DENSITY SEPARATIONS

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Previous discussions have established that the purposes of seed conditioning are primarily to remove contaminants, size grade to improve plantability, upgrade the quality of the lot, and to apply treatment materials.

The removal of contaminants is primarily carried out by the air and screen cleaner which is considered the basic machine in seed conditioning. Size grading usually involves machines such as the indent cylinder, disc separator and the width and thickness grader, all of which take advantage of physical differences among seeds to perform the desired separation. Seed treaters are used to apply fungicides and/or insecticides to seeds to protect them during storage and in the seedbed.

Seed lots can be cleaned and size graded accordingly, and the quality of some lots can still be further upgraded by using certain distinguishable physical differences among seeds. These physical differences include seed characteristics such as shape, density, weight, coat texture, color, electric conductivity, and affinity for liquids. These properties are also exploited for the removal of contaminants. My discussion will focus on density separations.

Seed density is the ratio of the mass of a seed to its volume. Thus, we can see why it is so important to start with a uniform size seed lot when we are going to perform a density separation.

Prior to performing a density separation a seed lot should be cleaned and, if necessary, size graded; otherwise the separation might be more of a size separation than a density separation.

When thinking about density separations we tend to think about the use of liquids to stratify and separate solid particles. This has been done, and it is still used in some industries, but for conditioning seed a more available, free element is used, air. Air can be moved and forced by fans to suspend solid particles, and depending on their density they can be stratified. When stratified, the layers can be separated and a density separation has been performed. The machine that does this - the gravity table - was originally developed to separate ores in the mining industry during the "gold" mining days.

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Taking a closer at the gravity table we can see that it consists of the following parts: (see Figure 1).

1. Base and frame
2. Oscillating deck
3. Fan(s)
4. Air chest
5. Drive mechanism, and
6. Feed hopper

The base anchors the machine to the floor securely. The frame provides the structural support for all other parts of the machine. Mounted on the frame above the air chest is the deck, which provides a perforated or porous surface through which the air is blown to stratify the seed mass. The deck is held tightly secured to the upper part of the frame by means of clamps or bolts. The deck is oscillated by motion transmitted from the drive mechanism by a series of metal toggles. One or more fans force air into (or pull air through) the air chest, where by a series of baffles (which can also be located above the fan outlets or built into the deck frame) the air is distributed uniformly and forced through the deck. In some models the fans are activated by the same motor which causes the deck to vibrate. In others, there might be more than one motor. "Vacuum" gravity separators have a hood to enclose the deck completely, and a fan pulls the air through the deck and exhausts it from the hood. A feed hopper is located in the back corner opposite to the high side of the deck to uniformly meter the flow of seed entering the deck.

Principles of Operation

A density separation on a gravity table is accomplished in two steps (Figure 2). First, as the seeds are fed by the feed hopper onto the deck, they are vertically stratified by the air-stream flowing upwards through the porous or perforated deck surface (Figure 2b). This takes place in the area near the feed point which is known as the stratifying zone (Figure 3). In the stratifying zone light seeds are suspended on a cushion of air, while the heavier seeds are not lifted by the air-stream, and, thus, remain in contact with the deck surface. A layer of intermediate weight seeds is found between the light and heavy seed layers (Figure 2b).

Once stratified, the seed layers have to be separated, and discharged through different spouts. To accomplish this, the deck which is mounted on inclined toggles, is slightly sloped sideways. An eccentric drive system moves the deck foward-up and back-down, and the motion is

