SOME SCREW CONVEYOR PARAMETERS THAT AFFECT CAPACITY AND SEED DAMAGE

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PREFACE

The work reported in this thesis was performed in conjunction with a cooperative castor bean mechanization project between the Oklahoma Agricultural Experiment Station and the United States Department of Agriculture.

The main objective of this project is to develop and improve equipment, methods, and techniques for harvesting, handling, hulling, and processing the castor bean crop. This investigation was made to obtain useful information applicable to the design of entrance sections for screw conveyors to convey hulled castor seed.

The author is grateful for the counsel and encouragement given during this study by the thesis advisor, Professor Jay G. Porterfield.

Appreciation is also expressed to Mr. L. G. Schoenleber, Head, Special Crops Harvesting and Processing Section, Agricultural Engineering Research Division, United States Department of Agriculture for his valuable suggestions and for providing the facilities necessary to carry out the study.

Appreciation is also expressed to Mr. N. R. Cole, Senior General Mechanic, and Mr. J. L. McMasters, former Student Assistant, United States Department of Agriculture, for their assistance in performing the tests conducted in this study.

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CHAPTER I

INTRODUCTION

Domestic castor bean production was given a greatly enhanced future in 1955 with the development of a mechanical harvester that gathered and hulled the seed in one operation. With the advent of the successful harvester, castor bean acreage in the United States increased from less than 5,000 acres in 1956 to approximately 28,000 acres in 1961.

Castor bean varieties which are high yielding and well suited for mechanical harvesting have recently been developed and have found favor with farmers in the irrigated areas of the Southwest. When harvesting, hulling, cleaning, and handling these varieties with machines some of the seed is damaged. This damaged material adheres to the surfaces it comes in contact with and coats them with oil. These oily surfaces collect dirt, pieces of broken seed coat, and other foreign materials which build up in critical areas, hampering conveying action.

One of the most popular types of conveyors for hulled castor seed, both on experimental and commercial harvesters and at commercial buying and loadout stations, has been the bucket elevator. Bucket elevators, if loaded and discharged properly, cause a minimum of seed damage but have been found to be extremely susceptible to the build-up problem. For this reason, a different type of vertical elevator is in demand.

Screw conveyors or "augers" have been used for many years for handling many different types of material. These conveyors have often been used in the vertical position for elevating. There are several reasons for attempting to adapt them for use in elevating hulled castor seed. They are simple in construction and operation, relatively inexpensive, and require a minimum of space since there is no idle return as with flight, bucket, or belt conveyors.

Screw conveyors have been found to cause little damage to castor seed when operating on a 45 degree incline, provided either 1/8 inch or less, or 3/8 inch or greater clearances between the auger and the housing are used. (3)*. Experience in handling oily, hulled castor seed with vertical screw conveyors has shown that the larger clearances allow the oily material to build up on the inside of the housing; however, little or no seed damage occurs. It has also shown that small clearances (1/8 inch or less) do not allow build-up to occur on the housing, but that seed damage occurs due to the shearing action at the entrance section. This shearing action, which is not present on inclines unless the screw is operating completely full, crushes the seed and adds to the oiliness problem.

Information is needed to design the entrance sections for close-fitting vertical screw conveyors for hulled castor seed. This study was intended to investigate various shapes of entrance sections with respect to the orientation of the shearing plane and its effect on seed damage. Also, other factors which could influence the performance of such an elevator for hulled castor seed were investigated.

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*Numbers in parenthesis refer to the number in the Bibliography.

CHAPTER II

OBJECTIVES AND HYPOTHESES

OBJECTIVES:

A. Determine the effect of auger speed and entrance opening height, both on the capacity of a close-clearance vertical screw conveyor and on the percent of castor seed damaged.

B. Determine the effect of the housing-screw shear-plane orientation on the percent of castor seed damaged and on the capacity of the same type of conveyor.

HYPOTHESES:

A. As auger speed was increased for each entrance opening height, the capacity of the conveyor was expected to increase up to a limit in the vicinity of 800 to 1000 RPM. A peak in capacity was expected at this speed. A decrease in rate beyond this speed was expected due to the centrifugal force of the material being thrown outward from the screw.

The percent of seed damage was expected to increase with auger speed, mainly because of a decline in the percent fill of the tube which should logically expose a greater percentage of the seed to the shearing edge. This was based on the assumption that an increase in speed would cause a greater percentage of the seed to be conveyed near the perimeter of the tube.

As the entrance opening height was increased, the capacity was expected to increase for each auger speed until a rate was reached whereby the speed of the auger would be the limiting factor.

An increase in opening height for a given speed was expected to increase the percent fill of the tube and thus reduce the percent of seed damage.

B. As the housing shearing edge inclination was adjusted in a manner to reduce the angle between it and the direction of travel of the seed at the periphery of the screw, the percent of seed damage was expected to be reduced. This seemed logical since the seed should have more opportunity to slide along the shearing edge to a point where a minimum amount of seed would be exposed to shearing.

CHAPTER III

REVIEW OF LITERATURE

Castor Beans

Seed of the castor bean plant is the source of castor oil. Industrial demand for castor oil in the U. S. has risen steadily since World War II although the domestic production of castor beans was economically unattractive after the war and production declined. In recent years, however, complete mechanization, improved varieties, and an increase in irrigation have combined to revive interest in the crop. In 1958 domestic production from about 24,000 acres produced approximately 20 percent of the castor oil used in this country. The remainder was imported. (1).

The principle use of castor oil in the U. S. is in the production of a fast-drying oil which is used in the manufacture of paints and varnishes. It is also used to produce sebacic acid for plastics manufacture. Other uses are in the manufacture of all-purpose greases, hydraulic fluids, artificial leathers, printing inks, cosmetics, and dyes. In addition, a small amount is used for medicinal purposes. (1).

Castor seeds may vary greatly in size depending on the variety and environment in which they are grown. Seeds of current commercial varieties range from about 1400 to 1800 per pound and have an average test weight of approximately 30-32 pounds per cubic foot. The seed shape may vary from obovoid to oblong to almost round. (2). Coppock (3) measured 50 seeds of a commercially produced variety and reported the mean dimensions in 64th's of an inch as: length, 30.40; width, 19.48; and thickness, 14.88. The oil-bearing kernel of the seed is protected by a brittle seed coat which is easily broken. The seed coat makes up about 25 percent of the weight of the seed of current commercial varieties. The seed, depending on variety and environment, contains 40 to 57 percent oil. (2).

Screw Conveyor History and Development

The Cochleon or Archimedian Screw is the progenitor of the present screw conveyor. Archimedes (287-212 B.C.) is generally given credit for its invention. It was first mentioned in early literature by Marcus Pollio Vitruvius in 16 B.C. (4). Early sketches, which have been passed down from Archimedes time, show that the general principles of screw conveyors were understood even then. Early screw conveyors consisted of wooden pegs driven into holes arranged spirally about a wooden shaft.

The screw conveyor came into quite general use about the middle of the Nineteenth Century. (5). It has taken about 100 years for it to come from the first crude form to its present use in farm machinery. In 1874, Mr. H. W. Caldwell undertook the improvement of sectional flight conveyors, which were then made of cast iron, hammered tin, or crude iron flights mounted on wooden or solid steel shafts. In 1898 he patented the "helicoid" or continuous-flight type conveyor. The helicoid flighting is manufactured by feeding a steel coil strip of required gage and width into a specially designed rolling mill. The resultant product is a continuous helicoid flight of a desired diameter and pitch with a center hole for mounting on a tube, pipe, or shaft. (6).

Screw Conveyor Application and Design

Essentially, a screw conveyor consists of a helical steel ribbon which encircles a central shaft and is encased in a cylindrical or semi-circular casing. The main advantages of screw conveyors are that they are low in first cost, require little space, and are simple in construction. The main disadvantages are that the power consumption is high, they are limited to conveying small-sized materials for relatively short distances, and wear is rapid, especially when handling abrasive materials. (7).

Because of their flexibility of application, screw conveyors are used to handle a wide variety of small materials. Within certain limits, practically any powdery or granular material, as well as certain pasty materials, can be handled. With suitable modifications in design, such conveyors are capable of operating, not only horizontally and at small inclines, but also at any angle up to and including vertical. (8).

The two basic types of screw conveyors presently in use are the helicoid and sectional-flight conveyors. The helicoid flight has previously been described. Sectional-flight screw conveyors are made in individual flights from flat steel sheets. The individual flights or sections are riveted together and fastened to a shaft or pipe. Both helicoid and sectional-flight-type conveyors are made in a wide range of diameters, pitches, and gauges. (6).

American practice adopts a standard ratio of pitch to diameter of one. The shorter the pitch the faster a screw must turn for a given capacity, but the steeper the slope up which the material can be conveyed. According to Atherton (9), screws with one-half pitch are used for inclines over 20 degrees. Long pitch conveyors are used most frequently for vertical screw agitators for fluid materials or for high capacity conveying of very free flowing materials.

Screw conveyors may form either right or left hand spirals. The "hand" of a screw can be determined by looking at it from either end. If the spiral curves up around the center shaft towards the left, it is left hand; if it curves up towards the right, it is right hand. (10).

Screw conveyors are not sensitive to intake or discharge methods. They may be gravity fed, or a portion of the screw may be operated under a head of material in a hopper. Screw feeders often have double or triple flighting to provide a steady flow. Discharge may be from the end or bottom of a horizontal trough or from the end or side of an inclined or vertical tube. Discharge may occur at one or more openings by either gravity or force. (11).

The most important factor governing the selection of a screw conveyor is knowledge of the physical characteristics of the material to be conveyed. The more important properties of materials are lump size, abrasive qualities, and flowability. Some materials may pack under pressure or may be hygroscopic, thus requiring more power to convey. Sticky materials and those with a high angle of repose also have high power requirements. (12).

In addition to material properties, the power requirement of a screw conveyor is a function of conveyor length and elevation, type of flights, and type of bearings. According to Henderson and Perry (13), the following formula gives an approximation of the horsepower required for normal horizontal operation.

$$\text{Horsepower} = \frac{CLWF}{33,000}$$

Where:

C = Capacity, in cubic feet per minute

L = Length of conveyor, in feet

W = Weight of bulk material, in pounds per cubic foot

F = Material factor (0.5 for castor beans) .

