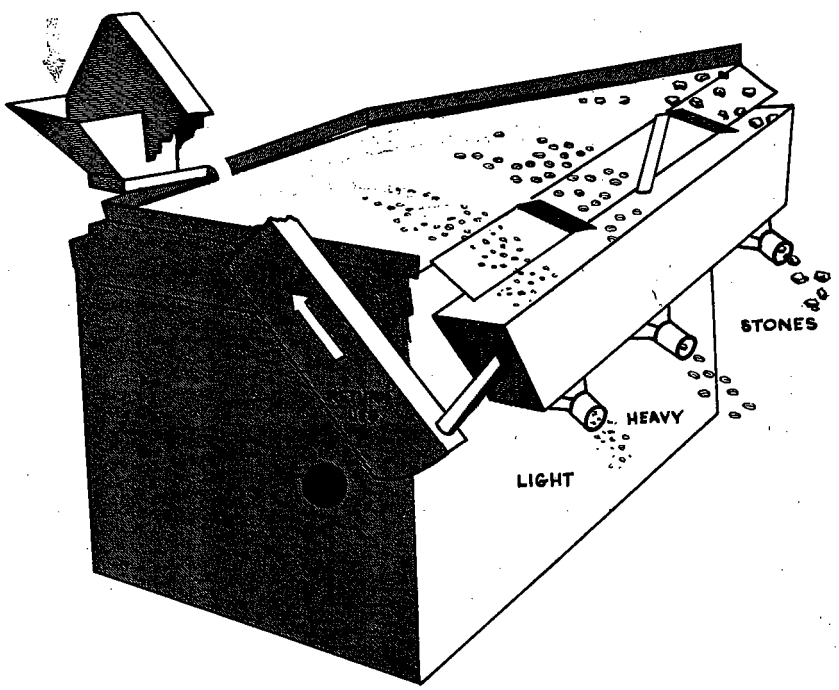


Figure A13. Diagram of gravity separator showing seed flow across the deck.

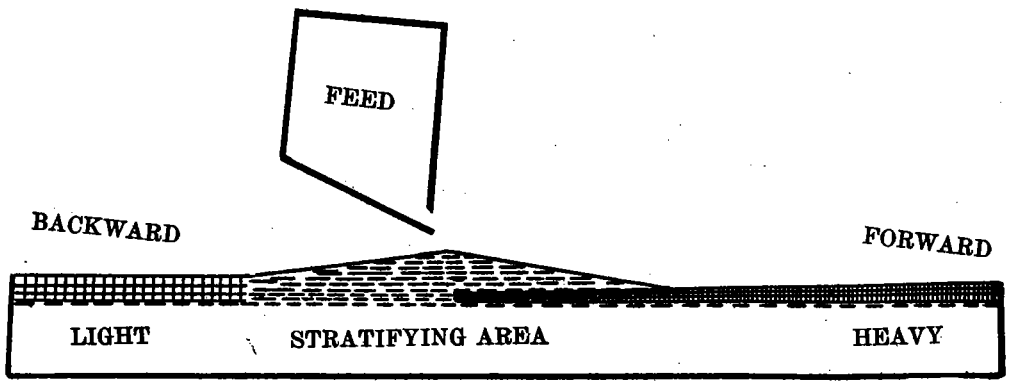


Figure A14. Section view of a stoner separator.

As the seed move from the feed spout through the stratifying area, the light seed flow downhill toward the low corner of the deck and heavier seed move uphill toward the upper corner. Between the paths of the heaviest seed and the lightest seed, a middling product is formed in the center which contains heavy, light, and intermediate density seed. The gravity makes a graded separation from the lightest seed at the lower end of the deck to the heaviest seed at the higher end of the deck.

The stoner makes only a two component gravity separation - a heavy and a light fraction. The seed mixture is fed onto the stoner deck while an air stream moves through it. Air stratifies the seed and causes light seed to flow to the downhill end. The reciprocating motion of the deck moves heavy seed toward the high end of the deck. The stoner is very useful in separating rocks from beans, sand from clover, or similar separations. Stoners are commonly used to salvage good seed from waste products coming off the high end of the gravity separator.

Aspirators and pneumatic separators also separate seed on the basis of differences in weight, specific gravity or density. Separation in the aspirator is accomplished by pulling a negative-pressure air stream through a column. Seed fed into the air stream move up or down,

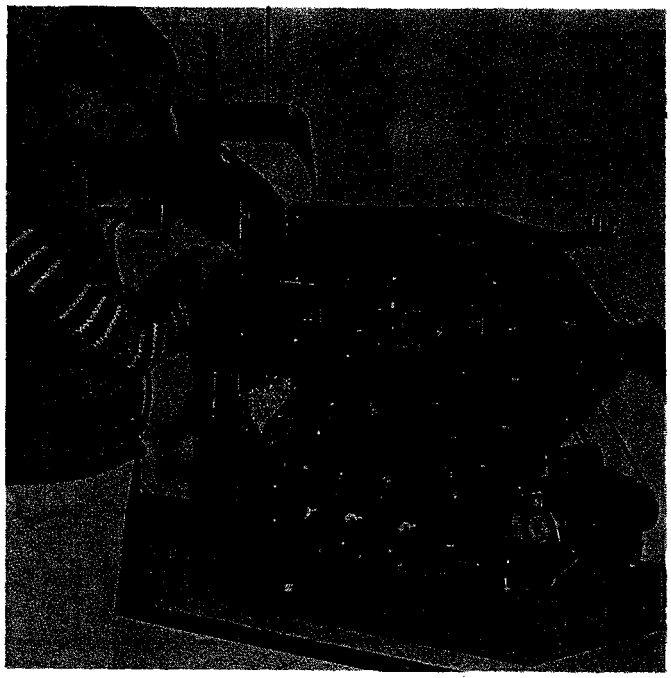


Figure A15. Small fractionating aspirator.

depending on their terminal velocity. Light seed of low terminal velocity will be carried along with the air stream and discharged through a spout. Heavy seed with terminal velocity higher than the air stream will pass through it and fall into a separate discharge spout. Some aspirators separate seed into several fractions, each differing in density.

The pneumatic separator is quite similar to the aspirator. In this machine, however, separation is accomplished by forcing a positive-pressure air blast through a separating column where light and heavy seeds are separated according to their terminal velocities.

Conductivity

Seeds also differ in their ability to hold or conduct an electrical charge. Although many conditions affect a seed's electrical properties, consistent differences in such properties can be used to make some difficult separations. The machine which separates seed on the basis of electrical properties is called an electrostatic separator. A typical electrostatic separator consists essentially of a conveyor belt which carries a single layer of seed beneath an electrode.

Two types of electrostatic separations are made. In the "pinning" separation, the electrode sprays a high-intensity electrical charge onto

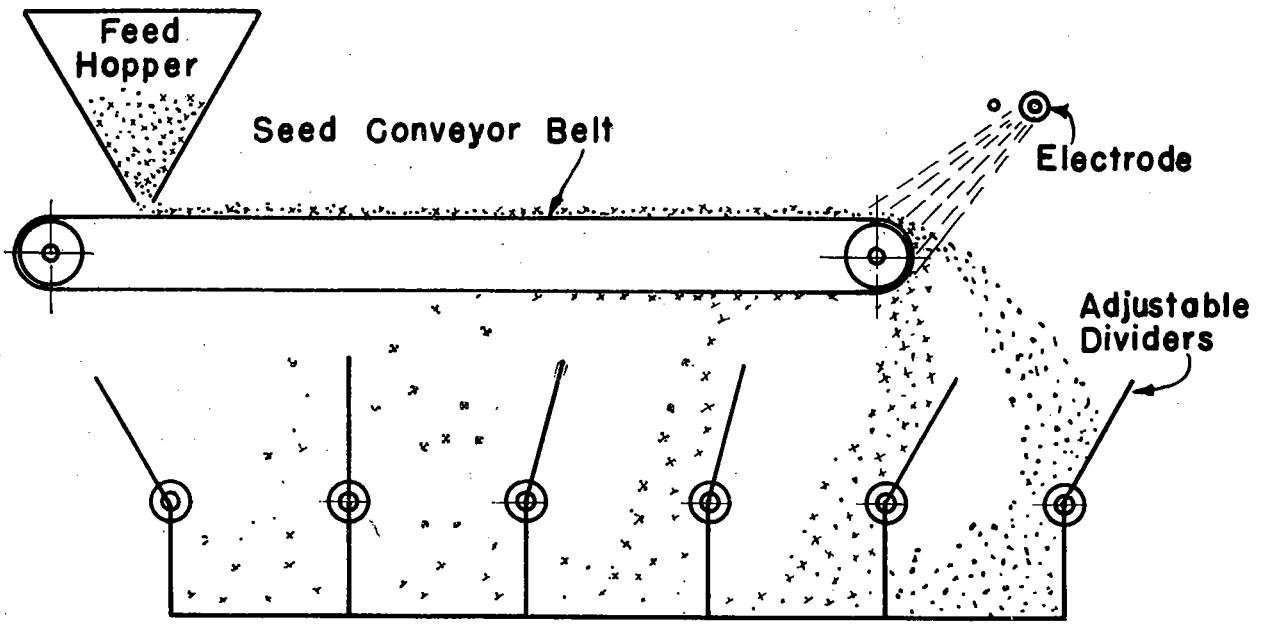


Figure A16. Schematic drawing of a belt-type electrostatic seed separator.

the seed. Poor-conductors absorb and hold the charge, stick to the grounded conveyor belt and are carried to a discharge spout. Good-conductors lose their charge readily and are dropped into a separate spout. The "lifting" separation is made by passing seed through an electrical field created by a different type of electrode. Here, charges on the seed are rearranged in reaction to this electrical field. Some seeds are attracted to the electrode and lifted into a different flight path as they fall from the belt or roller. Other seeds which react less to the electrical field follow a normal flight path to the discharge spout.

Summary

Many models and types of machines with a wide range of capacities are available to the seed processor. Properly operated, these machines allow him to remove contaminants which differ from the crop seed in size, length, shape, weight, surface texture, affinity for liquids, color, and electrical conductivity. They can be used to upgrade germination and purity at efficient and economical rates. To use the machines effectively, the processor must know the principle each machine uses to separate seeds, how to adjust them for maximum separation and capacity, and their proper places in the overall processing operations.

The processor must also know the physical properties of the crop seed he is processing, and the physical properties of the weed seed and other contaminants in the crop seed. After the differences in crop seed and contaminant physical properties are known, the processor can select the machine that will make the most efficient separation.

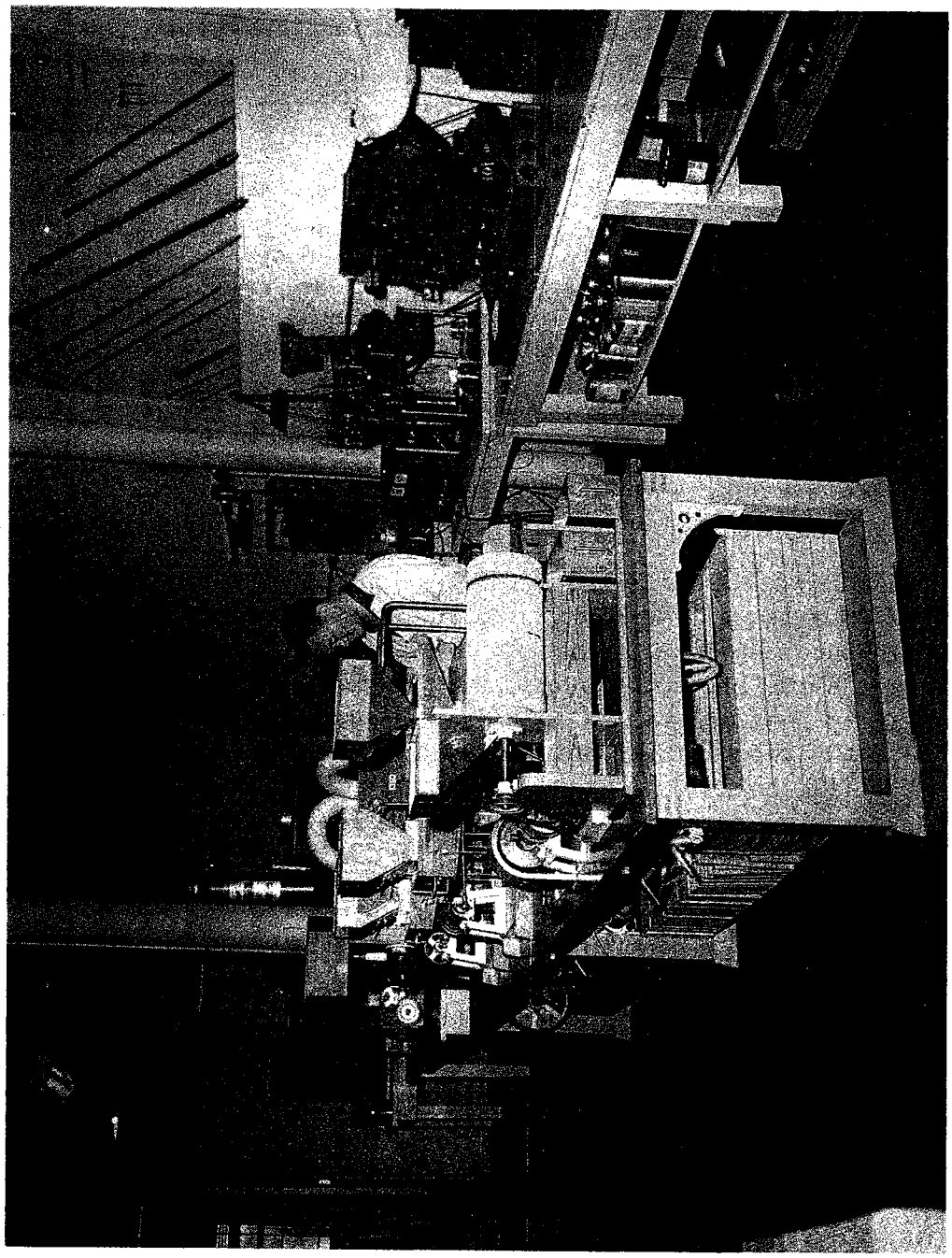


Figure A17. Laboratory models of processing equipment used in teaching and analysis of problem seed lots.

Precleaning and Conditioning Equipment

Section B

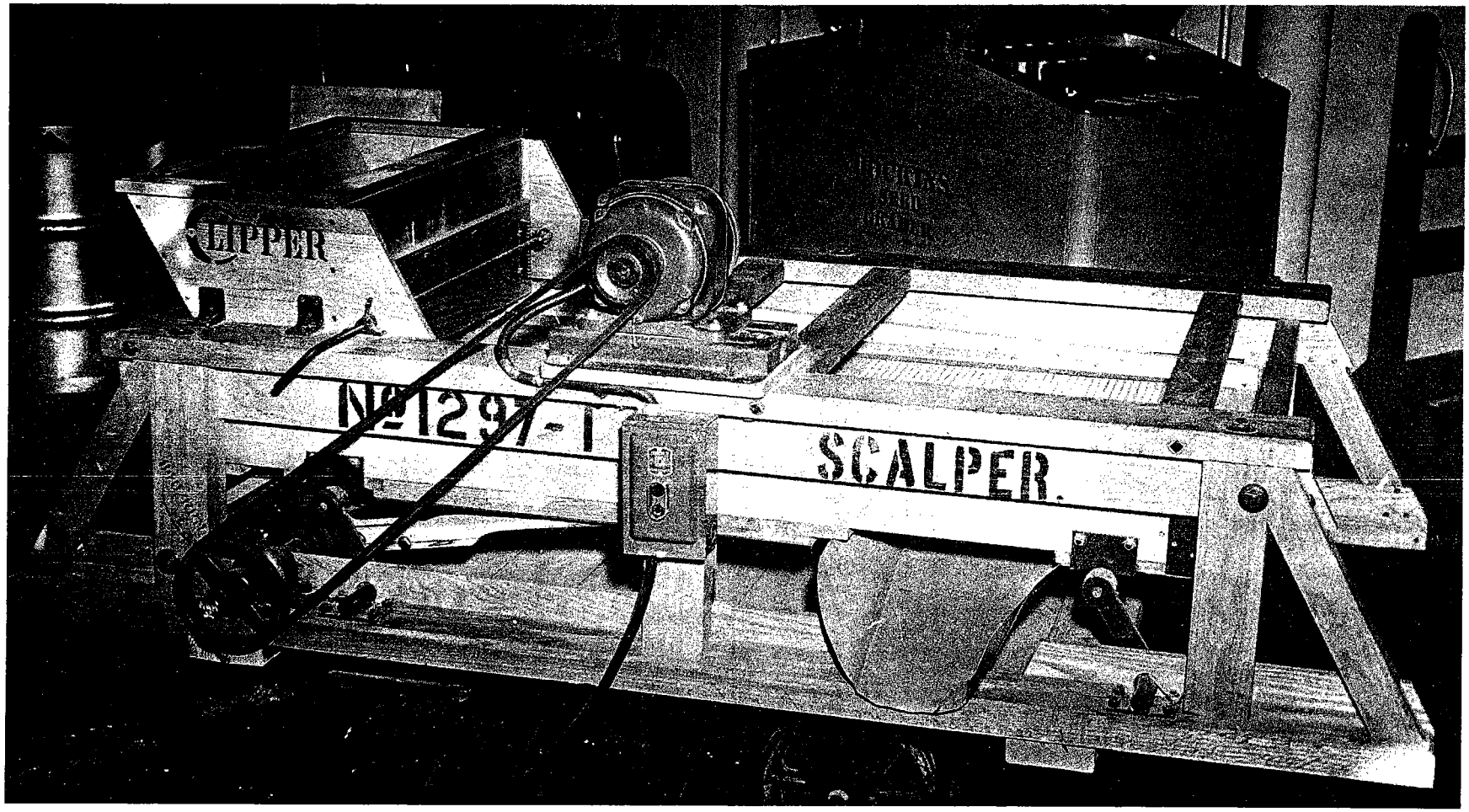


Figure B. Portable single screen scalper.

SCALPERS

Scalping is a precleaning operation in which material larger than the crop seed is removed from the seed lot. Rough-cleaning, on the other hand, is a process in which material both larger and smaller than the crop seed is removed. Scalping or rough-cleaning is now regarded as a basic operation by many seedsmen, because seed harvested with modern combines are often heavily contaminated with foreign material such as sticks, stems, leaves, trash and weed seeds. This material, which may be as much as 60 to 70 percent of the volume of the combine-run seed lot, needs to be removed before seed can be safely stored, efficiently dried or effectively cleaned.

Since processors' preferences and needs differ, there are many different sizes and types of scalpers available from which a unit can be selected to satisfy a specific need. Sizes range from high capacity receiving scalpers to the small diameter reel scalpers found, as standard equipment, on disc-cylinder separators. Types range from the single reel or the single flat perforated screen that removes long stems and green material to the more complex and flexible units consisting of several screens or reels with one or more controlled air separations. Near complete removal of foreign material is possible with the units that incorporate both screening and aspiration, so they are the most effective in preparing combine-run seed for further processing.

Parts of the Machine

A description of the more important parts of the various type scalpers follows. Not all parts are found as components of each type scalper.

Feed Hopper

The feed hopper receives the seed to be cleaned from the elevator or some other source and feeds it at a controlled rate to the cleaning components of the machine. Rate of feed is controlled by a sliding gate or feed roll at the bottom of the hopper.

Screens

The bulk of trash or other foreign matter in the seed lot is separated from the seed by screens. Although the screens in a scalper may have different overall dimensions than those in an air-screen cleaner, perforation sizes and types available are the same. (See the

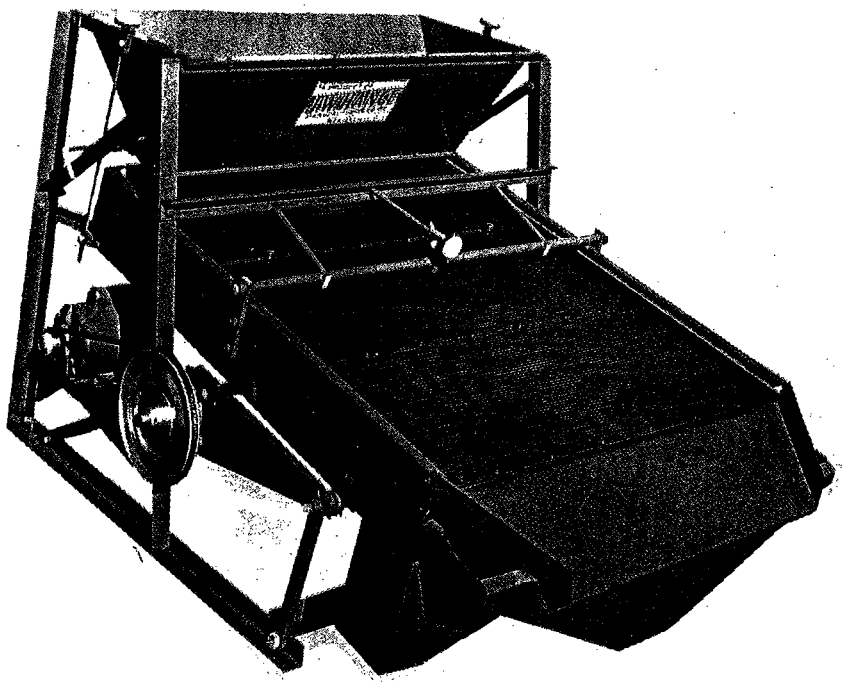


Figure B1. Hance Super-Speed scalper, Model 36. Scalper has two screens.

discussion on characteristics of screens in the chapter on Air-Screen Cleaners.)

Shoe

The shoe is the vibrating or shaking part of the machine into which the screens are placed. A machine may have one or two shoes, depending upon the size of the machine. The shoes are sloped to cause the seed to flow down the screens. In a two-shoe machine, the sloping is in opposite directions for each shoe, forming a V, so that the movement of one shoe counteracts the movement of the other. Therefore, vibration is held to a minimum.

Reel

Certain types of scalpers have a rotating reel screen instead of a flat vibrating screen. The reel screen may be of perforated metal or of heavy-gauge woven wire mesh.

Fan

Some scalpers have a fan, others do not. The air separation will be made before the seed reach the screens to remove dust and light material.

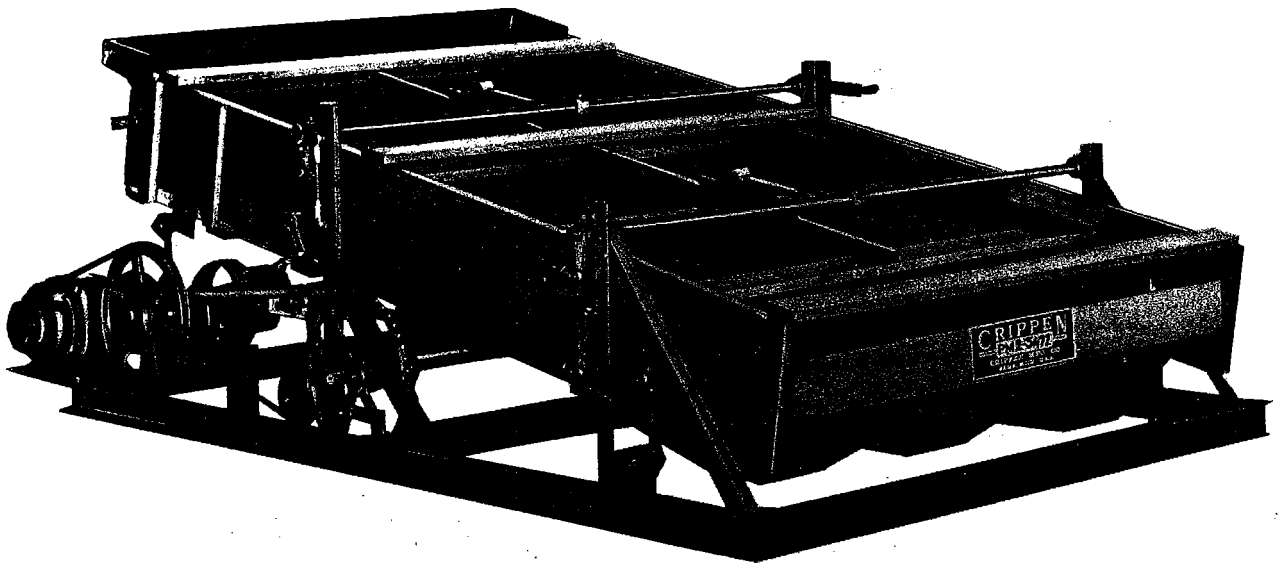


Figure B2. Crippen PM2-5472 scalper.

Principles of Operation

Seed to be scalped are fed into the cleaning area from the bottom of the feed hopper. If the scalper has a fan, the seed pass through the air separation to remove light chaff and dust before they reach the screens or reel.

Perforations in the scalping screen should be large enough to permit crop seed to drop through readily, but small enough to prevent large foreign material such as stems, sticks, and leaves from dropping through the screen.

If the scalper has two screens, the second is used to remove material smaller than the seed. So, perforations in the second screen should be small enough to retain all crop seed but large enough to drop foreign material smaller than the seed.

In reel type scalpers the seed fall through the rotating reel and discharge underneath the reel. Sticks, stems and other large foreign material are rolled out of the machine by the rotating reel.

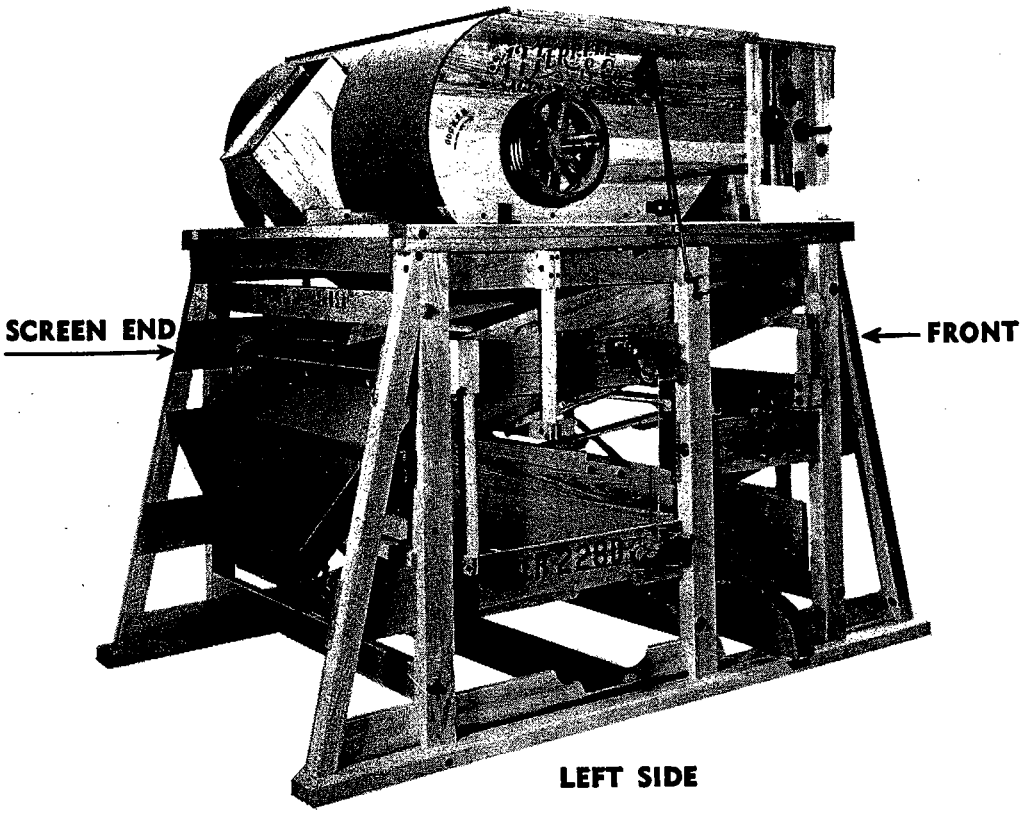


Figure B3. A. T. Ferrell, Super 228-D, receiving scalper. Scalper has two screens and an air system.

Adjustment of Equipment

Rate of Feed

When adjusting a scalper, capacity should not be sacrificed in favor of more thorough cleaning, since final cleaning will be made on the air-screen cleaner or other finishing machines. The feed gate should be opened sufficiently so that a steady, even flow of seed flows from the hopper into the cleaning area.

Screen Selection

Screen openings should not be so close to the size of the seed that capacity is reduced.

Fan

The air separation should remove most of the light chaff and dust before the seed reaches the screens or the scalping reel.

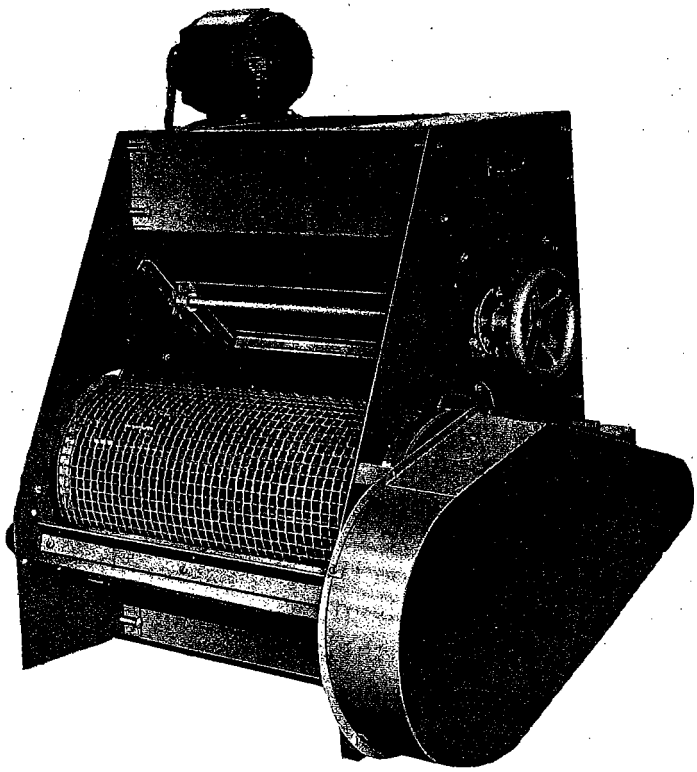


Figure B4. Carter-Day No. 4 reel type scalper.

Installation

The scalper should, with few exceptions, be the first piece of equipment used when the seed comes in from the field. In order to take full advantage of the benefits of scalping, many drying and storage facilities have receiving scalpers to rough-clean all seed lots that are to be dried or stored prior to being finally cleaned. These operators have learned that by removing most of the trash and green material as the first step in their operation they will encounter fewer handling problems, reduce drying costs and save on storage space.

Similarly, a scalper in the processing line should also be the first piece of equipment used. It should be installed either ahead of the main receiving elevator or just ahead of the air-screen cleaner. If ahead of the main elevator, it will allow easier and more rapid conveying of combine-run seed and increase capacity of holding bins. Even when installed just ahead of the air-screen cleaner, a scalper has many advantages. Scalping increases the capacity of the air-screen cleaner by minimizing feed hopper stoppages. As a result, feeding is more uniform and the operator can make more accurate and sensitive machine adjustments.

Scalping with a scalper-aspirator before the seed lot enters the processing area of the seed plant has still another advantage. It will help reduce the dust which is both a health and safety problem.

Summary

Scalping is regarded as a basic operation by many seedsmen, because seed harvested with modern combines are often heavily contaminated with foreign material such as sticks, stems, leaves, trash and weed seeds. There are many different sizes and types of scalpers ranging from high capacity receiving scalpers to small reel scalpers found as standard equipment on other machines. When a scalper is used, capacity should not be sacrificed in favor of more thorough cleaning, since final cleaning will be made on the air-screen cleaner or other finishing machines. The scalper should, with few exceptions, be the first piece of equipment used when the seed comes in from the field, in order to rough-clean all seed lots that are to be dried or stored prior to being finally cleaned.

DEBEARDERS

Important requisites for efficient and effective seed cleaning are that the seed be completely threshed and as "free flowing" as possible. These requisites are not always met because of inefficiency in threshing and harvesting equipment and/or peculiarities in the morphology of the seed heads or units. Seed of some forage grasses and small grains have awns, beards or glumes that are not completely removed during threshing. These cause the seeds to cling together and prevent effective size separations. Removal of these appendages allows more efficient cleaning and accurate planting, and improves the test weight. In other cases combine-run seed contains unthreshed pods, seed heads, or clusters of seed that are much larger than the completely threshed seed. To minimize good seed losses, these clusters, heads, or pods must be completely broken up before the lot is cleaned.

Many seedsmen use a machine called a "Debearder" to eliminate many of the difficulties described above and to better prepare the seed for the various cleaning operations. Basically, the debearder completes threshing of unthreshed or partially threshed seed and removes appendages or hulls that interfere with flow of the seed and prevent effective sizing separations.

Parts of the Machine

Feed Inlet

The debearder has a feed inlet which controls the flow of seed into the machine. Usually the feed inlet is offset, so that the commodity is introduced to the beaters in the direction of the rotating arm.

Rotating Beater Arms

The rotating beater arms are steel bars installed on a central shaft at a 15° angle to the perpendicular of the shaft. These rub the seed and convey it through the machine.

Stationary Beater Arms

The stationary beater arms are similar in construction to the rotating beater arms. They are permanently fixed to the inside of the machine at the same angle. The rotating beater arms pass between the stationary beater arms during operation of the machine.

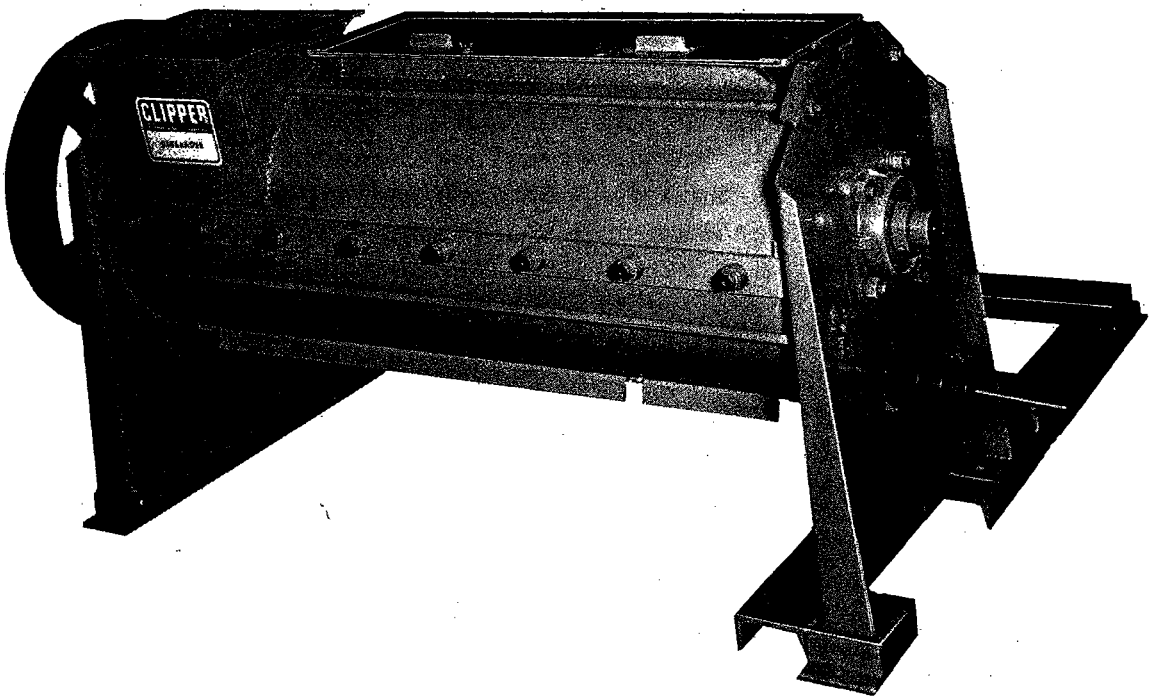


Figure B5. Clipper debearder.

Discharge Gate

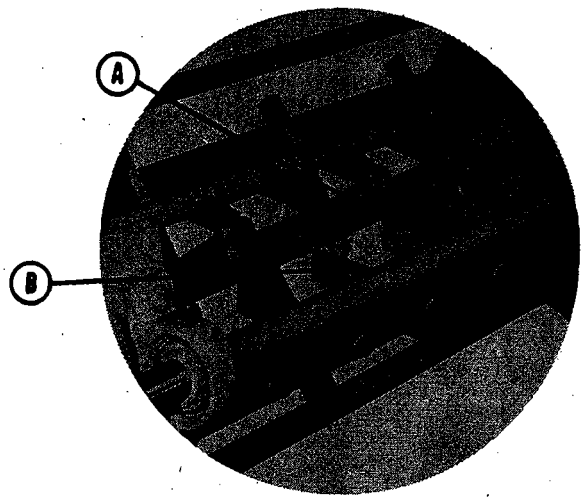
The discharge gate is a hinged gate at the end of the machine opposite the feed inlet through which the commodity passes after being subjected to the action of the beater arms. Attached to the discharge gate is a small shaft on which weights can be placed to control the length of time the seed remain in the debearder and hence the debearding action.

