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Separating Seeds by Length With Special Indent Cylinders

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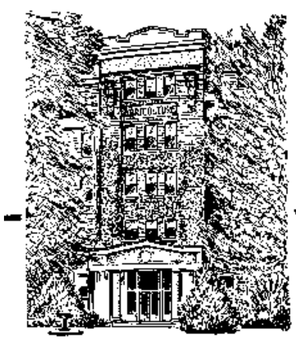

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Separating Seeds by Length With Special Indent Cylinders

N. Robert Brandenburg and Jesse E. Harmond

Summary

Conventional seed-length separators are effective with some seed mixtures but their use is restricted by limited indent sizes and depths. Many mixtures containing seeds with small but distinct length differences cannot be separated with existing equipment.

To improve processing efficiency and reduce loss of valuable seed, research on length separation was conducted. The study included (1) microscopic measurement and analysis of seed dimensions, and (2) design and construction of special indent cylinders with indent pocket sizes dictated by seed measurements. The special cylinders were evaluated for their separating ability by use of seed from the measured seed lot.

Information gained from the program was used to establish and recommend optimum indent sizes for particular separations. Cylinders with these special indents now have been constructed by individual seed processors and by commercial machinery manufacturers.

Introduction

Seed mixtures are separated by various methods which take advantage of physical differences between the crop seed and the contaminant. One method is to sense lengths and separate on this basis.

Conventional seed-length separators employ cylinders or discs with indentations that lift short seeds from a mixture and reject long ones (Figures 1 and 2). These machines do a good job with some seed mixtures, but they lack indent sizes necessary for some specific length separations. Many mixtures contain seeds with a small length difference and could be separated if indents of the proper size and depth were available. Additional indent sizes and shapes are needed to make length separations more precise.

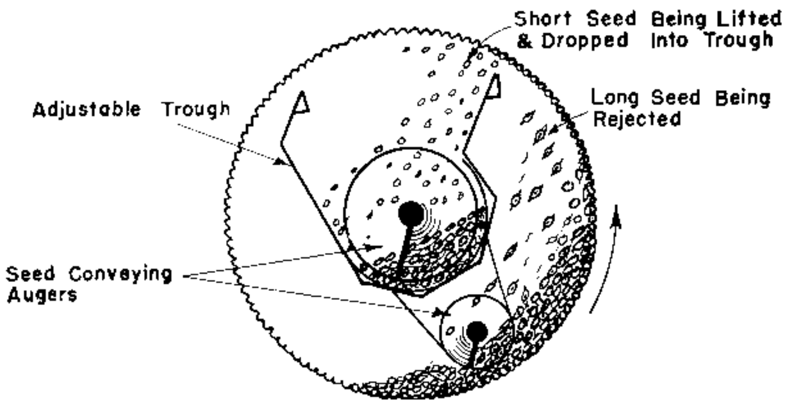

Figure 1. Cross-section view of an indent cylinder separator.

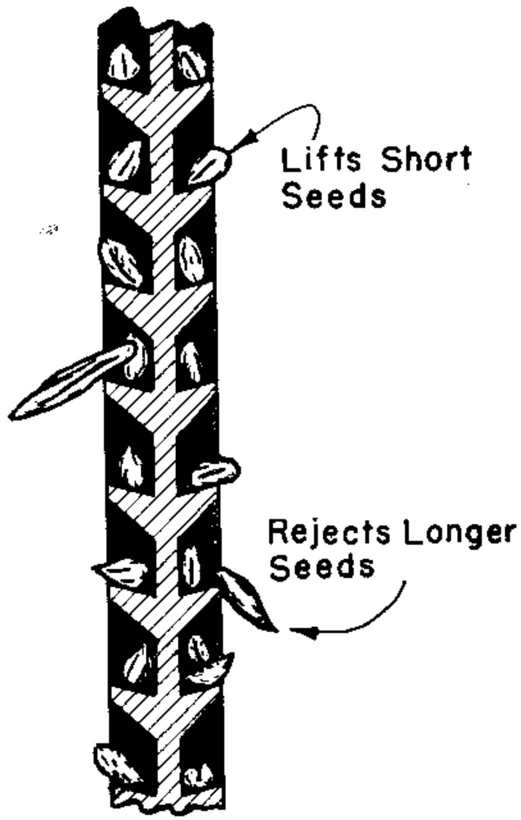

Figure 2. Cross-section view of an indent disc separator.

Accuracy in seed separation is increasing in importance because purity requirements of the clean product arc constantly being raised in effort to provide planting seed of higher quality. Annual seed sales in the United States alone are valued at more than $750 million ; in addition, millions of dollars are lost each year through the waste of good seed that could be saved in the cleaning process.

To improve efficiency and versatility in length separation, a research program was conducted by Agricultural Research Service, United States Department of Agriculture, in cooperation with the Oregon Agricultural Experiment Station, Corvallis, Oregon. The research involved accumulating seed size data determined by microscopic measurement, designing and constructing special indent cylinders dictated by specific seed measurements, and testing these cylinders with selected seed mixtures.

Seed and Indent Measurements

Many seed types and their contaminants have been measured to determine length, width, and thickness properties for each component. This was done microscopically, using a scale reticle in the eyepiece to permit dimension readings to the nearest thousandth of an inch.