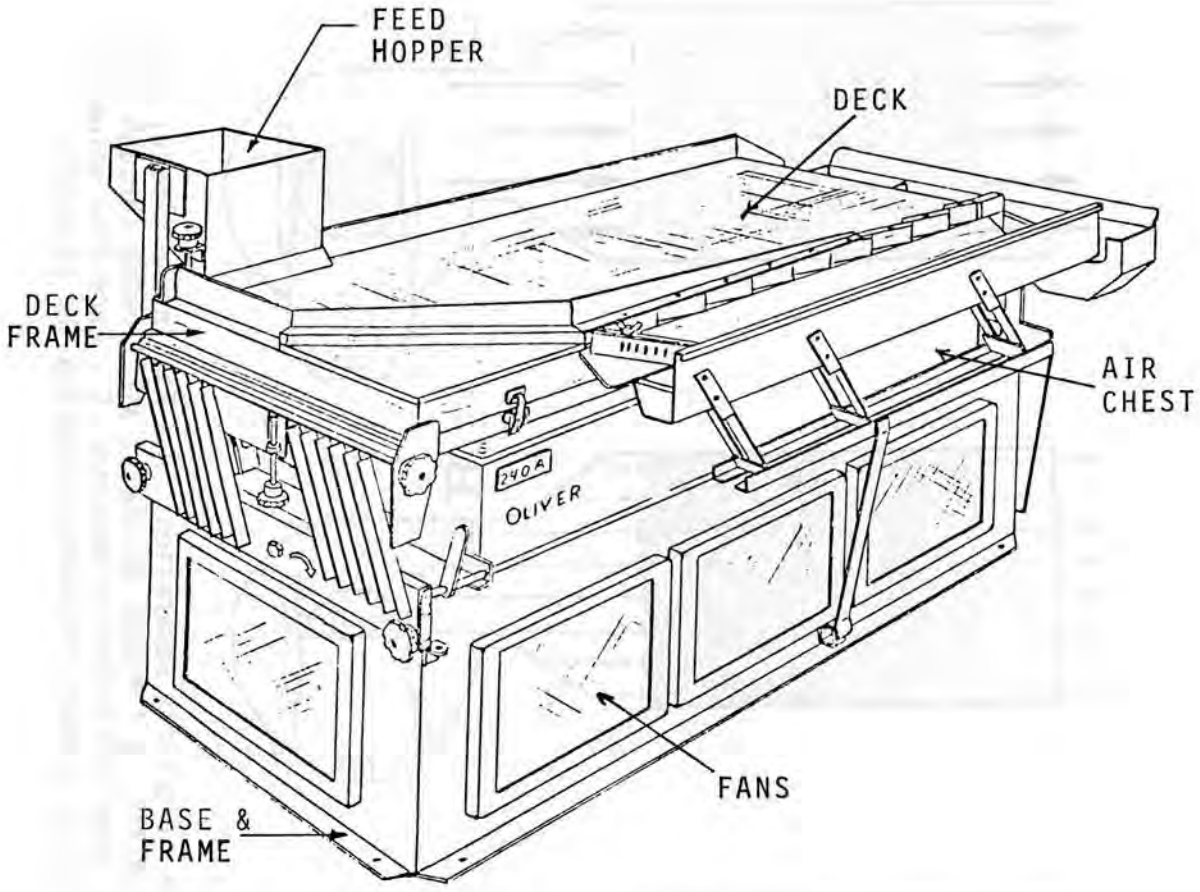

Figure 1. Diagram of a gravity table.

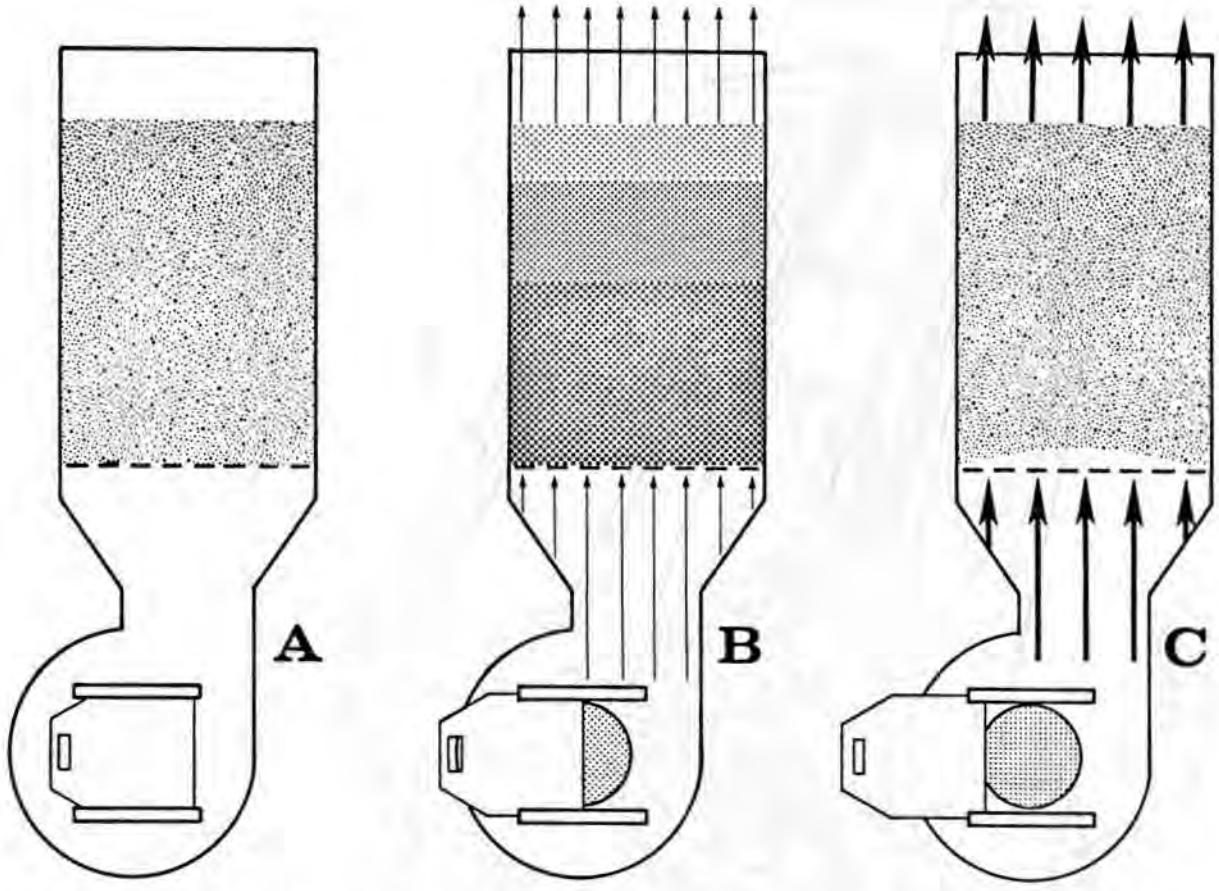

Figure 2. Principles of gravity separation. A - Fan intake closed; no o stratification. B - Proper volume of air flowing through the deck; seed stratified by density. C - Excessive volume e e e of air flowing through the deck disrupting the stratification.