Bottom Discharge Slide

A discharge slide located at the bottom of the machine can be opened for complete cleanout of the machine.

Principles of Operation

Seed are fed through the feed inlet into the machine from a bin above the machine. In the machine the seed are subjected to the action of the beater arms. The rotating beater arms move through the seed mass and between the stationary arms at a relatively high speed. The seed are subjected to a rubbing action which breaks



A. Rotating beater arm with special hard coated edges.
B. Stationary beater arm.

Figure B6. Internal operating parts of a Clipper debearder.

appendages, removes hulls, threshs seed clusters, and in general polishes the seed.

The seed are also conveyed to the discharge gate by the beater arms. When sufficient pressure forces the gate open, seed discharge out of the machine.

Some seed always remain in the machine after completing the operation. These are dropped from the machine through the bottom discharge slide.

Adjustments on a Debearder

Rate of Feed

The feed inlet must have some type of feed control. This is necessary so that the rate of flow into the machine can be adjusted at a rate that will not exceed the discharge capacity of the machine.

Speed of Rotating Beater Arms

An optional variable drive allows control of the speed of the

rotating beater arms. This is extremely useful because speeds and capacities are never constant, particularly when more than one kind of seed is handled. Although exact settings should be determined during each run, the following figures may serve as a guide:

	R.P.M.
Debeard barley	550
Oats - breaks doubles, de-awns, clips glume tips	550
De-awn Dill seed	500
Break-up flax balls	500
De-fringe carrot seed	500
De-awn watergrass (in rice)	350

Position of Weight on Discharge Gate

Changing the position of the shaft weights on the discharge gate will keep material in the machine either more or less time as required for adequate debearding.

Uses of the Debearder

Although primarily designed for debearding barley to improve appearance and planting qualities, debearders are now used for many other kinds of seed. Its principle use today is probably clipping of seed oats to improve their appearance and to raise the test weight. Clipping refers to the removal of the chaffy tips of the oat hulls that extend beyond the grain. Other uses include the partial decortication of sugar beet seed, hulling "whitecaps" in wheat, defringing carrot seed, polishing and removing mold from pepper balls, and breaking up flax balls, legume pods and seed heads. Another use is de-awning weed seed to permit their separation from crop seeds.

HULLER-SCARIFIER

Following scalping, and possibly debearding, most seed go directly to the basic air-screen cleaner. Other kinds, principally those of some legumes and grasses, may require hulling prior to cleaning, and scarification after cleaning.

Hulling and scarifying hastens germination by removal of growth inhibiting parts or by increasing the seed's permeability to water or oxygen. The terms "hulling" and "scarifying" refer to two different processes. In hulling, only the hull or husk surrounding the seed is removed while the seed itself remains unscathed. It is generally done to improve the seed's planting characteristics or to improve the efficiency and effectiveness of subsequent cleaning operations. In scarification, the seedcoat itself is scratched or ruptured to facilitate absorption of water and hasten germination.

Some examples of seed that may require hulling or scarification or both are:

A. Seeds that may require only hulling:

Bermudagrass, Buffalograss, Bahiagrass, Korean Lespedeza, Kobe Striate Lespedeza, Common Striate Lespedeza, Bicolor Lespedeza

B. Seeds that may require only scarification:

Alfalfa, White Clover, Subclover, Hairy Indigo, Crotalaria, Wild Winter Peas

C. Seeds that may require both hulling and scarification:

Sweet Clover, Crown Vetch, Sericea Lespedeza, Sour Clover, Black Medic

Hulling and scarification may be accomplished in separate or combined operations. A combination huller-scarifier is the most commonly used machine. A huller-scarifier will either hull, scarify, or hull and scarify.

Parts of the Machine

Feed Hopper

The feed hopper regulates the flow of seed to the machine.

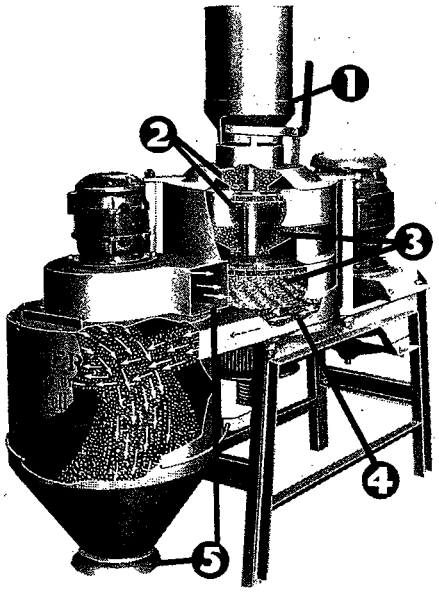


Figure B7. Clipper, Eddy-Giant, huller-scarifier showing: (1) feed hopper; (2) seed falling from the feed hopper onto the first rotating, distributing disc; (3) seed flowing down the funnel-shaped casting to the second rotating, distributing disc; (4) seed being blown into the suction chamber; and (5) suction fan removing light dust and the seed being discharged at the bottom of the chamber.

On some type machines, the feed hopper is funnel-shaped and can be raised or lowered. Other types provide only a feed inlet through which the seed pass.

Rotating Distributing Discs

Rotating distributing discs are corrugated metal discs that rotate in a horizontal plane. These discs throw the seed against the special hulling and/or scarifying surface by centrifugal force.

Carborundum Concaves

The hulling and scarifying parts are in the form of a large stone ring with a concave inside surface. These stones are similar to abrasive carborundum stones used in grinding.

Rubber Concaves

For less severe action, carborundum stones are replaced by hard rubber concaves of the same shape.

Fans

Huller-scarifiers have one or two fans. In two fan models,

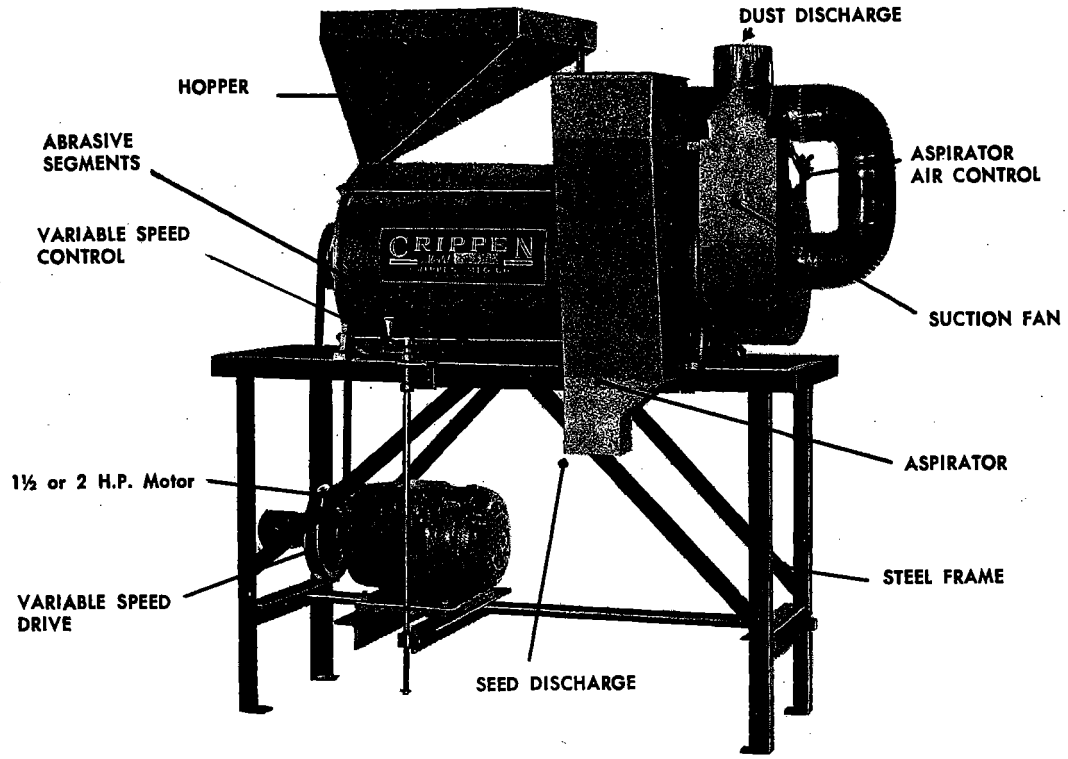


Figure B8. Crippen Model S scarifier.

one fan is located under the lower rotating disc in order to blow the seed into the suction chamber. When the material reaches the suction chamber, the suction fan removes dust and chaff from the seed. A single fan performs both functions in one-fan models.

Suction Chamber

The suction chamber is a settling type chamber, which allows the seed to discharge and the dust and chaff to be pulled away by the suction fan.

Principles of Operation

The seed fall from the feed hopper onto the rotating distributing disc where they are thrown against the hulling and scarifying surface by centrifugal force. At this point the seed are hulled and/or scarified. This type action may occur once or twice depending upon the machine. After this operation the seed are moved into the suction chamber where the suction fan removes the light, fine dust and the seed discharge at the bottom of the chamber.

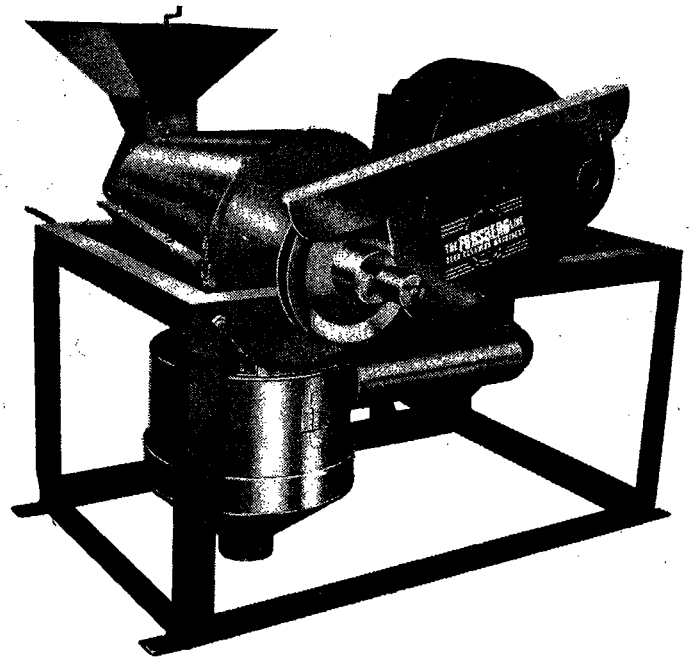


Figure B9. Forsberg huller-scarifier.

Adjustments of the Huller-Scarifier

Rate of Feed

Capacity varies with the kind of seed, its condition, and the job to be done. Rate of feed, however, is not critical. The main consideration is not to overload the machine.

Variable Speed Drive

With a variable speed drive, speeds from 500 to 2800 RPM can be obtained. The rotating distributing discs are driven directly from the variable speed drive. The force with which the seed strike the concaves is determined by the variable speed drive setting.

Position of Concaves

The carborundum rings are concave on the inside and since abrasive action only takes place against the upper part of the rings, the rings can easily be turned over when worn, to give a new, abrasive surface, which, of course, adds years of service to each stone ring.

Uses of the Huller-Scarifier

It should always be remembered that scarification is a delicate operation. The severity of the abrasion or the force of the impact must be accurately controlled to prevent seed damage. Correct machine settings should be determined for each individual seed lot, keeping in mind that seeds with a high moisture content are harder to hull and scarify than dry seed.

Scarification should never be attempted until after the seed lot has been over an air-screen cleaner. Clean seed scarifies much more uniformly and with less seed damage than uncleaned seed. Therefore, the scarifier should be installed either behind the air-screen cleaner or further along the processing line. Hullers, on the other hand, may be installed either between the scalper and air-screen cleaner or further down the processing line. The exact location depends on whether all, or only a portion, of the seed is to be hulled. The huller should be located ahead of the machine that separates hulled from unhulled seed if only a portion of the seed is to be hulled.

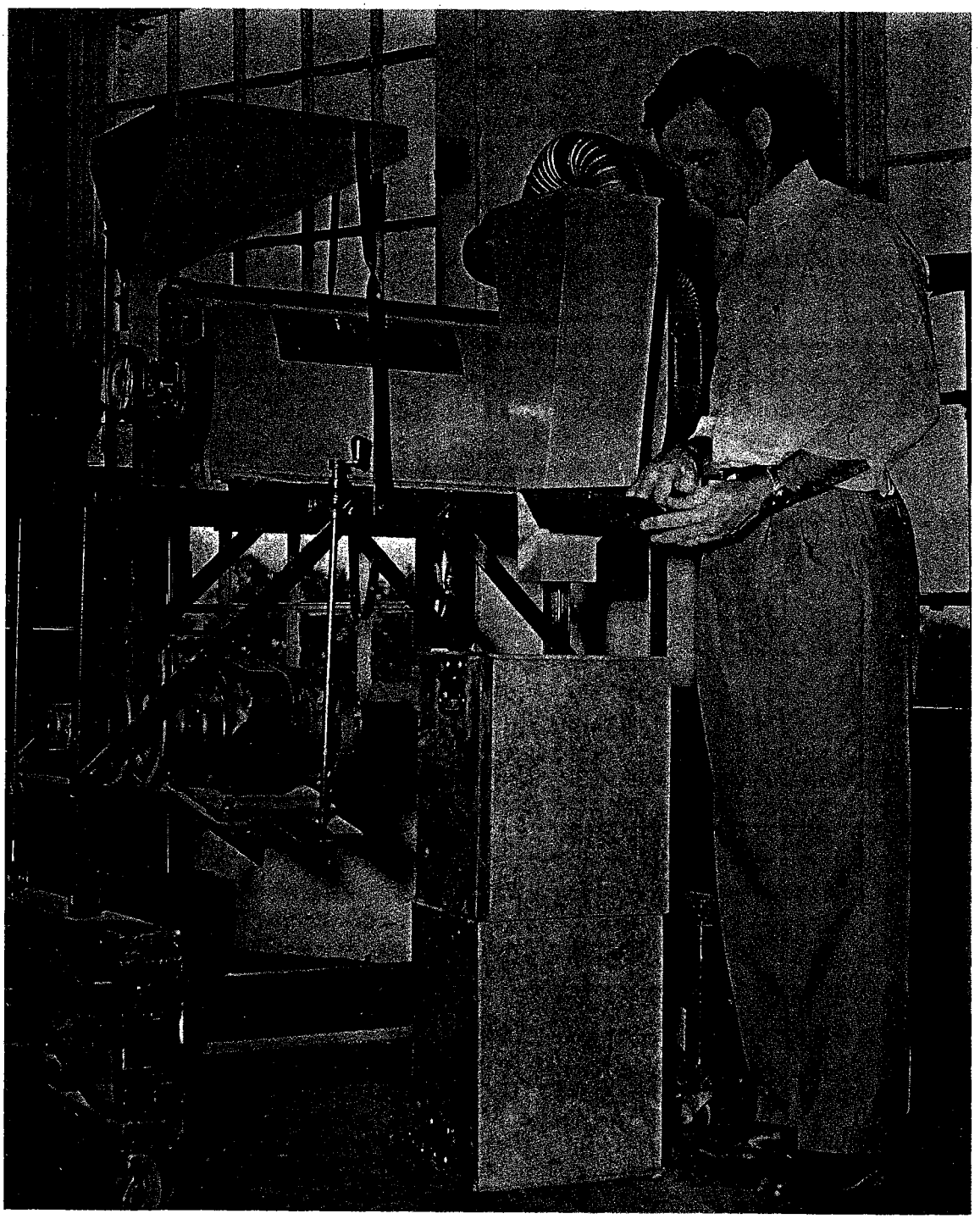


Figure B10. Scarifier mounted on rollers to facilitate change of location.

BUCKHORN MACHINE

Principle of Operation

The buckhorn machine was designed to remove buckhorn plantain seed from forage legume seed. The principle of separation is based on a characteristic of the seed coat of buckhorn plantain seed. When moistened the seed coat absorbs moisture and becomes sticky and mucilaginous. The mixture of legume and buckhorn seed is introduced into the mixing chamber of the machine where a small amount of moisture is added to the seed. The smooth, hard seed coats of the legume seed are relatively unaffected, while the seed coats of the buckhorn become sticky.

Finely-ground sawdust or hardwood bark is then introduced into the mixing chamber. The legume seed again are not affected, but the fine sawdust sticks to each buckhorn seed so that it emerges from the mixing chamber in a ball of sawdust. The buckhorn seed are then larger in size and have a different specific gravity than they had before treatment.

The mixture of legume seed and buckhorn-sawdust balls can be separated with an air-screen cleaner. Legume seed drop through the screen perforations, while the buckhorn-sawdust balls ride over the screen. If small buckhorn-sawdust balls drop through with the legume seed, they can be removed with a gravity separator.

Adjustments

The rate of feed, the amount of water, and the amount of sawdust introduced into the mixing chamber can be controlled to obtain complete separation with a minimum change in seed moisture content and minimum use of sawdust. The amount of water and sawdust added depends on the concentration of the buckhorn seed. The higher the concentration of buckhorn, the more water needs to be added. The rate of feed should be adjusted to allow the mixture to stay in the mixing chamber until all buckhorn seed are coated with sawdust. A high concentration of buckhorn seed requires slower feeding rates.

Installation

The buckhorn machine does not effect a separation, it only changes the physical properties of one component of the seed mixture. Since other separators make the actual separation, the buckhorn machine must

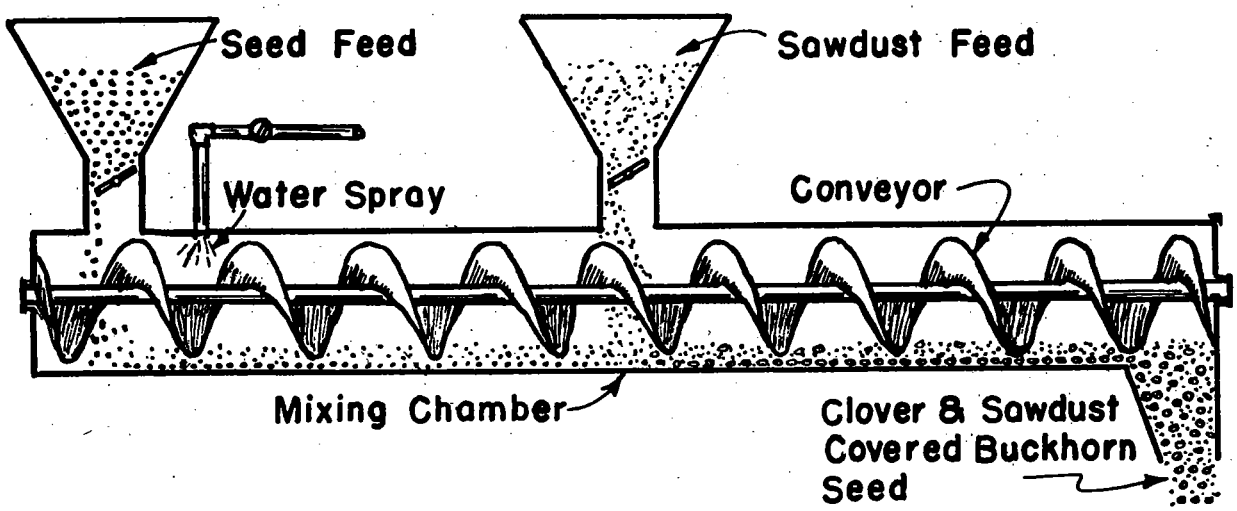


Figure B11. Section view of buckhorn machine.

be installed so that seed can flow from it to an air-screen cleaner or gravity separator. The buckhorn machine may be installed above the separating unit and feed into it by gravity, or it may be installed on the same level and feed into the separating unit through an elevator leg.

Uses of the Machine

While the buckhorn machine allows a precise and complete separation of buckhorn and other sticky seeds from small legume seeds with very little crop seed loss, it is an additional machine in the processing line. Many seed processors have replaced the buckhorn machine with magnetic separators, which make the same separation without a supporting air-screen cleaner or gravity separator, and are more versatile. The buckhorn machine, however, is very effective in removing buckhorn from legume seed, and fills an essential need in plants where this weed is a common problem.

Basic Seed Cleaning Equipment

Section C

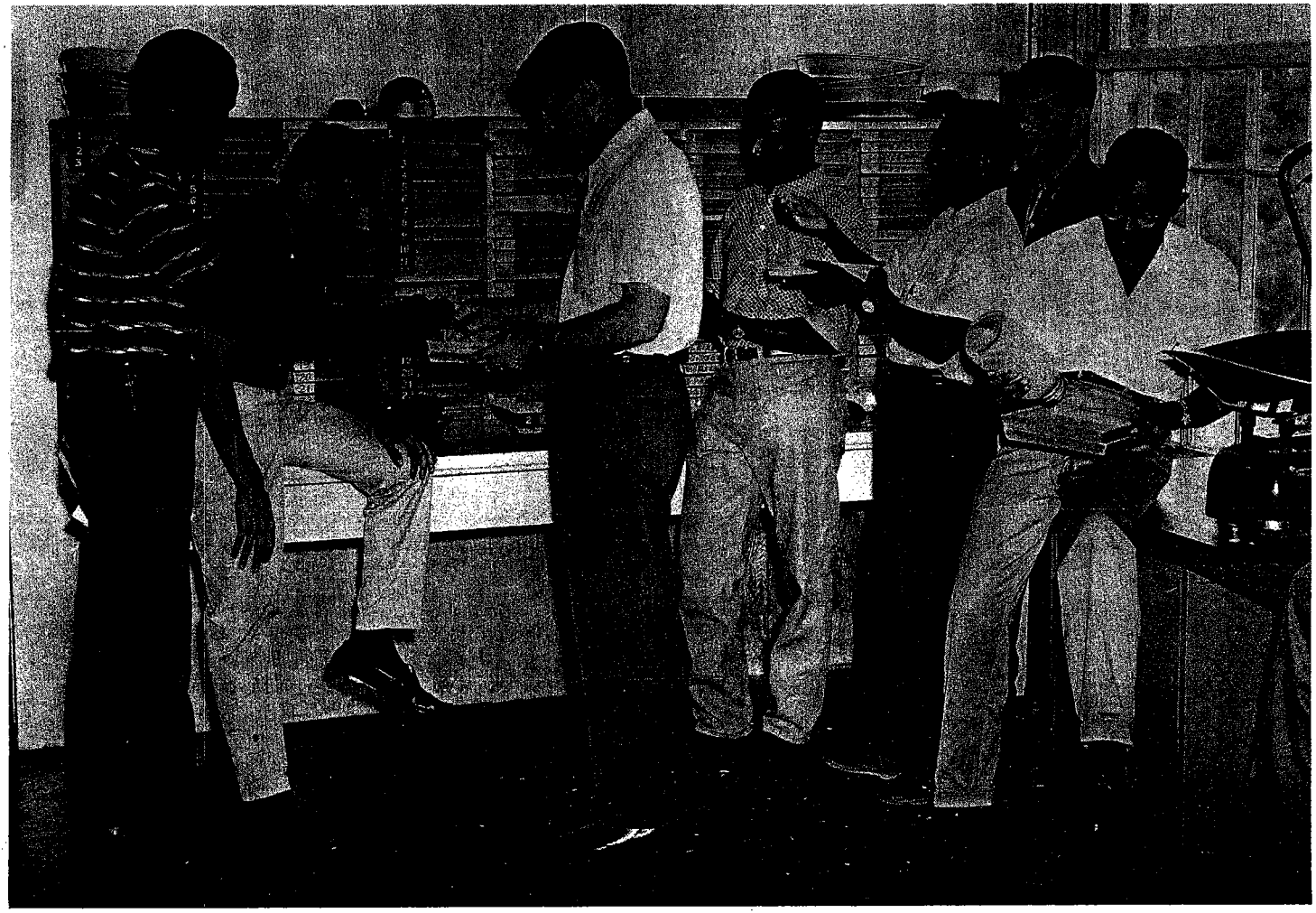


Figure C. Small hand screens can be used to determine screen sizes and types needed in an air-screen cleaner for different lots of seed.

AIR-SCREEN MACHINE

The air-screen machine is the basic cleaner in most seed processing plants. Almost all seed must be cleaned by an air-screen cleaner before specific separations can be attempted, and many seed lots can be completely cleaned by this machine. The original hand-powered fanning mills have evolved into many styles and types of air-screen machines. Machine size varies from small, two-screen farm models to large industrial cleaners with 7 or 8 screens, 3 or 4 air separations and capacities up to 6,000 pounds of seed per hour. Small, two-screen models are used on farms, in breeder and foundation seed programs and by experiment stations for processing small quantities of seed. Three- and four-screen machines fit into various size operations and are selected for precision as well as greater capacity. The 5-8-screen machines are used primarily for processing grain where high capacities are essential.

When selecting a size and type of air-screen cleaner for a particular operation, several factors must be considered, such as power requirements, amount and kind of seed to be processed and ease of cleaning the equipment.

In order for seed to be separated, cleaned or processed, the components of the lot or mixture must differ in some physical characteristic. In most machines separations are made on the basis of differences in only one physical characteristic. The air-screen machine, however, effects separations on the basis of differences in size and weight of seeds. This enables the air-screen machine to use three cleaning elements: aspiration, in which light material is removed from the seed mass; scalping, in which good seed are dropped through screen openings, but larger material is carried over the screen into a separate spout; and grading, in which good crop seed ride over screen openings, while smaller particles drop through.

To understand and successfully operate any seed processing machine, the operator must know three things: (1) the component parts involved in the work of the machine and the operations they perform; (2) the flow of seed through the machine; and (3) the adjustments which affect the precision of the separation and capacity of the machine.

Parts of the Machine

Feed Hoppers

Most air-screen machines use one of several general types of feed hoppers.

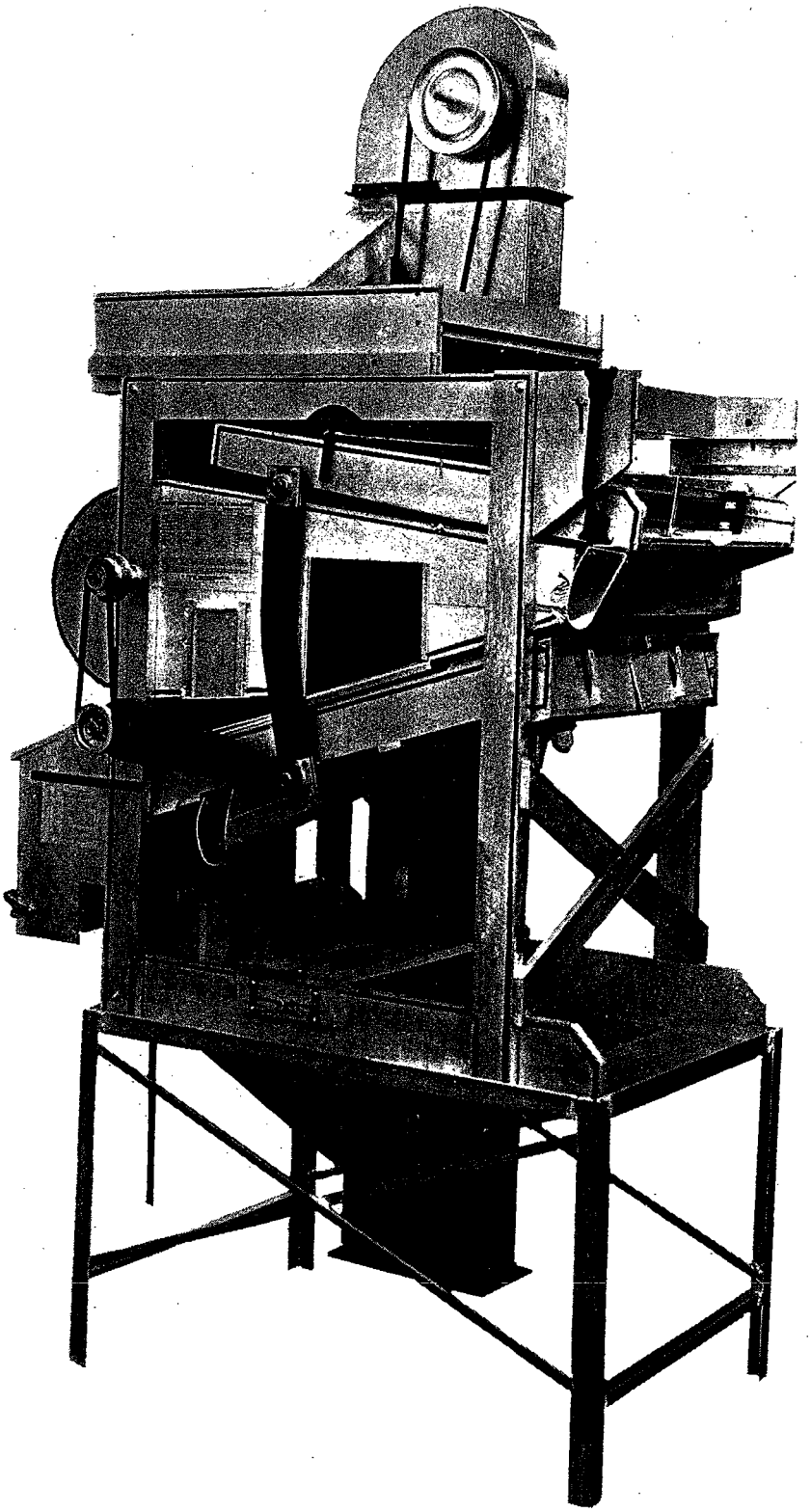


Figure C1. Vac-A-Way, Model 75S, seed and grain cleaner. Cleaner has four screens and one air system.

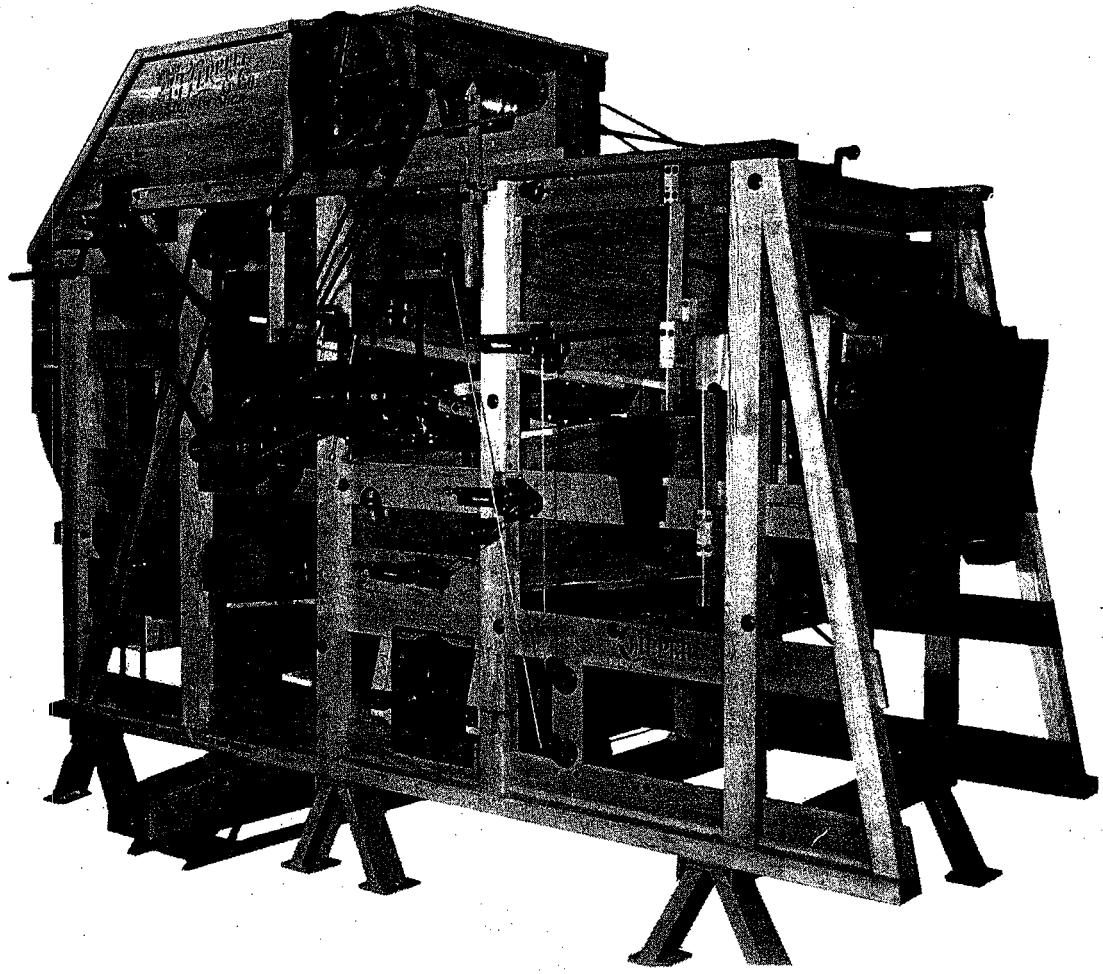


Figure C2. Clipper, Model Super X-29D, seed cleaner. Cleaner has four screens and two air systems.

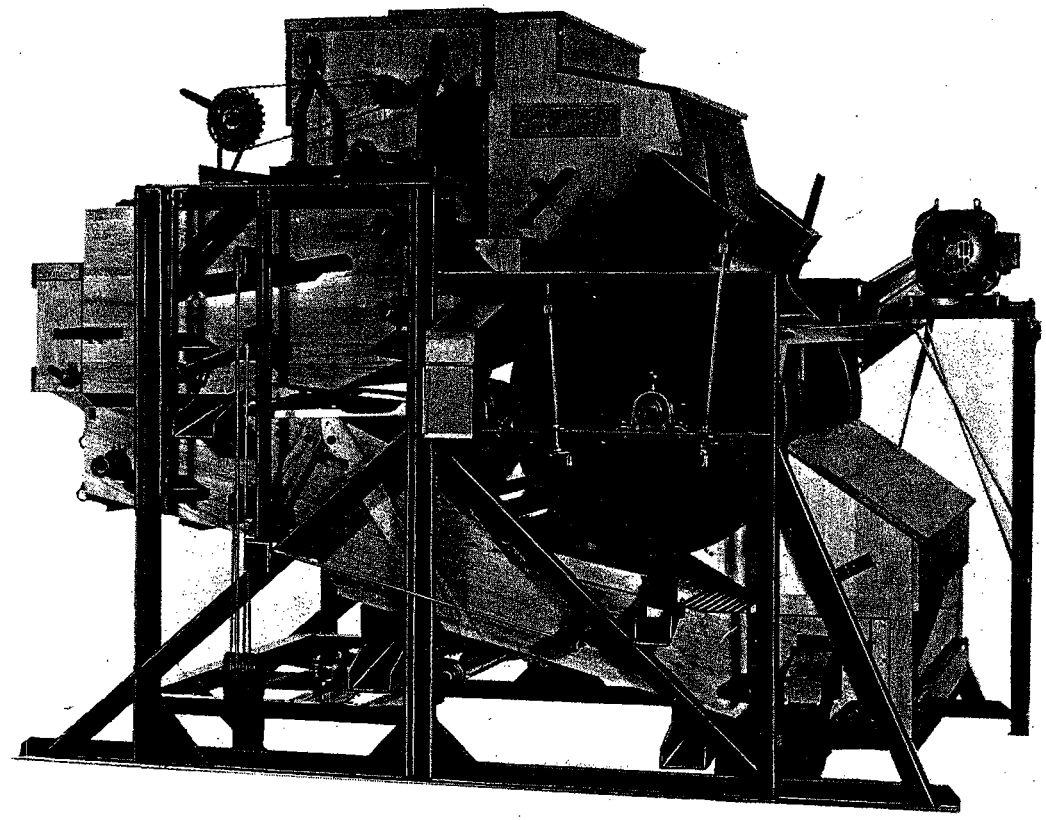


Figure C3. Crippen, Model H-454, seed cleaner. Cleaner has four screens and two air systems.