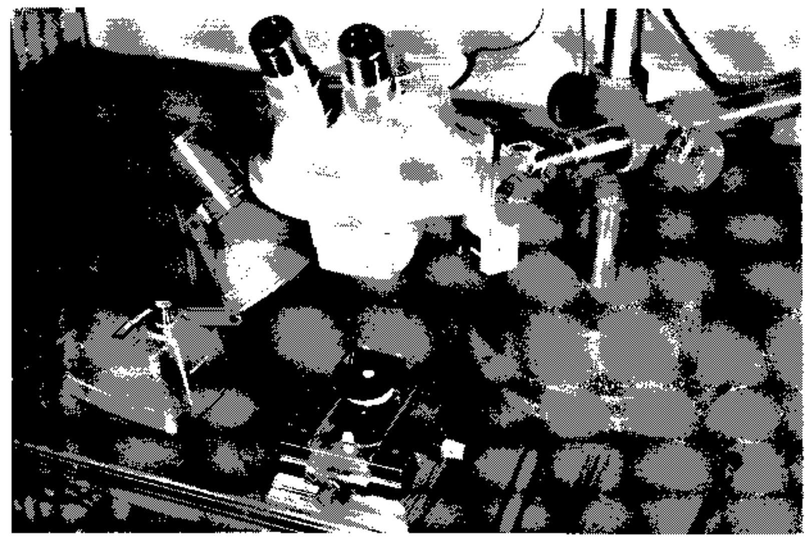

Figure 3. Equipment for measuring seed microscopically—binocular microscope with reticle eyepiece, adjustable platform, light, rotating stage, and inclined mirror.

Measuring technique

Seeds selected for measurement were obtained by subdividing an original lot in a "chaffy-grass" splitter to provide a representative sample of at least 25 crop seeds and 25 contaminant seeds. These seeds were measured with a binocular microscope equipped with measuring reticle, adjustable platform, rotating stage, light, and mirror fixed at a 45° angle (Figure 3). A seed is positioned on the center of the stage and length is measured, after which the stage is rotated 90° and width is measured. The stage assembly is moved forward to bring the angled mirror into the field of vision and provide a side view of the seed, where thickness is determined. Figures 4 and 5 are photomicrographs showing width measurements of reed canarygrass and white clover, respectively. The raw data obtained in this manner were recorded and tallied on data sheets.

Analysis of measurements

An analysis of the dimensional data can provide this information: (1) A direct comparison of length between seed and contaminant indicates if length separation is feasible; (2) diameter and depth of indent needed for optimum separation ; and (3) a basis for predicting yield and purity of final "clean" product.

An example of an analysis based on these three factor is presented in Figure 6, which gives measurement data in frequency distribution form kr Penncross bentgrass and red sandspurry. First, even though the seeds are very small, length distributions are different and show definite length separation possibilities. Second, the best indent to use should have a diameter of at least 0.020 inch to accept the longest sandspurry,, but less than 0.032 inch to reject the shortest bentgrass. Indent depth should be half or more of the maximum sandspurry thickness (0.012 inch) to insure the sandspurry will be lifted by the indent. Also, the depth should be less than half the length of the shortest bentgrass seed to prevent the seed from being lifted if it enters the indent lengthwise. A reasonable indent size for this mixture, then, is 0.027 inch diameter x 0.010 inch depth. Third, the measurements indicate that 100(.4 of the bentgrass can be salvaged entirely free of contaminant.

Summary of bentgrass-contaminant measurements

Measurements of additional bentgrass mixtures indicate that many of the contaminants are very similar in length and are consistently shorter than the crop seed. Figure 7 accumulates length data obtained in measuring seeds from 14 lots of bentgrass that were grown at different locations in Oregon over a period of several years. It appears that one indent cylinder can be designed to remove any of six common contaminants found in several varieties of bentgrass. This

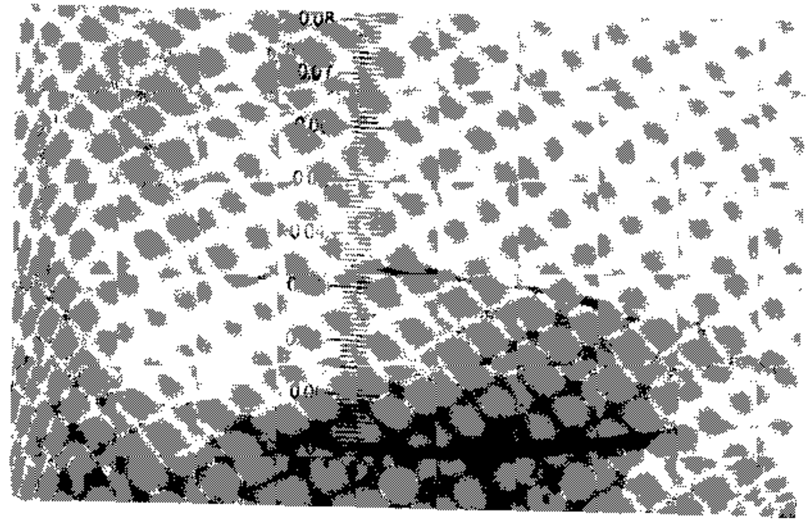

Figure 4. Photomicrograph of reed canarygrass showing width measurement in thousandths of an inch.