If the horsepower is less than 1, multiply by 2; if it is between 1 and 2, multiply by 1.5; if it is between 2 and 4, multiply by 1.25; and if it is between 4 and 5, multiply by 1.1. No correction is needed if the horsepower is more than 5.

The theoretical capacity of a screw conveyor is estimated by Henderson and Perry (13) with the following formula:

Theoretical Capacity, cubic feet per hour =

$$\frac{(D^2 - d^2)}{36.6} \times P \times RPM$$

Where:

D = Pitch diameter of screw, in inches

d = Diameter of shaft, in inches

P = Pitch of screw, in inches

RPM = Speed of screw, in revolutions per minute .

The actual capacity of the conveyor is much less because of the screw-to-housing clearance, fluid characteristics of the material, screw length, head of material, and elevation or lift.

Screw conveyor capacity decreases rapidly as angle of inclination increases. According to Hudson (14), a standard pitch screw in an open trough has 70 percent of its horizontal capacity if inclined 15 degrees and only 40 percent when inclined 25 degrees. With a jam feed and 45 degree incline, a conveyor in a tube has about 50 percent of horizontal capacity. At angles greater than 25 degrees, a tubular casing or shrouded "U"-shaped trough should be used. High speeds and shorter-than-standard pitch flights also become more important as the angle of inclination increases above the horizontal.

Vertical lifts can be made with screw conveyors to a practical height of about 50 feet. An estimate of the horsepower needed for vertical conveying is given by the following formula:

$$\text{Horsepower} = \frac{7QLF}{1,000,000} + C$$

Where:

Q = Maximum capacity, in pounds per hour

L = Height, in feet

F = Material factor (0.5 for castor beans)

C = Factor for type of elevator (1.0 for gravity feed). (12).

This formula does not include sufficient power to overcome drive losses or power required to start under full load.

Coppock (3) made a screw conveyor study to determine the effect of auger speed and flight-to-housing clearance on percent broken beans and horsepower requirement for a 45 degree inclined, 6 inch diameter, screw conveyor for hulled castor beans. He determined that one-half inch clearance and zero clearance damaged less beans than one-fourth inch clearance, and that a close relationship exists between the clearance which damaged the most beans and the smallest physical dimension of the beans. Within the range of the test (200 to 500 RPM), there was no indication that speed was a major factor in the number of beans broken.

He found that a close relationship existed between the area-arc ratio and the percent broken beans when the conveyor was tested at one-fourth inch clearance. The horsepower required for conveying varied from 0.13 to 0.31 and was highest at one-fourth inch where the most beans were damaged.

Regan (15) investigated the performance of screw conveyors at inclines from 0 to 84 degrees and speeds from 80 to 750 RPM using field run barley as the test material. He concluded that the speed of the auger and the angle of inclination determine the capacity of an auger for a given material. Capacity at horizontal was approximately three times greater than the capacity at 84 degrees. Terminal capacity was reached at 800 to 1000 RPM. Regan also found that the axial force on an auger is determined by the coefficient of friction of the material being conveyed, the axial component of the weight of the material, and the pressure of the bulk material on the entrance. Both the axial thrust and the torque required to turn the screw were found to vary with screw speed and angle. The frictional forces within the auger were difficult to determine accurately because the grain varied between a rolling and a sliding condition, but they seemed to decrease with an increase in speed in the range of 150 to 500 RPM.

Rehkugler (16) made tests aimed at discovering the effect of material, auger speed, angle, pitch, and diameter on the performance of an auger conveyor. The three characteristic materials which were used were wheat, oats, and corn meal. The tests were made with four inch and six inch augers of various lengths operating in cylindrical housings. The optimum range of auger speeds was found to be from 450 to 600 RPM. This range gave reasonable efficiencies, capacities, and power requirements.

An increase in auger speed increased capacity to a certain point at which the centrifugal effect of the flights on the material threw the material out of the intake opening, and the centrifugal action within the tube caused rotation of the material so that no further increase was noted. The centrifugal effect of the flighting was found to be smaller when conveying material with a greater internal friction.

Auger angle was found by Rehkugler (16) to effect capacity as follows:

$$\text{Capacity} = A + B \cos (\theta + 90)^\circ$$

Where:

A = Capacity at horizontal

B = Difference between horizontal and vertical capacities

θ = Angle of auger with horizontal .

For a given angle, conveyor, and material, the horsepower varied nearly linearly with auger speed. The length of the auger did not affect the amount of power required per foot of auger or the capacity of the auger.

Rehkugler makes the following statement concerning the flow path of the material and the percent fill of the auger tube.

> For the inclined and vertical auger conveyors an absolute axial path of material is not obtained. The material path through an inclined auger conveyor was observed by means of a clear plastic section installed between two sections of galvanized auger tubing. It was definitely established that material filled the tube completely regardless of auger speed and angle. The material in the tube moved along a helical path of opposite hand as that of the auger flighting. The material path direction was nearly perpendicular to the auger flighting surface. As a result of this phenomena the inclined and vertical auger conveyor does not convey the theoretical capacity of the conveyor.

Ross and Isaacs (17) formed a theoretical approach to predict the capacity of enclosed screw conveyors operating completely full of granular particles at any angle of elevation. Basic assumptions for their study were that all the particles conveyed in an enclosed screw move in the same direction and at a constant velocity. Parameters used in the prediction equation developed by Ross and Isaacs (17) included the weight and characteristic diameters of the particles conveyed, the angle at which the forces are transmitted in a particle stack, the direction in which particles move in a screw conveyor, the angle of elevation, the radius of the conveyor tube, the radius of the center shaft, the screw pitch length, the screw speed, and the coefficient of friction between the grain and the conveyor surfaces. Relatively large differences between experimentally determined and predicted values of capacity, for a 4-inch diameter screw operating at speeds above 600 RPM and for a 6-inch diameter screw operating vertically, were due to the screw not filling completely with grain. Ross and Isaacs (17) felt that if more helix could have been exposed at the entrance better agreement would have been obtained for the 6-inch diameter screw operating vertically. If such is the case, it would seem that the length of exposed helix should have been included in the prediction equation.

Observation of a conveyor with a transparent housing showed Ross and Isaacs (17) that the screw will not fill completely with grain when operating vertically. This seems to be in disagreement with the statement by Rehkugler (16) concerning this question. A test by Ross and Isaacs to determine the effect of length of exposed helix on the capacity of a 4-inch diameter screw showed that the capacity was still increasing slightly even after the length of exposure was increased to 25 inches.

Rehkugler and Boyd (18) used dimensional analysis and data from studies by Rehkugler (16) to develop prediction equations for volumetric capacity and torque for screw conveyors conveying wheat and oats. The prediction equations for volumetric capacity included angle of elevation, auger diameter, intake length, auger pitch, auger speed, and the gravitational constant as pertinent quantities while the equations for torque included these same quantities plus material density and conveyor length. Rehkugler and Boyd (18) state that a limited number of random checks indicated a maximum error of 10 percent in using the equations. No provision was made for different radial clearances between the periphery of the flighting and the inside of the housing or for different auger shaft diameters. The authors point out, however, that with additional experimentation other variables could be included in their equations.

Roberts and Willis (19) made a study of auger performance characteristics using a small scale model auger. The relationship of output and efficiency to speed, auger diameter, angle of elevation, intake length, and housing clearance was studied while conveying millet. Prediction equations and design charts for predicting output and efficiency when conveying wheat were developed using dimensional analysis. These equations contain several constants which were obtained from experimental data and, therefore, apply only to augers of the same geometrical proportions as the model. A choke length correction factor, to compensate for different ratios of intake opening to auger pitch length, was included for angles of elevation ranging from 30 to 90 degrees. The authors point out that their data applies mainly to granular materials with physical properties similar to wheat and that while the predicted performance data showed good agreement with actual performance data, further verification is necessary, particularly with large augers.

Roberts and Willis used clear plastic housings to observe the grain motion through the auger and make measurements of the "fullness" of the space between the flighting as well as measurements of the grain helix angle. This information was used to approximate the amount of rotational motion of the grain in the auger. An attempt to reduce the grain rotational motion using a housing having longitudinal vanes which extended into the space between the housing and auger resulted in greater leakage back in the clearance space and, hence, no increase in output. However, the vanes did arrest the rotation of the outer grain particles. The grain helix angle at the screw periphery was observed to increase from about 12 degrees at 200 RPM to about 45 degrees at 2000 RPM for an angle of elevation of 90 degrees.

Roberts and Willis found that when clearances approximately equal to the grain size were used the grains tended to wedge in the clearance space resulting in excessive power consumption and grain damage. This seems to verify results obtained by Coppock (3).

Stevens (20) measured the effects of auger speed, angle of elevation, radial clearance, pitch length, and moisture content on the output of 5½ and 3-inch diameter augers conveying wheat. The augers were operated in transparent tubes so that grain motion could be observed. Augers with no clearance appeared to be completely full only when conveying for angles less than 15 degrees at low speed. The cavity appearing behind each flight at the upper side of the tube increased in size with speed and angle of elevation. When conveying vertically, the grain formed a helical strip with a depth which was never more than half the pitch length. When the auger was operating full, the grain appeared to move as a solid helix whose angle could be observed.

With large clearances and steep angles of elevation, Stevens observed grain moving down the conveyor against the general flow. Vertical conveying ceased for a speed of 400 RPM at a clearance of 3/4-inch.

Summary

This review of literature has shown that several attempts have been made to develop equations which will satisfactorily predict screw conveyor capacities for a wide range of conveyor and material variables. The successfulness of these attempts has been limited. Without the benefit of experimental verification it is not possible to conclude that any of the equations mentioned are well suited for predicting the capacity of a vertical screw conveyor for hulled castor seed.

CHAPTER IV

APPARATUS AND INSTRUMENTATION

The vertical screw conveyor test stand used in this experiment is shown in Figures 1, 2, 3, and 4. The auger was constructed of 5 inch pitch diameter, left-hand helical flighting mounted on a $1^{5}/16$ inch diameter solid steel shaft. The screw pitch length was $5^{3}/16$ inches and the total vertical length of the flighting was 43 inches. The pitch diameter varied from 4.950 to 5.010 inches. Seven different conveyor housings, each 30 inches long, constructed of $5^{1}/2$ inch outside diameter, 10 gauge wall thickness, electric welded steel tubing were used in the investigation. Precise measurement of the inside diameter of the tubing revealed a range of 5.220 to 5.274 inches which provided a clearance between the auger flighting and the housing that ranged from 0.105 to 0.162 inches.