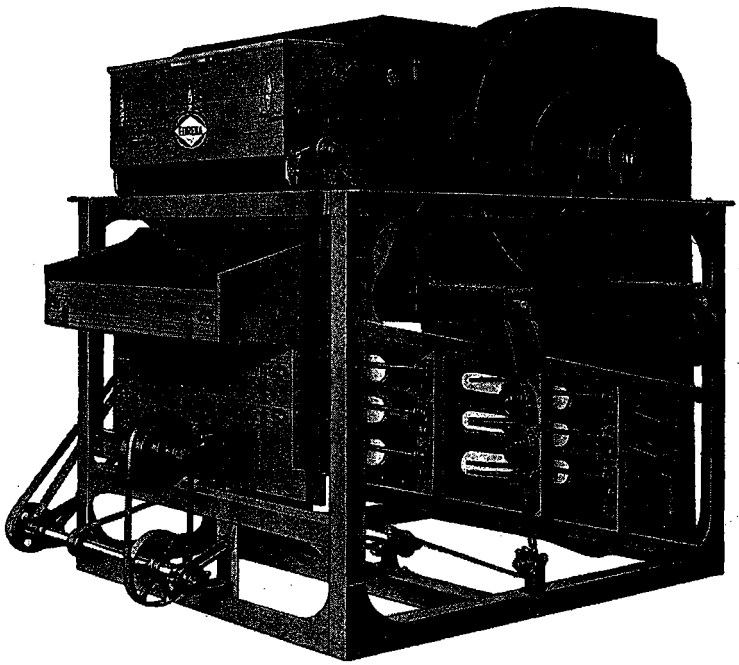
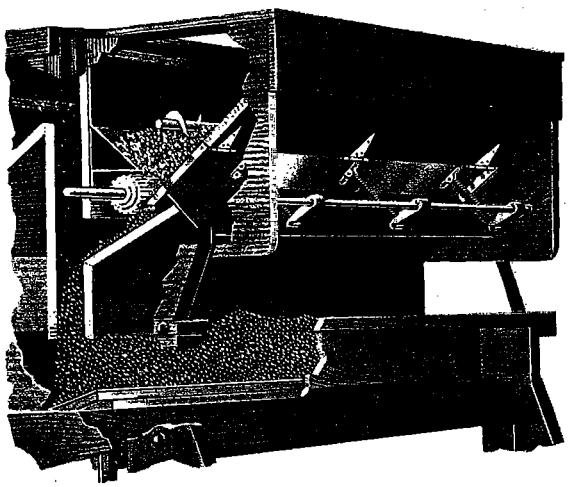


Figure C4. Eureka 3-screen, 2-air seed cleaner.

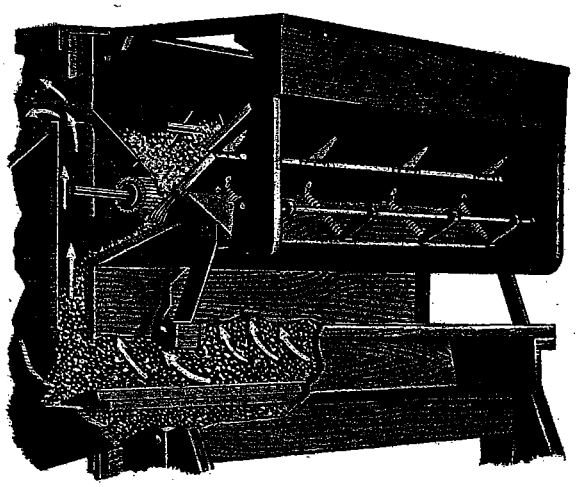
Roll-feed hopper: The roll-feed hopper consists of three basic parts: (a) a container to receive the seed; (b) hopper flights and augers to spread the seed across the width of the hopper as it is received, and; (c) a revolving fluted roll in the bottom of the hopper that feeds a steady, even flow of seed to the top screen and distributes the seed across the full screen width. The roll-feed hopper is recommended when cleaning small seed that contain very little trash.

Roll-feed brush hopper: The roll-feed brush hopper handles trashy seed and consists of four main parts: (a) a container to receive the seed; (b) a rotating spiked shaft that pulls trashy seed down to the revolving fluted roll; (c) a revolving, fluted roll, and; (d) a tough fiber brush. Seed are force-fed between the revolving fluted roll and this brush to prevent clogging and to maintain a steady even flow to the screens.

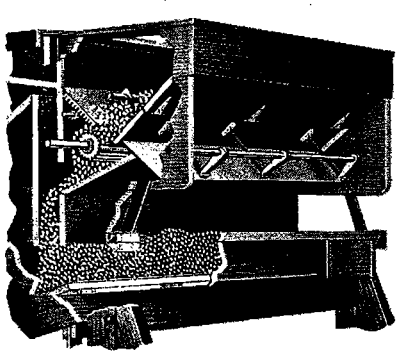
Metering hopper: A third type of hopper is the metering hopper. It is designed to feed all kinds of seeds from small clover and grass seed to the largest bean seeds accurately and continuously. It successfully handles seed containing considerable trash. It is similar to the roll-feed hopper except that a shaft with specially bent rods is used rather than an auger to spread the seed, and the flutes of the revolving roll are much deeper.



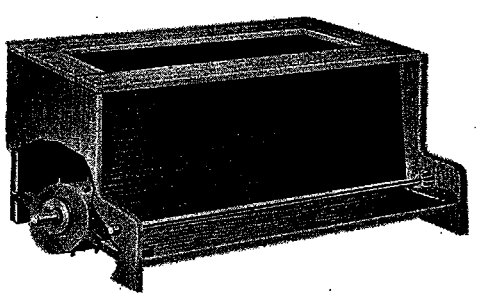
Roll-Feed Hopper



Roll-Feed Brush Hopper



Corn Hopper



Cotton-Seed Hopper

Figure C5. Types of feed hoppers used on Clipper air-screen cleaners.

Other types of hoppers such as the corn hopper and cottonseed hopper are specifically designed to handle specific crops.

Corn hopper: The corn hopper prevents cracking or chipping of kernels. It is also used for castor beans, shelled peanuts, and other easily damaged seed. The fluted roll of this hopper is equipped with wide flights which gently pick up and feed the seed to the top screen in the machine.

Cottonseed hopper: The cottonseed hopper handles cottonseed, and extremely trashy seed such as Kobe and Korean Lespedeza, brome and other non-free flowing grasses. As the large diameter spiked roll revolves, it pulls trashy material down and between the brush on the front of the roll. Seed which cling to the roll are removed by a second brush installed behind the roll.

Screens

Screens in an air-screen machine perform both scalping and grading operations as they separate crop seed from foreign material, other crop seed and weed seed. Screens are constructed of either perforated sheet metal or woven wire mesh. Openings in perforated metal screens may be round, oblong or triangular. Openings in wire mesh screens are square or rectangular.

There are over 200 different screens available, each identified by a number indicating its size and shape.

Perforated metal screens:

(1) Round openings - Round openings in a perforated sheet metal screen are measured by the diameter of the openings. Perforations of 5 1/2/64 and larger are designated in 64ths of an inch and are available in sizes ranging from 6/64ths to 80/64ths. These screen sizes are commonly designated by using only the numerator of the fraction, i.e., 6, 7, ... 64, 72, or 80, the denominator being understood.

Round openings of 5 1/2/64ths or less in diameter are designated in fractions of an inch, i.e., 1/12, 1/13, 1/14 . . . 1/25. Sizes ranging from 1/12th to 1/25th of an inch are readily available.

(2) Oblong openings - Perforated sheet metal screens with oblong or slotted openings are designated by two dimensions, the width and length of the opening. As

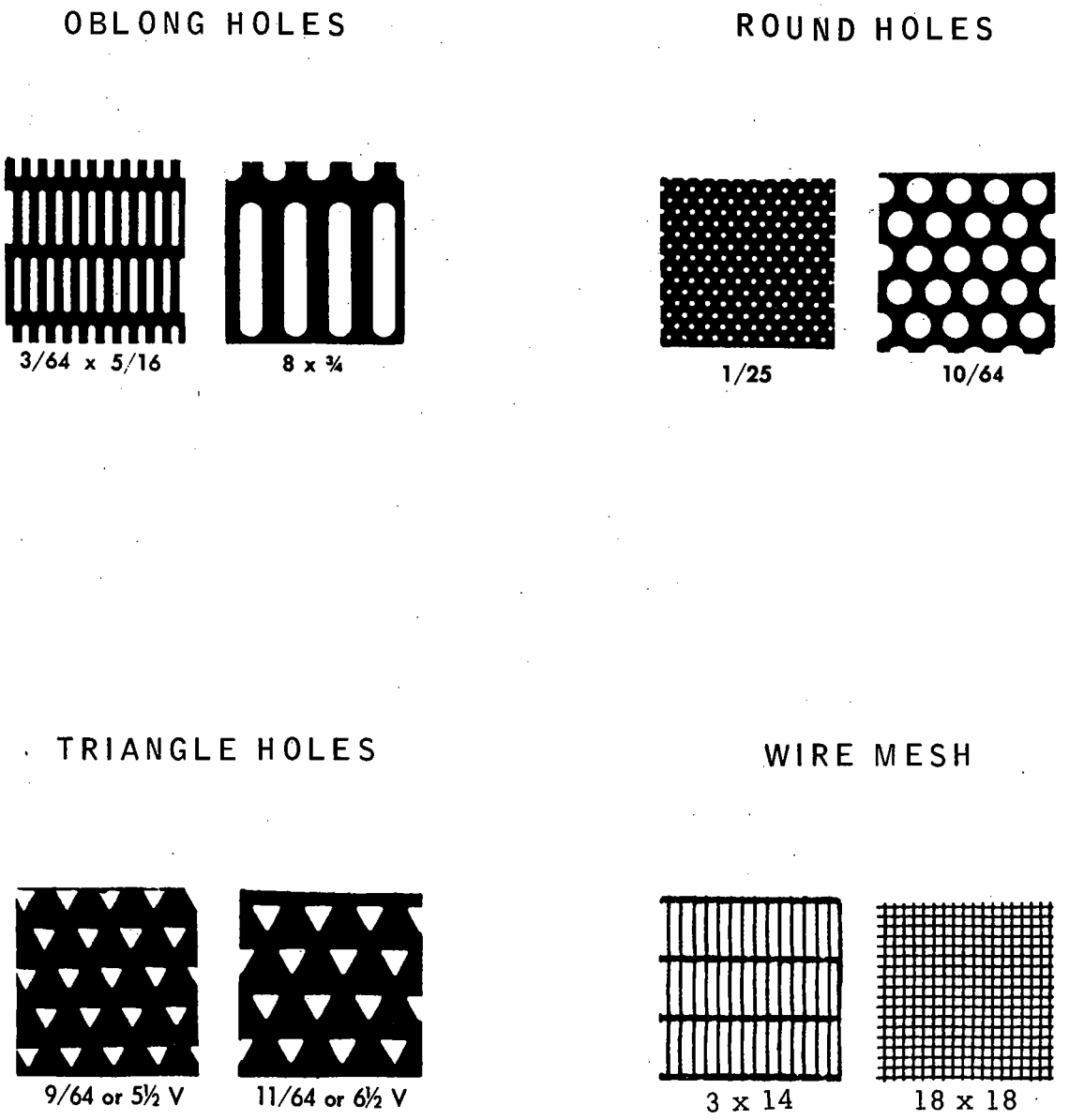


Figure C6. Types of screens and perforations used in cleaning seed.

with round hole screens, openings 6/64ths of an inch and larger in width are measured in 64ths of an inch and only the numerator is used. Openings less than 6/64ths of an inch in width are expressed in fractions of an inch. Oblong openings are usually 1/4 inch, 5/16 inch, 1/2 inch, or 3/4 inch in length.

When designating these screens, the width dimension is usually listed first and the length dimension next, i.e., 5 1/2 x 3/4, 6 x 3/4, or 1/22 x 1/2.

Generally, the direction of the oblong openings are in the same direction as the flow of seed on the screen. Screens with large perforations, however, are also available as cross-slots, i.e., slots perpendicular to the direction of the seed flow. Cross-slot screens are particularly useful in separating split beans from varieties that are relatively flat in shape. There is also a 1/22 x 1/2 diagonal with slots oriented at a 45 degree angle to the direction of seed flow. This screen is useful in cases where relatively short seeds are to be separated from slightly longer seed. Over 60 different slotted screens of assorted sizes ranging from 1/24th x 1/2 to 32/64ths x 1 inch are available.

(3) Triangular openings - Two different methods are used to measure triangular perforations. In one case, the length of each side of the equalateral triangle is measured and designated in 64ths of an inch. In the second method the screen opening size is the diameter of the largest circle that can be inscribed within the triangular opening - also in 64ths of an inch and designated with a number followed by the letter V, i.e., 4 1/2 V, 5 V, 7 V, etc.

It follows then, that two triangular screens with the same numerical size designation may not necessarily have the same size openings. For example, triangular screens with designations of 7 Tri., 8 Tri., 9 Tri., 10 Tri., 11 Tri., and 12 Tri. have openings identified by the length of the side of the triangle. These same openings measured by the circle-diameter method would be identified as 4 1/2 V, 5 V, 5 1/2 V, 6 V, 6 1/2 V and 7 V, respectively.

Wire Mesh Screens:

(1) Square Mesh - Square openings in wire mesh screens are measured by the number of openings per inch in each

PERFORATED METAL SHEET									WIRE CLOTH			
ROUND HOLES			OBLONG HOLES		TRI-ANGLES	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 61⅛" and 26" x 53¾"						
1/25	5½	24	1/24x½	5x¾	5	6x¾	6½	8½x¾	3x3	2x8	4x8½	6x14
1/24	6	25	1/22x½	5½x¾	8	7x¾	7½	9½x¾	4x4	2x9	4x15	6x15
1/23	7	26	1/22x½ Diag.	6x¾	9	8x¾	8½	10½x¾	5x5	2x10	4x16	6x16
1/22	8	27	3/64x5/16	6½x¾	10	9x¾	9½	11½x¾	7x7	2x11	4x18	6x18
1/21	9	28	1/20x½	7x¾	11	10x¾	10½	12½x¾	8x8	2x12	4x19	6x19
1/20	10	29	1/18x¼	8x¾-D		11x¾	11½	13½x¾	9x9	3x14	4x20	6x20
1/19	11	30	1/18x¾	9x¾		12x¾	12½	14½x¾	10x10	3x16	4x22	6x21
1/18	12	31	1/16x¼-A	10x¾-E		13x¾	13½		12x12	3x16 SP.	4x24	6x22
1/17	13	32	1/16x½	11x¾-F		14x¾	14½		14x14	3x18	4x24 SP.	6x23
1/16	14	34	1/15x½	12x¾-G		15x¾	15½		15x15	3x20	4x26	6x24
1/15	15	36	1/14x¼-B	13x¾-H		16x¾	16½		16x16	3x21	4x28	6x25
1/14	16	38	1/14x½	14x¾-I		18x¾	17½		17x17		4x30	6x26
1/13	17	40	1/13x½	15x¾-J		10½x¾	18½		18x18		4x32	6x28
1/12	18	42	1/12x½-C	16x¾-K		11½x¾	19½		20x20		4x34	6x30
	19	44		17x¾		12½x¾	20½		22x22		4x36	6x32
	20	48		18x¾			21½		24x24			6x34
	21	56		19x¾			22½		26x26			6x36
	22	64		20x¾					28x28			6x38
	23	72		21x¾					30x30			6x40
		80		22x¾					32x32			6x42
				24x¾-L					34x34			6x50
				32x1					36x36			6x60
									38x38			18x20
									40x40			20x22
									45x45			
									50x50			
									60x60			

Figure C7. Screen sizes available for air-screen machines.

direction. A 9 x 9 screen has 9 openings per inch. Available sizes range from 3 x 3 to 60 x 60. Since numbers on these screens do not increase consecutively, this range includes about 27 different screens.

(2) Rectangular Mesh - Rectangular openings in wire mesh screens are measured in the same way as square wire mesh screens. A 3 x 6 rectangular wire mesh screen will have 3 openings per inch in one direction and 6 openings per inch in the other. Rectangles formed by the wire mesh are parallel to the direction of seed flow. Approximately 50 different rectangular wire mesh screens are available in these sizes:

2 x 8 to 2 x 12, 3 x 14 to 3 x 21, 4 x 15 to 4 x 36 and 6 x 14 to 6 x 60. Openings of 18 x 20 and 20 x 22 are also available.

Clay-Crushing Rolls

Clay-crushing rolls may be installed in an air-screen machine to crush clay lumps comingled with the seed. These two large-diameter rolls are made of rubber hard enough to crush clay lumps without damaging the seed. The rolls are adjustable to various opening widths, and may be left apart and inoperative when not needed. Clay-crushing rolls are installed so that the seed passes through them after scalping.

One rubber roll and one steel roll are sometimes used to crush wild onion bublets in seed.

Brushes

Brushes which travel back and forth under each screen are standard equipment on most air-screen machines. The cleaning efficiency of a screen is directly related to the percentage of the perforations that remain open. Bristles of the traveling brushes sweep the underside of each screen to keep the perforations open.

Tappers or Screen Knockers

Tappers or hammer-like screen knockers may be installed over the scalping screens to help keep the screens clean. Screen knockers tap the screens to jar loose, material wedged in the perforations. Tappers or screen knockers are available for larger models of air-screen cleaners.

Shoes

The vibrating or shaking sections of the machine into which the

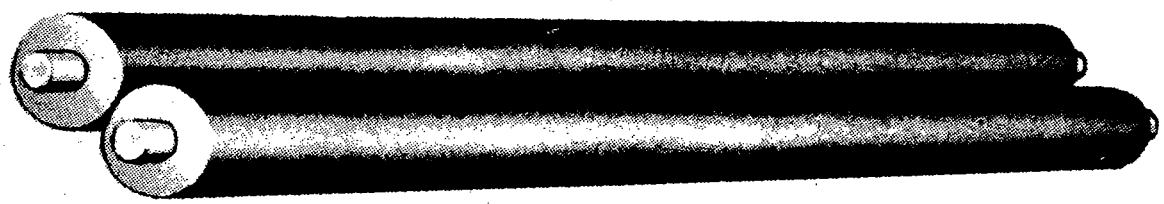


Figure C8. Clay-crushing rolls.

screens are fitted are called "shoes". A shoe usually contains fittings for two screens; one for scalping and the other grading. A machine may have one or two shoes, depending upon its size. The shoes are inclined to allow the seed to flow over the screens. In a machine with two shoes, the shoes are inclined in opposite directions forming a V, so that the movement of one shoe counteracts the movement of the other to hold vibration to a minimum.

Eccentrics

The off-center drives on the drive shaft shake the shoes and are called eccentrics. In machines with two shoes the eccentrics of one shoe are counter-balanced by the eccentrics of the other shoe.

Fan

The number of fans in a machine ranges from one in small cleaners to as many as four in larger cleaners. Most air-screen machines have two air systems which are designated as upper and lower air.

The upper air removes light chaff and dust from seed before they reach the first screen; and is regulated by an adjustable damper in the

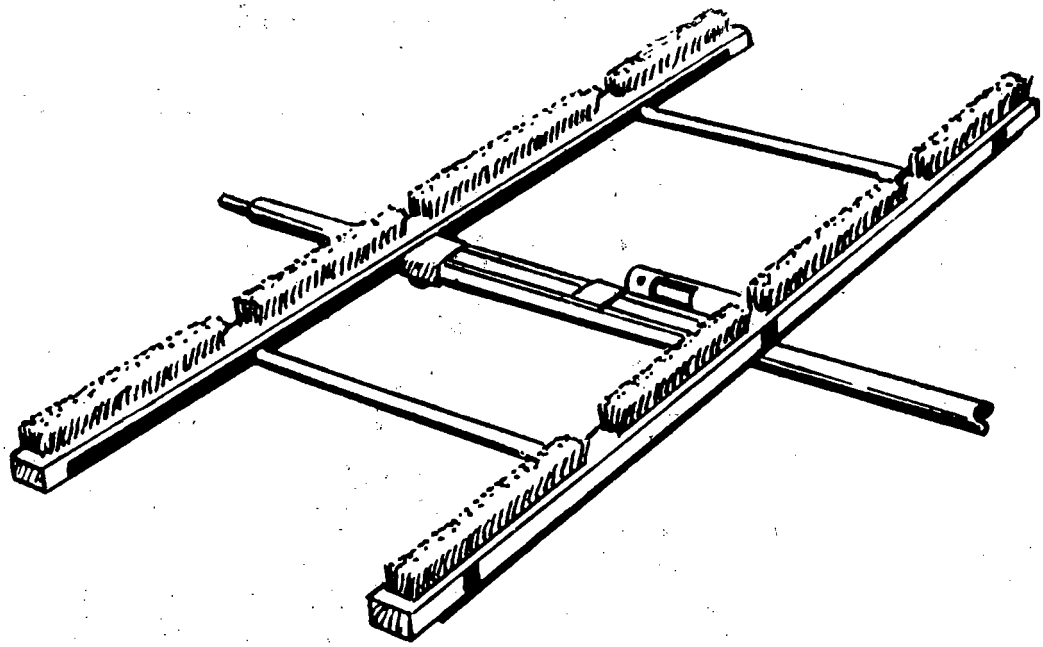


Figure C9. Brushes used to sweep the underside of screens to keep the perforations open.

air passage. The lower air blast removes light seed and trash not removed by the upper air or screens. When a machine has only one fan, it is usually used to remove light seed and trash left after screening.

Air Chest

Air passageways from the fans are connected to the air chest or air chamber which allows the material lifted by the air stream to settle. This is done by decreasing the air velocity as it passes through the air chest. The lifted material settles out by gravity, and is spouted out of the air chest.

Principles of Operation

Although screen arrangement may vary with make, model and number of screens per machine, a four-screen machine with the following screen arrangement is used as an example in this discussion: first screen scalping, second screen grading, third screen close scalping, and fourth screen fine grading.

Seed to be cleaned are fed from the feed hopper by the feed roll, where they pass through the upper air which removes light chaff and dust.

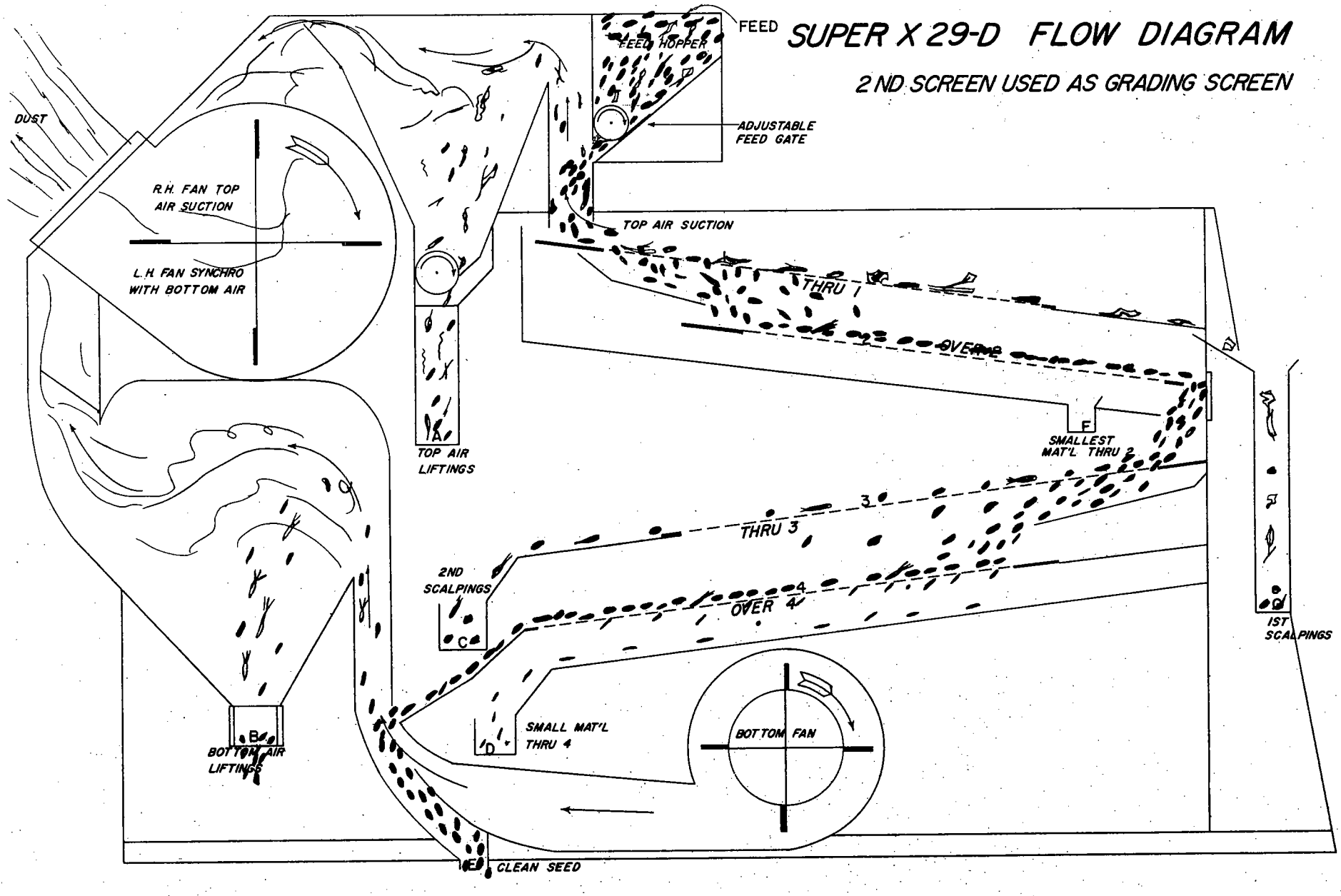
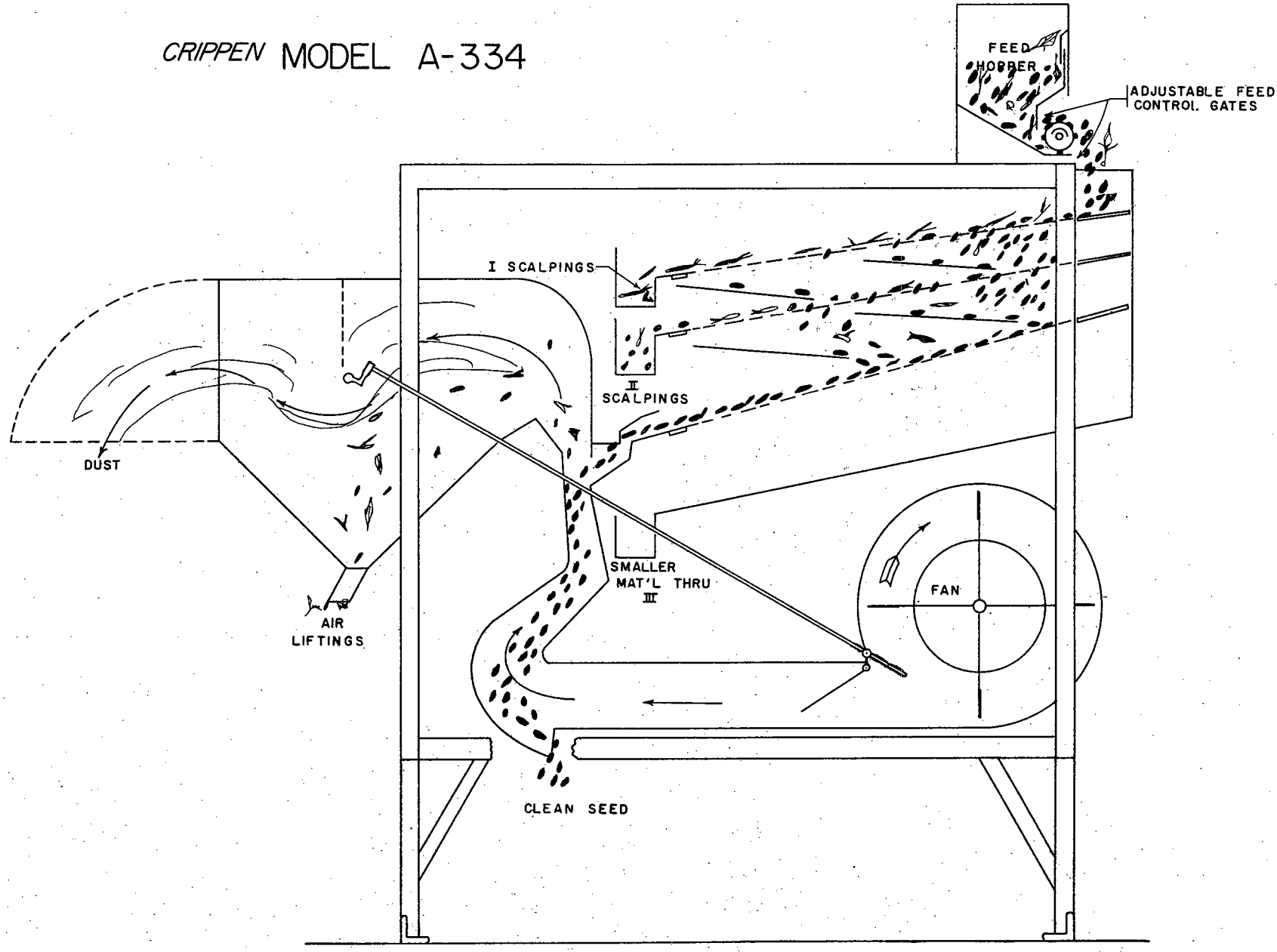


Figure C10. Flow diagram of Clipper Super X 29-D air-screen cleaner.

CRIPPEN MODEL A-334



DESCRIPTION

1. Main Hopper
2. Repeat Hopper
3. Repeat Spout
4. Feed Roll
5. Feed Lever
6. Repeat Control Board
7. Settling Chamber
8. Spiral conveyor. Empties settling chamber
9. Suction Fan
10. 3-Gang Sieve
11. 4-Gang Sieve
12. Adjustable Screen
13. Repeat Screen with Automatic Brush
14. Screen Brush Bracket
15. Reversible Screening Blank
16. Adjustable Tailings Board
17. Repeat Elevator Boot
18. Direct Blast Fan
19. Clean Grain Delivery
20. Brush Pitman

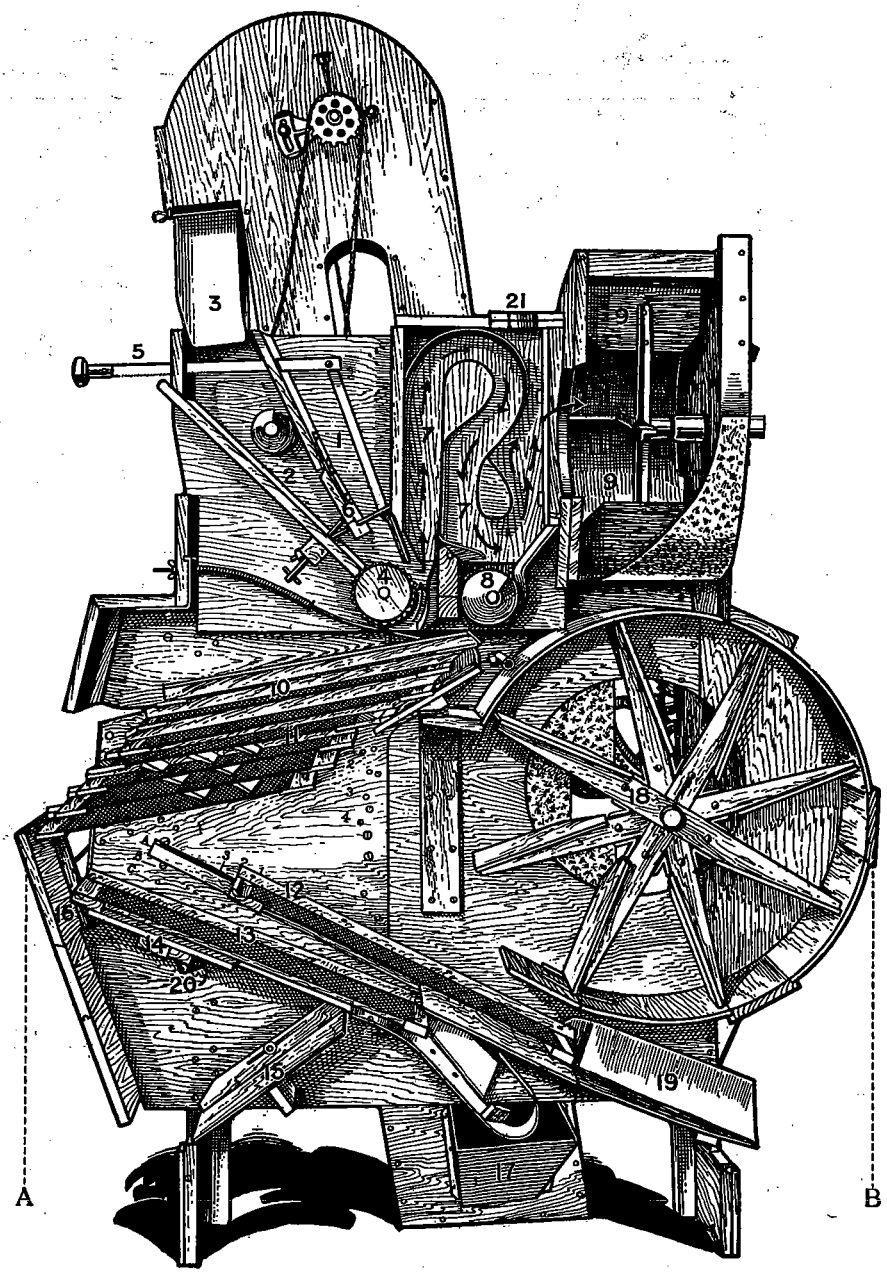


Figure C12. Flow diagram of Cleland Expert air-screen cleaner.

The top screen is used for rough scalping. Its perforations are large enough to readily drop the crop seed but small enough to scalp off large foreign material such as stems, sticks, dirt or weed seed.

Seed which pass through the first screen are caught on the second screen. Perforations in this screen drop out trash, weed seed, and dirt smaller than the crop seed. Good seed ride over the perforations in the second screen and drop onto the third screen. For maximum capacity the second screen should be kept covered with seed at all times.

The third screen in our example is a close scalper. It removes large foreign material or contaminating seed that were small enough to pass through the first screen.

The crop seed drop through the third screen and go to the fourth screen for a final close grading. This screen has perforations slightly larger than those in the second screen. Seed or other material smaller than the crop seed being cleaned but which were too large to drop through the second screen are removed here.

As the crop seed drop off the fourth screen, they fall through the lower air separation. This removes the light seed and trash which was not removed by the upper air and the screens. For efficient cleaning, the lower air blast should be strong enough to blow out a few good seed.

Adjustment of Equipment

Screen Selection

Screens must be selected according to the shape of the crop seed being cleaned.

(1) Round Seeds: A round-hole top screen and a slotted bottom screen are generally used to clean round-shaped seeds. The round-hole top screen prevents straw, trash, pods and other large and long material from dropping through while the slotted bottom screen drops broken seeds and weed seeds thinner than the round crop seeds.

(2) Oblong Seeds: An oblong top screen and an oblong bottom screen are generally used to clean long seeds. The oblong perforations in the top screen separates weed seeds or large material rounder or thicker than the crop seed. The oblong bottom screen drops thin weed seed, broken crop seed or hulled crop seed and other material thinner than the crop seed.

SUGGESTED SCREENS--FOUR SCREEN CLEANERS

Four Screen Cleaners — Use Col. 1 for top screen in top shoe, Col. 2 for bottom screen in top shoe, Col. 3 for top screen in bottom shoe, and Col. 4 for bottom screen in bottom shoe.

Three Screen Cleaners — Use Col. 1 for top screen, Col. 3 for middle screen, and Col. 4 for bottom screen.

COMMODITY	Col. 1	Col. 2	Col. 3	Col. 4
Alfalfa	1/14 or 1/13	6x26	1/15 or 1/14	6x24
Alsike Clover	1/18	6x34	1/19	6x32
Alsike, Sorrel from	1/18	6x34	6x20, 6x21, 6x22	6x32
Alsike, Mustard from	1/18	6x34	3/64x5/16, 6x20, 6x21	6x32
Alsike, Yellow Trefoil from	1/18	6x34	6x22, 1/21, 1/22	6x32
Alsike, Night Flowering Catchfly from	1/18	6x34	6x20 or 6x21	6x32
Alspice, Whole	21	6	20	8/64x3/4
Anise	14	1/20	12	1/18
Barley	11/64x¾ or 24	1/14x1/2	22, 21 or 20	1/13x1/2
Beans, Cranberry	32	14/64x3/4	30	16/64x3/4
Beans, Yellow Eye	24	11/64x3/4	22	12/64x3/4
Beans, Lima	56	16	48	20
Beans, Baby Lima	32	17	30	19
Beans, Red Kidney	30	13/64x3/4	28	14/64x3/4
Beans, Navy or Pea	22	10/64x3/4	20	11/64x3/4
Beans, Large Yellow Soy	22	10/64x3/4	20	11/64x3/4
Beans, Small Black Soy	20	6/64x3/4	18	7/64x3/4
Beans, Soy, Black Flat	18	7/64x3/4	16	8/64x3/4
Beans, Soy, Wild Morning Glory from	18	7/64x3/4	16	11, 12
Beans, Pinto	26	9/64x3/4	24	10/64x3/4
Beans, Great Northern	26	10/64x3/4	24	11/64x3/4
Beans, Mung	14	7	13	8/64x3/4
Beet Seed	24	7	22 or 20	8
Bent Grass	26x26	60x60	28x28	50x50
Bermuda Grass	6x28	6x42	6x30	6x40
Brome Grass	10	9 tri. or 6x26	1/13x1/2	6x24
Blue Grass, Canadian	1/18	6x42	1/20	6x40
Blue Grass, Kentucky	6x28	6x42	26x26	6x40
Buckwheat	16	7	14	6/64x3/4
Cabbage Seed	10	1/18	8	3/64x5/16
Canary Grass	9	6x26	3x16	6x24
Caraway Seed	1/14x1/4	6x24	1/16x1/2	6x22
Carrot Seed	7	6x28	1/12	6x26
Cane Seed	12	1/14x1/2	10	1/13x1/2
Carpet Grass	1/15	6x40	6x28	6x38
Celery Seed	1/14	30x30	1/16	28x28
Clover, Hop	1/20	6x36	1/25	6x34
Clover, Ladino	1/18	6x34	1/20 or 1/21	6x32

CONTINUED ON NEXT PAGE

Table C1. Screen sizes generally used for processing various kinds of seed.