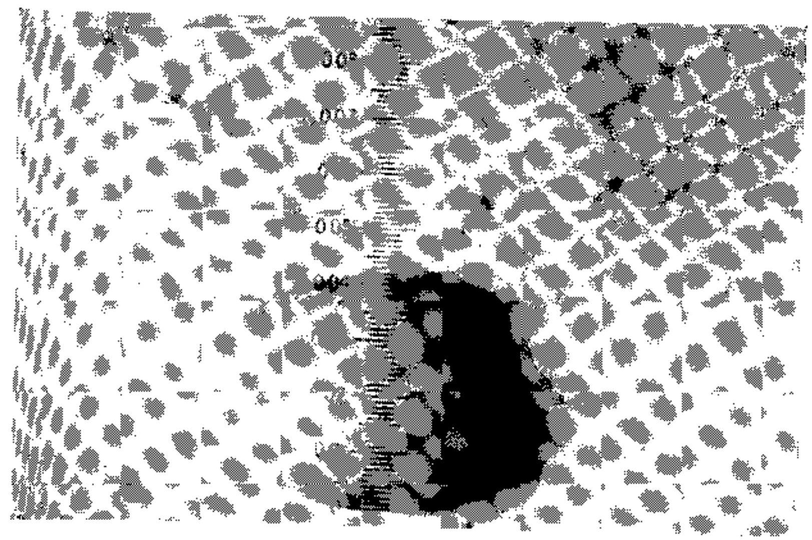

Figure 5. Photomicrograph of white clover showing width measurement in thousandths of an inch.

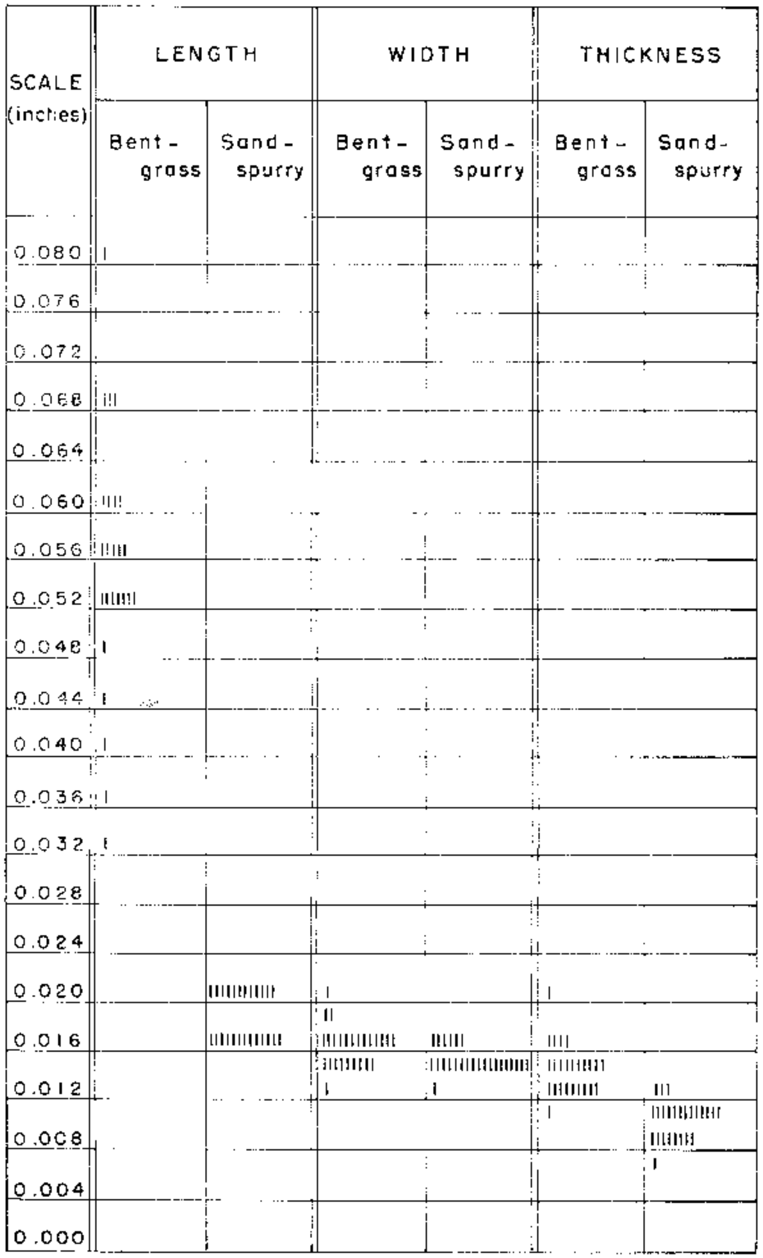

Figure 6. Dimension distributions for Penncross bentgrass and red sandspurry.