The lower end of the screw conveyor extended into the circular hopper that was $18^{5}/8$ inches deep and 18 inches in diameter. The bottom of the hopper was cone shaped with 45 degree sloping sides and a $5^{1}/4$ inch diameter at the base. The lower end of the auger nearly scraped the bottom of the hopper and the distance between the lower end of the housing and the bottom of the hopper was adjustable from 0 to 13 inches. The conveyor unit was constructed so that the seed hopper, auger, and housing portion could be tilted to facilitate seed removal and cleaning. The auger and housings were easily and quickly removed by removing the

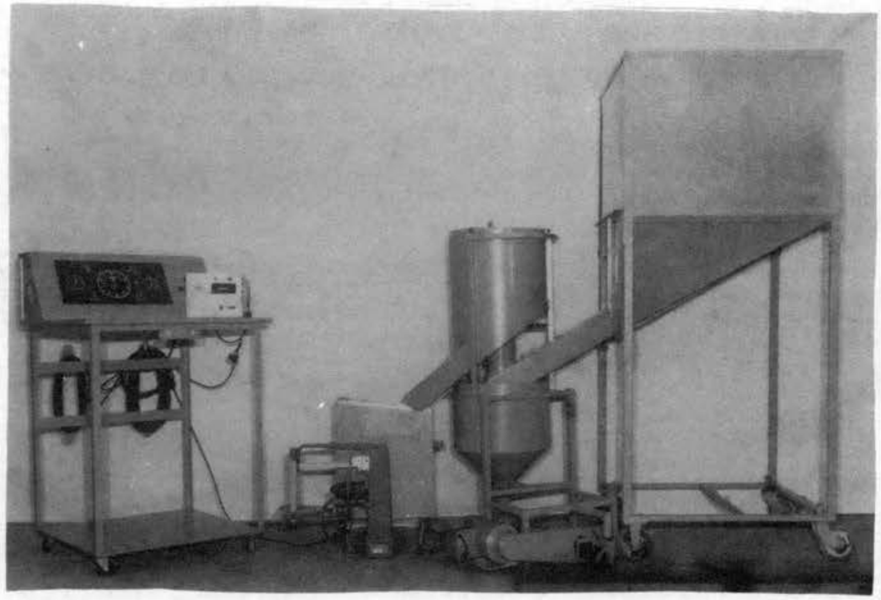


Figure 1. Test Apparatus

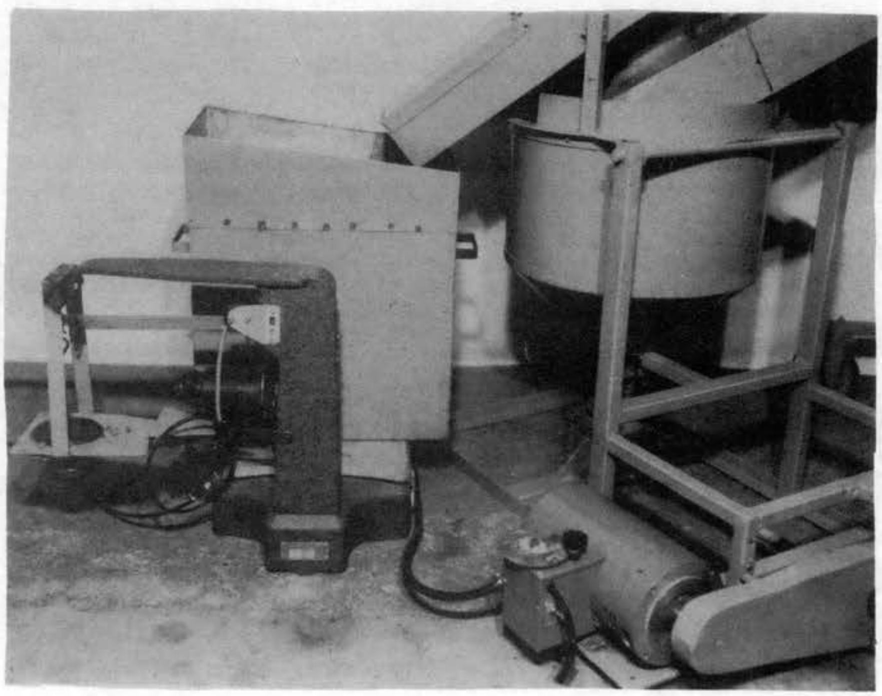


Figure 2. Platform Scale, Screw Conveyor
Hopper, and Drive Mechanism

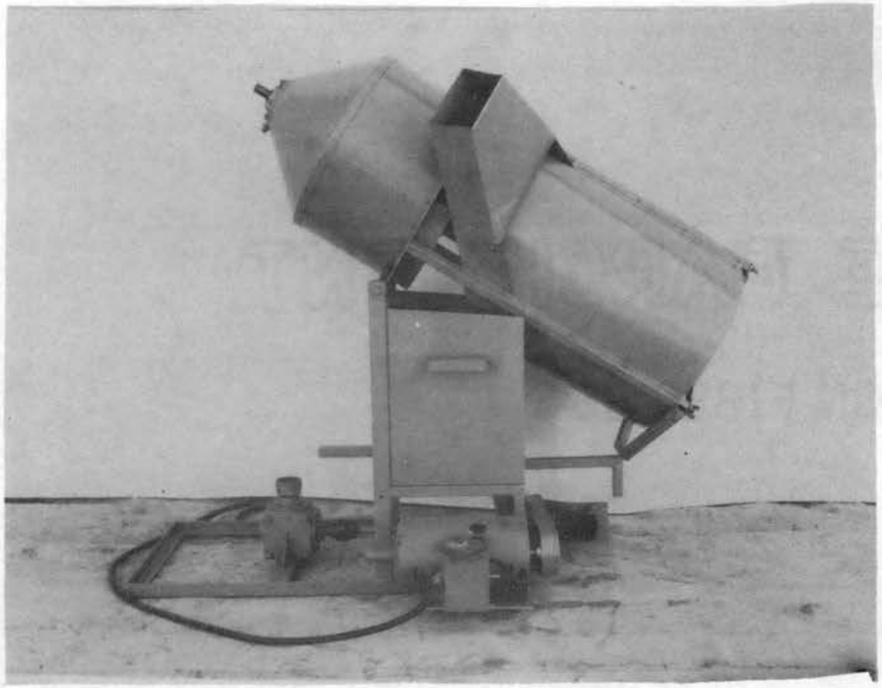


Figure 3. Conveyor Unit in Tilted Position for Removing Seed From Hopper and Housing

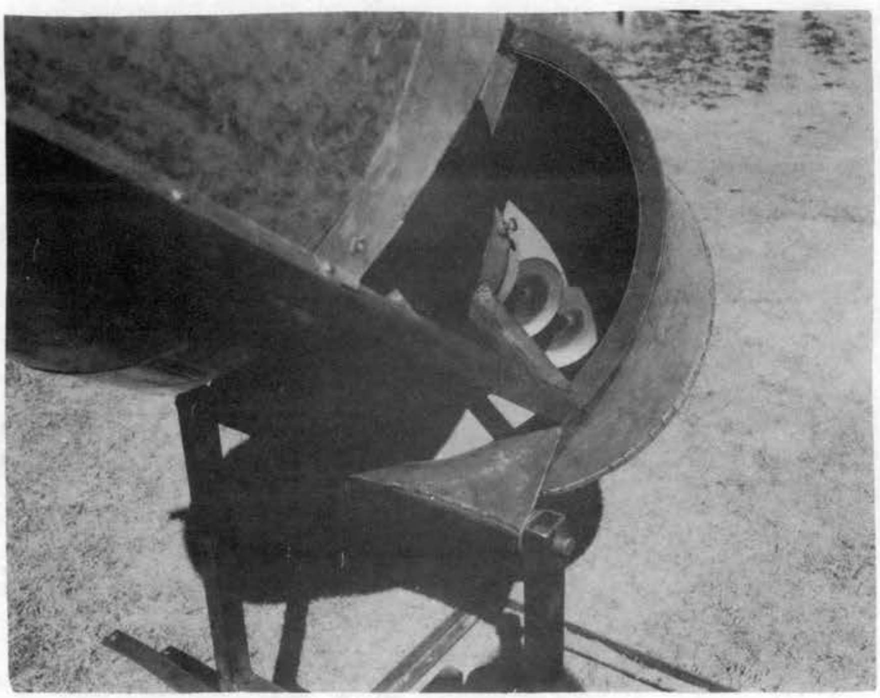


Figure 4. Conveyor Hopper With Standard Housing and Auger

upper bearing bracket.

One of the auger housings was constructed with both the upper and lower ends cut perpendicular to the longitudinal axis (Figure 5). This housing (hereafter referred to as the "standard" housing) was used to determine the effect of entrance opening height and auger speed on rate of conveying and percent of seed damaged. The other 6 housings (Figure 6) had their upper ends cut perpendicular to the longitudinal axis and their lower ends cut in various triangular shapes for the purpose of determining the effect of shear-plane orientation on the rate of conveying and percent of seed damage. Housing number 4 was cut in such a manner that a seed traveling in a line perpendicular to the outer edge of the flighting would bisect the angle formed by the sides of the opening. Housing number 3 was cut so that a line parallel to the axis of the housing bisected the angle formed by the sides of the opening. If an image of housing number 4 was placed on housing number 3 so that the lower points of the housings coincide, the upper points of the openings would be displaced 5.45 inches. The remaining 4 housings had the upper points of their openings spaced to either side of housings 3 and 4 by multiples of 5.45 inches. Figure 7 is a development diagram showing the configuration of the lower end of each of the angular housing surfaces unrolled to form a plane surface.