(CONTINUED)

COMMODITY	Col. 1	Col. 2	Col. 3	Col. 4
Clover, Crimson	6	6x24	1/13	6x22
Clover, Bur Hulled	1/12	6x24	1/13	6x22
Clover, Dalea or Woods	6	6x23	1/13	6x22
Clover, Red	1/15	6x24 or 6x26	3/64x5/16	6x22 or 6x24
Clover, Red, Hares Ear Mustard from	3/64x5/16	6x24	3/64x5/16	6x24
Clover, W. B. Sweet	1/12	6x26	1/14	6x24
Clover, W. B. Sweet, unhulled	10	6x26	8	6x24
Clover, White Dutch	1/16 - 1/18	6x34	1/18, 1/19, 1/20	6x32
Clover, White Dutch, Dock from	1/16	6x34	6x22 or 6x23	6x32
Comin	14	1/25	12	1/22
Corinder	15	1/13x1/2	13	1/12x1/2
Corn, Cleaning only	32	14	28, 30	16
Cotton Seed, delinted	20	9/64x3/4	18	10/64x3/4
Cotton Seed, not delinted	40	12/64x3/4	36	13/64x3/4
Crested Wheat Grass	1/16x1/2	6x30	1/18x1/4	5 tri.
Crotalaria	12	6	1/12x1/2	7
Cucumber Seed	18	8	17 or 16	9
Dallas Grass	8	1/15	3x14	1/14
Fescue, Meadow	1/13x1/2	6x21	1/14x1/4	4x22 or 5 tri.
Fescue, Chewings	3/64x5/16	6x32	1/22x1/2	6x30 or 5 tri.
Fescue, Ky. 31	3/64x5/16	6x32	1/22x1/2	5 tri. or 6x30
Fennel	14	1/16	12	1/14
Flax, Bison	1/16x1/2	1/14	1/18x3/4	1/13
Flax, Golden	1/13x1/2	1/12	1/14x1/4	6
Flax, Small	3x16	1/14	3/64x5/16	1/12
Flax, Walsh & Viking same as Bison				
Garbanzos (chick peas)	30	11/64x3/4	26	12/64x3/4
Hemp	14	1/13x1/2	12	1/12x1/2
Johnson Grass	10	1/18	8	1/16
Kaffir Corn	14	1/14x1/4	12	1/12x1/2
Lentils	18	12	7/64x3/4	12 or 13
Lespedeza, Korean	6	1/17, 1/18	6x15 or 1/18x1/4	1/16
Lespedeza, Kobe	8	1/16	6x14 or 1/18x3/4	1/14
Lespedeza, Sericea, Unhulled	7	1/15	1/14x1/4	6x26
Lespedeza, Sericea, Hulled	1/15	6x28	1/16 or 3/64x5/16	6x26
Lettuce	4x18	24x24	6x20	20x20
Melon, Water	28	14	24	16
Melon, Musk	20	7	16	9
Milo, Maize	14	1/13x1/2	13	1/12x1/2
Millet, German	8	1/22x1/2	6	3/64x5/16
Millet, Siberian	7	1/20	1/12	1/15
Millet, Proso	9	3/64x5/16	7	1/18x1/4
Mustard, White	9	1/22x1/2	7	3/64x5/16
Mustard, Brown	7	1/22	1/12	1/20
Oats	24	1/16x1/2 or 11 tri.	11/64x3/4	1/14x1/2
Oats, Corn from	10/64x3/4 or 9/64x3/4	1/16x1/2	9/64x3/4 or 8/64x3/4	1/14x1/2
Oat Grass, Tall Meadow	1/12x1/2	6x30	1/14x1/2	6x28

Table C1. Continued.

(CONTINUED)

COMMODITY	Col. 1	Col. 2	Col. 3	Col. 4
Okra	16	3/64x5/16	14	1/18x3/4
Onion Seed	11	1/15	9, 8	1/14
Orchard Grass	3/64x5/16	6x32	1/22x1/2 or 1/24x1/2	6x32 or 5 tri.
Onion Sets	1 1/4	3x3	1"	3x3
Peas, Austrian Winter	20	12 or 9/64x3/4	17	10/64x3/4
Peas, Blackeye	24	12 or 9/64x3/4	22	10/64x3/4
Peas, Canada Field	22	10 or 9/64x3/4	20	10/64x3/4
Peas, Cow	22	12 or 10/64x3/4	21	11/64x3/4
Pepper Seed, Red	14	1/12	12	7
Pepper, Black	18	6/64x3/4	16	7/64x3/4
Pinion Nuts	32	12/64x3/4	30	14/64x3/4
Poa Bulbosa	10	4x24	7	4x22
Pop Corn, Pearl	21	10	20	11
Psyllium Seed	4x18	6x38	6x20	26x26
Pumpkin Seed	36	18	32	20
Radish Seed	10	1/14	9 or 8	1/12
Rape, Dwarf Essex	7	1/23	1/12	1/22
Rape, German	9	1/18	7	1/16
Red Top	26x26	60x60	28x28	50x50
Red Top, Timothy from	26x26	60x60	6x34	50x50
Rice, Paddy	22	6 or 7	20 or 21	1/14x1/2, 1/18x1/2
Rice, Hulled	14	1/12	12	14x14
Rye Grass, English	3/64x5/16	6x32	1/22x1/2	6x32 or 5 tri.
Rye	14	1/16x1/2	12	1/14x1/2
Rye, Vetch from (100% impossible)	7/64x3/4	8	7/64x3/4	9
Sesbania	10	1/18x1/4	8 or 9	1/18x3/4
Sesame Seed	6	4x26	1/18x1/4	1/16
Spinach	14	1/14	11 or 12	1/12
Squash Seed	34	20	32	23
Sudan Grass	12	1/22x1/2	10	3/64x5/16
Sun Flower Seed	24 to 32	10	24 to 32	11
Timothy	1/18	6x36	1/19 or 1/20	6x34 or 6x32
Timothy, Sorrel from	6x20 or 6x21	6x36	6x20 or 6x21	6x34 or 6x32
Timothy, Red Clover from	6x24	6x36	6x26	6x34
Timothy, Pepper Grass from	1/19	6x34	1/20	6x32
Timothy, Black Plantain from	1/19	6x32	1/20	6x30
Timothy, Red Top from	1/19	6x36	1/20	6x34
Timothy, Buckhorn from	1/20	6x30	1/22	6x30 or 6x28
Timothy, Alsike from	1/20	6x34	1/25 or 6x26	6x32
Tobacco Seed	30x30	50x50	32x32	40x40, 50x50
Tomato Seed	12	1/14	10	1/12
Trefoil, Birdsfoot	1/14	6x26	1/16	6x24
Turnip Seed	1/12	1/22	1/14	1/20
Vetch	16	6/64x3/4	14	6/64x3/4 or 7/64x3/4
Wheat	16	1/13x1/2 or 8 or 9	14	1/13x1/2 or 10 tri.
Wheat, Oats from	12	1/13x1/2	11	1/13x1/2
Wheat Grass Western	1/13x½	4x24	1/14x½	4x22

Table C1. Continued.

(3) Lens-shaped Seed: An oblong top screen and a round-hole bottom screen are generally used to clean lens-shaped seeds. The oblong or rectangular top screen permits the lens-shaped seed to turn on edge and go through, while rounder or plumper seed and foreign material passes over the screen. The round-hole bottom screen holds up lens-shaped crop seeds while round weed seeds small enough to pass through the top screen drop through.

Most seed cleaning plants use air-screen machines which have more than two screens to permit better separations with several shapes and sizes of openings during the same cleaning operation. For example, oats containing freshly-killed insects about the same thickness but considerably longer than the oat kernel can be removed effectively with a round-hole top screen. The oats in this case drop through the round-hole screen and the longer insects lie flat on the screen and pass over the screen. When cleaners having more than two screens are used, it is generally recommended that the top screen have round openings as this type of opening will let straw and long weed seeds pass over better than any other type.

Since screen selection is extremely important it is necessary to go beyond a few generalizations and discuss several examples involving specific crops. Examples are: (1) Lespedeza, (2) Wheat, and (3) Oats.

Example 1 - Lespedeza (small lens-shaped seed normally with hulls)

The first screen used on the lens-shaped Korean lespedeza should be a No. 6 Round which takes off straw, stems, leaves and cheat seeds before the main separation is made with the rectangular wire mesh top screen. Because Korean lespedeza seeds are lens-shaped they will fit diagonally across the square on a square wire mesh top screen and drop through a smaller mesh than other seeds that have a round shape. Seed of rough button weed are not distincly lens-shaped, so the 12 x 12 wire mesh separates this weed seed from Korean lespedeza, although both are so nearly the same size and shape that neither round or slotted screens will make a clear-cut separation. Kobe lespedeza seed are also relatively lens-shaped but are slightly wider than Korean lespedeza. Consequently, a larger mesh must be used to drop Kobe lespedeza seed. The larger mesh also passes rough button weed seed so that a separation cannot be made. If rough button weed is present in a relatively small percentage, normal cleaning with a round-hole and slotted top screen will reduce the percentage in Kobe so that the seed are salable. On the other hand, if the percentage is very high, no screen or combination of screens will remove enough from unhulled Kobe lespedeza seed to make them salable. To separate them, hull the Kobe and change its relative size. It is then comparatively easy to remove the rough button weed

seed. A 1/18 x 1/4 is a good top screen for Kobe lespedeza. The short 1/4" slot drops the small Kobe lespedeza while longer weed seeds such as cheat lie flat and float over. This screen, however, reduces the normal capacity of the cleaner to about three-fourths, because the width of the Kobe lespedeza seed lying flat on the screen is almost as great as the length of the slot. Each seed has to fit exactly into the perforation to go through. The 1/18 x 1/2" and 1/18 x 3/4" slots have a longer opening and retain the width, therefore they will drop Kobe lespedeza much faster while separating plump or round-shaped weed seed.

Example 2 - Wheat

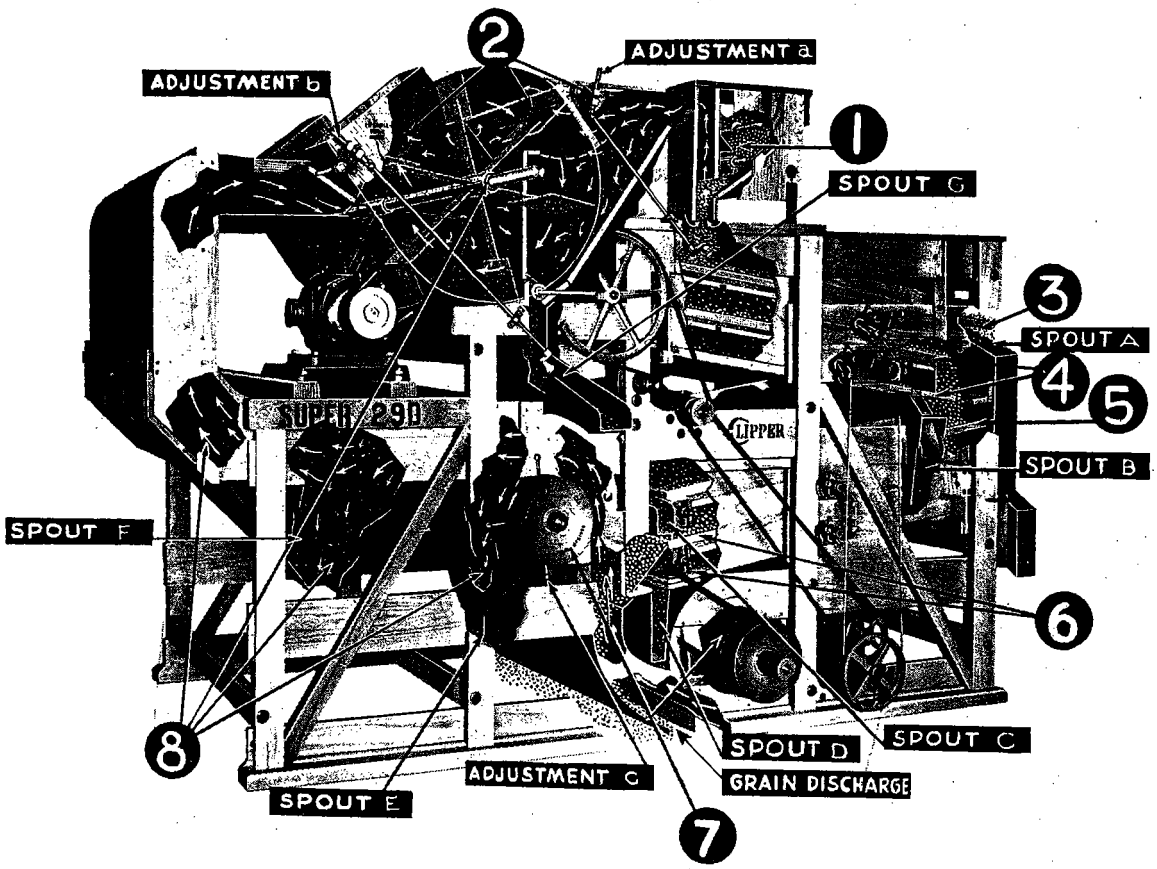
The purpose of a bottom screen for wheat is to drop split kernels of wheat and long weed seeds such as cheat and wild oats. Wheat kernels are relatively round so the length of slot is immaterial relative to holding up wheat seed. Length of slot, however, will drastically affect the separation of long weed seed which must drop through. The best separation is made with a slot long enough to quickly and easily accept long weed seed and screen them from the wheat as soon as possible.

Example 3 - Oats

When selecting a bottom screen for oats, a long slot will give the oats an extra opportunity to pass through. While a better separation may be possible with a 3/4" long slot it might be more economical to use a 1/2" long slot.

The cleaning brushes that brush the bottom surface of wire screens cause them to wear faster than perforated metal screens. Thus seedsmen usually ask if perforated metal slotted screens are available in the same sizes as wire mesh screens for cleaning small legume seeds. There are two reasons why a substitute of this kind is not practical. One is that the surface irregularities characteristic of a wire mesh screen permit it to do a better job of sifting than is possible with perforated sheet metal screen. The other reason is the percentage of open space. A wire mesh screen has more openings per unit area, therefore, there are more opportunities for small seed to be sifted through. The end result is that a wire mesh bottom screen has greater capacity and makes a better separation than perforated metal screen with openings of equivalent size.

Small hand screens are used by some processors for determining the best screen arrangement before setting-up production size machines. This can be done with a small sample of the seed. However, it is often necessary to use screens slightly different in size from the ones



1. Hopper—a special, slowly revolving, fluted roll to force-feed the commodity into the hopper air passage for the first air separation. Gives even distribution across the width of top screen.
2. Right suction fan adjusted by Adjustment (a) control removes light trash to the dust house; the heavier trash discharges at Spout (G).
3. Spout (A) discharges top screen scalpings. Quick change-over can also be made at this point to convert one finishing screen to a third scalper.
4. Discharge from the bottom screen in the top shoe can be directed out of Spout (B) or joined with discharge of final separation out of Spout (D) as desired.
5. Scalpings from the top screen in the lower shoe are discharged from Spout (C).
6. Immature seed, splits, dirt, smaller weed seed, etc., that drop through the fourth or finishing screen are discharged from Spout (D).
7. The final air separation occurs after the finishing screen has done its work. At this time the variable air adjustment is made at Adjustment (c) synchronized with left top suction Adjustment (b).
8. Heavier material drops into Spout (E), and lighter material not carried out to the dust house drops into settling chamber discharge at Spout (F).

Figure C13. Location of components, adjustments, and discharge spouts on a Clipper Super 29-D air-screen machine.

selected on the basis of hand screen results because of the somewhat different conditions caused by the air and vibration of the large machines.

Rate of Feed

Although the feed gate on a feed hopper is adjustable for large changes of rate of feed, the basic adjustment is made by increasing or decreasing the speed of the feed roll.

Screen Knockers and Tappers

When hand screens are tapped or jarred, seeds are turned and tumbled so that they orient in positions that allow them to pass through the screen rapidly. A similar action can be obtained on top screens by installing adjustable knockers or tappers that lightly tap the screens. This vibrates the screens so that seeds will pass through close and small openings, and will jar loose long weed seeds that wedge so tightly in the perforations that the brushes cannot remove them.

Upper Air Suction

The upper air suction is regulated by an adjustable damper in the air passage so as to remove most of the light chaff and dust before the seed reaches the top screen.

Variable Screen Shake

The variable screen shake adjustment permits the operator to adjust the screen vibration speed from slow to very rapid. The rate of vibration or shake should be adjusted to induce a desirable action of the seed on the screen and not to increase capacity by shaking the screens faster. For example, when cleaning fescue seed through a small round-hole screen, it is necessary to shake the screens rapidly in order to cause the fescue seed to turn on end and go through the round openings. If the screen vibrates slowly, the seed will lie flat and ride over the screen. When cleaning bluegrass seed or canary grass seed with a small square wire mesh screen, it is necessary to shake the screen rapidly or seed will pile up on top of the screen and will eventually flood over with the scalpings. On the other hand, when attempting to make a very accurate and close separation of small round seed through a small round screen perforation, either top or bottom, the screen must vibrate slowly to allow the seed to fit itself exactly in the opening and pass through.

Screen Pitch

Each screen is adjustable to different degrees of pitch. The

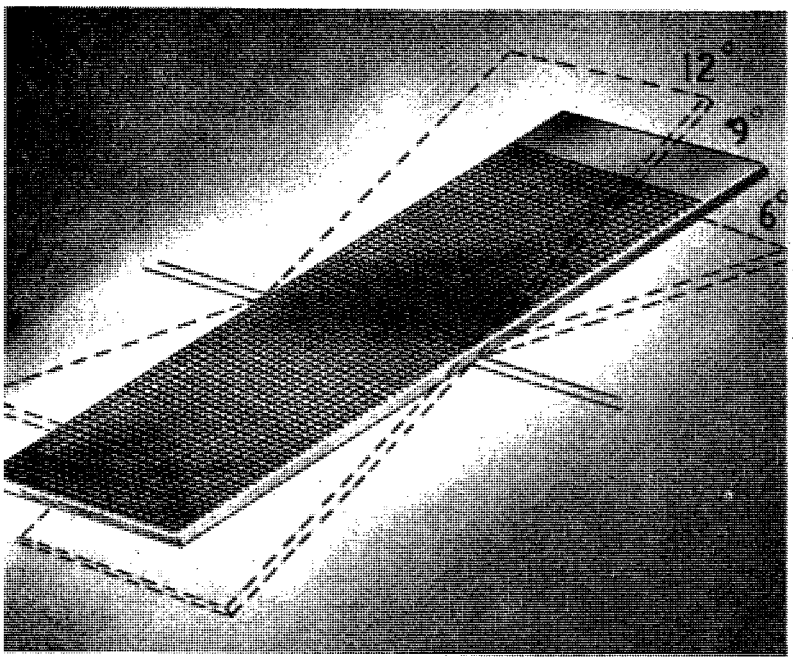


Figure C14. Possible variation in screen pitch.

common range in pitch adjustment is from four to twelve degrees. High capacity grain receiving separators may have a greater adjustable pitch range to move grain over the screens rapidly, but in a precision seed cleaner, 4 to 12 degrees of pitch give adequate cleaning capacity while allowing the exact separations required for seed cleaning.

Screen pitch has a greater effect on the speed at which the seed move over the screen than does rate of shake or vibration. The latter can be increased with little effect on capacity, but seed will pass over a screen in the steepest position almost twice as fast as when it is in the flat position at the same rate of shake. The speed at which seed pass over the screen should be governed by the desired capacity and desired separation. If the separation is difficult and capacity is secondary, the seed should remain on the screen as long as possible to give every seed an opportunity to pass through an opening. If capacity is important and the separation secondary, a steep pitch should be used. When a separation is made along the first few inches of the screen, the remaining material should be moved quickly over the screen by using a steep pitch.

Screens should be independently adjustable for pitch, since each screen may require a different pitch for optimum results. The best time to adjust screen pitch is while the cleaner is operating so that results can be observed.

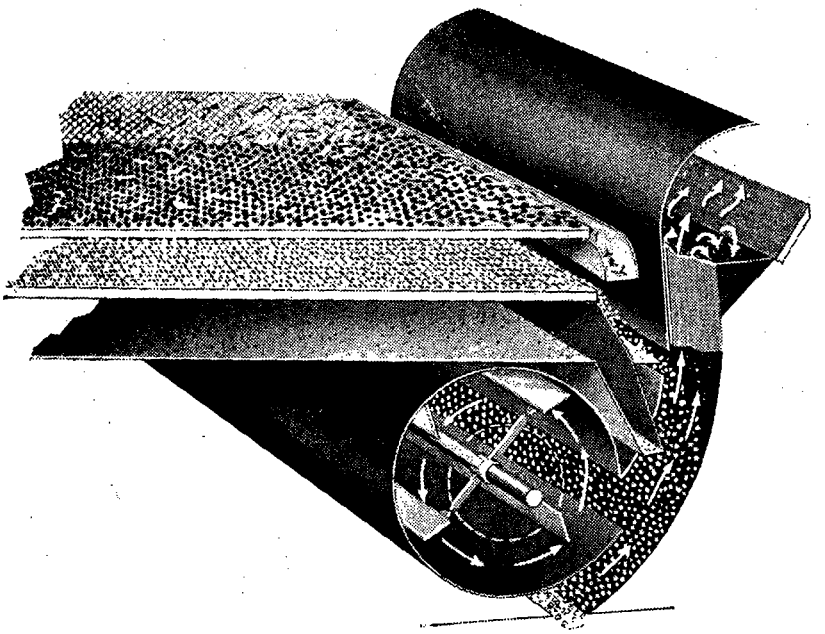


Figure C15. Section view of the bottom blast fan in an air-screen machine.

Lower Air Blast

The lower air blast fan serves two functions: as a very accurate, final weight separator and as a booster for the top suction fan. As the cleaned seed leave the bottom screen and fall in a curtain through the vertical air leg toward discharge, a variable air control can be adjusted to blow out light seed and trash not removed by the upper air and screens. For efficient cleaning, the lower air should blow out a few good seed.

Techniques for Precision Cleaning

It is easy to understand the operation of air-screen machines and how to make simple adjustments. However, many of the techniques of precision seed cleaning must be learned through experience or from an experienced operator. The following techniques help to improve the efficiency and effectiveness of seed cleaning.

Screen Dams

Attempting to make a close and accurate separation with a perforated metal grading screen with a heavy layer of seed passing over the screen creates the danger that some undesirable seed will not

contact the screen perforations and be separated. Screen dams - wooden strips twice as thick as the length of the seed cleaned - can be fastened perpendicular to seed flow across the top surface of the screen to interrupt the smooth flow of seed down the screen and cause them to turn, tumble and contact the openings. Screen dams properly placed provide greater opportunity for all seed to contact the perforations.

Scalper Apron

Round screen such as soybeans tend to bounce and roll down a screen so that some of them never contact a perforation and pass over the screen with the scalpings. A scalper apron made of canvas can be draped over the upper half of the screen to prevent bouncing of the seed and cause them to settle and contact the perforations. The apron should not be so long and heavy that pods and trash will be retained, but of sufficient length and weight to serve as a baffle to make bouncing seed settle to the screen and pass through.

Oil Cloth Drape

At times long stems or weed seeds that should be removed by the top screen will turn on end and go through the screen openings. An oil cloth with the slick side down draped over the top screen will prevent these long materials from turning on end and dropping through. They will slide down the screen underneath the smooth oil cloth and be removed.

Blanking Screens

If the desired separation is accomplished after a short distance of travel on the screen, there is no reason to leave the rest of the perforations down the length of the screen open for trash and weed seeds to drop through. The lower unneeded section can be blanked-off by taping brown paper over it. Permanent blanking can be accomplished by ordering the screen with a blank metal lower section.

Installation

The air-screen machine must be installed properly for best performance. Since it has vibrating parts, it should be installed on and securely fastened to a firm foundation. Although parts of the machine must vibrate, overall vibration of the machine should be held to a minimum.

Proper air ducting from the cleaner is extremely important. Sharp turns, improper junctions, poor connections and poor collectors all contribute to poor air separations in a cleaner. Improper air exhaust also causes a very dirty, dusty plant.

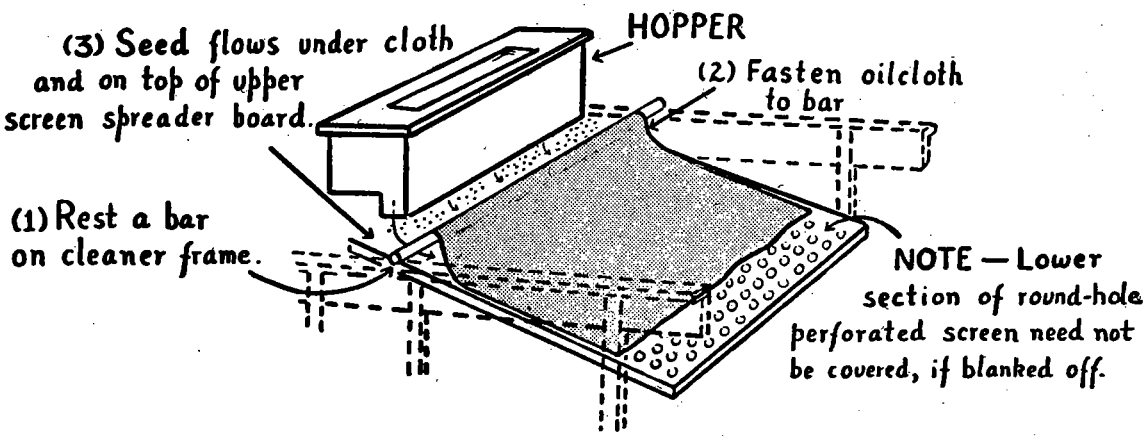


Figure C16. Oil-cloth apron used on screens to prevent long, slender seeds from turning on end and dropping through screen openings.

Single fan cleaners are generally installed with the air discharge near an outside wall so the air can discharge out into the open. In some cases, it is necessary to blow the dust into a large expansion chamber that permits dust and light chaff to settle while permitting the air to continue through and discharge relatively clean.

Dustless cleaners with a top suction fan and a bottom blast fan develop sufficient velocity that cyclone type collector or dust houses can be used to settle dust and chaff from the air stream without a booster. Separate collectors, one for each fan, are often used. However, unless too much air volume is to be handled, it is cheaper to bring the ducts from two fans together with a junction and a divider valve into a single air pipe and use a single air collector or dust house. When the two are joined, the duct approach angle should be kept to a minimum. If the pipes are brought together too abruptly or if a divider is not installed, back pressures which impede the proper flow of air may be created. In fact, as the two air streams converge one opposes the other, so when an adjustment is made on one fan, it will affect the separation that is being made with the other fan.

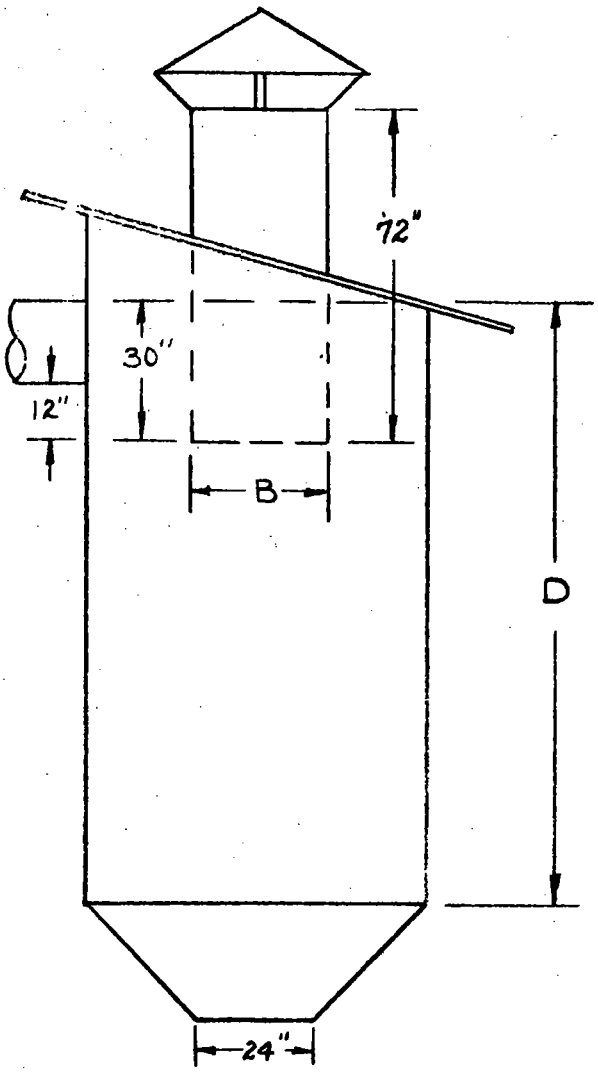
Elbows and sharp angles should be avoided. Back pressures are created at these points and light chaff will be dropped until it finally plugs the pipe. As a rule of thumb, the inside radius of an elbow should be at least two times the diameter of the pipe.

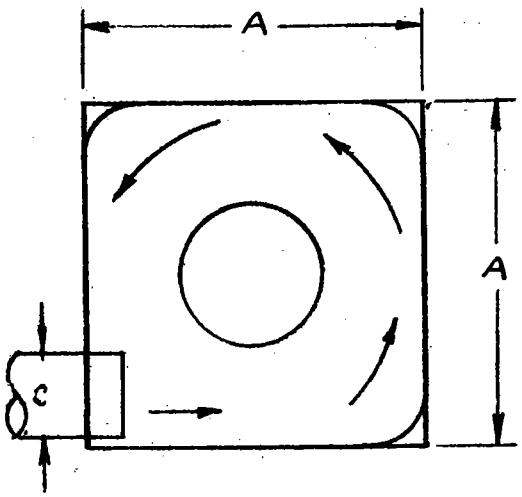
Anything that interferes with the cycloning action of air inside the dust collector or dust house will cause trouble. The most common problems are dust collectors or dust houses too large, too small, improperly designed or with a cap over the pipe discharging air from the top.

Many seedsmen build their own dust houses. Properly designed and large enough, they serve very well. Basic rules governing good dust house construction are:

1. The dust house should be 10-12 feet deep.
2. The entry duct should be horizontal.
3. The entry duct should be below the pitch of the roof.
4. The entry duct should enter along one side.
5. The area of the exhaust opening should be twice as great as the entry area.
6. The exhaust pipe should extend 2 feet below the entry duct.
7. The exhaust pipe cover should not restrict the opening of the exhaust pipe.
8. The clean-out opening should be as large as possible.

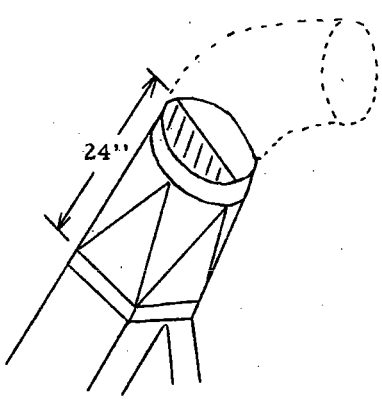
A common mistake is the use of a single dust house to handle the air from two separate cleaners. If the individual air streams from each cleaner were adjusted exactly the same, it is possible that a single dust house or cyclone would be satisfactory, however, frequently the plant will be cleaning large seed on one cleaner and small seed on the other, and air streams from the fans will seldom be identical. It is impossible to adjust one cleaner in this situation without affecting the standing adjustments of the other cleaner. If one cleaner is operating and the other is idle, there will probably be a blow back into the air ducting of the idle machine. This will either plug the piping or blow the dust back into the work room.





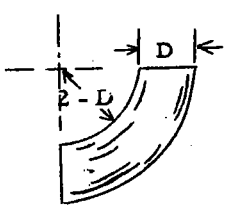
Dimension (inches) of

Fan RPM	A	B	C	D
1600	84	32	17	135
2300	90	34	18	153
3000	96	36	20	174



Use of one Collector for Two Fans

Divider at least 24 inches long should be installed in junction where ducts from two fans meet



Elbows in Ducting

Inside radius should be 2x diameter of duct

Figure C17. General rules applicable to ducting and dust collectors used with air-screen machines.

Dimensional Sizing Equipment

Section D

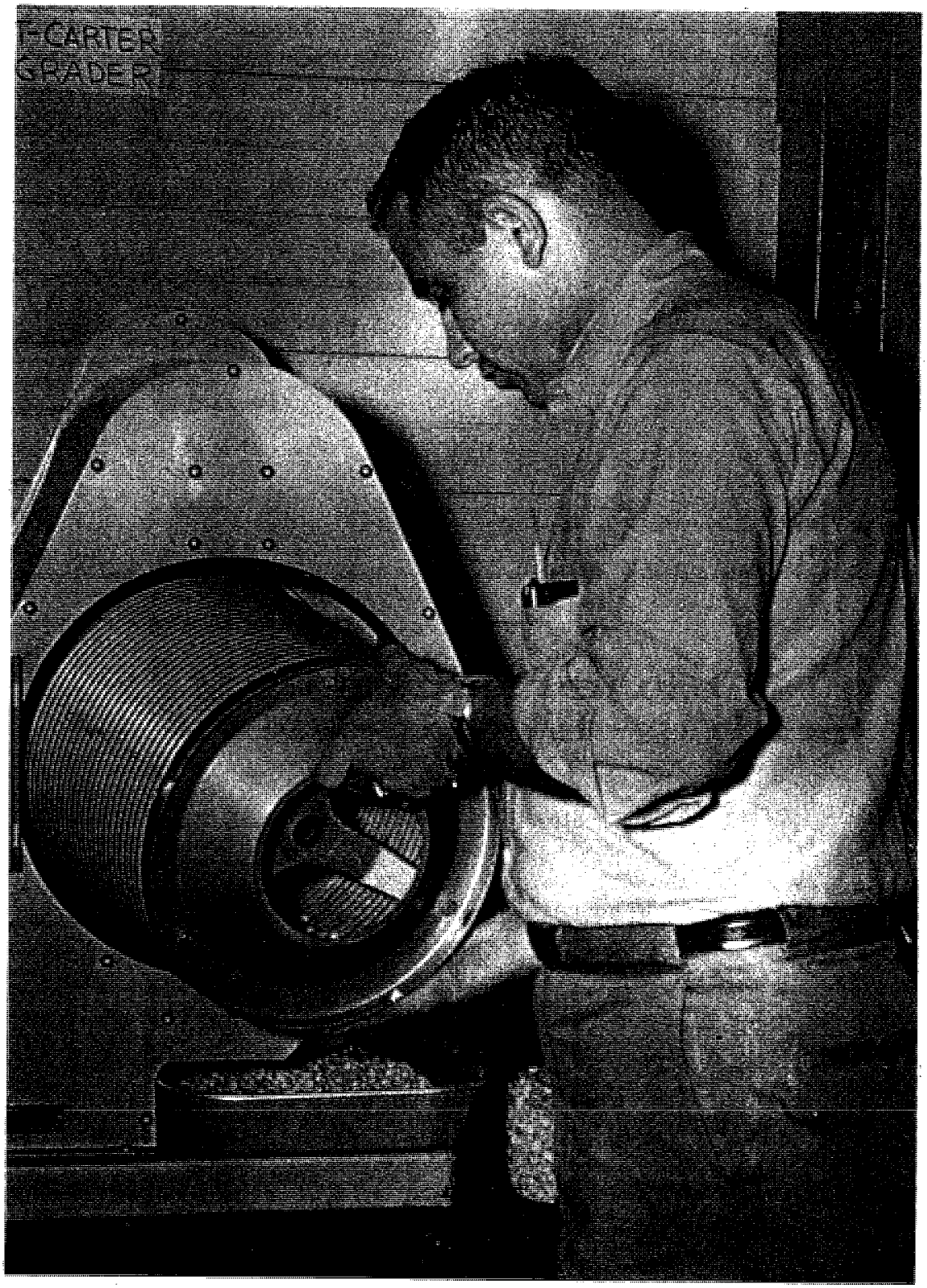


Figure D. Model width and thickness grader used to determine cylinder perforation sizes needed for grading large lots of corn.