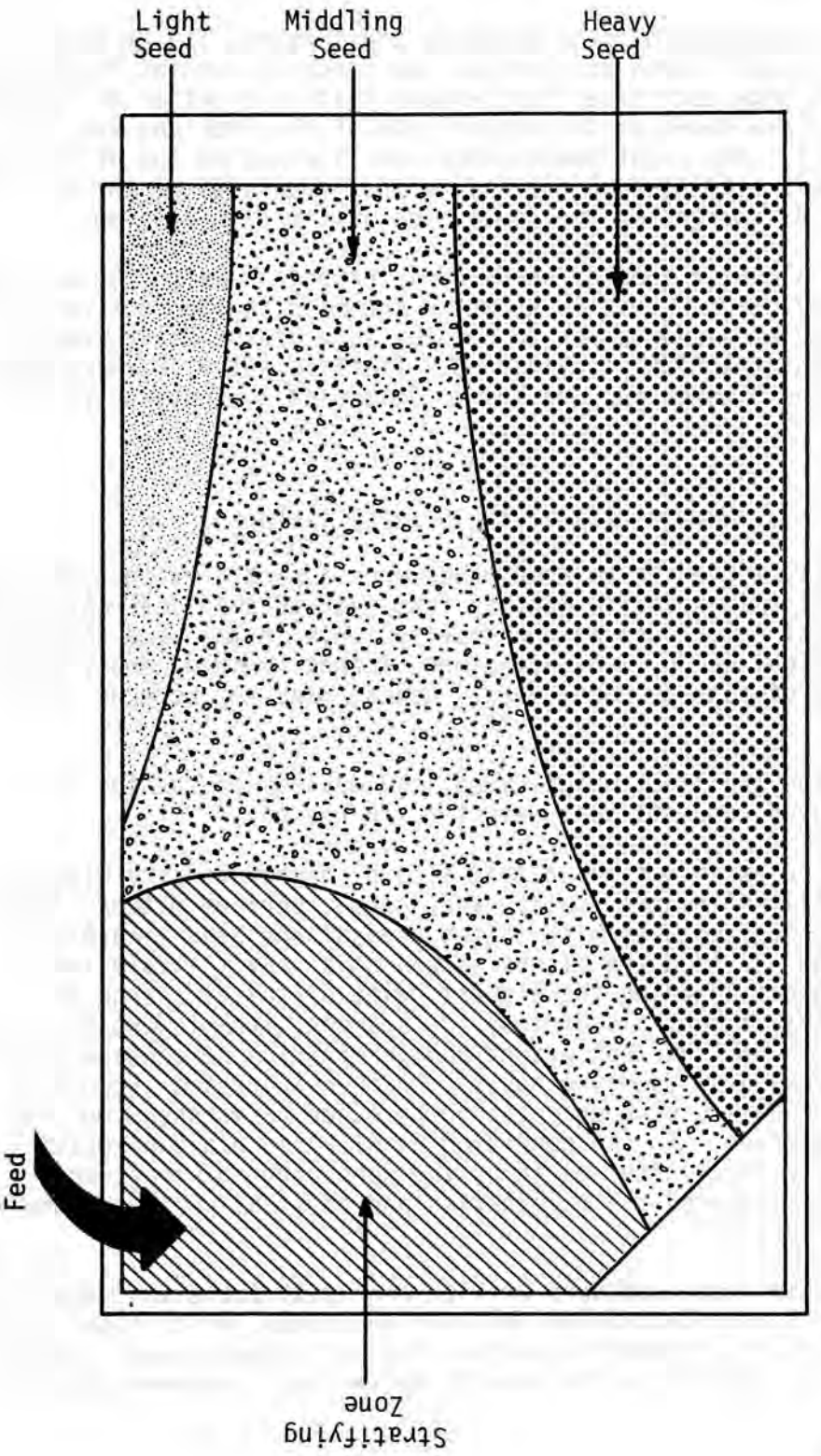

Figure 3. Top view of gravity table showing flow pattern of seed across the deck.

such that the heavy seeds are pitched up and forward, and by that time the deck returns back down and catches the seeds at a point farther up the deck. The deck oscillates fast enough that in a matter of seconds the heavy seed are moved to the higher side of the deck and are discharged from it. The light seeds which are floating on top of the layer of heavier seeds will flow by gravity to the lower side of the deck and eventually be discharged at the lower side of the discharge end.

There is always a zone of seeds of intermediate weight between the light and heavy seeds. This is known as the middling product which is normally accumulated and re-run to recover some of the heavy seeds before the light fraction is discarded. There is not a sharp delineation between these zones and one has to determine the cutting point between them.