Seed was fed to the unit from a small elevated storage bin through a specially constructed feed spout. Power for the conveyor was supplied by a type P, model 10023-D41-DX, 1 H.P., 220 volt, 3 phase, Adjusto-Spede drive unit manufactured by the Dynamatic Division of Eaton Manufacturing Company. The speed of the drive unit, which was a combination of an A.C. constant speed induction motor, an eddy current coupling, and an

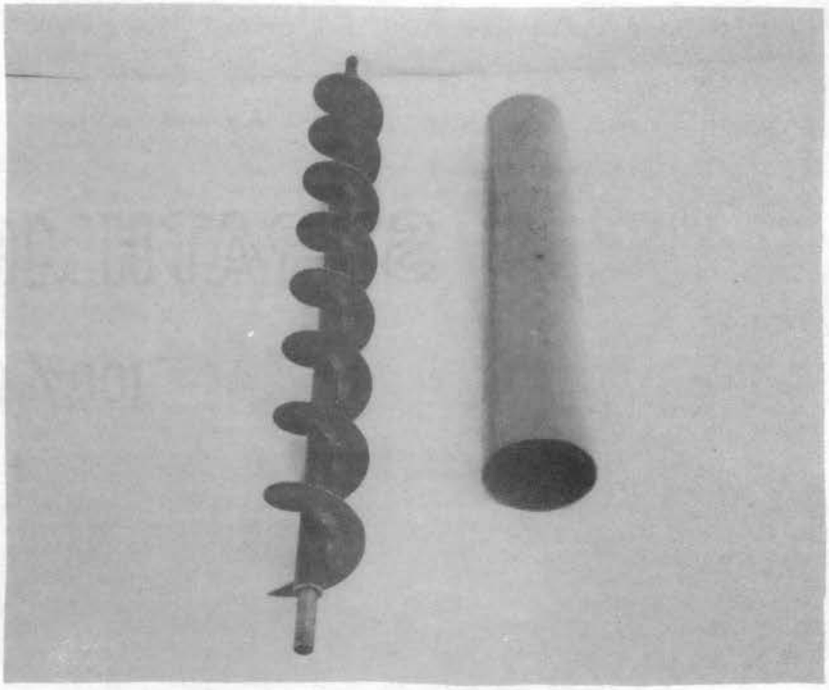


Figure 5. Standard Housing and Auger Used for Opening Height Versus Auger Speed Test

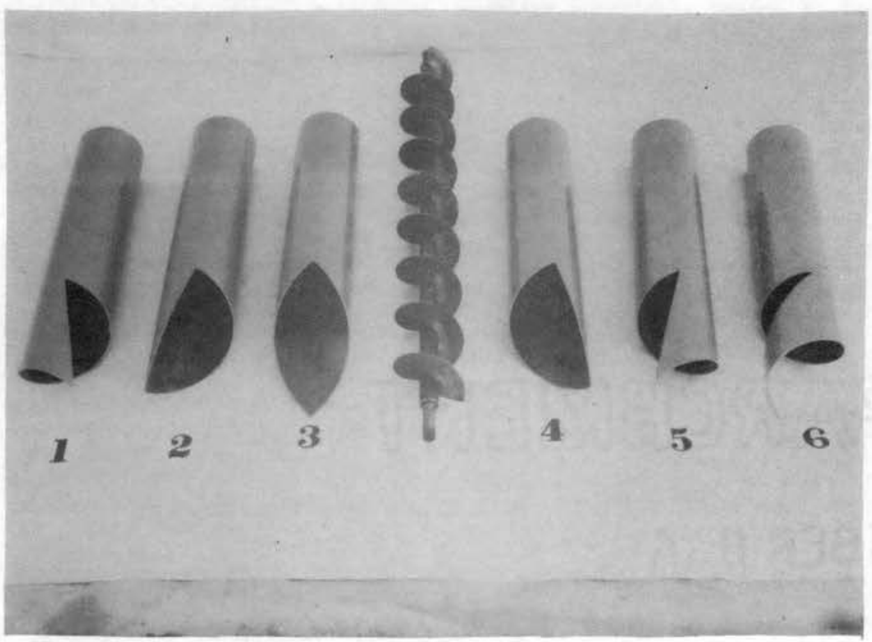
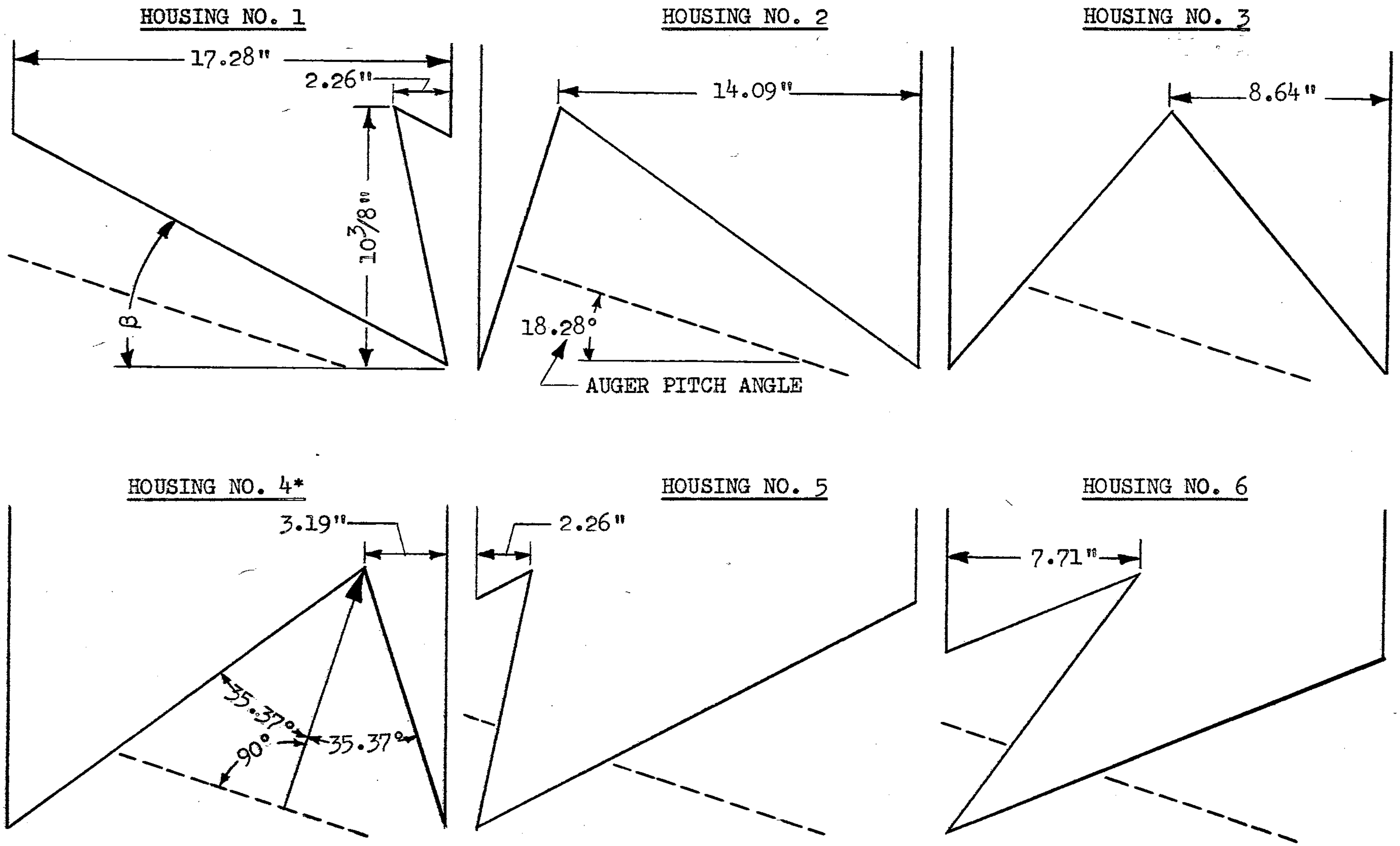


Figure 6. Angular Shear-Plane Housings and Auger Used for Shear-Plane Orientation Versus Auger Speed Test



*A seed traveling in a line perpendicular to the outer edge of the flighting bisects the angle formed by the housing opening.

Figure 7. Development Diagrams of Angular Shear-Plane Housings

electronic speed control, was adjustable from 130 to 3200 RPM. Power was transmitted from the drive unit to the auger through a number 40 steel roller chain with a 12 tooth to 30 tooth sprocket speed reduction, a 7/8 inch diameter steel shaft, a miter gear box, and two flexible couplings.

A model SG-6, Chromo-Tachometer, manufactured by The Standard Electric Time Company, was used to measure RPM of the auger and also the time and number of revolutions of the auger required to convey 40 pounds of seed. The instrument consisted of a precision timer calibrated in units of 1/1000 minute which totalized to 10 minutes before repeating, a revolution counter actuated by a 3-phase generator attached to the auger drive shaft which was calibrated in units of 1/5 revolutions to a total of 6000 revolutions before repeating, and an indicating tachometer also operated by the 3-phase generator which was accurate to 10 RPM with a range of 0 to 3500 RPM. As castor beans were conveyed through the test unit, they were deposited into a metal box which was located on a beam-type scale. A micro-switch operated by the scale beam controlled the timing and counting circuits. In addition, a solenoid automatically operated a weight-dropping device for placing a 40-pound scale weight on the scale beam (Figure 8). Figure 9 is a diagram of the instrument circuitry. The scale used was a model number 3305, serial number 6004811, single pillar, 300 pound capacity, platform-type counter scale manufactured by the Howe Scale Company. The beam was graduated 3 pounds by 1/4 ounce so that a high degree of accuracy was attainable.