WIDTH AND THICKNESS SEPARATORS

Width and thickness separators are commonly referred to as "graders" or "sizers" in the seed trade. Although substantially accurate, these terms are, nevertheless, misleading, for they foster the concept that the machines have a very limited application. Width and thickness separators are more widely used in the seed industry than generally realized. They are as effective in removing contaminating weed seed and other crop seed as they are in size-grading corn or peanuts.

Width and thickness separators are capable of an extremely sensitive, or precise, separation of particles according to their width or thickness dimensions. The separation is similar to, but generally more accurate than, the separation performed on the screens in a conventional air-screen machine. The following principles apply:

SEEDS ARE SIZED FOR WIDTH BY USING ROUND-HOLE SCREEN OPENINGS.

SEEDS ARE SIZED FOR THICKNESS BY USING SLOTTED SCREEN OPENINGS.

The indented round hole screen is used for width sizing, and differs from the perforated round hole screens used in conventional air-screen cleaners in that the hole is ringed by a "seat". Seed move over these screens in an interrupted type flow pattern, slowing briefly for a precise width measurement determination every time they are "seated" over a hole opening. If a seed is narrower than the diameter of the hole, it passes through and is termed a "through". Conversely, if the seed is wider than the diameter of the hole, it rides over the screen and is termed an "over".

Ribbed screens with oblong openings are used for thickness separations. The ribs cause seed to turn on edge and either go through the openings or to pass over on the basis of seed thickness.

Width and thickness separators are not all alike. Differences in structural features allow them to be divided into three general types: (1) the ribbed horizontal-flat screen type, (2) the vertical ribbed screen type, and (3) the cylindrical screen type. Of these three types, the horizontal-flat screen type and the cylindrical screen type are both width and thickness separators, while the vertical ribbed screen type is only a width separator.

Parts of the Machines

Although structurally different, the three types of separators have many similar features. In general, most machines have the following

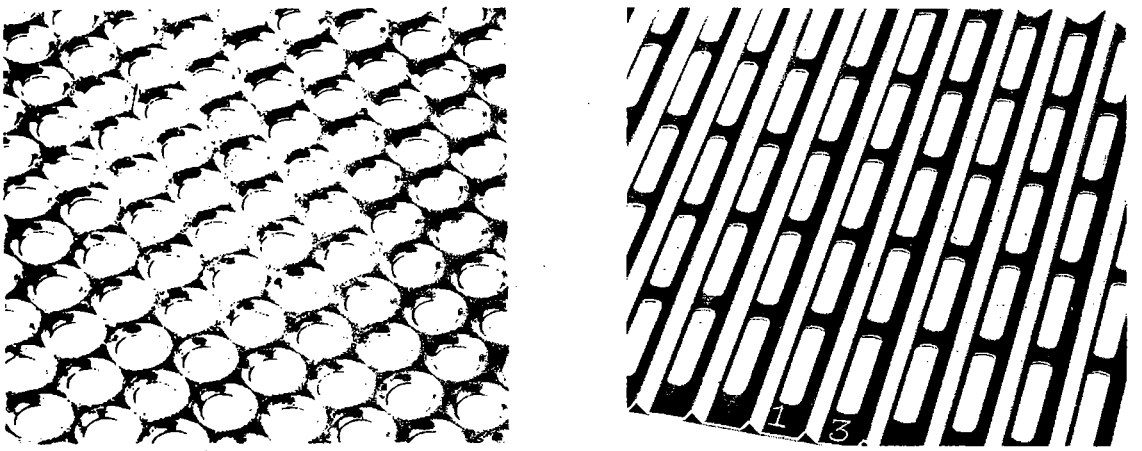


Figure D1. Types of screens used in width and thickness sizing; round hole for width sizing and oblong opening for thickness sizing.

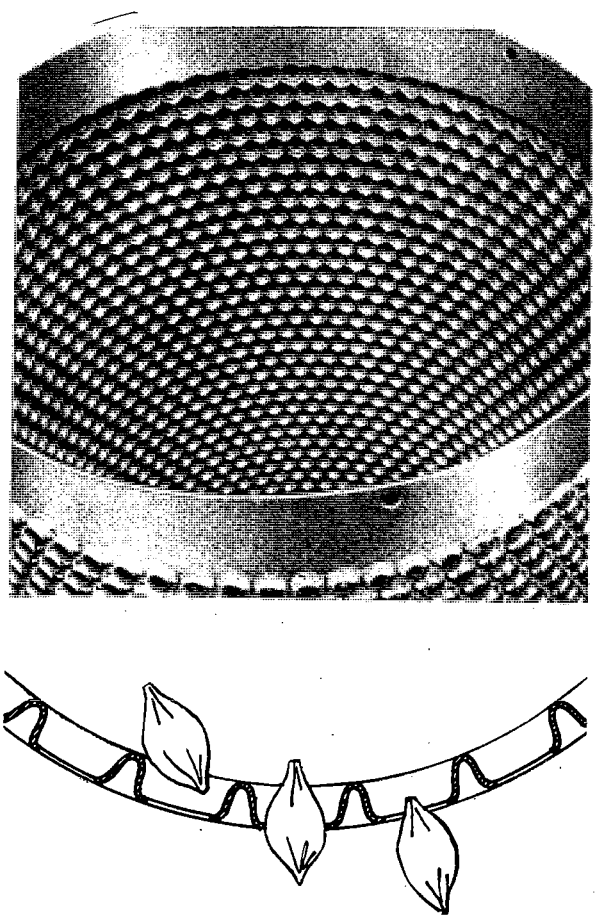


Figure D2. View from end of cylinder showing recessed round perforations used for width sizing and sketch showing how separation is made.

parts: a feed hopper, screens, a screen clearing device, and a mechanism to impart motion to the screens.

Feed Hopper

All machines come equipped with a feed hopper. Many hoppers are simple in construction and serve only as a funnel to direct the flow of seed from an overhead bin into the machine. Others are more complex and are equipped with a metering device, such as a variable speed feed-roll, or feed-gate, to closely regulate the rate of feed from the hopper onto the screens.

Screens

Regardless of the type of machine, separations in all width and thickness separators are accomplished by screens. Therefore, they are the essential parts of the machine. Shape, size and number of screens, and style of construction, vary among the different types of separators and frequently even among machines of the same general type. All screens, however, have either slotted or round-hole openings.

Screen Clearing Mechanisms

Most separators come equipped with a screen clearing device to keep the screen openings from becoming plugged, which reduces the separation efficiency of the machine. In some machines the device also aids the movement of seed across the screen. In general, two types of devices are used: rubber rollers, and tappers.

Screen Drive

Screens of all separators are in motion during operation. For a separation to take place, the seed must be conveyed through the machine. This is accomplished in some machines by eccentrics which move the screens back-and-forth on an inclined plane. On the other hand, seed are moved through cylindrical screens in a spiraling motion by rotational movement of the cylinder.

Types of Width and Thickness Separators

Horizontal-Flat Screen Separators

Two types of flat screen separators are used in the seed industry (see illustrations). Structurally they are quite similar. Both are equipped with feed hoppers having a metering device. The screens are also similar and are mounted in "shoes". Both types use eccentrics to impart motion

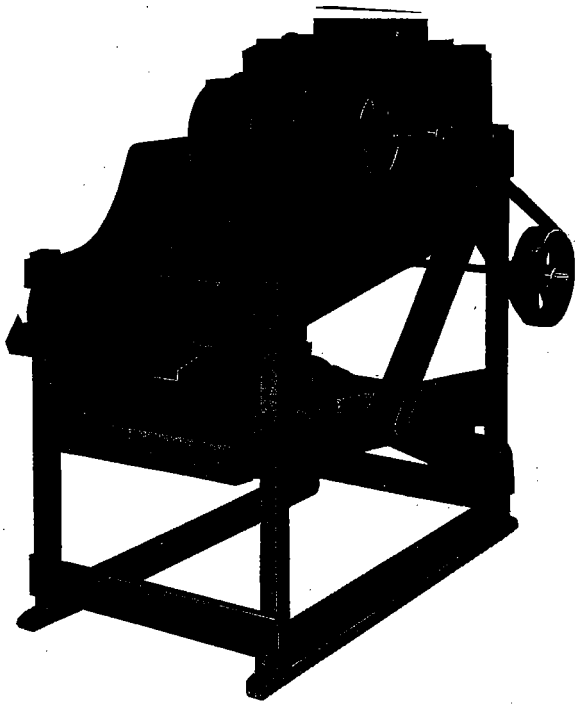


Figure D5. Cleland Expert corn grader.

to the screens. These separators were especially engineered for sizing hybrid seed corn and use a series of two or more ribbed screens to accomplish width, thickness, or width and thickness separations.

The corn cleaner-sizer illustrated is available in 2-, 3-, 4- and 6-screen models. When used for corn size-grading the two-screen machine produces a maximum of 3 size-grades; a three-screen machine produces 4 size-grades; a four-screen machine produces 5 size-grades, and a six-screen machine produces 7 size-grades. Additional size-grades can be obtained by re-running the seed through the machine.

The Superior Rock-it corn grader (see illustration) has been a principal corn size-grading machine for many years. It has two shoes, each of which holds two layers, or decks, of two screens each, making a total of four size-grading decks in the machine. Each deck contains both width and thickness sizing screens, so that in passing from one end of the deck to the other, the kernels will be graded first for width on a round hole screen, then for thickness on a slotted screen. A maximum of 12 grades can be produced in a single run.

Flat-screen size separators used in the seed industry are designed specifically for size-grading of corn. The range of screen sizes is limited to those sizes required by the corn industry. The most commonly stocked

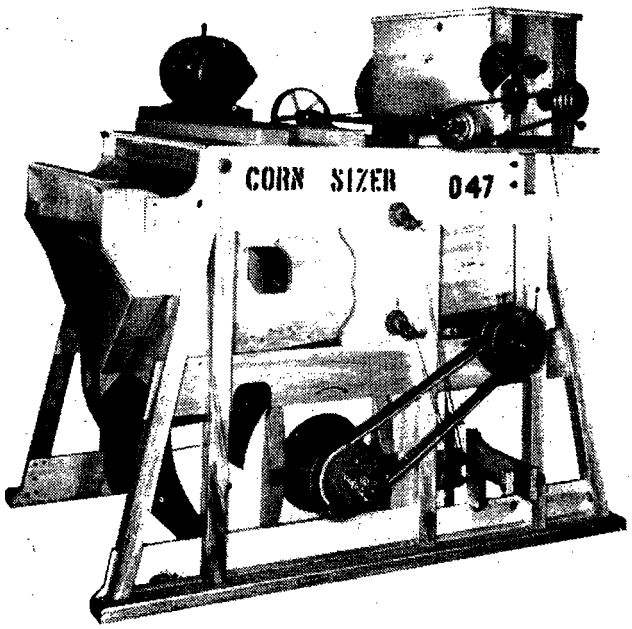


Figure D6. Clipper corn sizer, Model 047. This sizer has two screens and one air system.

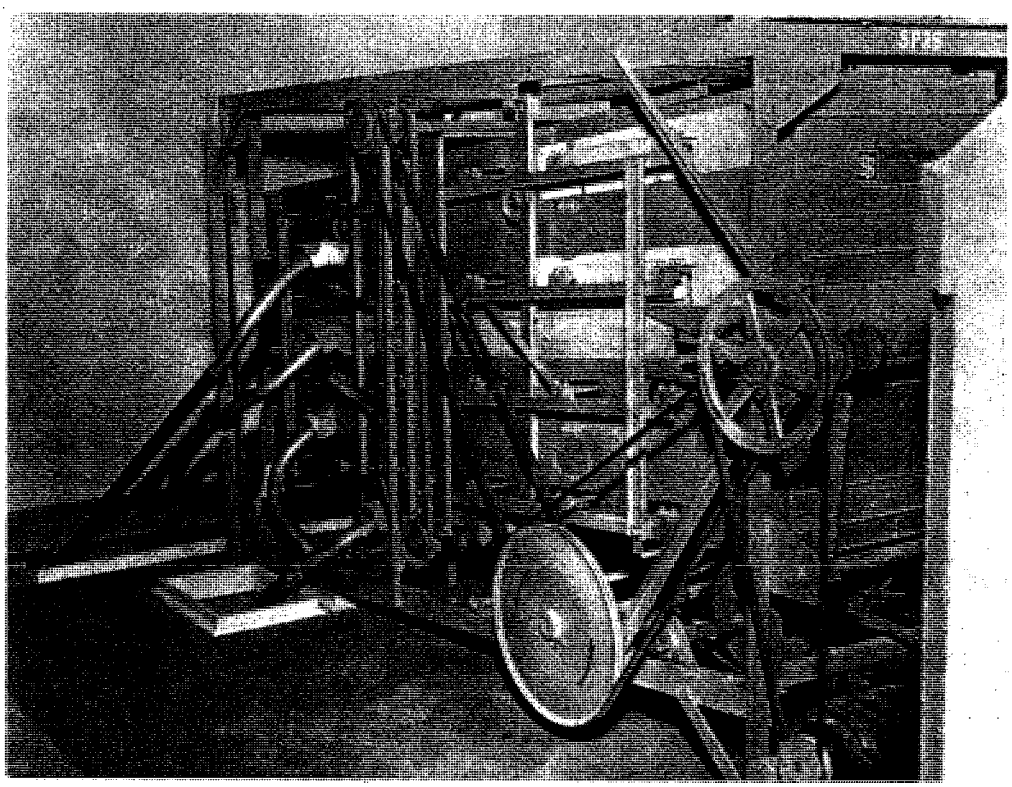


Figure D7. Superior S4 Rock-It corn grader. The Rock-It grader has eight screens.

screens range in size from 16/64th to 25/64ths inch for round hole screens, and 11/64s to 15/64ths inch for slotted screens. Length of the openings in slotted screens is usually 3/4 inch or 1 inch.

Principles of operation: Seed to be sized are deposited from the feed hopper on top of the upper-most screen. This screen can be either a slotted screen or a round-hole screen, according to the first separation to be made and the flexibility of the machine. For example, a standard arrangement of screens in the Rock-it grader calls for the top screen to be a round hole screen, whereas, in the cleaner-grader this screen may be either a round hole or a slotted screen depending on whether the operator chooses to width-grade or thickness-grade first.

In operation, the screens move forward and backward, all screens in a single shoe moving simultaneously in the same direction. This motion causes the seed to move down the inclined screens toward the discharge spouts. Seed larger than the hole-openings in any particular screen remain on top of the screen and are discharged at the end of the screen. Seed smaller than the openings, because of gravitational force, drop through and are deposited on top of the next lower screen in the machine. This screening action continues until the seed are appropriately sized and discharged according to screen types and sizes in the machine.

Adjustments: The machines must be properly adjusted to achieve a precise, efficient separation of differently sized particles. Rate of feed and rate of vibration are two adjustments common to all separators of this type.

(1) Rate of feed - Machines of this type usually come equipped with a variable speed feed roll or a feed gate to permit accurate metering of the seed onto the upper-most screen. When properly adjusted, seed flow on the screen carrying the heaviest seed load should be one layer deep.

(2) Rate of vibration - rate of vibration controls the speed at which seed flow through the machine. Generally speaking, the faster the rate of vibration the faster the flow. However, rate of vibration also affects the precision of the separation being made. A slow vibration rate causes the screen openings to become plugged, thus permitting some seed to travel the entire length of the screen without contacting a free opening. Conversely, a fast vibration rate causes seed to "bounce" or "skip" down the screen, failing to seat themselves long

enough or often enough to be properly sized. To determine the optimum rate of vibration, products being discharged should be checked for uniformity of size, then capacity requirements should be determined and adjustments made accordingly.

Vertical Ribbed Screen Separator

The Dockins Seed Grader is a vertical screen type separator used exclusively in the rice seed industry. Only two models are available, one containing 12 screens the other containing 20 screens. Since this machine is used only as a width separator it uses only round hole screens. Two perforation sizes of screens, a No. 10 and No. 11 (Manufacturer's designation) are available.

The screen-units in a Dockins Grader are arranged in vertical banks, in shoes on either side of a centrally-mounted feed hopper. They are removed from the machine by raising the feed hopper. An eccentric is used to impart motion to the shoes. As is the case with all two shoe separators, the two shoes move in opposite directions simultaneously to eliminate excessive vibration.

The screens in this separator differ from those in other width and thickness separators. They are termed "screen units". Each screen unit has two parallel screening surfaces. A series of parallel shelves run lengthwise between the two screening surfaces. These shelves are slightly inclined and convey the seed mass through the screen-unit. Openings in these screens have no seat.

Principles of operation: Seed enter from above and discharge from beneath the machine. As they leave the feed hopper, seed are funneled into the upper corner of the screen units and onto the first shelf. Vibration causes the seed to move along the inclined shelf until it is discharged from the end of the shelf onto the next lower shelf which is inclined in the opposite direction. The seed mixture continues to move in this forward-backward motion all the while moving closer to the bottom of the machine. Particles narrower than the diameter of the hole openings are forced, by product pressure, through the holes. They are discharged from the machine separately from the particles unable to pass through the hole openings.

Adjustment: There is only one adjustment. This adjustment controls the speed at which the seed mass moves through the machine. It is located at the bottom of each screen unit. This type of separator works best when the screen units are full, thus the rate of seed flow through the machine should be set so that the screen units are always full.

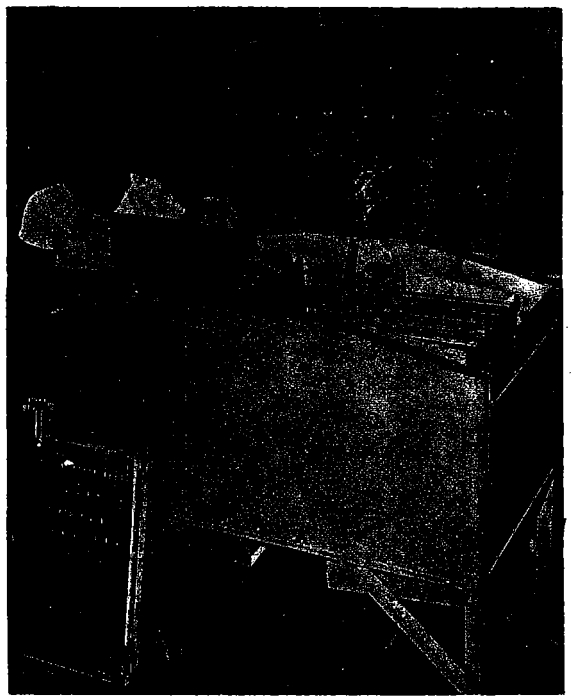


Figure D8. Dockins seed grader. This machine is used almost exclusively for width separations of rice seed.

Cylindrical Screen Separators

The Carter-Day Precision Grader and the Superior Hi-Capacity Sizer (see illustrations) are both cylindrical screen type width and thickness separators. They are but two of several models manufactured by these companies. Unlike the width and thickness separators previously mentioned, these machines are designed to size-grade accurately any material by width and thickness.

Structurally simple, these machines consist essentially of a feed hopper, a screen clearing device, screens and a source of power. They are relatively light in weight and can be stacked two and three high. Machines housing up to six cylinders are manufactured for operations in which large capacities are needed.

Screens used in each machine are cylindrical yet somewhat different. Both slotted and round hole screens for the Precision Grader are approximately 60 inches long and are one-piece, or a complete cylinder.

The Superior Hi-Capacity Sizer uses two types of screens. Slotted screens come as a 1/2 cylinder (180° of the circle) and two slotted screens are required to form a complete cylinder. Round hole screens come as complete cylinders. One reel, which is roughly comparable to one screen in a Precision Grader, is made up of three

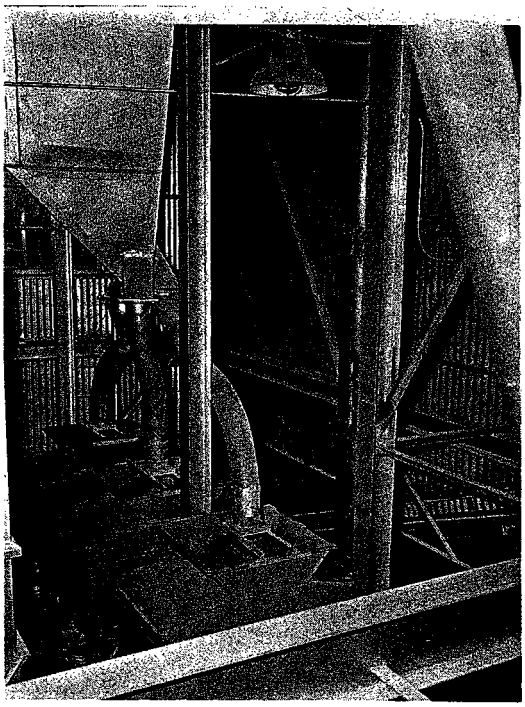


Figure D9. Dockins seed graders (lower left) installed in rice seed plant.

cylindrical screens of different sizes connected end to end to form the cylinder unit. Thus, several size grades are made by a single reel.

Screens of cylindrical screen type separators are available in a wide range of sizes because of the many uses of these machines. They can be used to perform any of the separations mentioned earlier in this chapter. Range of available screen sizes for any particular machine varies depending on the manufacturer and the model of the machine. Usually screen sizes range from 3/64 to 36/64th inch in width for screens with slotted openings, and from 4/64 to 26/64th inch for screens with round hole openings.

Various flow arrangements can be used which provide flexibility and the possibility of making from one to three separations in a single machine. Units are arranged in parallel flow or reversed from end to end to obtain these various arrangements.

Principles of operation: Seed to be sized are fed from a feed hopper into one end of the rotating cylinder. A combination of gravity, centrifugal force, and product pressure acts to force each particle into the perforations. This "press-fit" action insures that particles smaller than the openings pass through. In some machines a continuous spiral channel inside the screen

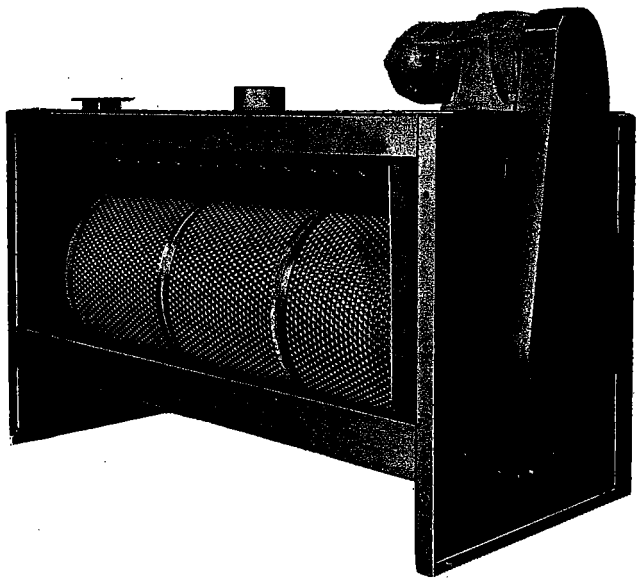


Figure D10. Superior Hi-Capacity sizer used for width and thickness sizing of seed.

keeps the "overs" moving through the cylinder. Other machines employ lifting bars, or baffles to do the same job.

Adjustments: The operation of cylindrical screen type width and thickness separators is simple because there is only one adjustment on most machines: rate of feed. Most machines come equipped with a feed control gate in the feed hopper. Opening the feed gate permits more seed to enter the screen.

Multi-screen or reel units sometimes have two adjustments - a feed control gate and a divider plate. The divider plate adjustment insures that each screen in the multi-screen unit receives the same amount of seed.

Uses and Operation of Width and Thickness Separators

All large corn seed processors use width and thickness separators to size-grade corn for precision planting. Rice processors in the southern region of the United States also employ these machines to separate red rice, a noxious weed, from varieties of long grain rice. Other common uses of width and thickness separators include: (a) the removal of splits from soybeans, edible beans, and peanuts; (b) the removal of chips and splits from sorghum seed; (c) the removal of cheat from wheat; (d) the

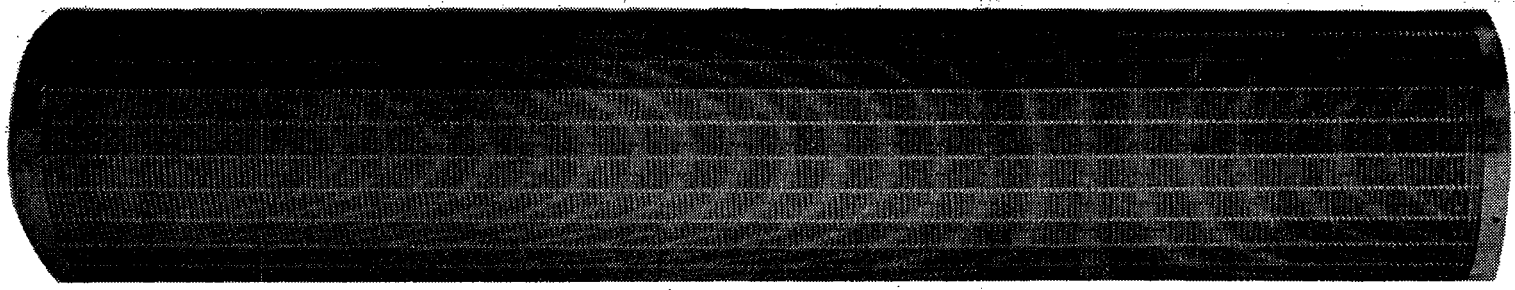


Figure D11. Cylindrical screen with slotted perforations.

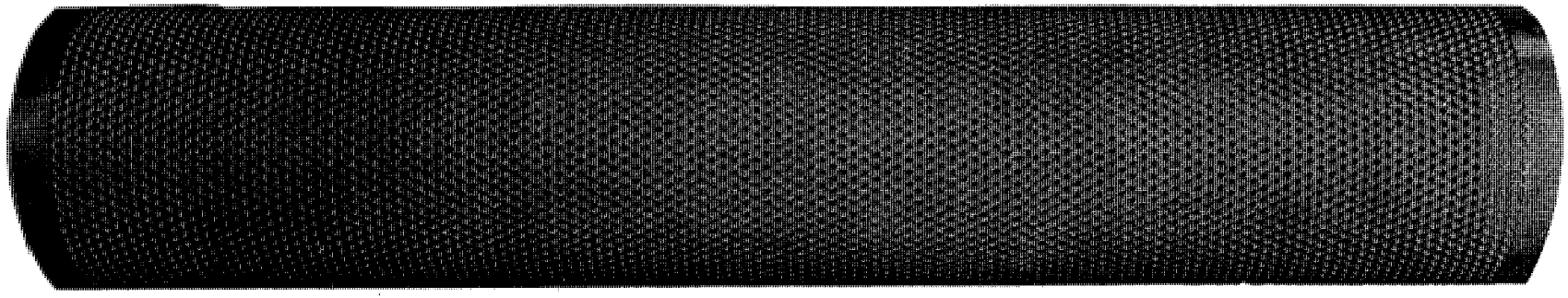


Figure D12. Cylindrical screen with round perforations

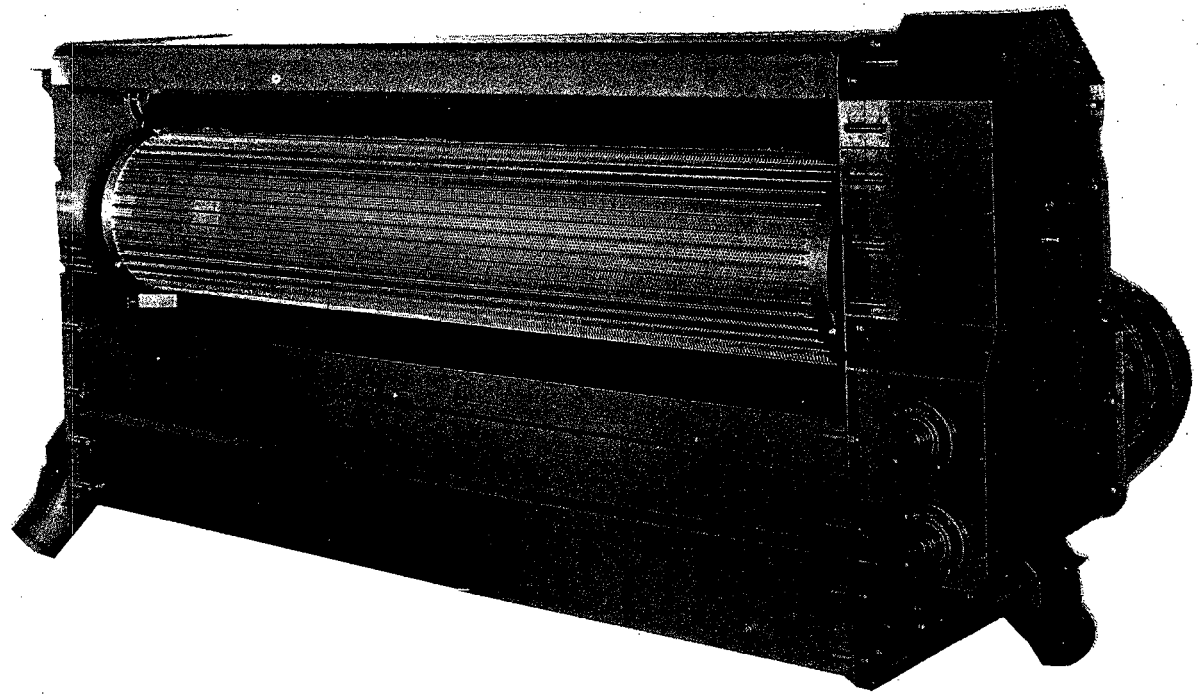


Figure D13. Carter-Day Precision Grader used for separating seed on basis of differences in width and thickness.

removal of cockleburs from cottonseed, wild onion from fescue, and wild oats from barley. Other agricultural, but non-seed, uses include size-grading of barley, oats, wheat, nuts and coffee beans for quality factors important in the feed, food or milling industries.

All separators employ gravity, centrifugal force, product pressure, or a combination of these forces to make width and thickness separations on screens. Screening surfaces used in the Rock-it Corn Grader are illustrated. Other width and thickness separators, with the exception of the Dockins Grader, use screens with similar type openings.

Summary

Machines classified as width and thickness separators make an extremely sensitive, or precise, separation of particles according to their width and thickness demension. It is a separation similar to, but generally more accurate than, the separation performed by the screens in a conventional air-screen machine. Several types and many styles of width and thickness separators have evolved from the original air-screen machine. Newer width and thickness separators are not classified as cleaners, but are designed to separate particles already pre-sized on an air-screen cleaner.

LENGTH SEPARATORS

Length separators are specifically designed to effect separations of particles differing in length. In fact, disc and cylinder separators are the only machines used in the seed trade to separate seed on a pure length difference basis. Both machines effect this separation by lifting the short particles out of a mixture containing both long and short particles. They are most effective when the undersized or short particles are relatively uniformly dimensioned. Therefore, they should be used only after processing with an air-screen cleaner.

Length separators are much used in the cleaning of small grain, grasses and legumes to make separations of weed and other crop seed that cannot be made by any other method.

Disc Separator

The disc separator is a length sizing separator which lifts short seeds out of a seed mass containing both short and long seed.

Originally disc separators were used to separate other grains and seeds from wheat. Now their use has been widened to include length separating and sizing of other grains, many kinds of seeds, and a variety of other granular materials. They are found in many seed processing plants. Also, many sizes and types are available from which a unit can be selected to satisfy a particular need. For example, a separator recommended for use in the grass and vegetable seed trade can be used equally well for cleaning seed grain.

Parts of Machine

Feed hopper: The feed hopper on most machines is a simple container that receives seed to be cleaned from the elevator or by some other means. From the hopper seed are fed into the machine for cleaning. The hopper is usually provided with slides or a sliding gate to control the rate of feed into the machine.

Discs: Discs are the primary components of the separator. They are wheel shaped and are made in four diameters, 15, 18, 21 and 25 inches. All discs in a single machine, however, are the same size. Each disc has three essential parts or features: a hub, spokes, and disc pockets. The hub and spokes, while not directly involved in the separation, have important functions. Each disc is mounted on a central shaft at the hub. The spokes

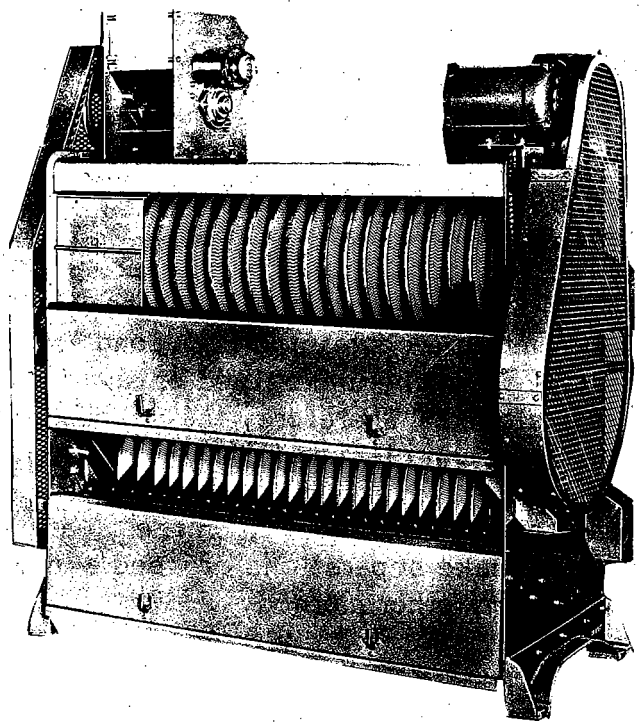


Figure D14. Carter disc separator, Model 1547.

form the connection that exists between the hub and the rest of the disc. Conveyor blades are attached to the spokes and act as a screw conveyor to move the material through the body of the machine. The open areas between the spokes on each disc are called the "eyes" of the disc. Material traveling through the machine must move through this open area. Disc pockets are undercut in each face or side of the disc. Hundreds of these pockets on both sides of a disc make a honeycomb effect.

The pockets are the effective separating mechanism of the disc and are made in many styles and shapes. Pockets are measured and designated by their width. Height of the pocket is essentially the same dimension as the width; and depth is approximately 1/2 of the width dimension. The bottom or undercut part of the pocket is called the "lifting edge", while the top portion of the pocket is called the "leading edge".

Disc pockets are made in three shapes: "V" pockets, "R" pockets and "square" pockets.

(1) "V" pockets - The "V" type pocket derives its name from vetch, since they were originally designed to remove vetch from wheat. This type pocket has a round lifting edge and a horizontal leading edge and is used to lift and separate short, round-shaped seed from a seed mixture. Tubular, cylindrical or elongated seed do not seat well in the rounded

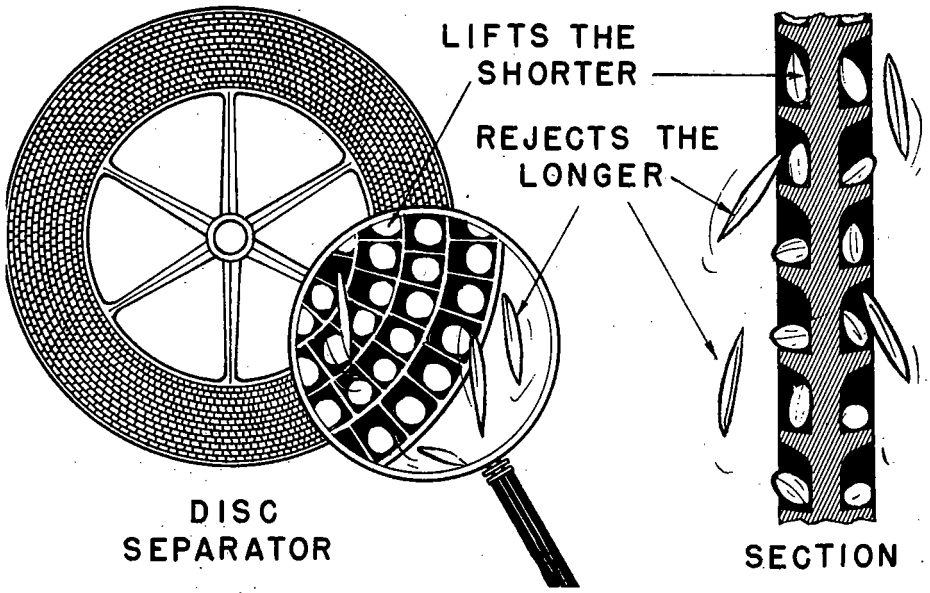


Figure D15. Face and cross-section of a single disc.

lifting edge of the pocket (the bottom of the pocket is cup-shaped) so they tip out of the pocket.