Common Uses of the Gravity Table

The gravity table can be used whenever the particles that need to be removed differ in specific density from that of the "desirable" seed. However the most common use of the gravity table in the seed industry is for removing light seeds, i.e., immature, insect damaged, empty seeds, as in the case of cotton, corn, wheat, beans, peas and bermuda grass seeds.

By removing the light weight seed, the quality of the lot as a whole is improved, and its test weight is increased.

Previous research has shown that seed of higher density within a lot are generally of higher quality and, hence, perform better in the field. Bill Gregg, working with cotton seed at the Seed Technology Laboratory, MSU, divided the discharge end of a gravity table into 10 segments: segment 10 being the highest point of the discharge end (where the heaviest seed discharges) and segment 1 the lowest point of the deck. He found that test weight and germination percentage of the separates increased as sampling position number increased (Figures 4 and 5). Similar results have been obtained by other researchers working with different crops. In the conditioning of Pensacola bahiagrass, the use of a gravity table after cleaning the seed with an air-screen cleaner greatly improved the germination and physical purity of the lot as a whole (Figure 6).

Some soybean seed producers utilize a gravity table to remove the majority of soil peds containing cysts of nematodes, which might not be removed by the A & S cleaner in certain lots of soybean seed. Cocklebburs can also be removed by the gravity table from a soybean seed lot.

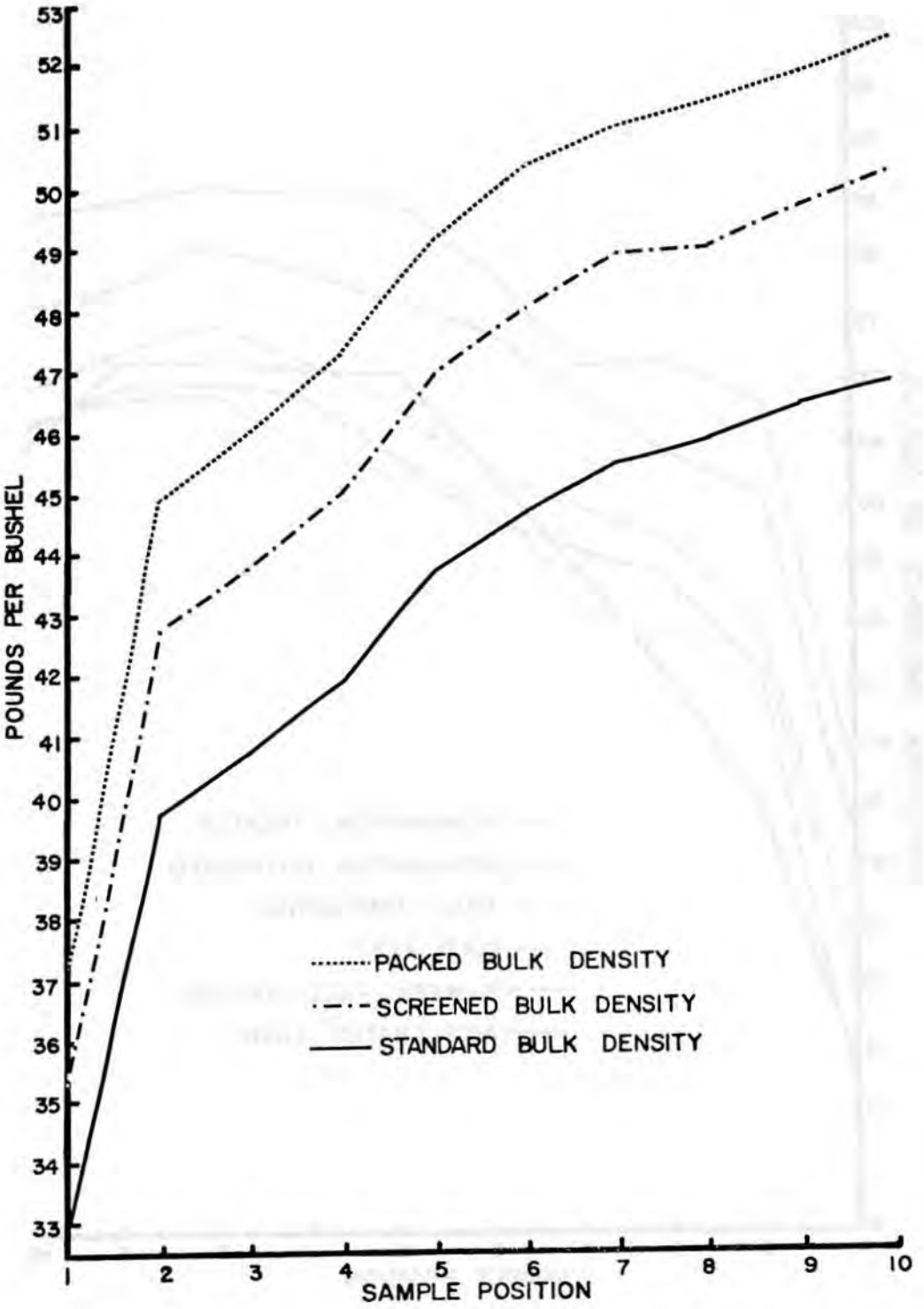

Figure 4. Average density (pounds-per-bushel) of cottonseed over 10 positions across the discharge end of a gravity separator. (Gregg, 1969).