A type HA43A608, model 2C61 Microflex Timer manufactured by Eagle Signal Company was used to automatically stop the auger after a preadjusted time interval for the portion of the preliminary tests involving

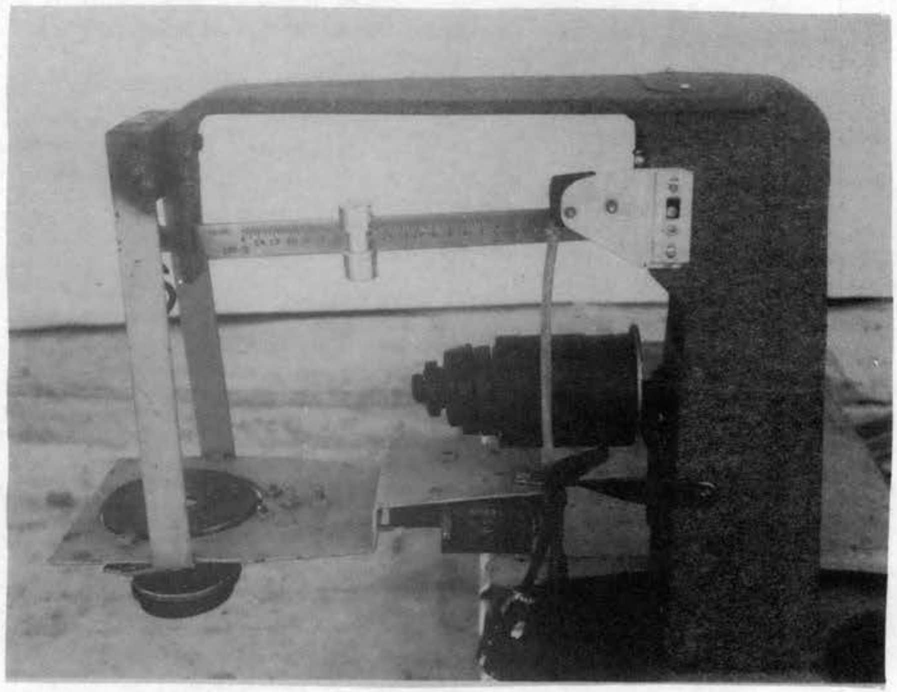
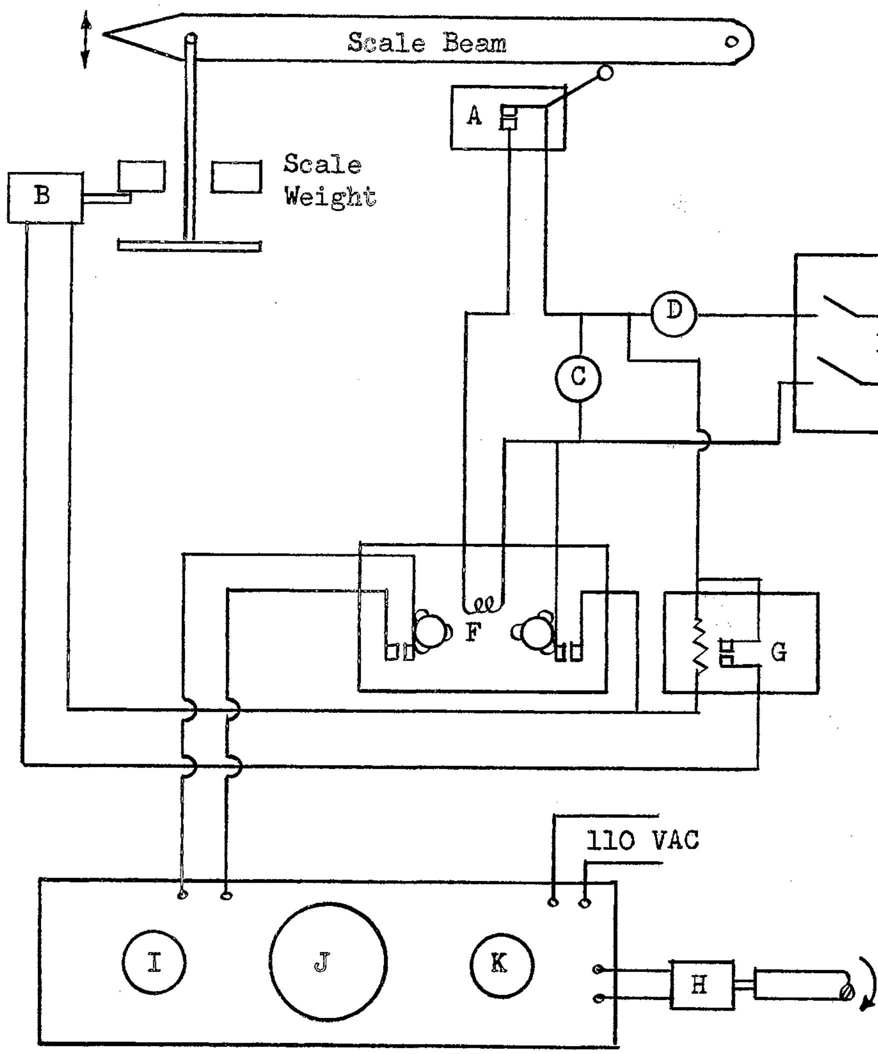


Figure 8. Automatic Scale-Weight Dropping Device for Measuring Rate of Conveying



A. Micro switch (normally open --- closed when scale beam is up)
B. Solenoid (releases scale weight)
C. Neon circuit indicator
D. Fuse
E. Snap switch
F. Ratchet relay
G. Time delay relay (normally open --- 2 second delay)
H. Three phase tachometer generator attached to auger drive shaft
I. Time meter (reads to nearest 1/1000 minute)
J. Tachometer (accurate to 10 RPM)
K. Revolution counter (reads to nearest 1/5 revolution)

Figure 9. Schematic Instrumentation Diagram

recirculation of the seed a specified number of times. The timer was provided with a maximum setting of 20 minutes, a minimum setting of 3 seconds, 1 second dial divisions, and a ±1 second accuracy.

Castor beans used in the test were cleaned by screen and air with a model M-2B Clipper Cleaner manufactured by A. T. Ferrell and Company (Figure 10). The cleaner was equipped with a top screen having 17/64 inch by 3/4 inch oblong openings which were just large enough to drop the hulled seed through and a lower screen having 13/64 inch by 3/4 inch oblong openings which were just small enough to retain the hulled seed. The air blast of the cleaner was adjusted so that everything lighter than completely "filled" hulled seed was lifted out of the stream of material. Castor beans were fed to the cleaner and carried away from the cleaner on specially designed canvas elevators. The elevator used to convey seed away from the cleaner was also used for bagging and for conveying seed to elevated bins.

A model G, Electro-Mechanical Selector (Figure 11), serial number 1007, manufactured by Gromax, Incorporated, was used to remove a portion of the damaged seed from the hulled seed prior to its use in the conveyor studies. This unit was also used to estimate the percentage of damaged seed in the material before it was used in the conveyor study and to analyze the lots of seed from each treatment, for damaged and unhulled seed, after they were passed through the screw conveyor. Figure 12 shows damaged and undamaged castor seed.

A specially constructed density bucket having a volume of 1/2 cubic foot was filled with seed and weighed to determine the seed density.

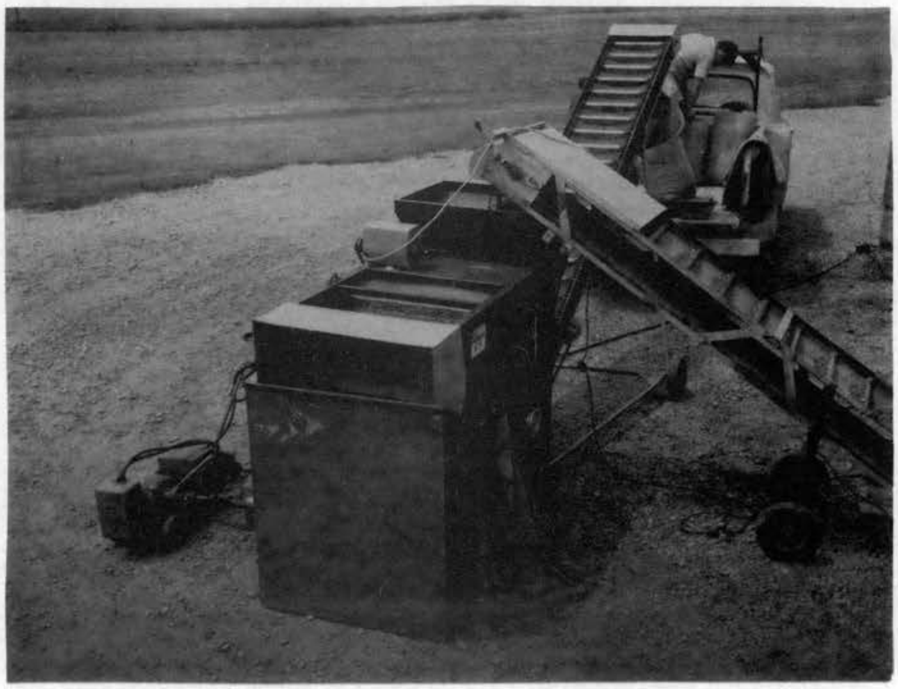


Figure 10. Clipper Cleaner and Conveyors Used for Cleaning and Bagging Test Material

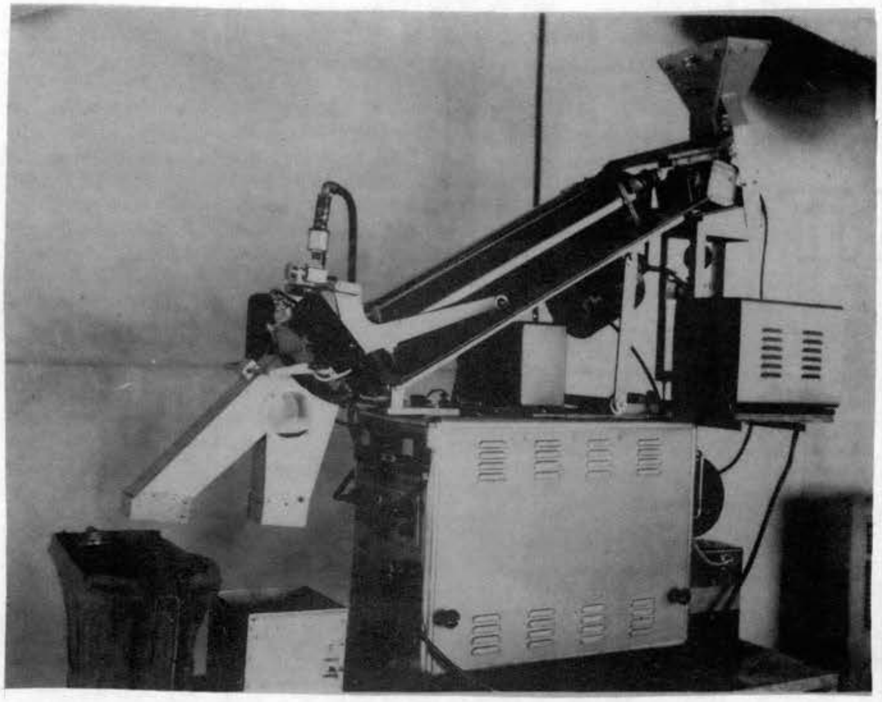


Figure 11. Electro-Mechanical Selector Used to Remove Damaged Seed and Analyze Samples