The letter designation "V" is always followed by a number, such as V4, V5 1/2 or V6. The number indicates the width dimension in millimeters, i.e., a pocket designated as V4 is a pocket with a round lifting edge which is 4 mm. wide. "V" pockets seldom exceed 6 millimeters in width.

(2) "R" pockets - The "R" type pocket derives its name from rice, since it was originally designed to remove cross-broken grains from whole grains of rice. It looks like an up-side-down "V" pocket. The lifting edge is flat and horizontal while the leading edge is round. "R" pockets are now used primarily for lifting and separating tubular and short elongated seed from a seed mixture. This type pocket will not lift spherically shaped seed. The letter "R" is also followed by a number such as R4, R5 or R6. The number indicates the width of the pocket in millimeters. The width seldom exceeds 6 millimeters.

(3) Square pockets - Alphabetically designated pockets other than "V" and "R" pockets, are square faced and have no

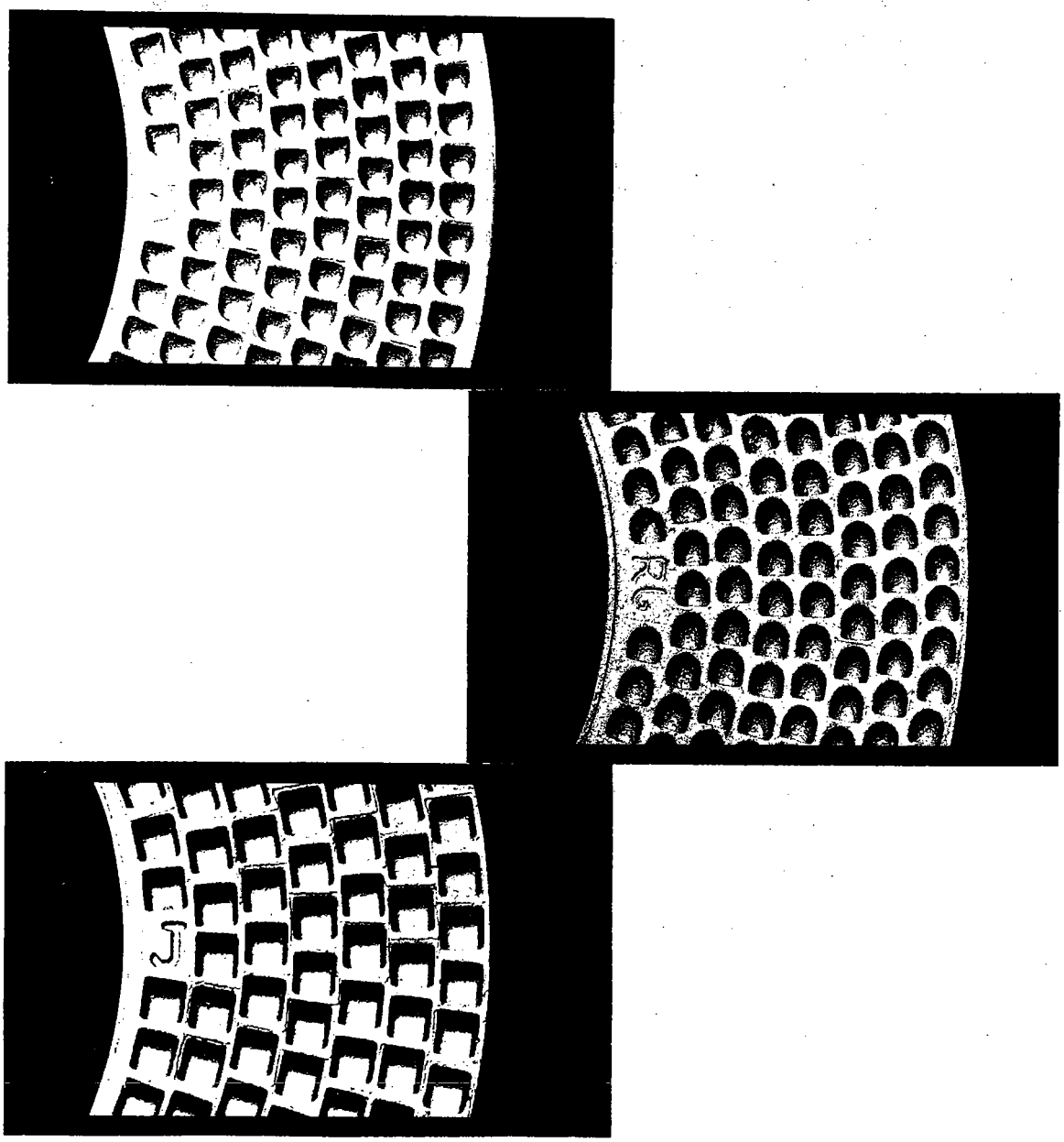


Figure D16. Three types of disc pockets: top, V-pockets; center, R-pockets; bottom, square pockets.

numerical size designation. Furthermore, alphabetical sequence is no indication of relative size. For example, "B" pockets are not necessarily larger than "A" pockets, nor smaller than "C" pockets. Since the pockets are square faced, they have a horizontal leading edge and a horizontal, sloping lifting edge. Square faced pockets less than 1/4 inch in width have been supplanted by the "V" and "R" pockets.

Generally speaking, square pockets have two functions. One is to remove seed from a mixture containing long pieces of inert matter such as stems or pieces of straw. Secondly, they can be used as splitters to divide the seed mixture into two fractions. Each fraction is then resized in separate operations, or on different types of machines.

There are over 75 different disc-pockets from which to choose. Each shape is made in a number of sizes ranging from 2.5 millimeters in "V" and "R" pockets to more than 1/2 inch in square pockets.

A series of discs assembled on a horizontal shaft revolve together through the seed mass and effect the seed separation. "V" and "R" pockets are usually used in combination on a shaft, where a variety of types of liftings are to be made, or where versatility is desired.

Trap doors and return conveyor assembly: Other parts of the disc separator are the trap doors and return conveyor assembly. They are located between the discs and the discharge chute for lifted material. The hinged trap doors cover a screw-type conveyor. This assembly permits returning some of the lifted, short material ("liftings") back into the body of the machine. When the traps are down, the liftings pass over the doors and out of the machine. When the doors are raised, the liftings are deflected into the screw conveyor and returned to the feed end of the machine, where it feeds back into the main seed mass.

Tailings gate: Long or non-lifted seed - called "tailings" - are conveyed through the machine and are discharged through the tailings gate. Raising the tailings gate raises the seed in the machine to a comparable level.

Discharge spout for liftings: Each machine is equipped with a discharge spout for liftings. There are splitters or dividers in the discharge spout for the purpose of separating the liftings into various components.

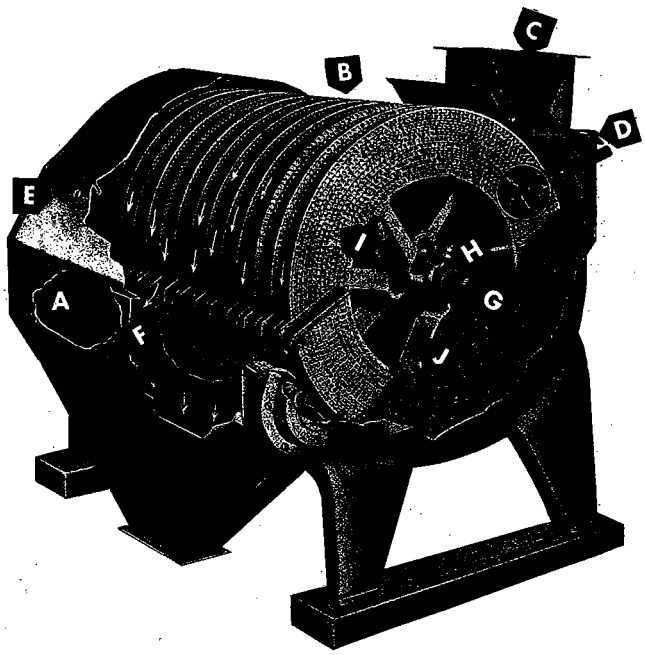


Figure D17. Parts of disc separator: A, return conveyor for lifted material; B, discs; C, feed hopper; D, sliding gate to control rate of feed; E, inspection door at front of the machine; F, trap doors; G, horizontal shaft; H, collar on shaft; I, undercut pockets in the discs; J, conveyor blades.

Principles of Operation

Seed are fed into the separator from the feed hopper. To reach the tail end of the machine they must pass through the eye of each disc. In so doing, the spokes and conveyor blades agitate and stir the mass assuring that all seed come in contact with the pockets in each rotating disc. As the discs rotate through the seed mass, short particles are picked up, held in the disc-pockets, and lifted out of the seed mass. They are discharged into the liftings discharge spout when the trap doors are closed. If the trap doors are open, they are discharged into the return conveyor and returned to the seed mass. Seed too long to fit securely into the pockets travel the entire length of the machine and are discharged through the tailings gate.

It is possible to arrange a series of discs on a single shaft using as many as six different pocket sizes and types. In a normal arrangement, the disc pockets are furnished in a progressively larger size from the intake end to the discharge, or tail end of the machine. With this arrangement, the shortest of the short particles will be lifted first.

Adjustments

Rate of feed: The rate of feed can be controlled on a disc separator by opening the slides on the feed hopper to give the desired

rate of feed. The desired rate is determined by two observations. First, check the clean material being discharged to see if it is thoroughly clean. Then make certain the longer rejected material is not overflowing through the discharge spout for the lifted material.

Position of tailings gate: The tailings gate may be raised or lowered as desired. By raising or lowering the tailings gate, the level of seed in the machine is raised to a comparable level; therefore, the distance from the level of the grain to the point of discharge of the rotating discs is reduced.

Position of trap doors: This adjustment is made by either raising or lowering any desired number of trap doors. By lowering the trap doors, lifted material is discharged from the machine. By raising the trap doors, lifted material falls into the return conveyor and is returned to the head of the machine for recleaning. During the operation of the machine, some of the trap doors may be raised while others are lowered. This gives more flexibility and allows a variety of crops to be cleaned with the same set of discs.

Arrangement of conveyor blades: Conveyor blades may be removed or added in whatever number is needed to make the material travel through the machine at the most efficient rate for complete separation. Sometimes it may be desirable to remove or reverse some of the conveyor blades for the purpose of slowing down the overall flow of the material through the machine.

Cylinder Separator

The cylinder separator is also a length sizing separator which lifts under-size or short particles out of a mass of seed. In this respect it is similar to the disc separator, but in other ways it is quite different. Although manufactured by several companies, cylinder separators are basically alike. They can be used as single units or stacked one above the other and used to complement each other.

Parts of the Machine

An indented cylinder machine consists of two basic parts: the cylinder and a receiving trough. Other parts, which are related to the effectiveness of the separation, are the leveler or conveyor, the retarder and the feed hopper. However, the cylinder is the most important part of the separator.

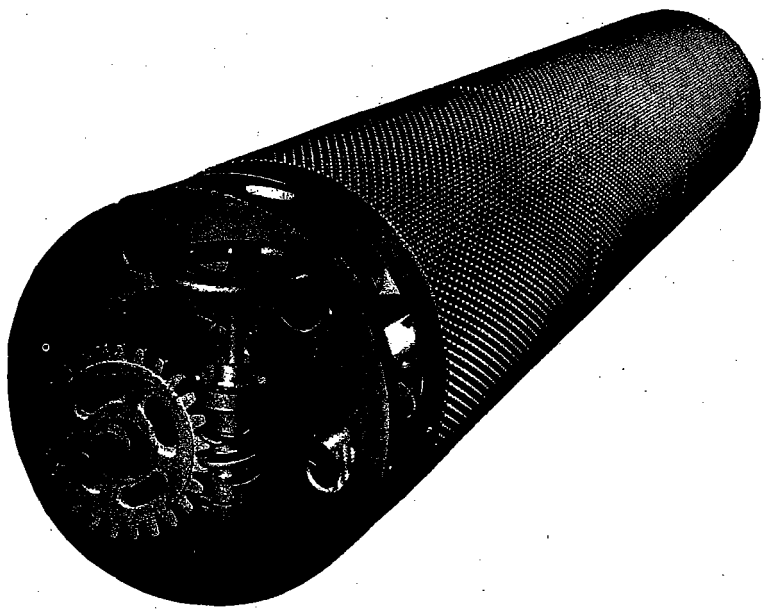


Figure D18. View of indented cylinder showing trough adjustment.

Feed hopper: The feed hopper receives seed to be cleaned from the elevator or from some other means. From the feed hopper the seed are fed into the machine for cleaning. The feed hopper can be equipped with a mechanical roll feeder, which provides uniform feeding when very light materials or small volumes are being handled. However, most feed hoppers on cylinder machines are small and provide only for the receiving of the seed into the machine.

Cylinder: The cylinder performs the separation. It is similar to a drum with both ends removed, and revolves about a horizontal central shaft. The walls of the cylinders or shells are lined with indents or pockets formed into a shape approximating a hemisphere. The size of the shells varies from machine to machine. They range from 17 inches to approximately 24 inches in diameter. They also vary greatly in length. Some are 56 inches long, while others are as long as 90 inches.

There are two basic types of indents - conical and hemispherical. The hemispherical indents have straight side walls and a circular bottom. The conical indent is tapered and is larger at the top than at the bottom.

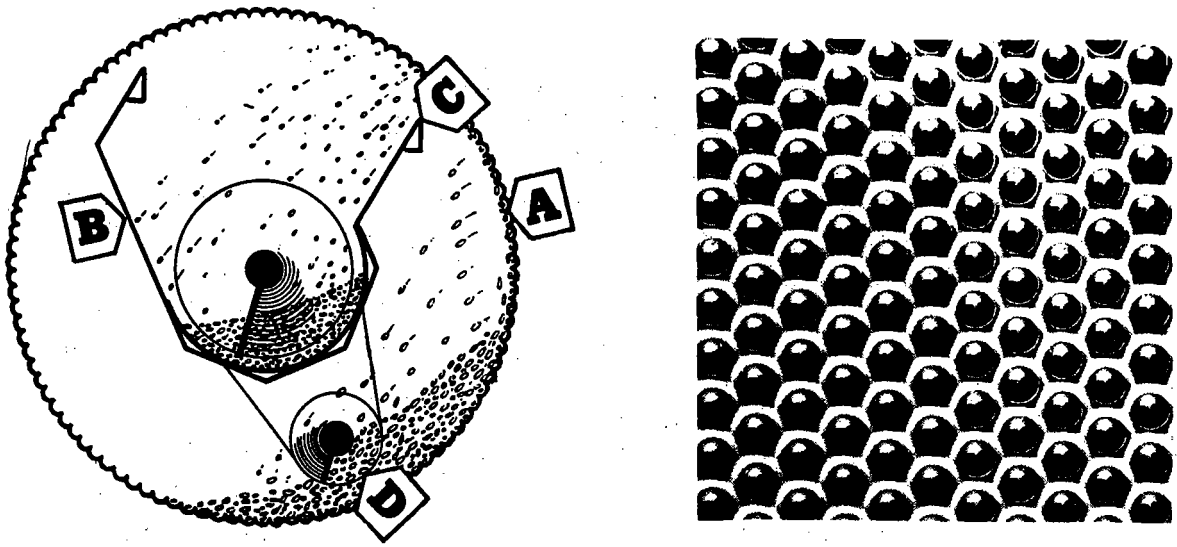


Figure D19. Cross-section of a cylinder length separator. A, the cylinder wall with indents stamped into it; B, the adjustable trough catching short lifted seed; C, the separating edge of the adjustable trough; and, D, the auger conveyor in the bottom of the cylinder that conveys long rejected material out of the cylinder. Interior surface of cylinder is shown at right.

Indent sizes are listed in 64ths of an inch and come in a wide range. For example, a cylinder designated by the number 22 has indents 22/64th inch in diameter. There are no other figures or letters used to describe the indents. Also, there is no way to determine the shape or depth of the indent from the number. Examples of cylinder sizes used for some separations are given in an accompanying table.

Receiving trough: The receiving trough is a device to receive the liftings. The configuration of the receiving trough varies from machine to machine, but its function remains the same. The trough is adjustable in order to permit making a "cut" at the most desirable point. Material dropped into the receiving trough is conveyed to the tail end of the machine and discharged into a spout that carries it away from the machine. Two methods are employed to convey this material: a screw-type conveyor or a vibrating type receiving trough. The latter type of trough is found in some American and some foreign made machines.

Leveler or conveyor: It is necessary to have some means of conveying seed through the machine in order to discharge the particles that are not lifted by the indents. This is usually accomplished by one of two methods. In some of the smaller,

especially, shorter cylinder type machines, it is accomplished by elevating the feed end of the machine to a point that allows the rejected material to flow uniformly through the cylinder. Most machines, however, use some mechanical means inside the cylinder to perform this operation. A screw conveyor in the bottom of the cylinder will keep the mass level, prevent stratification, and also convey the material to the discharge. Another method is the use of grain line blades which break up the mass and also convey.

Retarder: The retarder is a dam at the discharge end of the machine. It may be adjusted to hold the seed at any desirable level. Without the retarder, the seed mass is less at the discharge end of the machine because the smaller particles are lifted out of the seed mass. Without the retarder, surging sometimes results. Surging is the rocking back and forth of the seed mass as the cylinder rotates. By retarding the discharge, the depth of the seed can be increased to the point where no surging occurs and the best separation is accomplished.

Principle of Operation

Seed to be cleaned are fed into the upper, or feed, end of the rotating cylinder. Since all indents in a single cylinder are of the same type and size, all indents lift essentially the same size particles.

Short seed, or particles, drop into the indents, as the indents pass under the seed bank in the cylinder. They are lifted, and held in the indents until force of gravity overcomes centrifugal force and they drop into the receiving trough. From the receiving trough they are discharged out of the machine.

The long seed travel the entire length of the cylinder and are discharged over the retarder into a hopper that removes them from the machine.

At the feed end of a cylinder separator there is naturally a large quantity of undersized particles, two or three of which may fall into an indent at one time. As these are depleted, intermediate sizes are lifted out of the mass at approximately the center of the cylinder length. At the tail end of the cylinder the final and most critical size selection by the indent is accomplished.

Adjustments

Indented cylinders operate on the centrifugal force principle by which the speed of the cylinder holds the shorter seeds in the indent,

Figure D20. Cylinder separators stacked two high and arranged for parallel flow. This arrangement is used to increase capacity.

lifting them out of the mass until the indent is inverted to the point where gravity causes the lifted particles to fall out of the indent. Shape and size of the indent and the seed, seed coat texture, moisture content and weight of the seed all combine to make certain seeds lift close to the vertical center before they fall out. Since it is only practical to use one size and shape of indent in a cylinder, separations are accomplished by two adjustments: speed change which increases or decreases centrifugal force, and the setting of the edge of the trough which catches the desired liftings. These two adjustments give the cylinder separator extreme flexibility.

Rate of feed: It is necessary to control the rate of feed. If the rate is too slow, then failure to attain capacity becomes a problem. If the rate is too fast, not enough time is allowed for cleaning. If the feed varies, all particles will not have the same length of time to be separated as other particles. Rate of feed is controlled by opening and closing the feed gate.

Position of Trough: The degree of separation is controlled by the position of the separating edge of the receiving trough. The separating edge is the edge adjacent to the rising side of the cylinder. If some of the long seed are lifted out by the indents, the trough is set too low. If the trough is set too high, short seed picked

up by the indents will fall back into the mixture and be discharged with the long seed at the end of the cylinder.

Speed of cylinder: The desirable speed can be determined by setting the trough level and then adjusting the speed of the cylinder so that the seed picked up by the indents will fall into the trough from the top of the cylinder. It is important that the cylinder be run at the correct speed. If the speed is too slow, the indents will reject some of the short seed that should be lifted. Speed is adjusted by changing a variable speed drive.

Action of leveler or conveyor: In those machines that use an increase in elevation of the feed end of the machine as a means of conveying, an adjustment is sometimes necessary. This is done by increasing or decreasing the elevation to properly convey the material through the cylinder.

Position of the retarder: The retarder is adjusted to maintain a proper level throughout the entire length of the cylinder. The adjustment of the retarder will depend on the type of seed being processed, and the amount and size of the material being lifted.

Maintenance of Cylinder

Indent cylinder machines are relatively service-free, but one thing should be pointed out in order to eliminate potential dissatisfaction with a new machine. A new machine will not operate properly until the indented surface has opportunity to become polished. Sometimes it is necessary to clean new cylinders with a thinner or steam. Until a cylinder is polished, grain or seed will surge or will be carried over the top of the cylinder at normal speeds, due to increased friction. Cylinders which have not been used recently may become rusty and act the same way. Polishing can be done by running waste grain in the machine until the cylinder becomes "shiny". When handling oily material, indents may tend to fill with dust imbedded in oil and the effective depth of the indents is lowered. Periodical "scouring" may be needed in this case.

Uses of Length Separators

Examples of uses of disc and cylinder separators in the seed industry are shown in accompanying tables. The range of each type of machine is wide, and these ranges overlap, giving rise to the question, "Which type of machine should be used?". The answer depends on several factors. However, generally speaking, lightweight seeds, whose

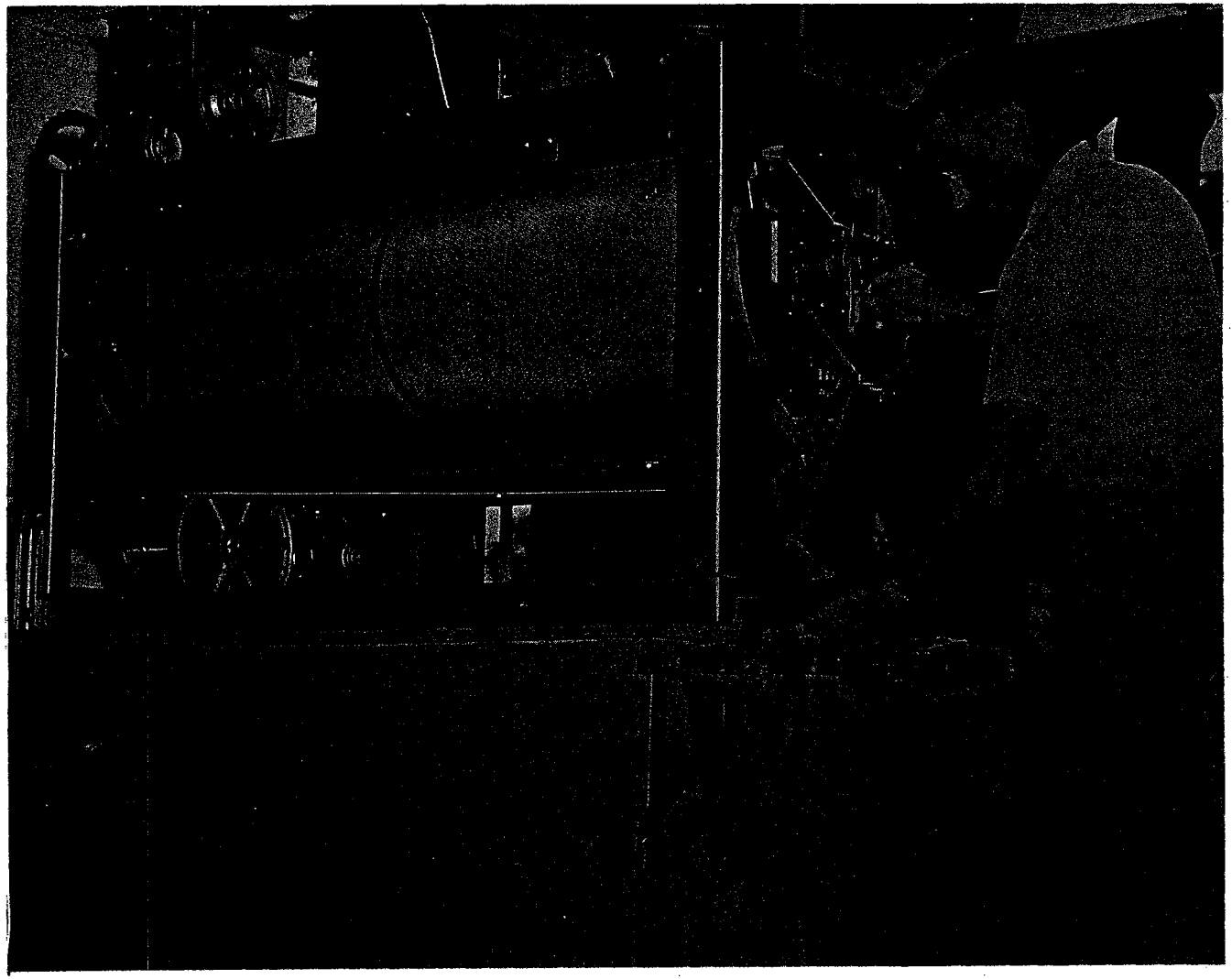


Figure D21. Indented cylinder separator in operation.

Table D1. Disc pocket sizes used for separating grasses, grains and seeds.

Type of Pocket	Will Lift	Will Reject
V2 1/2	Alsike, Timothy, Ladino, White Dutch, etc.	Buckhorn, Canada Thistle
V3	Red Clover, Small Sweet Clover, etc.	Thistle, Sticks, etc.
V3 1/2 V3 3/4	Alfalfa, Sweet Clover, Water Grass, etc.	Hulled Quack, Large Thistle, Flax, etc.
V4	Water Grass, Mustard, Small Cockle, Small Cracked Grain, etc.	Wheat, Barley, Pin Oats, Large Flax, etc.
V4 1/2 V5 V5 1/2	Wild Buckwheat, Large Cockle, Vetch, Cracked Grain, Onion Bulblets	Wheat, Oats, Barley, Rye, etc.
V5 3/4 V6 V6 1/2	Flax, Extra Large Cockle, Vetch, Small or Broken Wheat, Large Wild Buckwheat, etc.	Unhulled Quack, Pin Oats, Wheat, Barley, Oats, Rye, etc.
R3 1/2 R3 3/4 R4	Water Grass, Mustard, Smartweed, Bentgrass, Buckhorn	Flax, Fescue, Ryegrass, Orchard Grass, etc.
R4 1/2 R5 R5 1/2 R6	Small Seeds, Cracked Grain, Wild Buckwheat, Bluegrass, Buckhorn	Wheat, Barley, Oats, Pin Oats, Rye, Alta Fescue, Meadow Brome, etc.

Table D1. Continued.

Type of Pocket	Will Lift	Will Reject
K L	Large Wild Buckwheat, Broken Wheat, Broken Barley, etc.	Wheat, Barley, Oats, Pin Oats, Rye, etc.
M AC EE	Spring Wheat, Small or Broken Durum, Pearled or Broken Barley, Fescue, Orchardgrass (Ky. 31, Alta Fescue - may use J & A)	Durum, Large Spring Wheat, Barley, Oats, Pin Oats, etc.
J	Spring Wheat, Small Durum, Kentucky 31 Fescue, Alta Fescue, etc.	Oats, Wild Oats, Barley, etc.
A MM	Wheat, Winter Wheat, Durum, Small Barley, Hulled Oats, Rye, Safflower	Oats, Wild Oats, Ragged Barley, etc.
B	Barley	Oats, Wild Oats, Sticks, etc.
RR-SS DD	Tailless Barley Oats and all shorter Grains	Sticks, Stems, etc.
AE-AD	Peanuts	Sticks, Stems, etc.
SS-DD		

Table D2. Indent cylinder sizes used for separating grasses, grain and seed.

Indent Number	Will Lift	Will Reject
2	Small Pigweed, Alsike Clover, Small Dodder, Mullenweed, Sand, etc.	Buckhorn, Timothy, Black Medic Clover, Bluegrass (all varieties), Alfalfa, Crimson Clover, Lespedeza, etc.
3	Small Sweet Clover, Pigweed, Dodder, White Clover, Alsike, etc.	Thistles, Buckhorn, Sticks, Alfalfa, Red Clover, etc.
4	Timothy, Small Clover (Red & White), Dodder, Hulled Water Grass, Mustard, Sheep Sorrel	Canada Thistle, Quackgrass, Sticks, Alfalfa, Bluegrass, etc.
5	Red Clover, Alfalfa, Small Flax, Water Grass, Mustard, Bluegrass, etc.	Meadow Fescue, Wild Brome, Large Buckhorn, Quackgrass, Cheat, Chess, Sticks, etc.
6 1/2	Small Broken Grain, Small Wild Buckwheat, Small Vetch & Cockle, Wild Mustard	Fescue, Wheat, Ryegrass, Wheat Grass, Hulled Orchard Grass, Flax, etc.
8 1/2	Buckwheat, Cockle, Vetch, Sudangrass, Small Sugar Beet Seed, etc.	Wheat, Rye, Fescue, Ryegrass, Orchard Grass, etc.

Table D2. Continued.

Indent Number	Will Lift	Will Reject
11	Broken Grain, Vetch, Small Onion and Garlic, Wild Peas, Coffee Weed, etc.	Spring Wheat, Rye, Rice, Alta Fescue
13	Spring Wheat, Small or Broken Durum, Pearled and Broken Barley, Flax	Durum, Large Spring Wheat, Barley, Pin Oats
19	Spring Wheat, Small Durum	Oats, Wild Oats, Barley, etc.
22	Wheat, Winter Wheat, Hulled Oats, Rye, etc.	Oats, Wild Oats
24	Barley	Oats, Wild Oats, Barley with tails, etc.
26)		
28)	Used primarily in length grading of Seed Corn and similar sized material.	
32)		
S-3	Equal to #22 Indent but has flat bottom used primarily on Corn.	

bushel weight is less than 45 pounds cannot be separated as efficiently as heavier weight seed. For this reason the cylinder is more practical to use with small grains, corn and soybeans, than with grasses. Corn, soybeans and similar seed which might wedge in the pockets should not be cleaned in a disc. An explanation of the principles used by each separator in effecting its separation may help answer the question "Which machine should be used?".

Both disc and cylinder separators effect separations on the basis of length, but the principles involved in obtaining results are somewhat different. The disc lifts uniformly shaped and sized, under-size particles out of a mass of seed. The machine's speed is relatively constant- it can be varied only a few RPM from its normal setting or the efficiency of the separation is affected. A disc separation is not affected by seed-coat texture, weight per bushel, or moisture content.

Cylinder separators perform similar separations but in a different manner. Cylinders operate on the centrifugal force principle, in which the speed of the cylinder holds seed in the indents, lifting them out of the mass until the indents are inverted to the point where gravity causes the particles to fall. Shape and size of the indents and seed, seed coat texture, moisture content and weight of seed all combine to affect separation.

Both the cylinder type and the disc type machines have their advantages and disadvantages. One advantage of the cylinder type separator over the old model discs is the rapidity in which the cylinders can be changed. Only a few minutes are required for changing cylinders in most of the cylinder separators. In the old model discs, all the discs have to be unbolted and the shaft slipped out and sometimes several hours are required to change the discs. However, in the late model disc separators, the top cover can be removed and the discs and shaft lifted out as a unit.

An advantage of the disc separator is that it is possible to have several different sizes of pockets in the same machine. With this arrangement, a number of separations can be made without having to make changes. Also with a combination of different sizes, it is possible to make several separations in one operation.

The cylinder separator is more effective for such jobs as oat sizing, rice sizing, length grading of hybrid corn, and separating minute quantities of contaminating material such as traces of dock or sorrel seed in orchardgrass or fescue seed. The disc separator can be used to an advantage where a large mass of material is to be lifted. An example would be the separation of a small amount of Canada thistle

from alsike clover. The disc separator is also widely used for removing elongated particles of foreign material such as sticks, stems and straws from seed.

As to comparative capacities, each type of length grader has its own advantages, but in the field for which the disc separator is found to be particularly suited, capacities of the disc type have been found to be much greater.

Summary

Disc and cylinder separators are the only machines used in the seed trade to separate particles on a pure length difference basis. Both machines effect this separation by lifting the short fraction out of a mixture containing both long and short particles. They are most effective when undersized, or short particles are relatively uniformly dimensioned. Therefore, for most effective and efficient use they should be used only after the air-screen cleaner.

The disc is accurate, flexible, and consistent in the middle-size seed groups. Its main limitation is that it cannot be used on corn or soybeans and similar seed which might wedge in the pockets.

The cylinder is flexible. It is not fixed in that indent size alone governs entirely the results that can be obtained. Unlike the disc, only free-flowing seeds can be handled effectively. It is best suited to the heavy seeds.

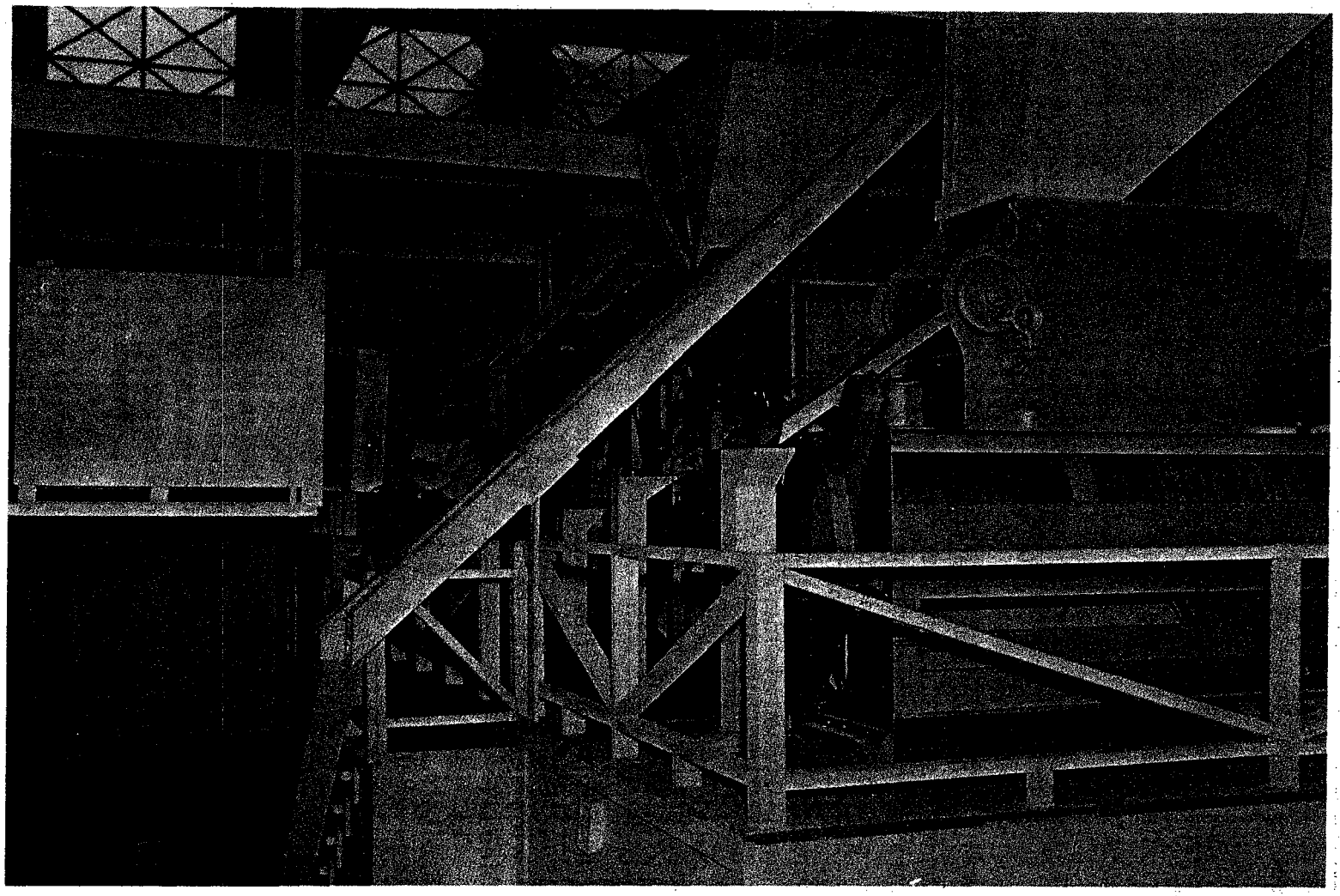


Figure D22. Sizing equipment installed in seed plant. Note scalping aspirator mounted on disc separator.