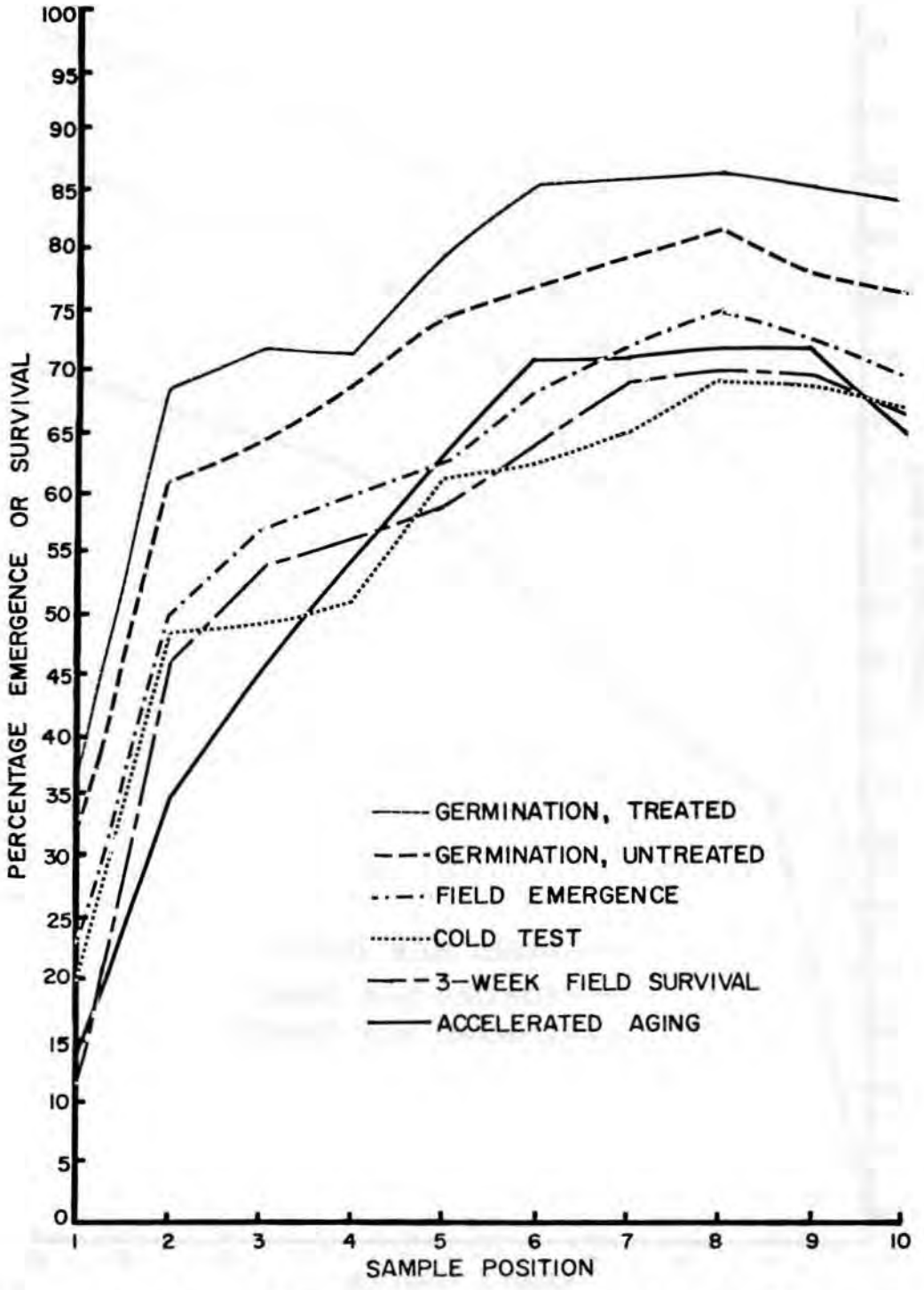

Figure 5. Average "performance" of cottonseed from different sampling positions at the discharge end of a gravity separator. (Gregg, 1969).