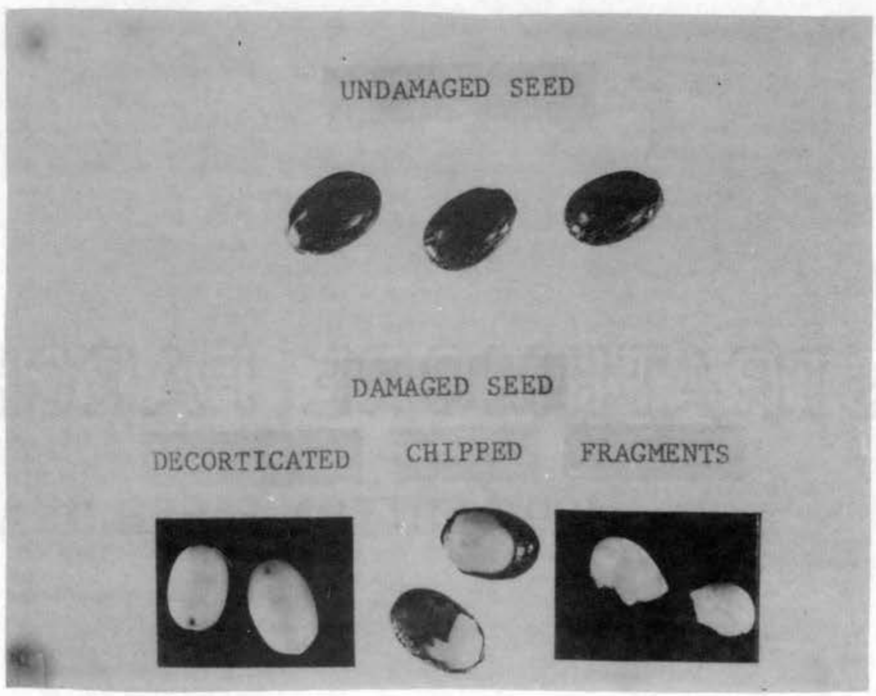


Figure 12. Damaged and Undamaged Castor Seed

CHAPTER V

METHODS AND PROCEDURE

Preliminary Investigation

Several preliminary tests were conducted, the first of which was for the purpose of establishing the range of variation for entrance opening height and auger speed that would provide practical rates of conveying for a 5 inch screw conveyor. The investigation was conducted using the standard housing and auger previously described. Seed for the first preliminary test contained small amounts of damaged seed, unhulled seed, and foreign material. Samples were not analyzed to determine the specific amounts of this material present or to determine seed damage due to the conveyor. Data from the preliminary tests are presented in Appendix E.

Castor seed was passed through the unit, and the amount of seed conveyed for a measured time interval was collected and weighed. The speed of the auger was varied from 29 RPM to 1300 RPM, and the entrance opening height was varied from one inch to eleven inches. The unit was cleaned as often as was necessary to keep build-up from forming. The results of varying the speed for several opening heights are shown in Data Sheet I (Appendix E) and Figure 13. Figure 13 shows that for each opening height a maximum rate of conveying was reached, and any further increase in speed caused a reduction in rate. The maximum point was

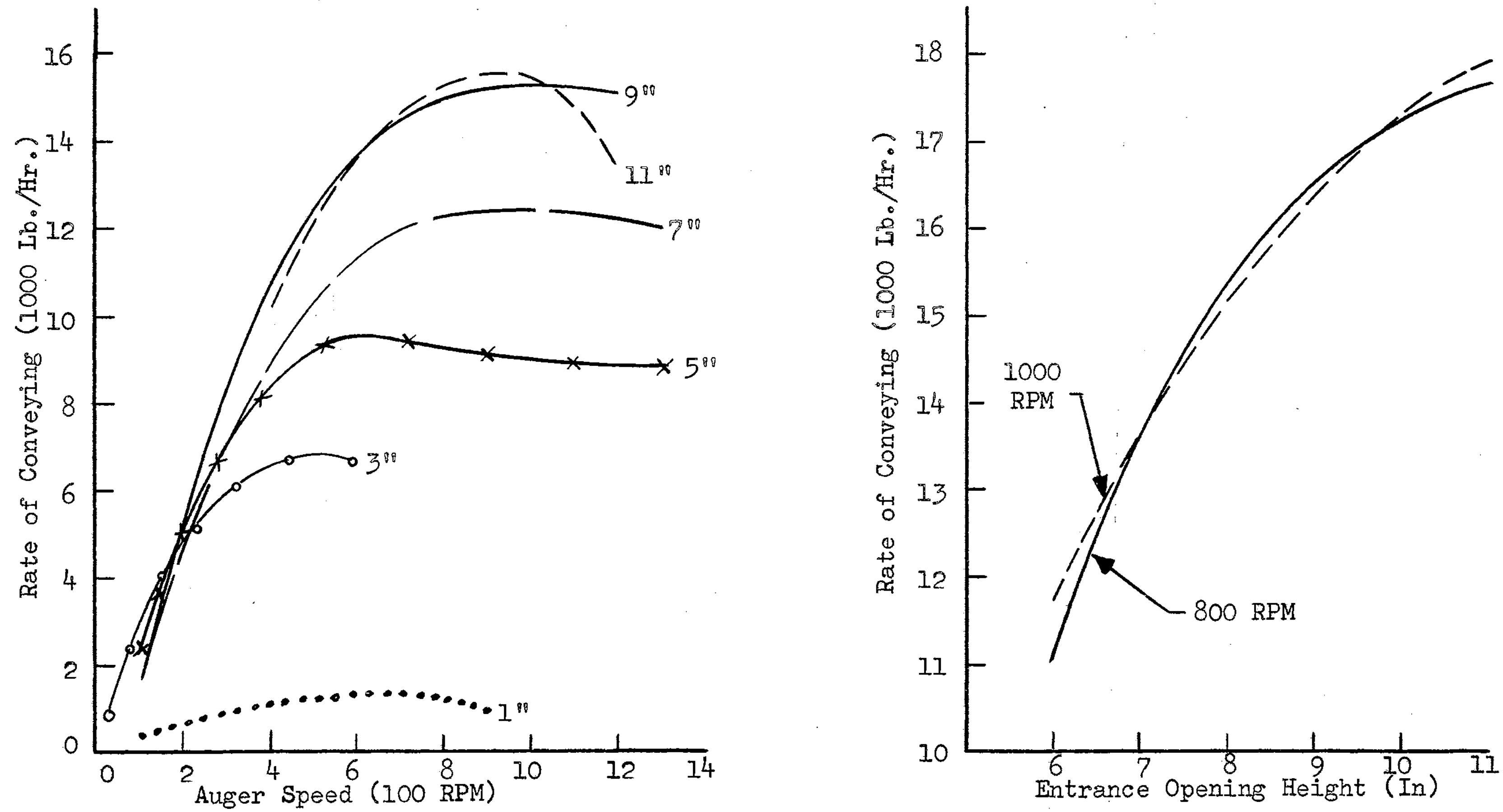


Figure 13. Preliminary Investigation - Rate of Conveying Versus Auger Speed and Entrance Opening Height

found to increase from about 500 RPM to 1000 RPM as the opening height was increased from one inch to eleven inches. Figure 13 also shows the data from Data Sheet II (Appendix E) for 800 and 1000 RPM where the opening height was increased from six to eleven inches. Each increase in opening height caused an increase in rate of conveying.

One of the objectives in varying the auger speed over a wide range was to determine the maximum rate of conveying at each particular entrance opening height, as limited by the capacity of the auger to move the seed away from the opening. In order to make certain that the factor limiting the capacity of the conveyor at each entrance height was not the orifice size (in other words, not the rate at which seed would flow through the opening between the bottom of the housing and the bottom of the hopper if no auger was present), a second preliminary test was conducted. A hopper having the same dimensions as the one on the test conveyor was constructed for the purpose of measuring the orifice flow rates at various heights. The circular plate in the bottom of the hopper was replaced with a sliding gate. The hopper was filled with 50 pounds of seed and the gate opened rapidly. The time required for the hopper to empty was recorded for entrance opening heights ranging from one inch to eleven inches. The time for the hopper to empty with the tube removed was also recorded. Data Sheet III (Appendix E) shows the data from that test. By comparing the rate of seed flow through the orifice opening to the rate of conveying by the auger at various housing heights, it is seen that the orifice did not restrict the conveying rate for any height within the range of the test. The maximum rate of conveying at any height and speed was 17,876 pounds per hour at 1000 RPM and eleven inches height. The rate of flow through the hopper orifice section was 20,833 pounds per hour at the two inch opening height.

Past experience in measuring the damage of castor seed seemed to indicate that oftentimes the variability in the percent of damaged seed was large enough, when added to sampling errors, to mask the increase in damage caused by passing the seed through a conveyor; particularly if the increase was relatively small. For that reason, a third preliminary test was conducted to determine the feasibility of recirculating the seed in order that the increase in damage might be magnified. To test this possibility one auger speed and two entrance opening heights (using the standard housing) were selected. The seed used for each of the recirculation tests was first passed through the conveyor using the predetermined speed and opening heights and collected in the scale box for the purpose of determining the rate of conveying for each opening height. The discharge chute was then removed from the conveyor and the sides of the test stand enclosed so that when the conveyor was operated the seed in the hopper was conveyed up through the housing and returned to the hopper to make another cycle. The same lot of seed was used for recirculation for each opening height as was used to determine the rate of conveying for that opening height.

The speed selected was 1200 RPM, and the opening heights selected were $2^{19}/32$ inches and $12^{31}/32$ inches which were $1/2$ and $2^{1}/2$ pitch lengths of the auger respectively. The data obtained for the two opening heights during the first circulation of the samples through the conveyor is presented in Data Sheet IV (Appendix E).