Specific Gravity Separators

Section E

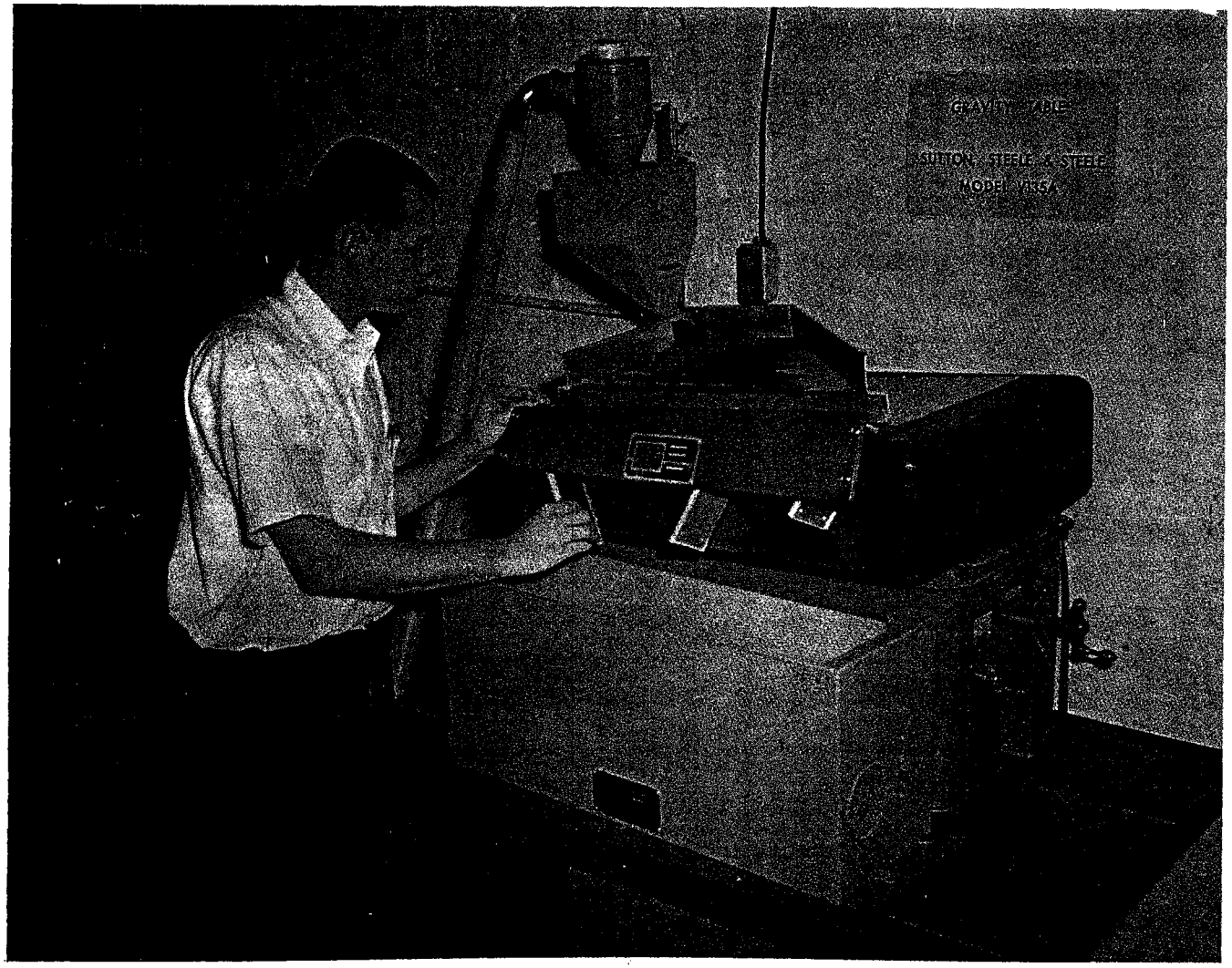


Figure E. Small gravity table used to process breeder's seed, vegetable and flower seed.

SPECIFIC GRAVITY SEPARATORS

Introduction

Undesirable seed and contaminants are often so similar to the "good" seed in size, shape and seed coat characteristics that efficient separations cannot be effected by air-screen, magnetic, velvet-roll, or dimensional sizing machines. These undesirable materials, however, may differ from the good seed in unit weight or specific gravity. There are many examples of such differences. Insect-damaged seed often retain the same dimensions as undamaged seed, but are much lighter because of interior destruction of the seed by the insects. Deteriorated, moldy, or rotten seed are usually similar in size to good seed, but have a lower specific gravity and consequently are much lighter. Empty, blind or sterile seed are a problem in many seed kinds, including small-seeded grasses, rice, oats, members of the carrot family (Umbelliferae), tree and ornamental species. Their seed coats, hulls or other coverings develop normally and in terms of shape and size the "unit" looks like a good seed, although the grain or embryo has not developed and is lacking. Empty seed are always much lighter than fertile seed.

Although the adobe balls, soil particles, gravel and sand mixed with some kinds of seed are largely removed in the basic cleaning, some are similar in size and shape to the crop seed and are still in the seed lot after basic cleaning. These contaminants are usually heavier than crop seed. Contaminating crop or weed seed of the same general size and shape as the good seed may also be lighter or heavier because of differences in structure, morphology or chemical composition.

Contaminating seeds or materials differing from the crop seed in unit weight or specific gravity can be separated with a specific gravity separator (commonly called the gravity table).

Several types and styles of specific gravity separators are available. Small "table-top" models are used for processing valuable breeder's seed, vegetable and ornamental seed, and for special items such as tobacco seed. Intermediate farm-size machines are used by growers or seedsmen with a limited quantity of seed to process. In large commercial operations, large gravity separators in the processing line match other machines in capacity.

As with several other types of seed processing equipment, the specific gravity separator was not designed originally for seed. It was first used - and is still used - in the mining industry to separate ores. It is an advancement on the pan or sluice trough techniques of gold

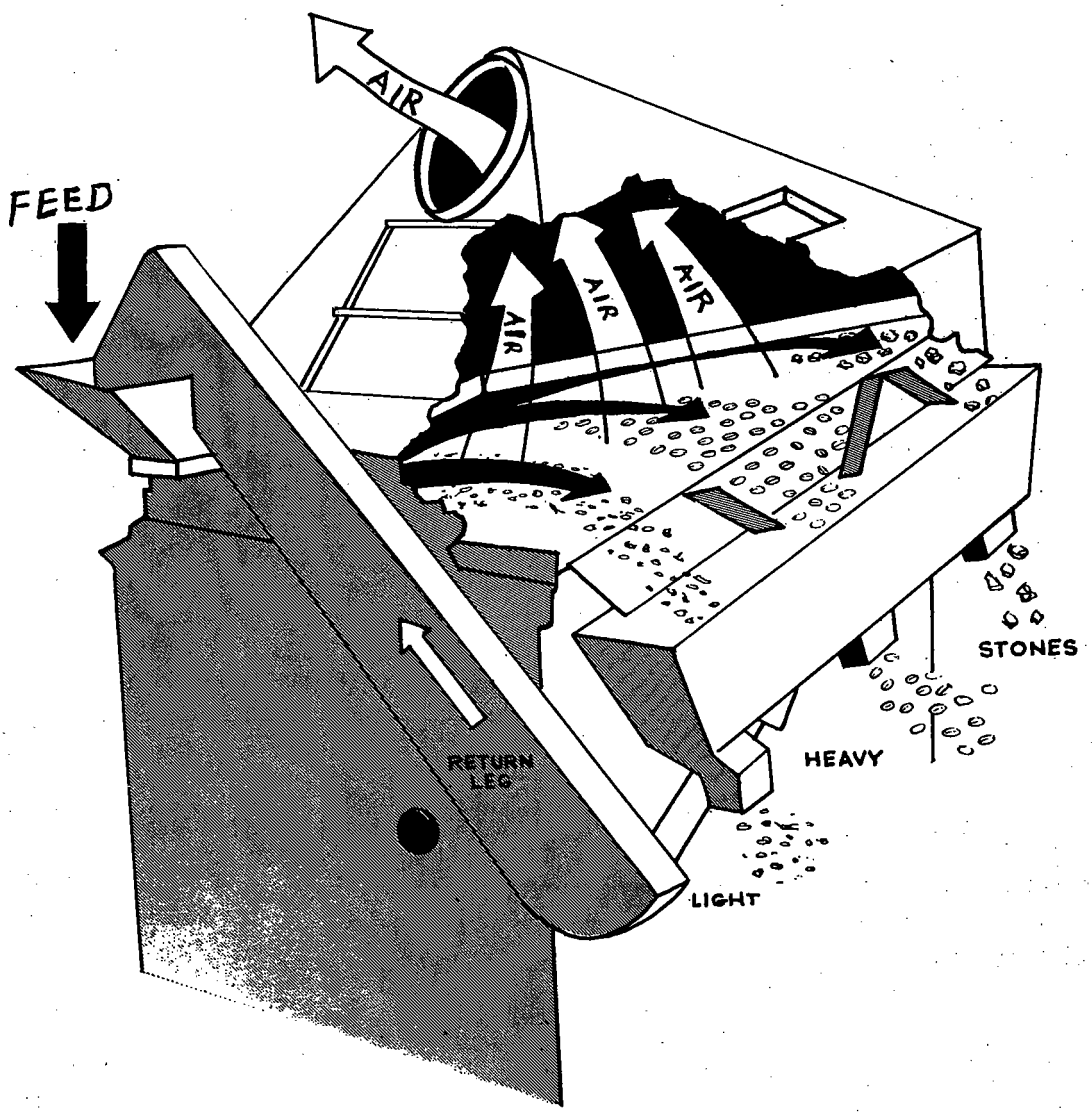


Figure E1. Diagram of a "vacuum" type specific gravity separator showing air flow and movement of seed across the deck.

STRATIFICATION

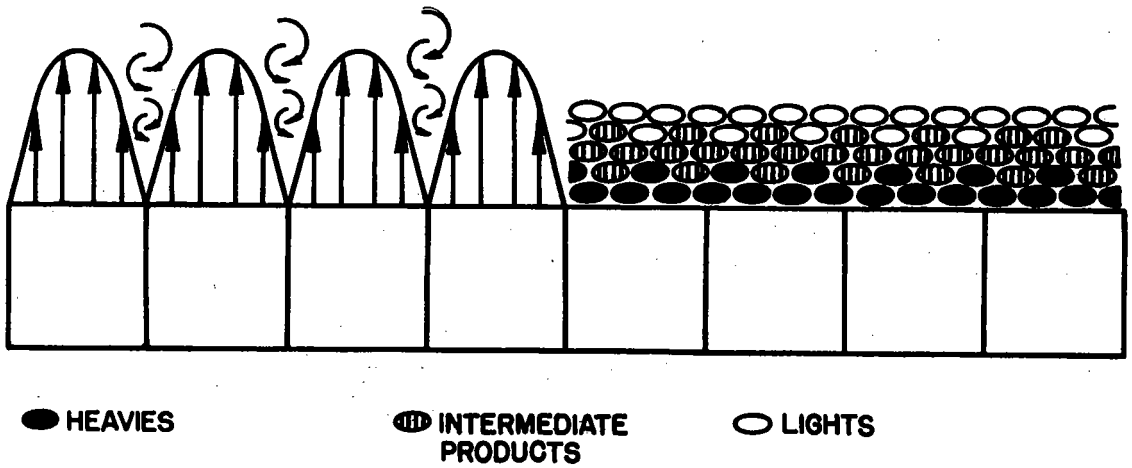


Figure E2. Air flow and stratification in a gravity table.

field fame. The specific gravity separator is also used for many other purposes, including processing food beans and coffee beans.

Parts of a Gravity Separator

Mechanically, a gravity separator is a simple machine. It consists of (A) a base and frame, (B) one or more fans, (C) a plenum chamber called the air chest, (D) a porous deck, (E) a feed hopper, (F) a drive system, and (G) a seed discharge system.

Base and Frame

The base and frame of the gravity table are built as a single unit. The base section is bolted to a solid foundation to keep the machine from shaking so that all deck motions will be created by the drive mechanism. False vibrations created by a weak foundation or poorly mounted base interfere with the separating action on the deck.

The frame provides structural support for all other parts of the machine, and may serve as part of the walls of the air chest. The frame also provides a level surface from which the deck is adjusted for side slope and end slope.

Fans

One or more fans pull air from outside the machine and force it into the air chest, which is located below the deck. Fans are normally mounted on a shaft inside the frame of the air chest. They either pull air from a pipe extending out of the building, or through filter systems of the machine. (Filters may be mounted on the sides of the air chest or on a special connected filter box.)

Air flow is controlled by knobs, cranks or levers which open or close the ducts that supply air to the fans. Air supply to each fan can be controlled separately in machines which have more than one fan.

Vacuum gravity separators operate on the same principle, but the fan is located above the table. The deck separating-area is enclosed in a large hood, and the fan exhausts air from the hood.

Air Chest

The air chest is an airtight, shallow, boxlike plenum chamber mounted inside the frame and beneath the deck. The fan forces air into the air chest and builds up a static air pressure in it. Air pressure built up in the air chest forces air up through the porous deck.

Deck

The deck is a lightweight removable and interchangeable frame which provides the surface on which seed are separated. It may serve either as the upper wall of the air chest, or be mounted atop a flexible extension of the air chest. An airseal between the rim of the deck frame and the air chest prevents air loss between them. The deck is held securely to the air chest by bolts or clamps which can be readily released by hand to change decks.

A solid upright frame called the banking rail extends around all sides of the deck except the discharge side. This banking rail servies as a wall to hold a bed of seed on the deck until they reach the discharge edge.

The deck is covered with a porous material such as cloth, woven wire screen, or perforated sheet metal which allows air to pass through. It is supported on the deck frame which may also function as air baffles to smooth out turbulence and supply an even flow if air through the deck. Baffles are built into the deck frame, and may also be mounted above the fan outlets or in the air chest. They are essential for uniform air distribution.

The deck is, thus, a porous oscillating table through which air is blown. Seed flow across the deck from the feed side to the discharge side and are separated as they move.

Feed Hopper

Seed flow from a surge bin to a feed hopper which meters a uniform stream of seed onto the corner of the deck opposite the discharge side. The feed hopper is adjustable for different feed rates.

Drive System

The upper part of the air chest to which the deck is attached is mounted on rockers or toggles which allows it to rock back and forth with the deck. A motor-driven eccentric system beneath the deck-mount rocks the deck in a rapid back-and-forth "oscillating" motion. The speed of the motion can be controlled by a variable speed drive.

Discharge System

The banking rails hold the seed on the deck until they reach the discharge side, which is open to allow them to flow off the deck. An apron or shield mounted beneath the lip of the discharge side directs the discharging curtain of seed to a series of discharge spouts. Adjustable dividers or "fingers" can be placed on the apron to direct seed into the spouts for the desired number of density grades.

Hooks along the discharge spouts can be used to attach cloth bags for collecting the separates. In continuous-flow operations, the separates are discharged directly into spouts or conveyor hoppers.

Principles of Separation

The features and structural elements of the specific gravity separator described above, combined with the operator's skill in controlling their action, create conditions in a narrow zone above the deck's surface that effects a separation of seed differing in specific gravity or density.

Separation of seeds differing in specific gravity involves two distinct steps. First, the seed mixture feeding onto the deck is vertically stratified so that the heavier seed are at the bottom and the

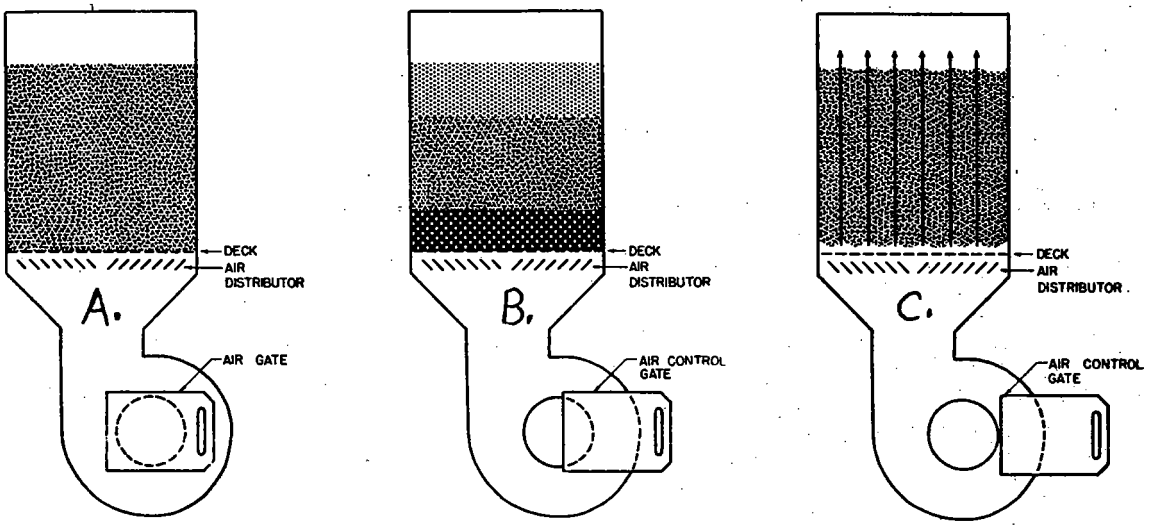


Figure E3. Diagram of stratification on the gravity separator deck: A, seed mixture fed onto the porous deck contains heavy intermediate and light seeds randomly distributed; B, proper air adjustment separates seed into vertical weight zones, with light seeds at the top and heavy seeds at the bottom; C, excessive air destroys the stratification by blowing heavy seeds into the upper zones and causing them to mix randomly with light seed.

lighter seed are at the top. Secondly, the layers of seed differing in specific gravity are separated so that they travel along the deck in different directions to the discahrge spouts.

Stratification

As seed feed onto the deck from the hopper, they fall into the air stream forced upward through the porous deck surface. The air stream causes the seed to become partially fluidized so that they flow almost like a liquid. The velocity of the air stream is adjusted so that light seed in the mixture are lifted and float on a cushion of air, while heavy seed are not lifted and lie on the deck surface. The seed are thus stratified in vertical layers of seed of decreasing specific gravity from bottom (deck surface) to top.

The relative terminal velocities of the individual seeds and the air stream determines whether a seed is lifted into the upper layers or remains in contact with the deck. If the velocity of the air stream is greater than the terminal velocity of a seed, the seed will be lifted; if it is less than the seed's terminal velocity, the seed is not lifted and falls through the air until it contacts the deck surface. When the air velocity is the same as the terminal velocity of a seed, the seed is suspended motionless by the air stream and neither falls nor rises.

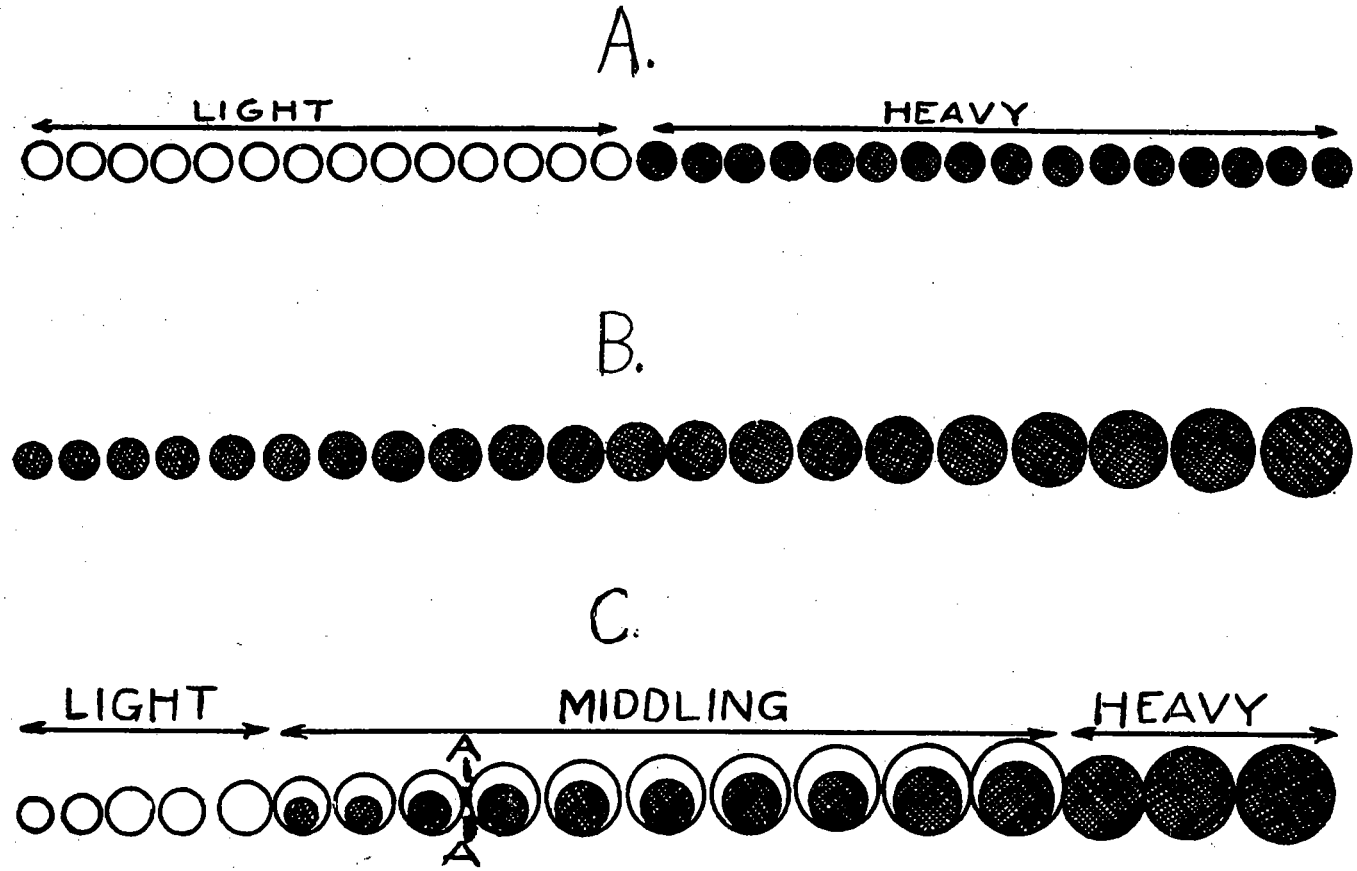


Figure E4. Gravity separation rules. A, seeds of the same size that differ in specific gravity will be separated according to specific gravity; B, seeds of the same specific gravity that differ in size will be separated according to size; C, seeds that differ in both size and specific gravity cannot be effectively separated.

The density or specific gravity of a seed greatly influences a seed's terminal velocity. Overall size of seeds affects their total weight and terminal velocity, even though they may have the same density. To some extent, shape and surface texture also affect the resistance a seed offers to the air stream, and have some influence on its terminal velocity.

Since size and specific gravity primarily influence the terminal velocity and thus the relative stratification of seeds on the deck, they also define the principles of stratification and separation on a gravity separator.

1. SEED OF THE SAME SIZE WILL BE STRATIFIED AND SEPARATED BY DIFFERENCES IN THEIR SPECIFIC GRAVITY.

2. SEED OF THE SAME SPECIFIC GRAVITY WILL BE STRATIFIED AND SEPARATED BY DIFFERENCES IN THEIR SIZE.

3. IT FOLLOWS THAT A MIXTURE OF SEEDS DIFFERING IN BOTH SIZE AND SPECIFIC GRAVITY CANNOT BE STRATIFIED AND SEPARATED EFFECTIVELY.

Separation

After the seed have been properly stratified into vertical layers by differences in weight, these layers are moved apart and separated so that they discharge into different spouts. A combination of deck slope and deck motion is used to separate the layers.

The deck can be adjusted to varying slopes in two directions - end slope, from the feed end to the discharge end, and side slope, from the low side to the high side of the discharge end. End slope influences the speed at which seed move across the deck to the discharge end. Side slope determines tilt or inclination across which the seed move as they are separated.

As seed move across the deck, side slope forces them to flow across an inclined surface. Since light seeds are suspended on an air cushion and do not touch the deck surface, they slide downhill across the air cushion toward the low side of the deck under the influence of gravity. If all adjustments are properly coordinated, light seed will flow all the way down to the low side of the deck before reaching the discharge end and float along the low side banking rail to the discharge spout.

An eccentric drive causes the deck to oscillate back and forth toward the high side, or high end of the discharge side. This oscil-

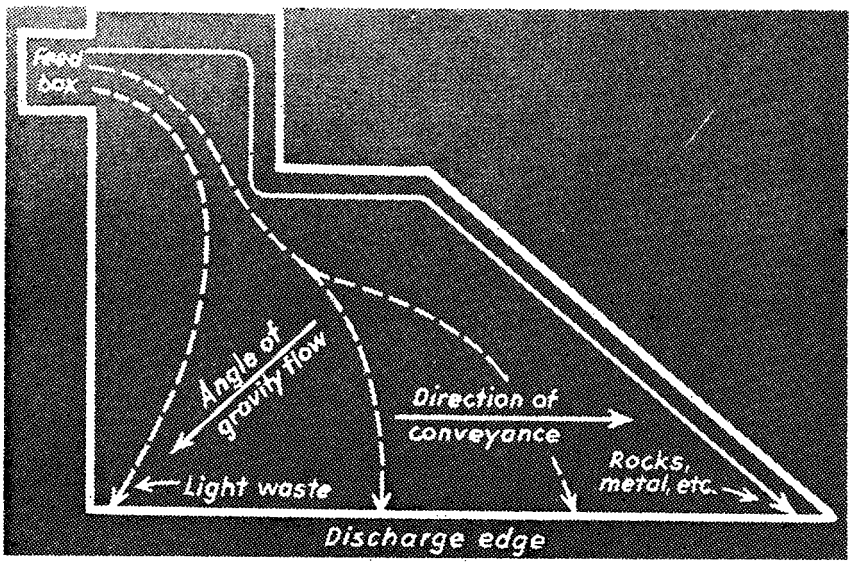


Figure E5. Flow pattern of seed across deck of a gravity separator.

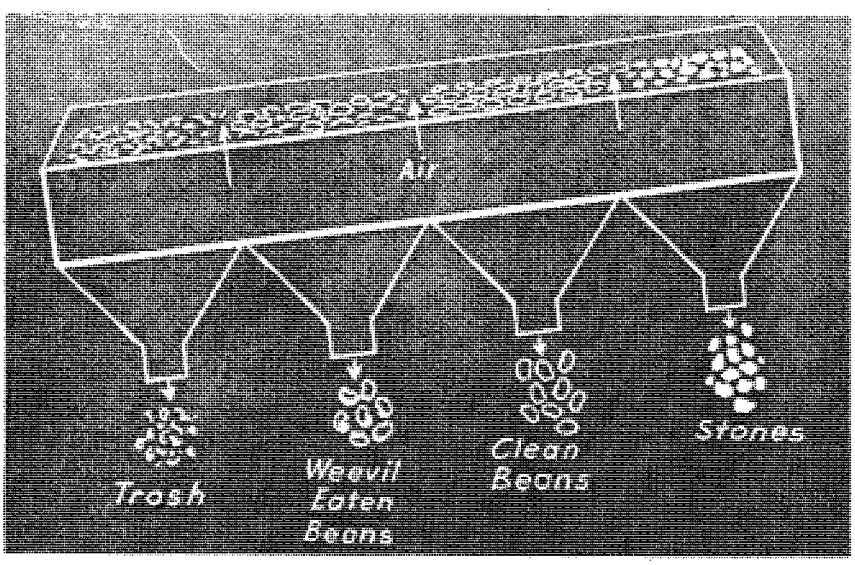


Figure E6. Discharge of separates along the edge of the gravity deck in a typical bean separation.

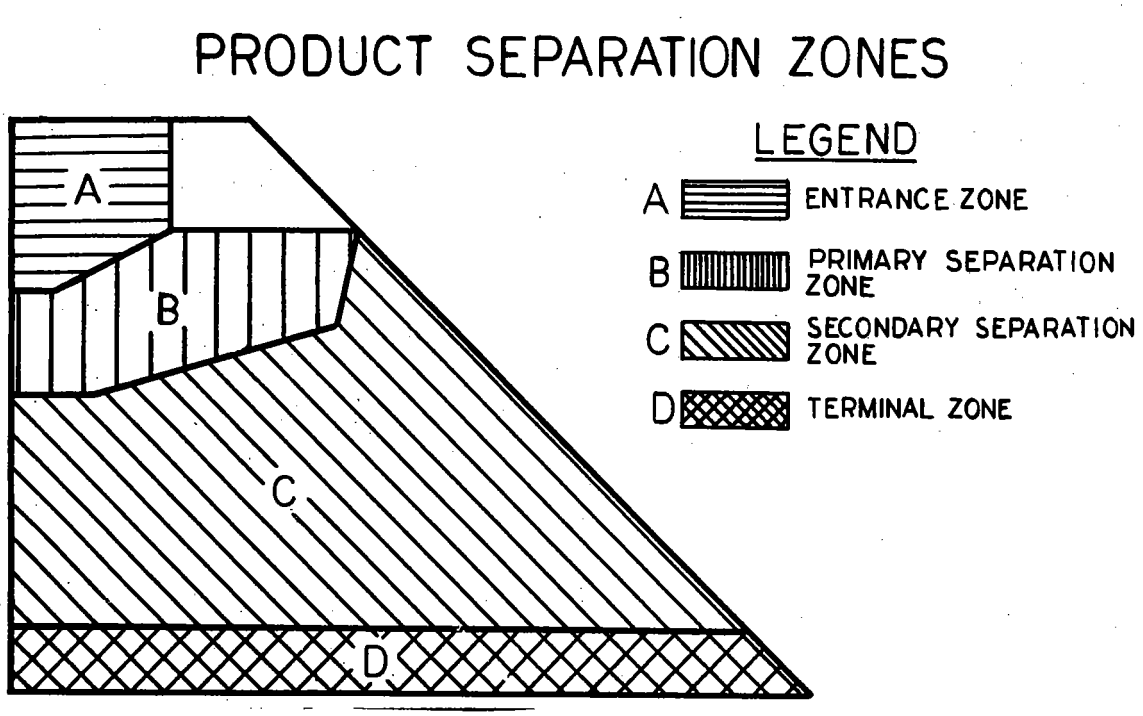


Figure E7. Zones of stratification and separation on the deck of a gravity table. Vertical stratification is effected in A. Separation of vertical layers is accomplished in B and C. Seed discharge from deck along D.

lating motion pitches the deck up and toward the high end, then drops it down slightly and pulls it back into position for the next up and forward motion. This motion is repeated so rapidly that the deck appears to be vibrating.

The oscillation of the deck in an uphill direction toward the high end of the discharge side has no effect on light seeds which float on the air cushion. The heavy seeds, however, are in contact with the deck surface; as the deck moves up and forward, all seeds lying on the deck move with it. As the deck moves back into position for the next up-and-forward move, it drops slightly downward and momentarily causes the seed to lose contact with the deck. Consequently, when they regain contact with the deck they are closer to the high end of the deck. As the deck moves up and forward again, this action is repeated. Thus, this rapid oscillating motion of the deck gradually moves all seed in contact with the deck surface uphill in the direction of the motion.

The feed hopper constantly adds seed to the deck, so those already on the deck are pushed to the side by the added seed. Since the light seed are fluidized on a cushion of air and flow almost like a liquid, they flow toward the discharge end because of the downhill slope. Heavier seed move uphill with the deck motion. The constant

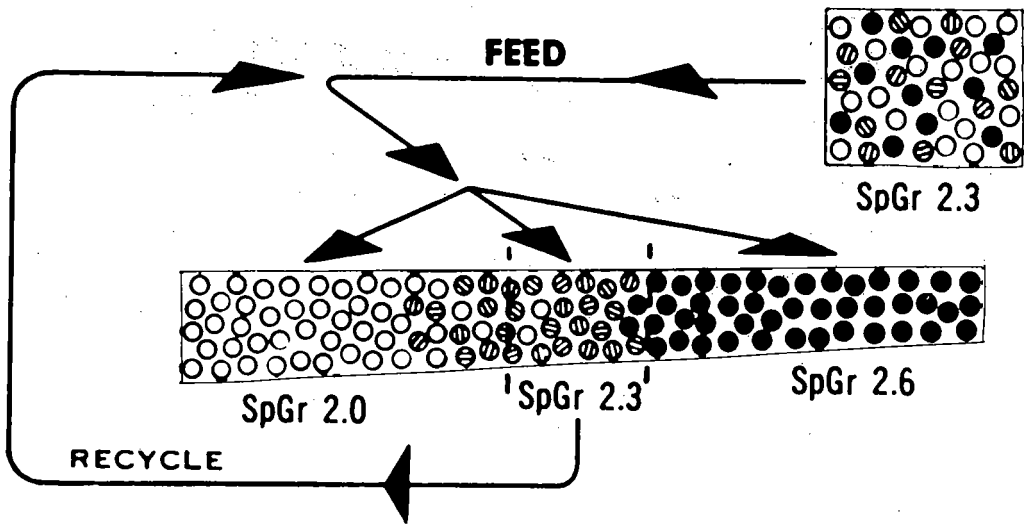


Figure E8. Cross-section of a gravity deck showing overlapping of specific gravity zones along discharge edge.

addition of seed onto the deck forces the entire seed mass to move toward the discharge end. When all adjustments are properly coordinated, the stratified layers of seed separate and move to different sides of the deck before the moving seed mass reaches the discharge end.

Action Zones on Deck

Stratification and separation are the two distinct actions that occur on the deck of a specific gravity separator. The first action is stratification of the seed into vertical layers. The stratification zone begins beneath the feed hopper and extends out over as much of the decks surface as is required for effective stratification of the seed. Stratification must be accomplished before any separation can be made. Seed mixtures differing widely in specific gravity stratify quickly and the area required is small. However, if the seed to be separated do not differ widely in specific gravity, stratification is difficult and takes place slowly. Since seed are constantly flowing across the deck, slow stratification extends the stratification zone out over much more of the deck surface.

As soon as the seed are stratified, the layers separate and move in the direction dictated by their specific gravity. Separation

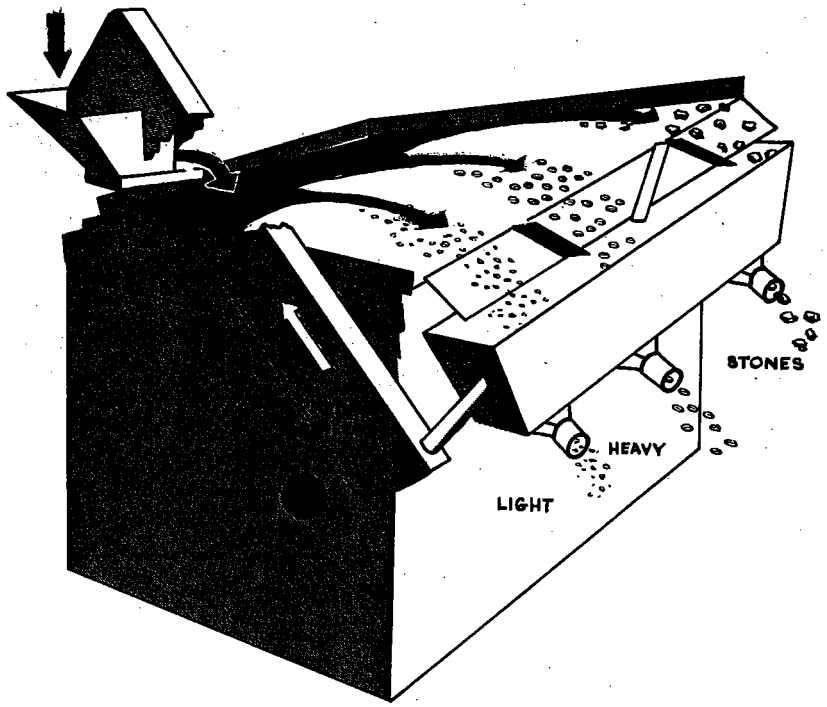


Figure E9. Diagram of a gravity separator showing seed flow across the deck.

occurs in the zone or area not required for stratification. If follows then that if the stratification zone is small, more deck area and more time are available for separation, so the separation will be sharper and more complete. However, if stratification is slow and requires much of the deck area, the separation will be poor, and a large amount of middling product consisting of a mixture of light and heavy seed will discharge from the deck.

Place in Processing Line

Effective use of the gravity separator requires precise air stratification of seeds. Seed should, therefore, be carefully sized on an air-screen machine or other sizing machines before they are cleaned on the gravity. This eliminates size differences and allows better stratification and thus separation solely on the basis of differences in specific gravity. Pre-sizing results in sharper separations, less middling product and higher capacity.

The gravity is an upgrading or finishing machine, and is usually the last separating machine in the processing sequence. In some special cleaning operations, a gravity is used ahead of another upgrading or separating machine, as in cleaning alfalfa seed.