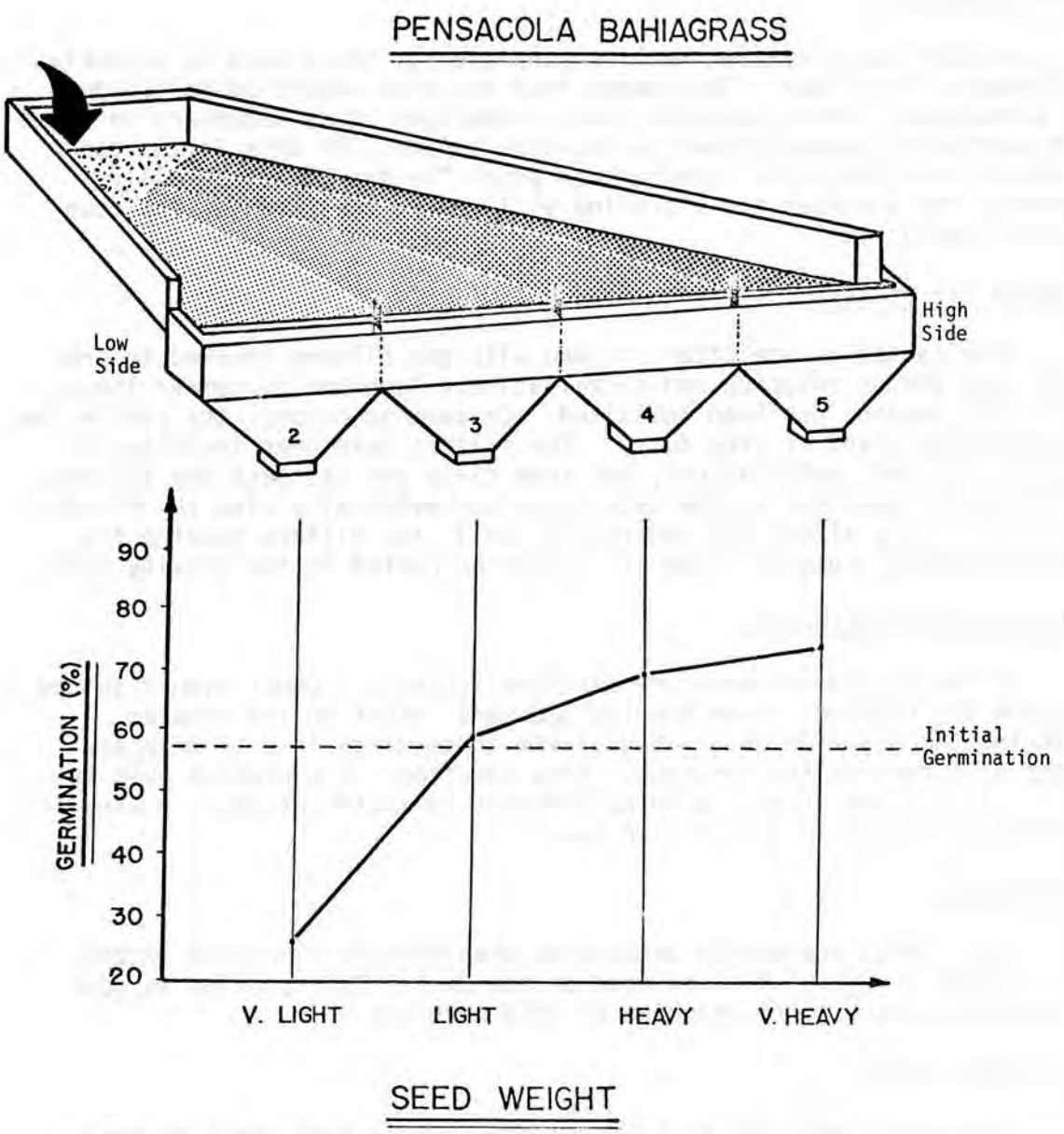

Figure 6. Germination of Pensacola bahiagrass from different discharging points of a gravity table.

Common Mistakes in the Installation and Use of the Gravity Table

Weak Foundation

As with any vibrating machine, the gravity table must be securely fastened to the floor. This means that the base should be bolted down to a reasonably thick concrete slab. Sometimes it is necessary to raise the machine to properly feed an elevator hopper. If this is the case, remember that the higher the base on which the gravity table will be mounted, the stronger the vibration will be, so the stronger the foundation should be.

Blocked Air Filters

Gravity tables are often shipped with the filters covered to protect them during shipping and installation. Remember to remove these after the machine has been installed. On some occasions, the air in the conditioning plant is very dusty. The filters have been installed to protect the deck perforations, but some dirty air can pass the filters, plug the air openings in the deck cover and eventually clog the filters. This will badly affect the separation, so if the filters require frequent cleaning, outside clean air should be ducted to the gravity table.

Fan(s) Running Backward

If inadequate air pressure develops in the air chest even with the maximum air opening, "fans running backward" might be the problem. Changing the position of any two of the three wires in a three-phase motor will reverse its rotation. This sometimes is a problem even in old installations after electrical repairs or modifications. A wire is sometimes changed in the service box.

Loose Belts

Loose belts are easily detectable when erratic vibration of the deck causes irregular flow of seed on the deck. This problem is most common when starting the machine on cold mornings.

Wrong Deck Cover

Deck covers made out of cloth or sheet metal with small perforations are used for small seeded lots. Larger seed (such as cottonseed, soybeans, corn, etc.) require more air for stratification, and a wire mesh deck cover with larger openings is used. The metal strips (riffles) located on the deck parallel to the vibrating motion aid in retaining the seed a little longer on the deck, thus improving stratification and guiding heavy seed to the higher side of the deck. Check to be sure that the proper deck is being used.

Rectangular Deck vs. Triangular Deck

The main difference between a rectangular and a triangular deck gravity table is the distance which the light and heavy seed travel across the deck.