Based upon the length of time required for one pass of the seed through the conveyor for the $1/2$ pitch length opening height (36.7 seconds), the conveyor was operated an additional 146.8 seconds to complete five circulations. Three samples of seed were then removed from the hopper and analyzed for damage. After the samples were analyzed they were returned to the hopper, and the conveyor was operated an additional 73.4 seconds to complete seven circulations. Three samples were again analyzed for damage. This same procedure was repeated for nine circulations. The same method was used to determine the damage for several circulations using the $2\frac{1}{2}$ pitch length opening height except that 9.9 seconds were required for each circulation; the first samples were analyzed after three circulations. Data Sheet V (Appendix E) shows the results of the sample analyses.

After nine circulations were completed for each opening height, the discharge chute was again placed on the conveyor, and each of the lots of seed passed through the unit and discharged into the scale box. The data obtained for the two opening heights during the tenth circulation is also presented in Data Sheet IV (Appendix E).

The entire lot of seed used for the $\frac{1}{2}$ pitch length opening height was analyzed to determine seed damage after 10 circulations. Even with the aid of a clipper cleaner and an electronic sorting machine, approximately two hours of hand sorting was required to analyze the sample. This length of time was considered prohibitive, considering the total number of tests to be conducted. Total damage to the seed after 10 circulations was found to be 10.45 percent.

Upon comparing the rates of conveying for the first and tenth circulations, it is seen that the tenth circulation rates were much lower. This lowering of the rate of conveying was a result of the accumulation of oil on the seed surface, which in turn was brought about by the increase in damaged seed as it was circulated. As the percent of damaged seed increased, the seed oiliness increased and the rate of conveying decreased. Thus, it became impossible to predict the length of time required for a desired number of circulations by measuring the rate of conveying for the first circulation. This means that the data in Data Sheet V (Appendix E) is not actually from the number of circulations indicated but is, in fact, for less circulations than the number indicated. Since it was not possible to predict the rate of conveying without first knowing the seed damage, and since the extra seed damage made sample analysis extremely time consuming, the idea of magnifying seed damage by recirculation was discarded.

Specific Test Conditions

1. Conveyor settings selected for studying the effect of auger speed and entrance opening height on the rate of conveying and percent of seed damaged were as follows:
   a. Auger speeds: 300, 450, 600, 750, 900, 1050, and 1200 RPM.
   b. Entrance opening heights: $2\frac{19}{32}$, $5\frac{3}{16}$, $7\frac{25}{32}$, $10\frac{3}{8}$, and $12\frac{31}{32}$ inches. These opening heights were respectively $\frac{1}{2}$, 1, $1\frac{1}{2}$, 2, and $2\frac{1}{2}$ pitch lengths of the auger.
2. The conveyor settings selected for studying the effect of auger speed and shear-plane orientation on the rate of conveying and percent of seed damaged were as follows:
   a. Auger speeds: 300, 450, 600, 750, 900, 1050, and 1200 RPM.

b. Shear-plane orientation: The angular shear-plane orientation housings are discussed in Chapter IV. The angle labeled "β" in Figure 7 was selected as the parameter to describe the various angular shear-plane housings. This angle, which hereafter will be referred to as the "shear-plane angle," had the following values for the various angular shear-plane housings: number 1, 27.97; number 2, 36.37; number 3, 50.22; number 4, 72.91; number 5, 102.27; and number 6, 126.60 degrees. The relationship of the various housings to the auger pitch angle is also shown in Figure 7. The lower points of the angular housings rested on the bottom of the feed hopper. The inlet area for the angular housings was equal to the inlet area for the 5 3/16 inch opening height tests.

3. Castor beans used in the test were Baker 296 variety. They were machine harvested and precleaned with a clipper cleaner and electronic color sorting machine to remove as much of the foreign material, fragments, chipped seed, decorticated seed, and unhulled segments as possible. After the cleaning operation, the material consisted of 1.68 percent damaged seed. This percentage was obtained by analyzing 208 subsamples of the cleaned seed as it passed through the sorting machine.

Design of Experiment

Upon the selection of the test conditions, or more specifically, the number of levels required to adequately cover the range of variation of the variables, a decision was required as to the number and size of samples necessary to obtain reliable information. A study of the rate of conveying obtained for the preliminary investigation indicated that rates of conveying as high as five or six pounds per second might be obtained during the tests. Based on the method of rate measurement and previous experience in sampling castor seed to determine the percentage of damaged seed, it was decided to collect at least 50 pounds of seed. Forty pounds of the approximately 50 pound sample was automatically timed to obtain the rate of conveying, and the entire 50 pounds was analyzed to determine the percentage of damaged seed.

After selecting the sample size, it was determined that a sufficient quantity of seed was available to provide three observations of each test treatment. An estimate of the standard deviation of the percent of damaged seed in the test material prior to its passing through the conveyor was obtained and used to determine the probable maximum error in the sample means. Although admittedly this standard deviation probably did not accurately define the standard deviation of the percent damaged seed in the test material after it was passed through the conveyor, it was the best estimate available. The probable maximum error in the sample means, based on the computation of 95% confidence limits as shown by Cochran (21), is as follows:

$$L = \frac{2s}{\sqrt{n}}$$

where:

L = Probable maximum error in the sample mean

s = Sample standard deviation

n = Number of samples .

The standard deviation found for the percent of damaged seed in the test material was 0.25. The probable maximum error in the means was then:

$$L = \frac{2(0.25)}{\sqrt{3}} \text{ ; or } 0.29 \text{ percent.}$$

As this measure of error was considered acceptable, three observations were selected for each treatment.

It was known that a considerable amount of time would be required to conduct the tests and analyze the samples to obtain the percentage of damaged seed, and it might, therefore, be necessary for a time lag to exist between portions of the test and between portions of the seed analysis. As it was thought that these time lags might allow the seed condition to change sufficiently to affect the results of the experiment, the test was randomized by blocks. Also, the stipulation was made that all test runs for each block be completed in as short a period as possible, and that all samples from each block be analyzed in as short a period as possible.

Consideration of the test variables and apparatus led to the conclusion that for both the opening height and shear-plane orientation tests, the variable most easily adjusted would be the auger speed. Therefore, the auger speed was randomized within each opening height and each shear-plane angle. The opening heights and shear-plane angles were randomized within each block. This design is a split-plot factorial in a randomized block. (21).

Experimental Technique

1. Clean approximately 20,000 pounds of hulled castor beans with clipper cleaner to remove most of the unhulled segments, fragments of seed, and free foreign material.
2. Pass cleaned seed from step 1 through Electro-Mechanical Selector to remove part of the remaining decorticated, chipped, and unhulled seed. Obtain one 500 gram subsample of accepted seed, for each 80 pounds (approximately) of accepted seed passing from the selector, to be used to determine the percent of damaged seed remaining in the accepted seed.
3. Adjust the test apparatus to the first opening height and auger speed as specified by the randomization scheme for block 1.
4. Fill the small elevated storage bin, feed spout, and screw conveyor hopper with accepted seed from step 2.
5. Start the auger, causing seed to flow through the conveyor and into the box on the scale platform.
6. Collect approximately 55 pounds of seed in the scale box, using the automatically operated scale-weight dropping device, time meter, and revolution counter to measure the time and number of auger revolutions required to convey 40 pounds of the approximately 55 pounds collected.
7. Record the data obtained in step 6 and bag and label the entire 55 pounds collected from each test run, indicating

the block number, opening height, and auger speed for that particular run.

8. Readjust the auger speed to the next speed specified by the randomization scheme and conduct the next test run.
9. Repeat steps 5, 6, 7, and 8 until all speeds have been run for each opening height; then empty the seed from the conveyor hopper and disassemble and clean the conveyor to remove any oily coating which may have formed on the conveying surfaces.
10. Reassemble the conveyor, adjusting the housing to the next opening height and the auger to the next speed to be tested according to the randomization scheme.
11. Repeat steps 4 through 10 until all opening heights have been tested for block 1; then conduct block 2 and block 3 tests for all opening heights in exactly the same manner as the block 1 tests were conducted.
12. Place the first angular shear-plane housing to be tested in the test apparatus and adjust the speed as specified by the randomization scheme for block 1.
13. Repeat steps 4 through 11, except that shear-plane angles were tested in place of opening heights.

Sample Analysis

The analysis of the 55 pound samples to determine the amount of decorticated, chipped, and unhulled seed was performed according to the sample flow diagram (Figure 14). As each sample was passed through the Electro-Mechanical Selector, small sub-samples were obtained simultaneously