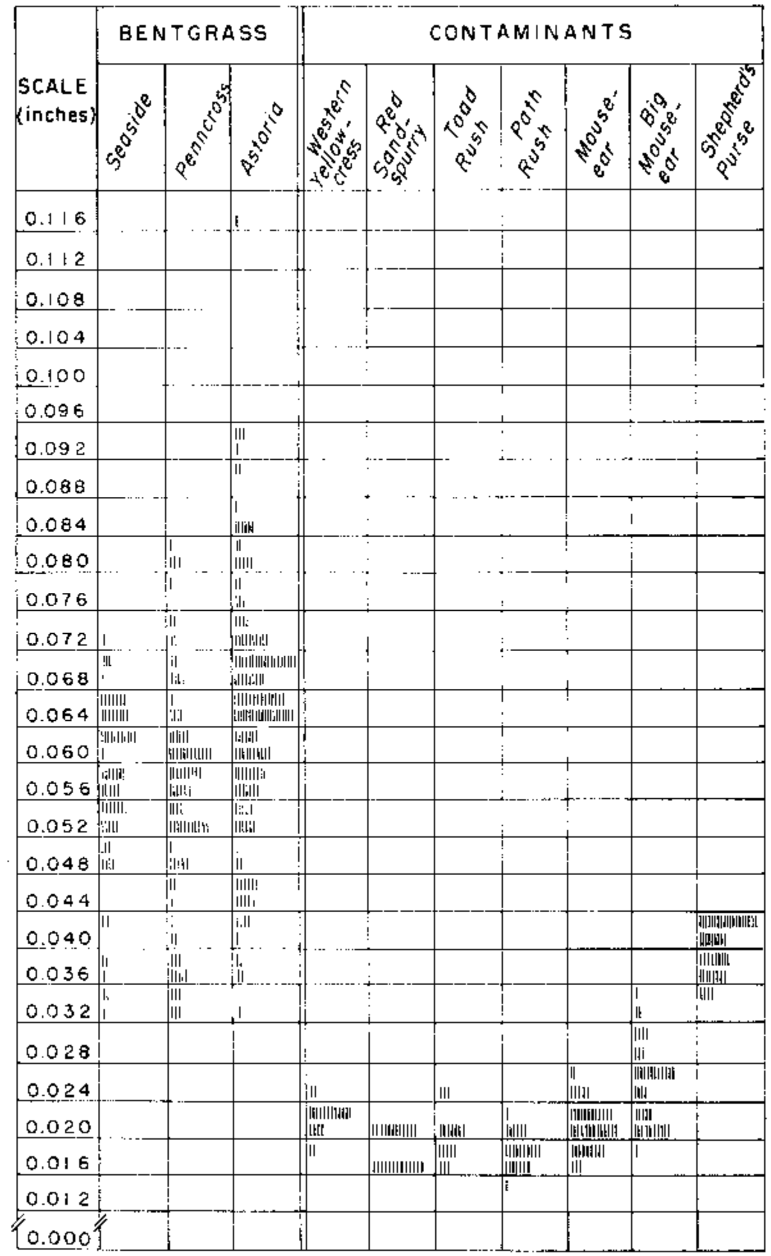

Figure 7. Length measurements of bentgrass and contaminants.

"bentgrass cylinder" should contain indents 0.032 inch in diameter and about 0.012 inch deep. Another contaminant shown (shepherd's purse) can be removed if the indent diameter is increased to 0.044 inch. However, sonic short bentgrass also will be removed in the process.

Summary of alfalfa-pigweed measurements

The removal of pigweed from alfalfa poses another challenging problem. It is significant that even in sonic discard fractions from conventional length separators there is still a small but definite length difference between crop and contaminant that can be exploited. The discard fractions usually contain much alfalfa because the ordinary indents are so deep that short alfalfa is lifted along with the pigweed.

A compilation of seed measurements from six alfalfa-pigweed mixtures is shown in Figure 8. These dimensions are typical for alfalfa mixtures from Oregon, California, and Idaho, measured throughout a six-year span. It is readily apparent that width distributions are very similar and so are thickness distributions. Lengths, however, show differences even though the distributions overlap. it appears that an indent 0.064 inch in diameter will accept nearly all of the pigweed and only a few of the shortest alfalfa. In practice, a smaller indent can be used because the pigweed characteristically has a ledge that helps the seed to scat in a smaller hole.

Nominal depth of the indent should be 0.022 inch to pick up most of the pigweed, but the "ledge" effect again acts to reduce the size requirement. When actual seed measurements are modified slightly because of the pigweed shape, the optimum indent size becomes 0.062 inch diameter and 0.019 inch depth. The No. 4 commercial indent generally used for pigweed removal is hemispherical in shape and has an average top diameter of 0.063 inch and a depth of 0.044 inch. Although this indent lifts pigweed readily, it also can lift alfalfa seeds up to 0.088 inch long when they enter the indent lengthwise and their centers of gravity are inside the lifting edge. Actually, even longer seeds can be lifted in some cases. (If an alfalfa seed enters the indent lengthwise, and its width is slightly less than the indent diameter, the seed may wedge momentarily as it tries to tip out of the indent and then be discharged later along with lifted pigweed.)

Such an action may explain the presence of long alfalfa seeds in the lots of Figure 8. For the most part, these lots represent material lifted in No. 4 commercial indents and discarded. Since lengths prohibited the alfalfa seeds from entering the indents crosswise, they must have entered lengthwise. The optimum indent defined earlier (0.062 inch x 0.019 inch) is less than half as deep as the No. 4 indent and tends to reject the alfalfa. This makes possible a more precise distinction between alfalfa and pigweed.