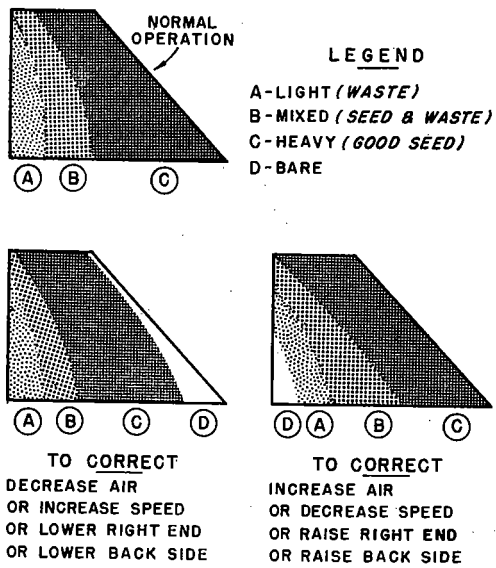


Figure E10. Corrective actions for gravity table separations.

The gravity removes sand from alfalfa seed ahead of the roll mill to reduce the amount of material that must be removed by the roll mill and to reduce wear of the velvet-covered rolls.

Installation

Vibrations from a weak foundation are greatly magnified by the time they reach the deck of a gravity. These false vibrations will upset stratification, counteract the separating motion of the deck, and destroy the separation. A firm foundation solid enough to prevent false vibration is essential. The best foundation is a concrete floor at ground level, with the gravity securely bolted to the foundation.

Clean air supply must be considered in planning a gravity installation. When inside filters are used, the gravity should be installed where the air is as clean and dust-free as possible. If clean air is piped to the gravity from outside, it should be installed as near to the air source as possible to reduce the length of pipe needed. Dust collectors from other machines should not be on the side of the building from which air is piped to the gravity.

Adjustments

The gravity separator is a versatile machine and can accomplish a wide range of separations primarily because it has many adjustments which allow the operator to control the separating action precisely. Since each adjustment affects the action of the others, all adjustments must be coordinated to produce a sharp separation.

The five variable controls on a gravity separator are: feed rate, air control, speed control, end slope, and side slope.

Feed Rate

Rate of feed is an important adjustment on the gravity separator. A constant and uniform rate of feed is essential to maintain a uniform bed of seed on the deck. Variations in the feed rate will change the seed bed, and cause the points of discharge of the different seed fractions to move up or down along the discharge end. A clean separation is impossible when the seed bed surges because of variable feed. Every gravity separator should have a surge bin sufficiently large to allow for a uniform flow of seed. A bin-level sensing device should be installed in the lower part of the bin to signal the operator or stop the gravity when seed level in the bin is low. This prevents undesirable light seed from falling into the clean seed spout when the feed stops and light seed shift uphill on the empty deck.

Enough seed must be fed onto the deck so that a bed of seed thick enough to stratify into different layers will cover the deck at all times. The thickness of the bed should be just sufficient to allow the most effective stratification and separation. This can only be determined by observing the separation obtained at the discharge spouts.

Rate of feed must also be coordinated and balanced with other adjustments. When seed are fed onto the deck faster than the actions created by the other adjustments can handle them, they are not stratified and appear to lie "dead" on the deck. A feed rate too low will not cover the deck properly. Seed should be fed onto the deck at a rate that can be fluidized readily and separated. If feed rate is increased, other adjustments can then be changed to match the new feed rate.

Air Control

Air control is the basic adjustment. It allows the operator to vary the velocity or pressure of the air coming through the deck within

close tolerances. Proper air adjustment will fluidize and stratify the seed so that heavy seed lie on the deck and lighter seed are lifted into the upper layers of the seed bed. Air should be adjusted so that the seed bed fluidizes and flows freely without "boiling". Excessive air forces heavy seed up into the layers of light seed, and destroys the stratification. It is characterized by "boiling" or bubbling in the seed bed, and the discharge of heavy seed with the light seed. Insufficient air fails to lift light seed above the deck surface and thus fails to stratify the seed. This causes the seed to lie "dead" on the deck and light seed to discharge with the heavy seed.

End Slope

End slope, or the slope of the deck from the feed hopper to the discharge end, controls the speed at which seed move across the deck and thus the length of time they remain on the deck and are exposed to its separating action. When differences between the seed to be separated are slight, the deck should have a relatively flat end slope to hold the seed on the deck longer. The longer the seed remain on the deck the sharper the separation will be. Crop seed and contaminants that differ greatly in specific gravity will stratify and separate quickly, so the end slope can be increased to move the seed off the deck rapidly and increase capacity.

Side Slope

Side slope is the tilt or inclination of the deck from the low side to the high side of the discharge end. Side slope creates an inclined surface over which the stratified seed bed must flow to reach the discharge end. This allows the light seed layers riding on a cushion of air to slide downhill to the low side of the deck while deck oscillation moves heavy seed uphill to the opposite side of the deck.

Deck Oscillation Speed

The motion of the deck causes heavy seed to move toward the high side as they flow from the feed area to the discharge end. An increase in deck speed moves heavy seed uphill faster and they discharge further up the deck. A decrease in deck speed causes heavy seed to discharge lower on the deck since they do not move as far uphill before they reach the discharge end.

Balancing Adjustments

All five adjustments - feed rate, air, end slope, side slope, and deck speed - affect the stratification, separation and movement of seed across the deck. When one adjustment is changed, the action

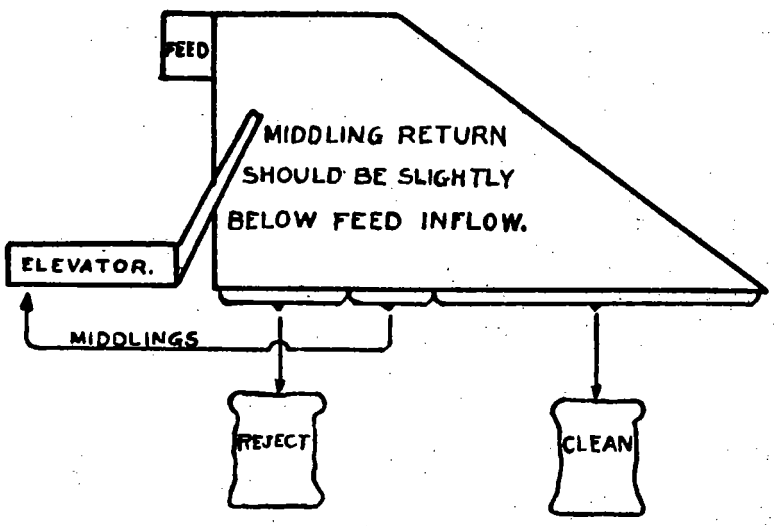


Figure E11. Middling product returned to the feed hopper of the gravity table.

of the other four adjustments is altered in proportion to the change made in the first adjustment. Therefore, all adjustments must be coordinated and balanced with each other to produce the best separation at the highest capacity.

Adjustments must be balanced to produce two basic results: first, the seed must be stratified as rapidly and effectively as possible; second, the seed bed must cover the entire deck. The seed must be effectively stratified before they can be separated. Stratifying them as rapidly as possible uses up less deck space, and leaves more space for the separation zone. The seed bed must then cover the entire deck to separate the different zones as widely as possible, to give efficient capacity, and to prevent air pressure loss through blank or uncovered space.

Efficiency adjustments: A change in any adjustment will change the balance of forces affecting the seed bed moving across the deck, and will change the relative position of seed on the deck. Effects of changes are:

1. Air
   A. Increasing air shifts the deck load toward the low or light seed side.

B. Decreasing air shifts the deck load toward the high or heavy seed side.

2. Side slope
   A. Increasing side slope shifts the deck load toward the low or light seed side.
   B. Decreasing side slope shifts the deck load toward the high or heavy seed side.

3. Deck oscillation speed
   A. Increasing deck speed shifts the deck load toward the high or heavy seed side.
   B. Decreasing deck speed shifts the deck load toward the low or light seed side.

Capacity adjustments: After the efficiency adjustments have been set to give the best possible separation, the feed rate and end slope can be changed to increase capacity. A change in either capacity adjustment requires changes in the efficiency adjustments to maintain the same separation and depth of seed on the deck. Normally these are:

1. Changes in feed rate
   A. Increasing feed rate requires:
      (1) more air
      (2) more deck speed
      (3) sometimes more side slope

   B. Decreasing feed rate requires:
      (1) less air
      (2) less deck speed
      (3) sometimes less side slope

After changing the feed rate, a good procedure is to overcompensate with the air and sometimes the side slope, and then bring the separation back into balance with the deck oscillation speed.

2. Changes in end slope
   A. Increasing end slope requires:
      (1) less air
      (2) sometimes less side slope
      (3) more deck speed

   B. Decreasing end slope requires:
      (1) more air
      (2) sometimes more side slope
      (3) less deck speed

Changes in end slope can be coordinated by under-compensating with the air and sometimes the side slope, and then balancing the separation by changing deck speed.

3. Changes in both feed rate and end slope

When both are changed, the same depth of seed bed should be maintained.

A. Increasing feed and end slope requires:
   (1) no change in air
   (2) sometimes less side slope
   (3) more deck speed

B. Decreasing feed and end slope requires:
   (1) no change in air
   (2) sometimes more side slope
   (3) less deck speed

If changes in feed and end slope have maintained the seed bed at the same depth on the deck, the separation can be brought into balance normally by changing only the deck speed.

Making Adjustments

A change in any adjustment causes a change in the behavior of the seed as soon as they fall onto the deck from the feed hopper. The result of any change, however, is often evident only as the seed fall off the discharge side. Since seed remain on the deck for some time, the gravity separator appears to respond slowly to changes in adjustments. Adjustments should be made gradually, one at a time, and the effects observed before making further changes. Wide changes in any adjustment should be made gradually in steps.

After the effect of an adjustment is evident, other adjustments can be changed - one at a time - until a satisfactory separation and capacity are obtained. Never make two adjustments at the same time.

Adjustments for efficiency or close separation should be made first. After the desired separation is obtained, capacity can be increased with only minor adjustments to get efficient separation at a high capacity.

Middling Product

Once the seed are stratified, the light seed layer flows toward

the low side of the deck and the heavy seed layer moves toward the high side. As these layers move in opposite directions, they also flow across the deck toward the discharge end. The result is that three major fractions fall off the discharge end of the deck.

Light seed discharge on the lowest side, while the heaviest seed discharge along the highest side. Between these fractions is a partially-separated intermediate mixture of heavy and light seeds called the middling product. It usually contains too many good seed to discard, but too many undesirable seed or particles to go into the finished seed lot. The middling product is usually recleaned to salvage the good seed it contains, or returned to the deck.

Three conditions increase the volume of the middling product:

1. Poor presizing of the seed causes the gravity table to separate seed by size and produce a large middling product of large-light and small-heavy seed.

2. When two seed fractions are very close in specific gravity, stratification and separation is slow, and the middling product is larger because less separating surface is available.

3. When the feed rate is too great for the separation being made, the stratification zone covers a larger deck area and less area is left for separating the vertical seed layers. They will not be separated fully before they reach the discharge side, and the middling product is larger.

Proper presizing of the seed, close adjustment of the gravity separator, feeding at a rate determined by the separation being made, and using a gravity separator with a larger deck area and longer seed travel will reduce the amount of the middling product. However, a middling product will always be formed in greater or lesser quantity, and must be reprocessed to salvage the good seed it contains. Commonly-used methods for salvaging the middling product are:

1. Return the middling product to the gravity feed hopper with a small elevator.

2. Return the middling product to the air-screen cleaner hopper.

3. Collect the middling product in bags or a bin and re-run it over the gravity after the seed lot is finished.

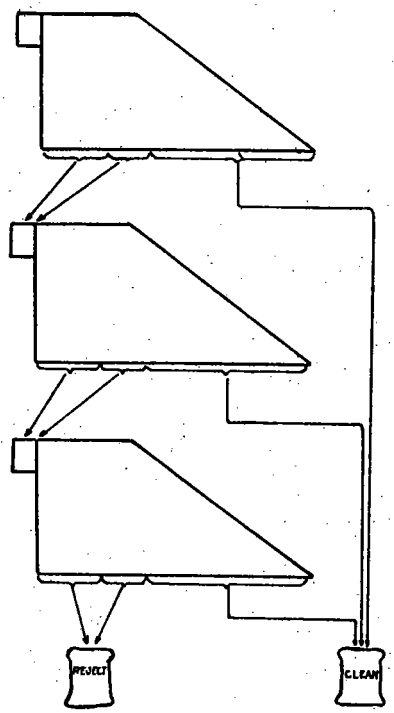


Figure E12. Middling product and light fraction fed onto successive gravity separators.

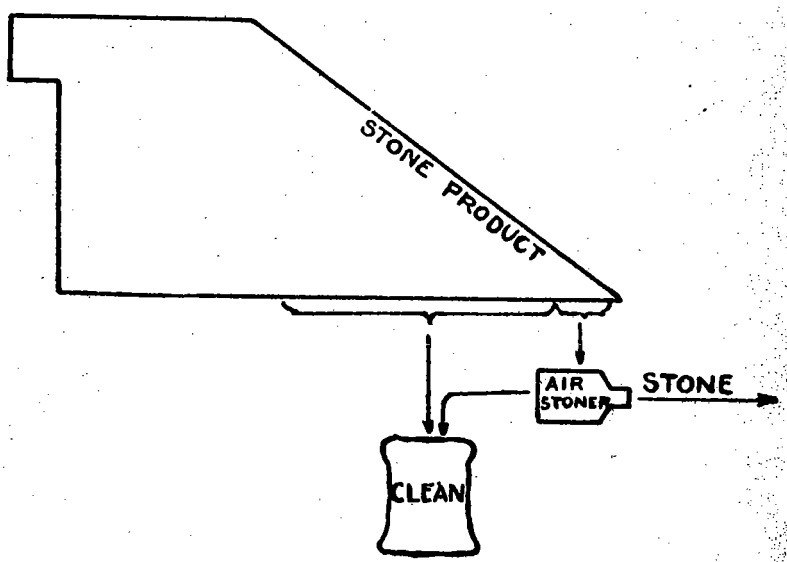


Figure E13. Salvage of good seed from mixture of heavy seed and gravel discharged along "high" edge of gravity by use of a stoner.

4. Feed the middling product from a large gravity onto a small gravity separator added to the cleaning line.

5. In high-volume operations, the middling product from several gravity separators can be fed onto a secondary gravity set up to salvage good seed from the middling product.

Starting and Operating Sequence

Proper initial adjustment of a gravity separator saves time, reduces the amount of seed that must be recleaned, and produces a sharp separation. A suggested starting and operating sequence follows.

1. Select the right deck surface for the size of seed to be cleaned. Use a wire mesh deck surface for large seeds and a cloth or perforated sheet metal deck surface for small seed.

2. With the separator turned off, loosen the deck clamps. Set the end slope (from feed hopper to discharge) and side slope at the slope recommended by the manufacturer. This can be measured as distance above a reference point such as the frame. Then tighten all clamps so that the deck will be held securely.

3. Close the air completely. Be sure the fan or fans are turning in the right direction.

4. Turn the machine on and open the feed gate just enough to feed a relatively small band of seed across the deck. This band of seed, which should cover slightly less than half the deck, will flow across the deck along the upper side.

5. Adjust the eccentric speed until the seed move uphill smoothly. Excessive speed causes the seed to "jump" uphill; insufficient speed causes the seed bed to move sluggishly.

6. Gradually increase the air until the seed bed fluidizes and stratifies. Light seed will begin to flow downward. If the machine allows selective air adjustment, use slightly more air under the deck near the feed hopper. Adjust the air carefully to obtain the best possible stratification. Excessive air "boils" seed and causes all seed to flow downhill.

7. Continue to adjust the feed and air until the light seed move down to the lower banking rail and the deck is completely

covered with a uniform bed of seed and light seed discharge from the low side while heavy seed discharge from the high side.

8. Additional adjustments can now be made to gain a more precise separation and to increase capacity.

Separation Problems

Failure to obtain an efficient separation is usually due to one or more operator or installation errors. Properly installed and operated, gravity separators seldom fail to separate seeds differing in specific gravity.

Weak Foundation

The gravity is a reciprocating machine and must be securely bolted to a solid foundation. A slight vibration at the base is multiplied many times on the deck. Weak foundations allow false vibrations which counteract the mechanical vibration of the eccentrics and upset the flow of seed across the deck. The seed bed will surge or flow in waves across the deck when false vibrations synchronize with the eccentric motion. When the seed bed flows in waves at regular intervals, look for false vibrations.

Fans Running Backward

This is a common mistake in new installations. The fans must build a static air pressure in the air chest to insure even air flow through the deck cover. Running backward, the fans cannot built up the necessary pressure. Arrows usually mark the direction of fan rotation. The fan should turn toward the opening into the air chest, and deliver a strong air blast into it. Switching any two of the three wire connections of a three-phase motor will cause it to run in the opposite direction.

Air Filter Covered

Most gravity separators are shipped with shields over the air filters to protect them during shipment and installation. Remove these before operating the machine. Avoid damaging the filters after the shields are removed.

Dirty Air

Clean air is essential. Dust-laden air will clog the filters and

plug air openings in the deck cover. The deck is soon blinded, and dead spots appear. The seed bed lies dead on these spots, and both stratification and separation are ruined. Most gravity separators provide two means of getting clean air. The air filter built into the gravity can be used if air around the machine is clean and free of floating dust and chaff. If this air is relatively dusty and the filters require frequent cleaning, clean, dust-free air should be piped in from another location.

Loose Deck

The clamps or other devices which hold the deck in the selected position must be loosened before either end slope or side slope is adjusted. After the slope is adjusted, retighten the clamps immediately. Loose clamps cause false vibrations and the deck position may change.

Wrong Deck

Deck covers are designed to support the seed while allowing air needed for stratification to pass through. Large seed require more air and can be supported by a more open surface, so a wire mesh deck cover with larger openings is used. Small seeds require less air, and smaller openings will support the seed. Deck covers of cloth or sheet metal with fine openings are used for small seeds.

Trying to Get High Capacity Before Getting Efficient Separation

Inexperienced operators often fail because they try to get high capacity without taking the time to get an efficient separation. The initial adjustment sequence must be followed carefully until an efficent separation is obtained. Then the rate of feed can be increased and balanced with changes in other adjustments until the maximum capacity, at which the separation can be made, is reached. Maximum capacity varies as weight differences between the seed vary, and can be exceeded only by accepting a poorer separation.

Seed Mixture not Suitable for Gravity Separation

The gravity separator will: (a) separate seed of the same size according to differences in specific gravity, or (b) separate seed of the same specific gravity according to differences in size. If the seed mixture does not meet either of these requirements, it is not suitable for gravity separation. Seed should be carefully sized and cleaned on basic cleaning machines before going to the gravity separator.

Insufficient Air

The stratification zone of the deck must have sufficient air to

stratify the seed mass into vertical layers of different weights. The separation zone must have sufficient air to maintain this vertical stratification. Insufficient air prevents proper stratification, and lets all seed lie on the deck and move uphill.

Excessive Air

Most inexperienced operators use too much air. Excessive air destroys the stratification by blowing or "boiling" heavy seed into the upper layers of lighter seed. When stratification is ruined, the separation is ruined. Excessive air causes heavy seed to flow downhill with the light seed.

Belt Slippage

Slipping belts deliver power to the eccentrics erratically, and cause irregular flow of seed across the deck. Slipping belts are common, especially when the gravity is first started on cold mornings. V-belts should be kept tight, but not too tight, since excessive pressure causes undue bearing wear.

Deck Shape

Gravity separators are built with either a triangular or a rectangular deck shape. Both utilize the same separating principle, and both decks have a stratifying zone and a separating zone. The difference between the two deck shapes is primarily in the distance that light and heavy fractions travel across the deck before they discharge.

The longer seed remain on the deck, the more efficient is the final separation. When seed are forced to travel a longer distance on the deck, a better separation can be made. When the separation is good, the middling fraction is small.

The triangular deck allows light seed to move a relatively short distance down the low end to the discharge side and the middlings product also has a short distance to travel. Heavy fractions, however, are forced to travel a longer distance along the back side and across the slanted high end to reach the heavy seed discharge. The triangular deck is thus good for separation of a small fraction of heavy seed from a large fraction of lighter seed.

The rectangular deck has a longer low end, and light seed travel further before they discharge. The middlings product also travels further so that it is separated into a much smaller final amount. The

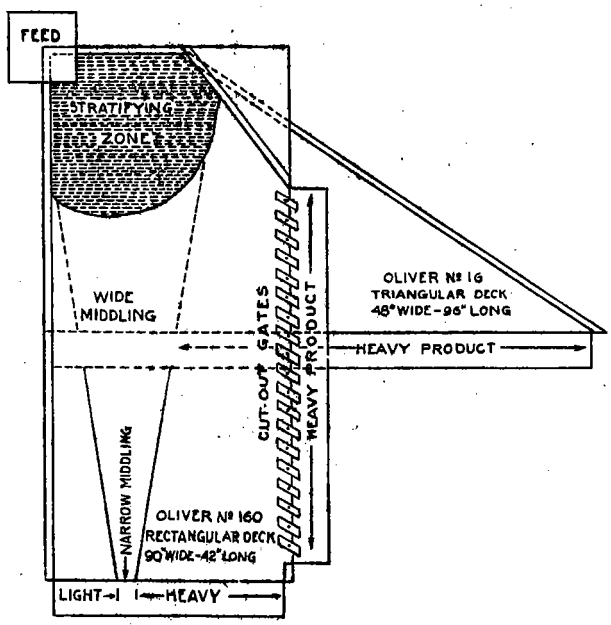


Figure E14. Comparison of rectangular and triangular gravity separator decks.

rectangular deck is thus a good separator for reducing the amount of middlings product, and for removing a small fraction of light seed from a large fraction of heavier seed.

Deck Covers

Several types of deck covering materials are available. The deck cover must support the seeds and keep them from dropping down into the air chest, but still be sufficiently porous to allow enough air to pass through its surface to stratify the seed. Another function of the deck covering is to provide the proper friction to help hold seed on the deck until they are separated, or to move seed across the deck rapidly when they are easily separated.

Small seed such as those of clovers and forage grasses are cleaned on decks covered with either cloth or perforated sheet metal. The cloth cover is usually a durable porous material such as oxford cloth. Perforated metal decks are usually of copper or a similar material slightly ridged and with small perforations to pass air. The openings in both cloth and sheet metal decks are very small to keep small seeds from falling through and to lessen air flow, since small seed require less air for stratification.

Large seed such as corn and beans are separated on decks covered with closely-woven wire. The woven wire will support the seed and allows the higher air volume and pressure required for stratification.

Friction offered by the deck surface as the seed bed moves across it also influences the choice of a deck surface. Perforated copper decks are smooth, create little friction, and have greatly increased capacity in cleaning seeds such as alfalfa when the seed stratify readily. On the other hand, deck surfaces are sometimes chosen for extra friction to keep seed on the deck until they can be separated. Some woven wire decks have a coarse 1/2-inch by 1/2-inch wire mesh on top of the woven wire cover to create added friction. Decks may also have rows of raised strips, called riffles, fastened on top of the deck surface.

These rows of riffles run in the direction of the deck motion, perpendicular to the seed flow toward the discharge side. They serve as dams to hold smooth heavy seed on the deck longer and cause them to move closer to the high side of the deck before they discharge.

Maintenance

Bolts securing the gravity separator to the foundation may vibrate loose and should be inspected and retightened regularly. All bolts on and in the machine should also be inspected and retightened at regular intervals.

Sealed bearings which come packed with a good grade of grease are now used on most machines. These bearings should be regreased sparingly at intervals. More bearings fail because of excessive greasing than from insufficient greasing. When greasing, grease should not be forced into the fitting until it comes out the seals. This not only damages the grease seals, but may let excess grease reach the deck surface and cause dead spots. Cold weather causes grease to harden in the bearings. If set screws locking the inner bearing race are loose, the shaft will slip in the bearing housing and will be scored. Most modern machines use self-aligning bearings; however, if bearings run hot they should be checked to see that they are properly aligned before greasing them.

V-belts driving the separator should run fairly tight, but not overly tight. Excessively tight belts cause undue wear on the bearings. If belt slipping is suspected, stop the machine and feel the sides of the pulleys. If they are warm, slipping belts are indicated.

Decks must be kept clean. Dust or grease will plug up air openings in the deck and cause blind or dead spots which destroy the

separation. Only clean, dust-free air should be fed into the air chest. When the machine is not in use, a cover should be kept over the deck. Bags, tools, grease guns, and other materials should never be stacked on the deck of an idle gravity separator.

Operator's Record Book

Different crop seed with different contaminants will require different settings and adjustments of deck speed, air, side slope, end slope, and feed. Once the adjustments that give the most efficient separation are determined, they should be measured and recorded in a special Operator's Record Book. The next time a similar lot must be cleaned, the time and effort required to make initial adjustments can be minimized by starting with the adjustments used on a similar previous lot. The record should include:

1. Crop Seed _____
2. Variety _____
3. Material Being Removed _____
4. Deck Surface Used _____
5. Side Slope Difference (in inches or cm) _____
6. End Slope Difference (in inches or cm) _____
7. Air Gate Openings (setting or number of turns from closed)_____
8. RPM of Eccentric Shaft _____
9. Feed Opening (in inches or cm) _____

STONERS

The stoner is a special purpose gravity separator designed to remove a small amount of heavy material from a larger volume of seed. Like the gravity separator, its operation depends on vertical stratification of the seed mixture according to weight, followed by separation of the different strata on an oscillating deck. It differs from the gravity separator, however, in the number of fractions of seed it produces. In the gravity separator, seed are discharged along a single side, ranging in weight from lightest at the low end to heaviest at the high end. Thus, the seed can be divided into as many fractions as desired. The stoner produces only a light fraction and a heavy fraction, which discharge at opposite ends of the deck.

Parts of the Machine

The operating parts of a stoner are basically similar to those of a gravity separator. They are:

Base

A base or frame, bolted to a firm foundation, provides a solid base for the oscillating deck.

Fan

A fan draws outside air through a filter and builds air pressure in the air chest.

Air Chest

An air chest collects air under pressure and delivers it to the deck in effective pressure patterns.

Drive Mechanism

An eccentric drive mechanism drives the deck in an oscillating back-and-forth motion.

Feed Hopper

A feed hopper delivers a uniform stream of seed to the stratification zone of the deck.

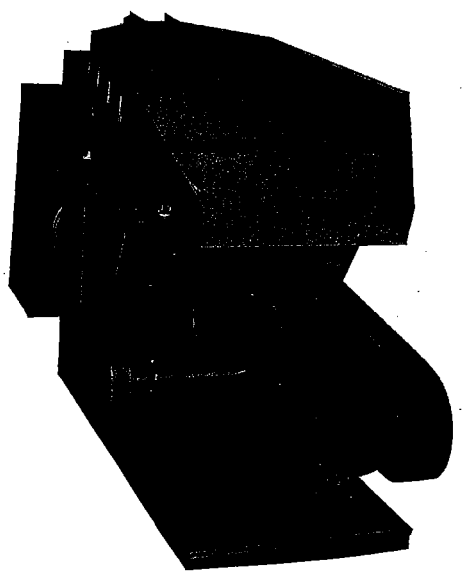


Figure E15. Sutton, Steele and Steele Stoner, Model S-40-60.

Deck

A porous deck provides the surface on which the seed are stratified and separated. The typical stoner deck is rectangular in shape, with banking rails along both sides to hold the seed bed on the deck. The low end of the deck is open so that a large volume of seed can be discharged. At the high end, the side banking rails angle inward and leave only a narrow opening to discharge a small volume of material.

Principles of Operation

The feed hopper mounted over the center of the long dimension of the deck feeds a uniform curtain of seed across the deck. The air blowing through the porous deck surface vertically stratifies the mixture on the center area of the deck into layers differing in weight. Heavy material remains in contact with the deck, while the light material is fluidized and floats on a cushion of air.

Since the deck is inclined, the light seed held up by the air float toward the low end under the influence of gravity. At the same time, the deck oscillates back and forth in the direction of the inclination in much the same manner as the gravity separator. Heavy

particles of dirt, rock, or sand in contact with the surface of the deck are moved uphill as the deck oscillates toward the high end. As the deck moves toward the low end, it drops downward very slightly. The heavy particles momentarily lose contact with the deck and do not move back with it. Thus, they regain contact with the deck at a higher position. This continuous deck motion moves heavy particles up the deck toward the narrow discharge opening at the high end. An adjustable gate in the discharge opening allows discharge of heavy particles but also maintains a layer of the heavy particles on the deck to prevent light seed from being forced out with the heavy materials.

Adjustments

Four adjustments on the stoner must be balanced with each other to produce an efficient separation at high capacity.

Feed Rate

Feed rate must be uniform and sufficient to maintain a bed of seed on the deck. As the feed rate increases, however, the size of the stratifying zone increases. Feed rate should be adjusted so that the stratifying zone does not cover more than 1/3 of the deck area. If small heavy particles discharge with the good seed, feed rate should be reduced.

Air Flow

Air flow should be just sufficient to stratify the seed mixture into vertical weight zones. If excessive air passes through the deck, the upper end of the deck may be blank, because heavy particles are lifted and forced toward the low end of the deck. Insufficient air allows some good seed to move up into the neck of the high end discharge and go out with the heavy particles.

Deck Tilt

Deck tilt can be adjusted for a greater or lesser slope from the high end to the low end. No side slope adjustment can be made; the deck should be level from side to side. Excessive deck tilt creates too steep a slope for the deck motion to move heavy particles to the high discharge end, and the upper end of the deck may be blank, or some heavy particles may discharge with the good seed. Insufficient deck tilt allows good seed to mix with the heavy particles at the high end discharge.

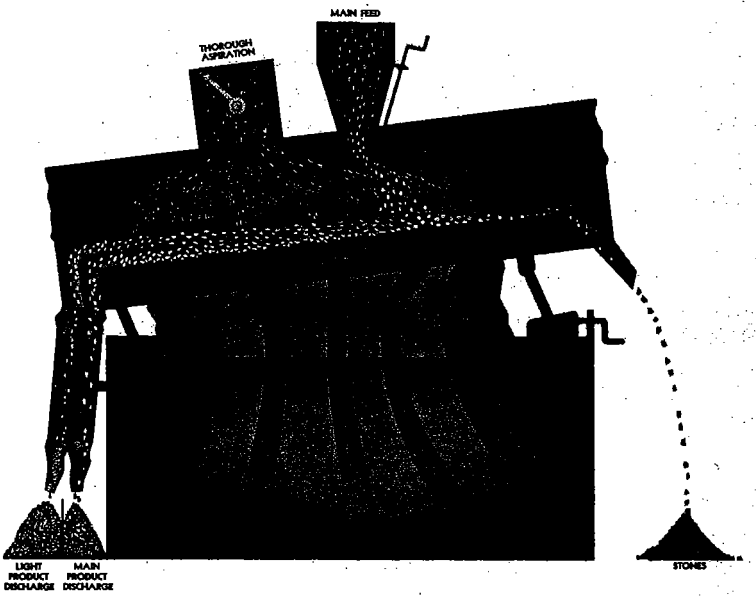


Figure E16. Section of vacuum stoner illustrating air flow, aspiration, and separation of components. Use of "gravity knife" or horizontal splitter produces two separates at low end of deck.

Deck Speed

Deck speed should be adjusted after deck tilt and air flow have been set properly. Deck speed should move heavy particles up the deck without interfering with the flow of lighter materials toward the low end.

A minor but important adjustment is the gate across the narrow discharge area at the high end of the deck. It should be kept closed until a bank of heavy particles sufficient to fill the narrow discharge neck and extend back several inches into the deck area accumulates. This bank of heavy material keeps good seed from working out the high end with the heavy particles. The gate should then be opened slightly to allow heavy particles to discharge at about the same rate they are separated from the seed, so that the bank of heavy materials is maintained.

Installation

The stoner is used in the processing line in two principal ways. First, it is installed immediately following gravity separators to receive the mixture of heavy good seed and heavy particles of sand, rock, or dirt that discharge along the upper banking rail of the gravity. The

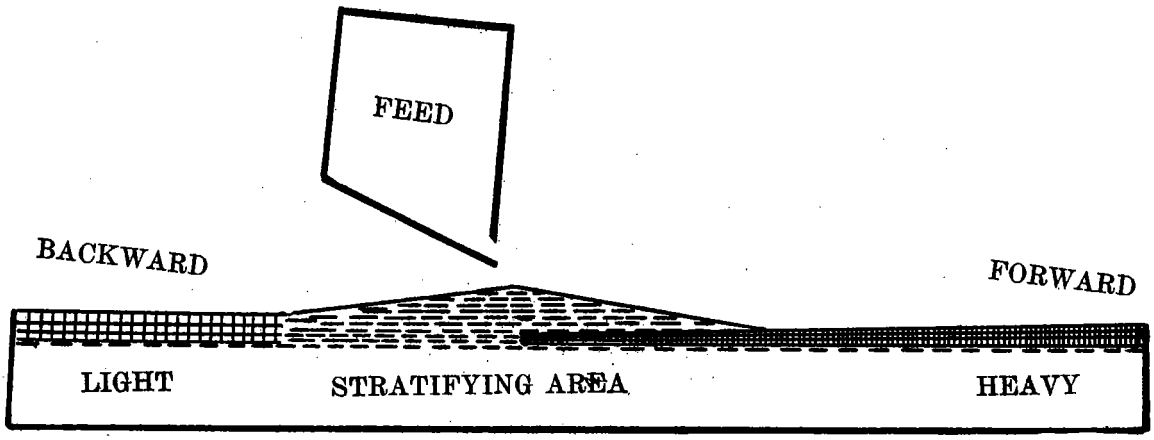


Figure E17. Cross-section of the stratifying area of a stoner. Light seed flow downhill and heavy particles (stones, gravel) move uphill after stratification.

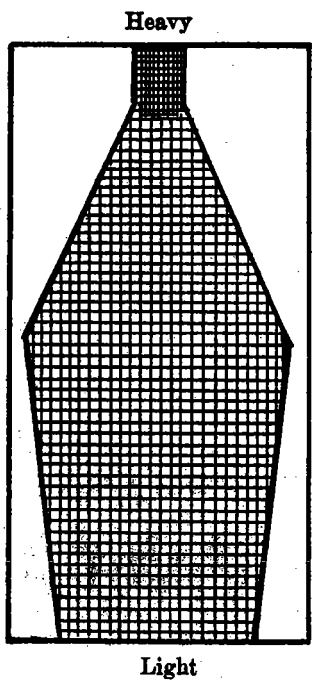


Figure E18. Imporperly adjusted stoner. The light seed are allowed to move too far into the heavy material end of the deck.

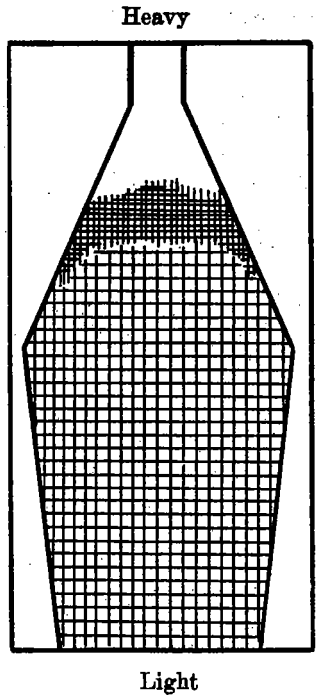


Figure E19. Improperly adjusted stoner. Heavy particles do not move up into the high discharge end.

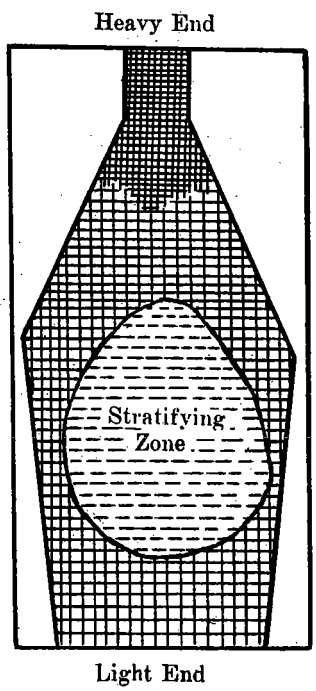


Figure E20. Properly adjusted stoner. Note the stratifying zone and distribution of light and heavy components.

stoner will remove the heavy particles and salvage the good seed. Second, windrow-harvested beans, peanuts, or similar seed with a high dirt or rock content may be cleaned over a stoner before going into the basic cleaning line. The stoner serves here as a receiving cleaner or pre-cleaner to remove heavy foreign material.

The stoner is an oscillating separator, and should be securely bolted to a firm foundation to prevent false vibrations which prevent efficient separations. It should be located in an area of dust-free air, or where clean air can be piped to it.

SUMMARY

The stoner is a special purpose gravity separator used principally to separate heavy inert material (sand, dirt, gravel) from seed. While its basic components are similar to the gravity separator, it is much less versatile because its design has been simplified and adjustable features minimized.