A triangular deck allows the heavy portion of a seed lot to remain longer on the deck since it has to travel further than the light and middle portions before it is discharged. On the other hand, the rectangular deck has a longer "low" end, thus, light seed remain longer on the deck before they discharge.

Since in most cases seedsmen use the gravity table to remove lighter material and this material makes up a small portion of the lot, a rectangular deck seems appropriate for most seed conditioning operations. However, both types of decks will perform a good separation when the gravity table is properly installed and operated.

Stoners

A stoner is a special type of gravity table, which is commonly used to remove a small amount of heavy material (stones, soil peds, etc.) out of a seed mass. it can also be beneficial in recovering heavy crop seed which are mixed with the soil peds and sand and gravel discharged at the high side of a gravity table.

In contrast to a gravity table, a stoner discharges only two products: a heavy fraction and a light fraction. There is no middle product. The principles of operation and cares of installation are the same as those of a gravity table.

Aspirators and Pneumatic Separators

Although not as precise as the gravity table, there are other machines that by using forced air can separate different materials based on their weight. In the seed industry the two most important ones are the aspirator and the pneumatic separator (Figures 7 and 8).

The main difference getween an aspirator and a pneumatic separator is the location of the fan. In a pneumatic separator the fan is located in the intake end of the machine. The air is blown in the machine, creating an air current with greater pressure than the outside atmospheric pressure. This air blast when properly regulated is able to lift light material out of the seed mass. In an aspirator, on the other hand, the fan is located at the air outlet of the machine. When the fan is running it creates a low air pressure in the machine which is filled up by air "rushing" from the outside. This rushing air then is used to lift the lighter material.

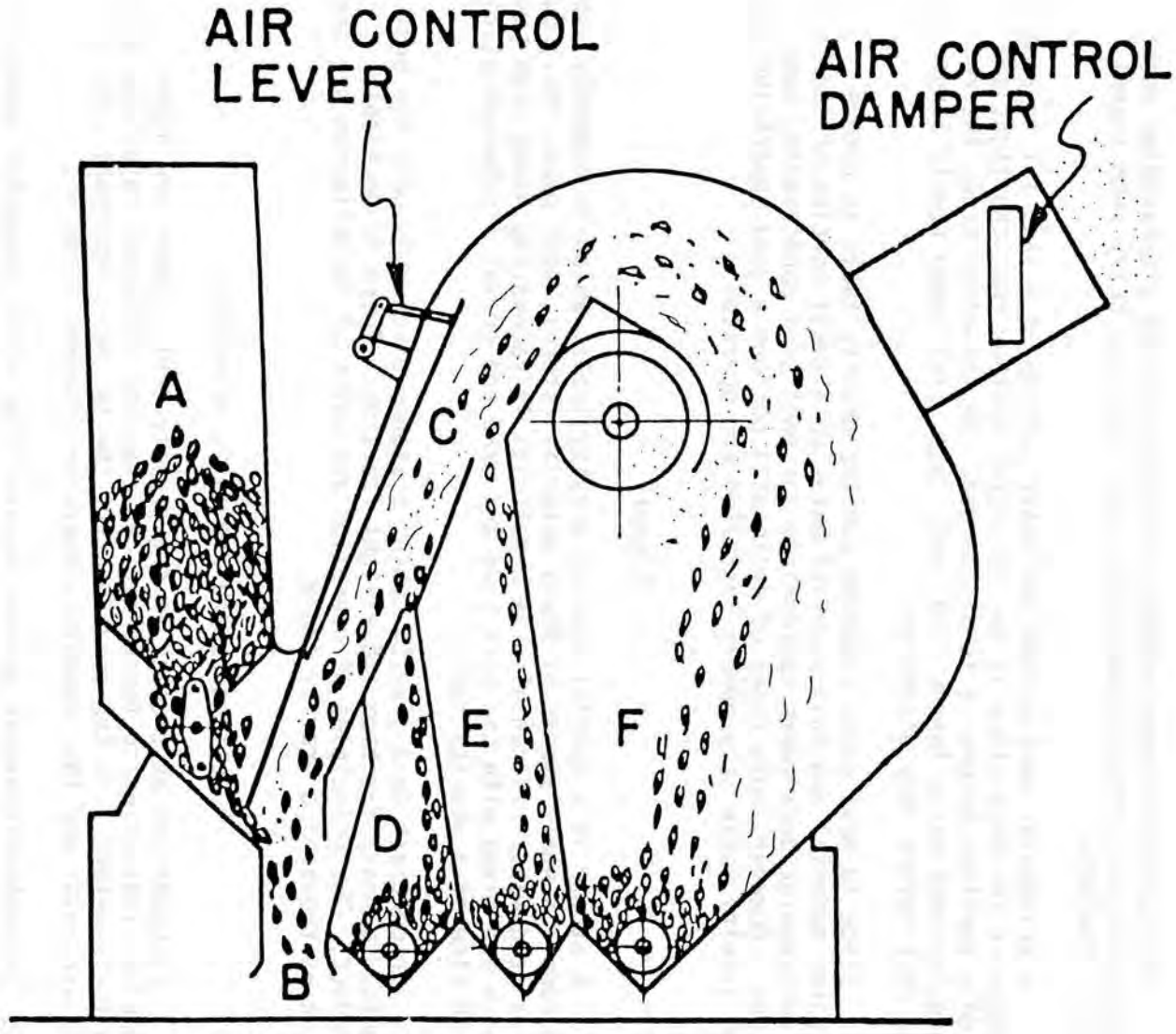

Figure 7. Flow diagram of a fractionating aspirator.