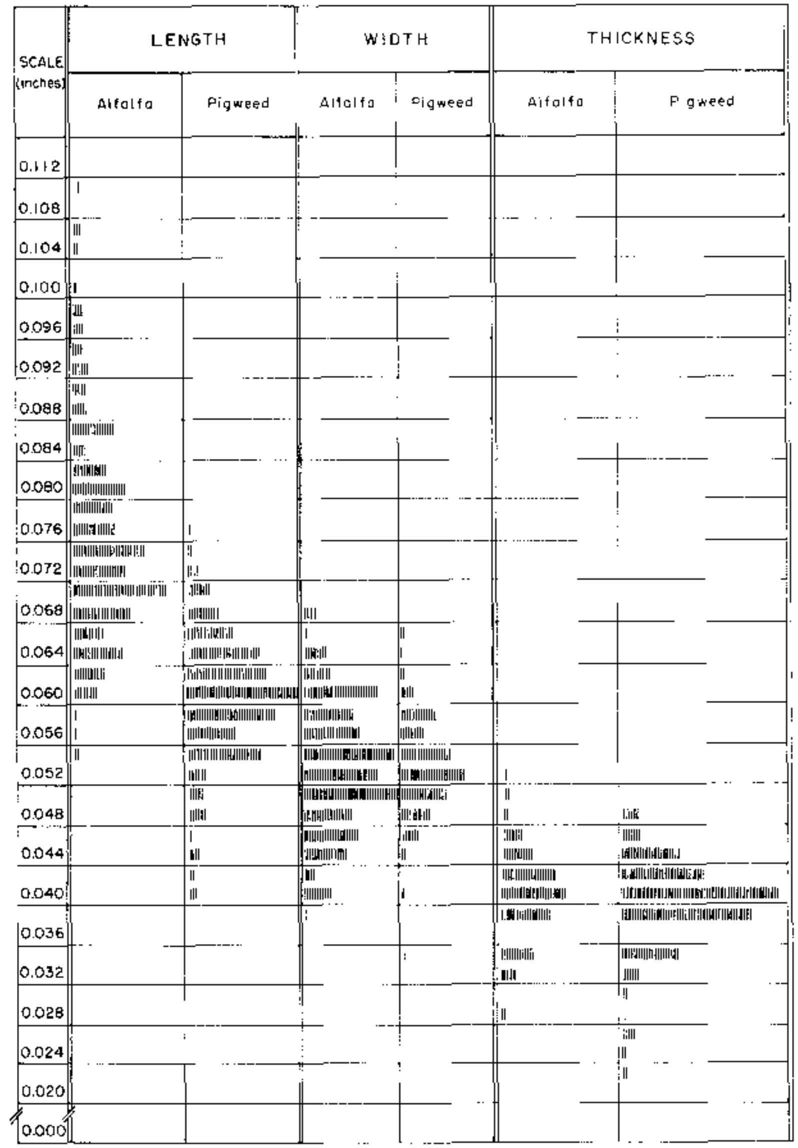

Figure 8. Dimension distributions for alfalfa and pigweed.

Design and Construction of Indent Cylinders

Different techniques of fabricating special indent cylinders were investigated to determine methods of producing the size and shape of holes desired and ways of backing up the holes.

Cylinder sizes

Most of the experimental construction was in the form of short cylinders (4-inch length x 12-inch diameter) which fit a laboratory separator (Figure 9). In addition, some 30 inserts were made which can be fitted into a blank cylinder of the laboratory separator for preliminary indications. Bigger cylinders (15-inch length x 17-inch diameter) were built to permit larger scale trials (Figure 10). These cylinders have the same diameter as some commercial units.

Indent sizes

Holes or indents of various required sizes were obtained by selecting perforated round-hole screen of the desired hole diameter and metal thickness, by drilling holes through metal sheets, and by pressing or drilling holes to a specified depth in metal blanks.

Backing methods

Effective backing of perforated metal screen is important in the fabrication of special cylinders. If this is not done properly, holes Of variable depth will result, or clearances will occur between backing material and screen (where awns or other parts of seed can adhere). Different methods explored for attaching backing plates were spot welding, riveting, sweat soldering, spot soldering, epoxy cementing, differential curving, and use of a solvent-treated fabric that hardens and bonds to the screen. "Differential curving" consists of carefully sizing a hacking plate so that when rolled it uniformly contacts and backs up the rolled screen cylinder. Plate and screen are spot welded only at the joint, and a close fit is obtained elsewhere by mechanical contact.

Of the several backing methods tried, best results were found with spot welding, differential curving, and the special fabric.

Indent shape

Most of the indents had perpendicular sides because of the perforated round-hole screen used in their construction. This type of indent performed very well in removing many contaminants from different crop seeds. However, seed from some lots tended to lodge in the indents, reducing capacity and making it difficult to clean the separator between runs. To alleviate plugging, hemispherical and tapered indents were explored since their sides provide a relieving condition and re-

Figure 9. USDA Seed Processing Laboratory. The table in the foreground shows experimental length separators and cylinder inserts.

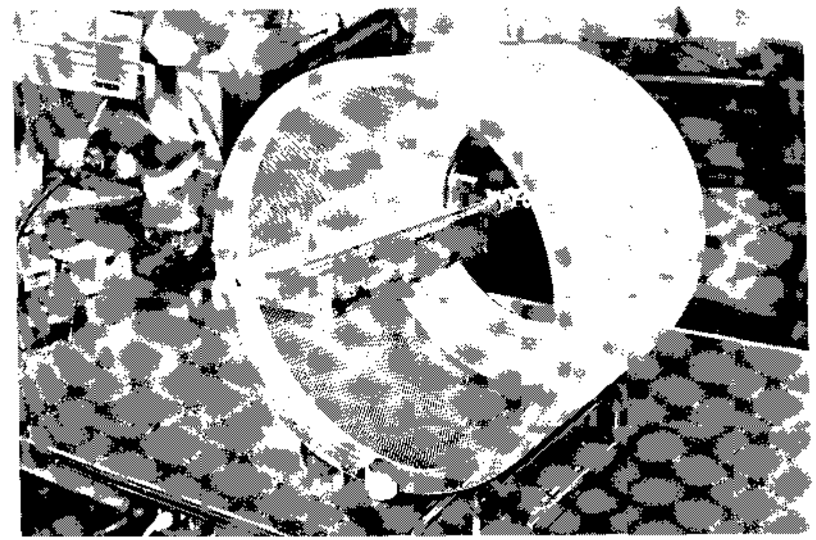

Figure 10. Large-scale experimental indent cylinder (15-inch length and 17-inch diameter).

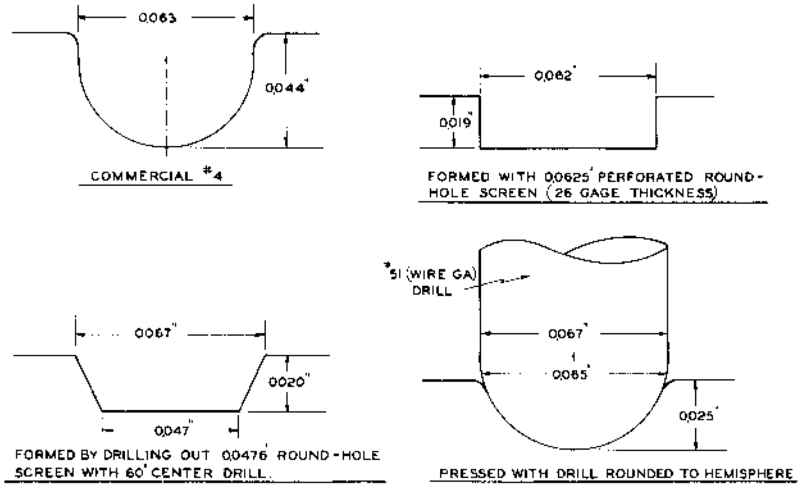

Figure 11. Indents used for removing pigweed from alfalfa.

duce the tendency for seeds to lodge. Several indent shapes are illustrated in Figure 11.

Hemispherical indents were formed in lead sheet 1/16 inch thick, using the rounded shank end of a drill as a punch. Diameters and depths of indents were controlled by the drill shank diameter, amount of rounding, and degree of penetration.

Tapered indents were produced by drilling out 1/21 round-hole screen with a 60° center drill, or by pressing a specially ground indent tool into sheet lead. For a seed shaped like alfalfa, it can be shown mathematically that a condition providing relief and nonplugging requires an indent cross section whose side departs from the vertical at a 15° angle. In practice, an angle near 19° produced better results with alfalfa. Generally, the tapered indents showed little or no tendency to plug hut were less effective than the hemispherical shape in removing pigweed.

Laboratory Trials and Results

After various indent cylinders were constructed according to specific seed measurements, they were tested with the seed lots that prompted their design. The main purpose of actual trials was to experimentally verify the theoretical predictions stemming from analysis of the seed measurement data. When test results correlated well with predictions, the particular indent design was recommended to interested processors.

Limitations

Certain limitations in the test procedure should be considered in evaluating a given indent's performance. First, the laboratory operation was "batch," whereas all full-scale operations are continuous. Second, the laboratory cylinders are either 4 inches or 13 inches long, compared to about 96 inches for full-size units. This causes undesirable edge effects to be much greater proportionately in the small cylinders. Other factors present in the laboratory trials were representativeness of the seed sample measured, static electricity generation, cracks around the cylinder inserts, and random bounce-out of seed; all of these influence the purity of lifted and rejected fractions.

In view of these limitations, the test results are not necessarily typical of full-scale operation with the same indent design. However, the results do indicate what can be expected generally.

Tests of perpendicular-side indents

Some of the data obtained with experimental indents having perpendicular sides are shown in Table 1. As indicated, many different seed types can be separated effectively when there is a length difference to be exploited.