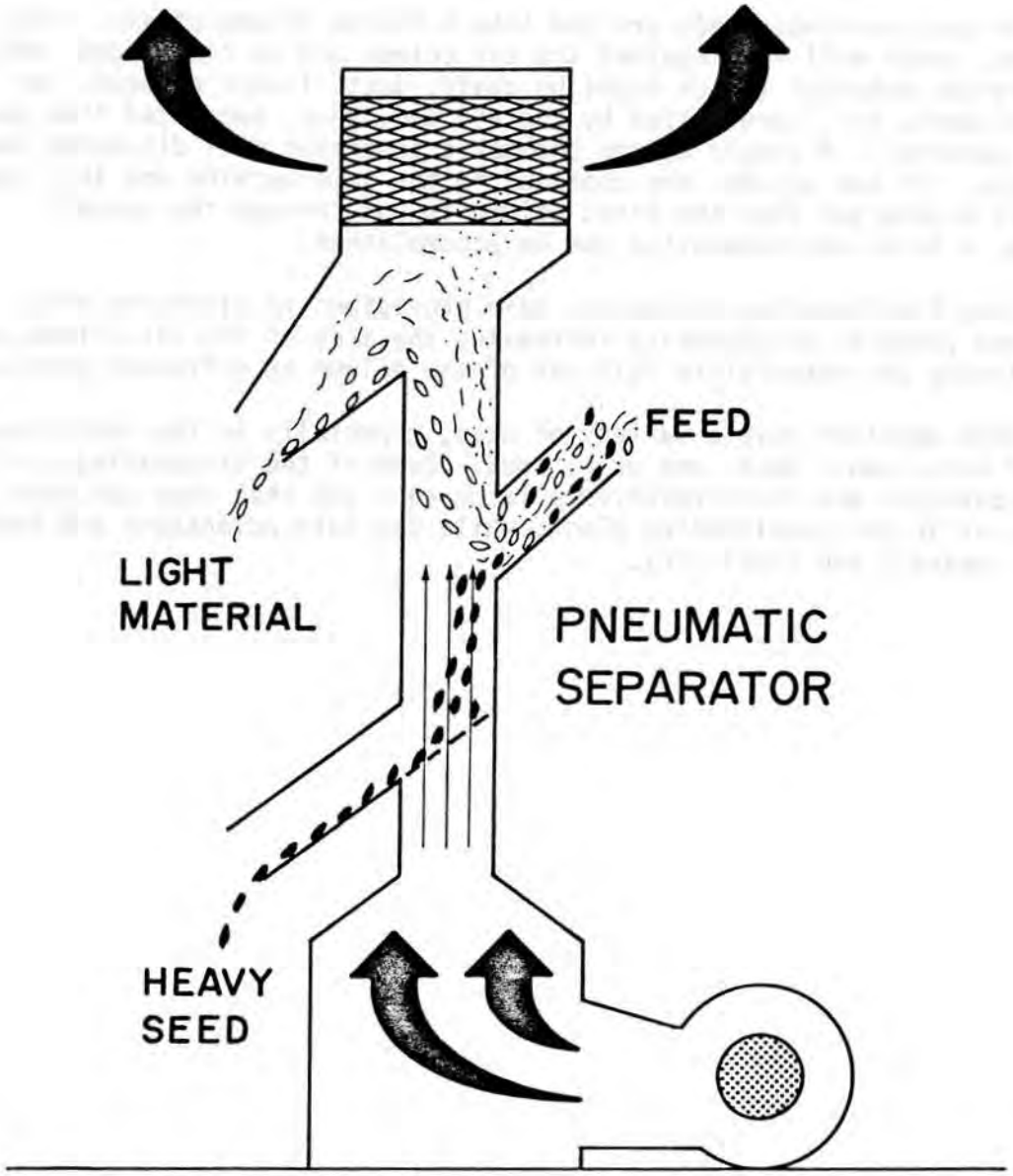

Figure 8. Flow diagram of a pneumatic separator.

In both machines seeds are fed into a rising column of air. The heaviest seeds will fall against the air column and be discharged, while the lighter material (which might be chaff, dust, insect damaged, immature seeds, etc.) are lifted by the air and, thus, separated from the heavy material. A single column pneumatic separator will discharge two products. If two columns are combined in the same machine and the light product dishcarged from the first column is run through the second column, a three way separation can be accomplished.

Some fractionating aspirators have provisions to discharge more than two products by gradually increasing the area of the air column and by allowing the material to fall out of the column at different points.

Both machines have a variety of uses, especially in the conditioning of corn, peas, beans and grass seed. Some of the disadvantages of air separators are their relatively large size and that they can blow dusty air in the conditioning plant, while the main advantages are their large capacity and simplicity.