Indent plugging

Occasional plugging of indents was noted in alfalfa-pigweed trials where seeds (mainly short alfalfa) lodged firmly in the indents and could not be tapped out. The plugging tendency was studied in greater detail with larger cylinders (15-inch length by 17-inch diameter) and seed lots from full-scale length separators. Some lots were reject fractions that contained many short alfalfa seeds and had pigweed concentrations as great as 65%, based on original weight. Other lots were "clean" fractions made up of long alfalfa seeds and having pigweed content below 5%. Various diameters and depths of indents with perpendicular sides performed about the same; plugging was excessive with reject fractions but practically nonexistent with clean fractions. Some cylinders were sandblasted and shot blasted to round the indent edges slightly, but this did not reduce plugging appreciably. Attempts to remove potential "pluggers" by preliminary screening also were unsuccessful.

Tests of hemispherical indents

At this point, trials were made with the hemispherical indent described earlier. The test lot was one of the same alfalfa-pigweed mixtures which had plugged indents excessively in earlier trials. Pigweed content was about 10% and seed length measurements overlapped, identifying this as a difficult separation problem. Results from the

Table 1. SEPARATION TESTS WITH PERPENDICULAR-SIDE INDENTS

Sample No.	Crop	Contaminant	Indent (inch)		Results		
			Diam.	Depth	Contaminant[1] Initial	Contaminant[1] Final	Clean seed yield (percent by weight)
178	Merion bluegrass	Dogfennel	0.075	0.030	20.4%	1.1%	75.6
210	Merion bluegrass	Sheep sorrel	0.052	0.025			
233	Penncross bentgrass	Mouse-ear	0.032	0.013		3,600/lb.	93.0
205	Penncross bentgrass	Red sandspurry	0.027	0.012			
242	Astoria bentgrass	Big mouse-ear	0.032	0.013			
88	Seaside bentgrass	Western yellow cress	0.041	0.016			
181	White clover	Catchfly	0.049	0.025	14.0%	2.5%	70.0
264	White clover	Canarygrass	0.059	0.019		0	99.5
201	Red clover	Buckhorn plantain	0.075	0.030		1.4%	94.3
228	Lespedeza	Foxtail	0.094	0.025		0	75.0
213	Barley	Wild oats	0.450	0.109			
	Cotton	Cocklebur	0.450	0.110			
180	Alfalfa	Johnson grass	0.116	0.037		0.5%	89.0
71	Alfalfa	Pigweed	0.062	0.019	19.5%	0.3%	68.8
128	Alfalfa	Pigweed	0.062	0.019	1.2%	185/lb.	98.5
281	Alfalfa	Pigweed	0.062	0.019		200/lb.	73.0

[1] Expressed either in percent by weight or number of seeds per pound of mixture.

Table 2. SEPARATION TESTS WITH HEMISPHERICAL INDENTS (Alfalfa-pigweed mixture)

Diameter	Depth	Length of run	Yield fraction: Percent by weight	Yield fraction: Pigweed per pound	Plugging tendency
inch	*inch*	*minutes*			
0.063	0.033	50	39	465	Severe
0.062	0.027	20	42	2,870	Severe
0.061	0.025	20	60	9,135	Small
0.061	0.025	40	60	7,960	None
0.065	0.025	20	67	8,880	Small
0.065	0.025	40	48	945	Small

hemispherical indent test appear in Table 2. As might be expected, the greatest yields are associated with high pigweed counts and low plugging tendency.

The indent that best meets the dual requirements of good pigweed removal and low plugging has a maximum diameter of 0.065 inch and a depth of 0.025 inch. This indent produced a yield fraction of 48%; this seems low but is reasonable in view of the overlap in length dimensions of alfalfa and pigweed. Actually, the measurement data for this mixture indicate that about half the alfalfa seeds (short ones) will be lifted in the process of lifting and removing nearly all of the pigweed.

The pigweed content of the 48% yield fraction was 945 per pound, which is less than 0.25% by weight. This is a substantial reduction in pigweed from the initial 10(4 figure. Also, the final product is acceptable, particularly if blended with other cleaner seed.

It should he pointed out that "Length of run" in Table 2 is not meaningful except in comparing different indents of this series. A long time was needed in these trials because the indents tested were small inserts fitted into a blank cylinder of the laboratory separator. Also, capacities were low because the test lots were recognized problem mixtures and separation attempts were aimed at complete removal of contaminants.

Results of Recommendations to Processors

Analyses of seed measurements and separating trials have formed the basis for indent recommendations to many seed processors. Seed types studied ranged in size from bentgrass (10,000,000 seeds per pound) to cottonseed (5,000 seeds per pound).

In a few cases, processors have constructed complete length separators incorporating special indent design and use of perforated metal with a backing plate. Figure 12 shows a farm-built unit of this type. However, in most cases, the processors have inserted specially made cylinders in their commercial indent separators.

Complete length separator construction

The separator in Figure 12 was built to remove western yellow cress from Seaside bentgrass. The indents were formed by using 1/22 round-hole perforated steel sheet of 28 gage (U. S. Standard) thickness spot soldered to a backing plate. Typical operating data for this machine were : (1) capacity, 100 pounds per hour; (2) lot shrinkage, 3%; (3) total season throughput, 20,000 pounds; (4) initial weed content, 2.8(4' ; and (5) final weed content, less than 0.50 %.

Special cylinder constructions for bentgrass

Another processor had a cylinder constructed for his commercial separator to remove red sandspurry from Penncross bentgrass. Here, we recommended an indent 0.027 inch in diameter and 0.010 inch deep, which was provided by spot welding special perforated metal to a backing plate. With a 2,500-pound lot, capacity was 30 pounds per hour and total shrinkage was 50 pounds in producing a certifiable product with less than 0.20% weed seed.

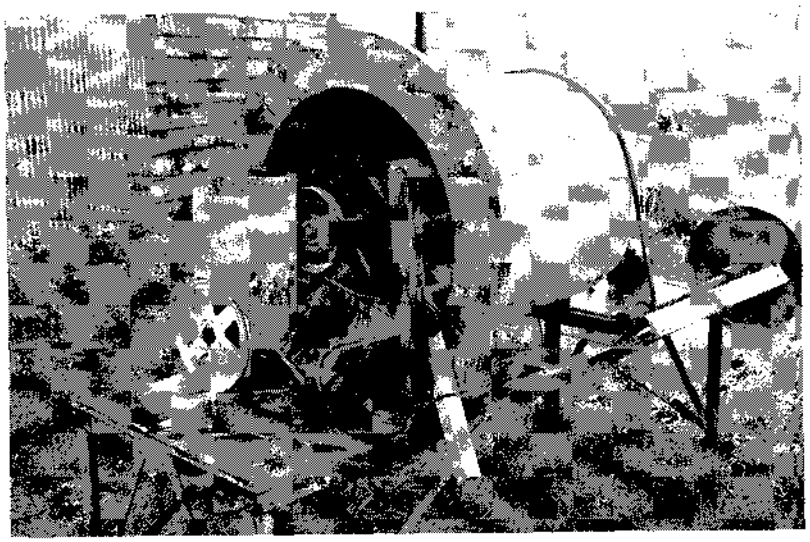

Figure 12. Farm built indent cylinder separator.

A third bentgrass processor needed to remove big mouse-ear from Astoria bentgrass. The recommended indent was produced by using perforated metal (1/25 round-hole x 24 gage), again spot welded to a backing plate. With this cylinder in his commercial machine, the processor reported that the mouse-ear was reduced from 8,500 seeds per pound to less than 700 with very little loss of bentgrass.

Operating technique with bentgrass

In each of these full-scale operations, it was relatively easy to flood the machine—letting some contaminant remain in the clean fraction rather than being lifted out by the indents. Small seeds flood a cylinder easily because of the large number of them required to form the size mass necessary for good action in the cylinder. With so many seeds in the cylinder at one time, some fail to contact an indent where they can be rejected or lifted.

Another important factor in processing small seeds such as bentgrass is cylinder speed. Tests have shown that slow speeds must be used to permit small seeds to nest in the indents. Best results were obtained with a peripheral speed of 30 feet per minute, which is equivalent to five revolutions per minute in a cylinder of 23-inch diameter.

In analyzing seeds run through special cylinders in commercial plants, measurements verified that contaminants remaining in the final product were short enough to be lifted. To improve separating performance in these cases, the feed rate should be reduced, the lot rerun, or both feed rate and cylinder speed decreased.

Special cylinder construction for alfalfa

A special indent cylinder was constructed to remove pigweed from alfalfa. This cylinder employed perforated metal (1/16 round-hole and 26 gage thickness) backed with a sheet metal plate in a form of the differential curving process described earlier. A machinery manufacturer fabricated the cylinder to be inserted as a liner in existing length separators.

In commercial operation, the cylinder did an excellent job of removing pigweed, but short alfalfa tended to lodge crosswise in the indents, gradually reducing capacity. These findings are similar to the laboratory results. When this type of cylinder is used, it will require frequent cleaning, especially when attempting to salvage short alfalfa in lifted material from the No. 4 commercial cylinder. However, when lifting remaining pigweed from the long, rejected fraction, there should be little or no lodging.

Conclusions

Based on seed measurements and test processing of selected seed mixtures with special and commercial indent cylinders, the following conclusions may be drawn :

1. Commercial indent cylinders are suitable for processing many . mixtures, but unsuitable for others because indent sizes are limited. This limitation has been illustrated many times by use of problem mixtures ; conventional cylinders cannot separate these mixtures, but specially designed cylinders can.
2. Actual seed measurements show that many seed lots not now separated by conventional means have components of different length which could be separated with indents of the correct diameter and depth.
3. Special cylinders with indents designed according to seed measurements do a very selective job of separating one component of a mixture from another.
4. A cylinder with indents much smaller than those usually available can be specified to remove many contaminants from several varieties of bentgrass. Indents in this "bentgrass cylinder" have a diameter of 0.032 inch, a depth of 0.012 inch, and perpendicular sides.
5. A cylinder with indents shallower than those previously available can be specified to remove pigweed from alfalfa. These indents are 0.062 itch in diameter, 0.019 inch deep, and have perpendicular sides.
6. The 0.062 inch x 0.019 inch indent does an excellent job of removing pigweed from alfalfa, but short alfalfa seeds from some lots tend to plug the indents, which then require frequent cleaning.
7. Another special indent that removes pigweed from alfalfa effectively with very little plugging is hemispherical, with a maximum diameter of 0.065 inch and a depth of 0.025 inch.
8. Experimental results and performance data from processors indicate that a greater size selection in commercial indents and special indent construction, where warranted, are feasible means of increasing efficiency in precise length separation of seed.