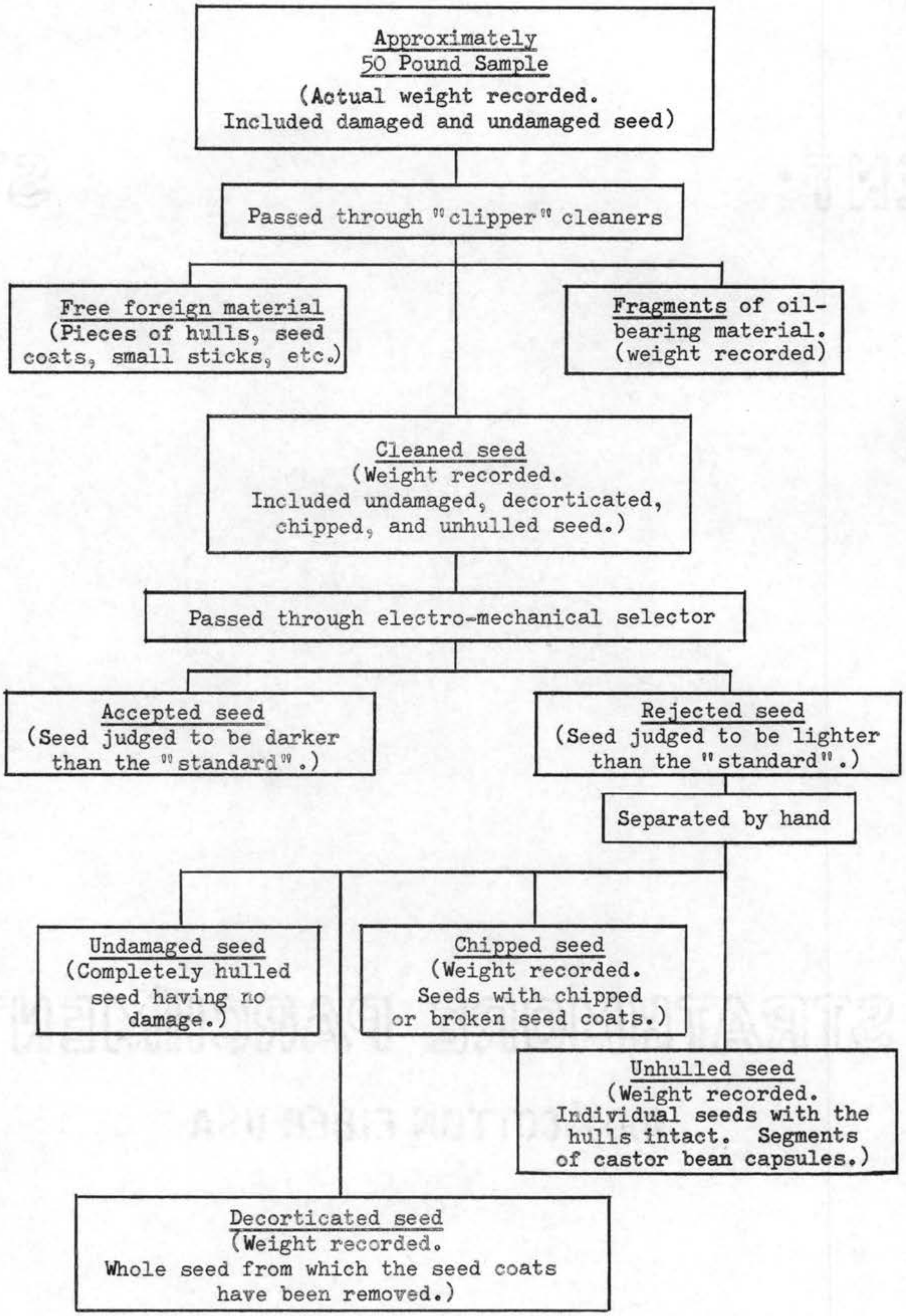


Figure 14. Sample Flow Diagram

from the accept and reject chutes. These accept and reject sub-samples were then analyzed by hand to determine the performance of the selector in terms of the percentages of decorticated, chipped, and unhulled seed rejected from the total amounts present in the sample. The weights of decorticated, chipped, and unhulled seed in the rejected seed were then divided by the percentage of decorticated, chipped, and unhulled seed respectively that was rejected by the selector. In this manner, it was assumed that a reliable estimate was obtained of the amounts of decorticated, chipped, and unhulled seed in the samples.

CHAPTER VI

PRESENTATION AND ANALYSIS OF DATA

The measured or computed attributes which were used to evaluate conveyor performance were:

1. Pounds per hour conveyed: The rate of conveying on a weight basis.
2. Cubic feet per hour conveyed: The rate of conveying on a volume basis. This attribute was obtained by dividing the pounds per hour conveyed by the specific weight of the seed conveyed for each individual sample.
3. Pounds per revolution conveyed: The weight of seed conveyed for one revolution of the auger.
4. Pounds per hour conveyed per square inch of opening area: The pounds per hour conveyed divided by the entrance opening area for the conveyor. The opening area was computed by multiplying the circumference of the outside wall of the housing by the entrance opening height for the opening height tests. The entrance opening areas for the angular shear-plane housings were identical for all housings and were computed by multiplying the circumference of the outside housing wall by one-half of the opening height.

5. Percent total sample weight damaged: The total weight of damaged seed in the sample (including residual damage which was present before the seed was passed through the conveyor) expressed as a percentage of the total sample weight. Damaged seed consisted of decorticated seed, chipped seed, and fragments.

6. Percent oil-bearing material damaged: The total weight of damaged seed in the sample (including residual damage which was present before the seed was passed through the conveyor) expressed as a percentage of the weight of oil-bearing material in the sample.

7. Percent decorticated seed in damaged seed: The weight of decorticated seed in the damaged seed expressed as a percentage of the weight of damaged seed.

8. Percent fragments in damaged seed: The weight of the fragments of oil-bearing material in the damaged seed expressed as a percentage of the weight of damaged seed.

9. Percent chipped seed in damaged seed: The weight of chipped seed in the damaged seed expressed as a percentage of the weight of damaged seed.

The rate of conveying was expressed in four different manners (attributes 1, 2, 3, and 4). Attributes 1 and 2 were both included so that a comparison could be made between the results obtained by expressing the rate in terms of weight and volume. It was felt that the specific weight of the seed might vary sufficiently from one sample to another that a difference in the two methods of rate measurement could be detected. The weight of seed conveyed per revolution of the auger (attribute 3) was included to obtain a measure of conveyor load. Attribute 4 (pounds per hour conveyed per square inch of opening area) was included because the entrance opening area was varied for the opening height tests.

Seed damage was evaluated by attributes 5, 6, 7, 8, and 9. The percent total sample weight damaged and percent oil-bearing material damaged were the same with the exception that all foreign material was removed from the samples where only oil-bearing material was measured. The damaged seed from each sample was divided into three parts to obtain attributes 7, 8, and 9. These attributes provide a measure of the severity of seed damage. A high concentration of decorticated seed and fragments is more objectionable than a high concentration of chipped seed. Chipped seed does not release oil as readily as decorticated seed and fragments, and, therefore, the build-up of oily material does not occur as rapidly.

Tables I, II, III, and IV show the mean values for all of the attributes. The opening height means shown in Table I are the results of three blocks and seven speeds while the speed means (Table II) are the result of three blocks and five opening heights. The shear-plane angle means shown in Table III are the result of three blocks and seven speeds while the speed means (Table IV) are the result of three blocks and six shear-plane angles.

Tables V and VI are summaries of the analysis of variance of each attribute for the two separate tests. Table V shows the level of probability of significant differences among the sources of variation as obtained from the statistical "F" test for the entrance opening height versus auger speed study. Table VI presents the same information for

TABLE I

OPENING HEIGHT MEANS FOR ALL SPEEDS

Opening height (inches)	Pounds per hour	Cubic feet per hour	Pounds per revolution	Pounds per hour per sq. in. opening area	Percent total sample weight damaged	Percent oil-bearing material damaged	Separation of damaged seed into fractions		
							Percent decorticated	Percent fragments	Percent chipped
2-19/32	5,560	181.88	0.157	124.04	1.87	1.88	11.25	8.72	80.03
5-3/16	9,795	320.08	0.261	109.27	1.71	1.72	11.47	7.64	80.89
7-25/32	13,189	430.07	0.325	98.09	1.61	1.62	10.12	7.40	82.49
10-3/8	14,987	494.19	0.355	83.60	1.51	1.52	11.03	6.13	82.84
12-31/32	16,647	543.53	0.391	74.28	1.38	1.39	11.49	6.76	81.76

TABLE II

SPEED MEANS FOR ALL OPENING HEIGHTS

Auger speed (RPM)	Pounds per hour	Cubic feet per hour	Pounds per revolution	Pounds per hour per sq. in. opening area	Percent total sample weight damaged	Percent oil-bearing material damaged	Separation of damaged seed into fractions		
							Percent decorticated	Percent fragments	Percent chipped
300	7,562	246.69	0.414	71.35	1.43	1.44	10.52	5.65	83.83
450	10,439	342.44	0.383	94.28	1.40	1.40	10.25	6.05	83.70
600	12,663	415.08	0.351	106.76	1.44	1.44	10.97	6.35	82.69
750	12,795	417.66	0.283	103.43	1.59	1.60	10.34	6.74	82.92
900	12,975	426.63	0.241	101.63	1.70	1.70	10.83	7.85	81.32
1050	13,784	450.91	0.219	103.58	1.74	1.74	11.99	9.06	78.95
1200	14,031	458.25	0.195	103.96	2.04	2.05	12.60	9.60	77.80

TABLE III

SHEAR-PLANE ANGLE MEANS FOR ALL SPEEDS

Shear-plane angle (degrees)	Pounds per hour	Cubic feet per hour	Pounds per revolution	Pounds per hour per sq. in. opening area	Percent total sample weight damaged	Percent oil-bearing material damaged	Separation of damaged seed into fractions		
							Percent decorticated	Percent fragments	Percent chipped
27.97	9,894	325.62	0.255	110.38	2.98	2.99	15.55	12.31	72.14
36.37	10,814	354.10	0.277	120.63	2.53	2.54	14.74	11.56	73.70
50.22	11,457	376.80	0.293	127.81	1.86	1.86	11.17	7.46	81.37
72.91	11,600	378.52	0.302	129.41	1.61	1.62	8.06	4.38	87.56
102.27	10,997	359.23	0.287	122.68	1.67	1.68	7.43	3.98	88.59
126.60	10,351	338.96	0.274	115.47	1.68	1.68	8.61	4.76	86.63
5-3/16"*	9,795	320.08	0.261	109.27	1.71	1.72	11.47	7.64	80.89

*Opening height test.
The inclusion of this test with the shear-plane angles provides a comparison of results for equal entrance opening areas. This housing can be considered to have a shear-plane angle of 0 or 180 degrees.

TABLE IV

SPEED MEANS FOR ALL SHEAR-PLANE ANGLES

Auger speed (RPM)	Pounds per hour	Cubic feet per hour	Pounds per revolution	Pounds per hour per sq. in. opening area	Percent total sample weight damaged	Percent oil-bearing material damaged	Separation of damaged seed into fractions		
							Percent decorticated	Percent fragments	Percent chipped
300	7,876	258.33	0.431	87.86	1.81	1.81	9.32	5.95	84.73
450	10,460	342.87	0.389	116.69	1.77	1.77	10.16	6.57	83.27
600	11,893	390.12	0.335	132.68	1.89	1.90	10.11	6.84	83.06
750	12,051	393.93	0.270	134.43	1.96	1.97	10.89	7.46	81.65
900	11,670	381.84	0.218	130.18	2.12	2.13	11.38	7.93	80.69
1050	11,297	370.66	0.179	126.02	2.34	2.35	11.73	8.07	80.20
1200	10,720	351.03	0.149	119.58	2.50	2.52	12.87	9.04	78.08

TABLE V

PROBABILITIES OF "SIGNIFICANT" DIFFERENCES AMONG THE SOURCES OF VARIATION FOR THE ENTRANCE OPENING HEIGHT VERSUS AUGER SPEED TESTS

Attributes studied	Source of variation*		
	Opening heights	Speeds	Speeds x opening heights
Pounds per hour conveyed	$99.5 < P$	$99.5 < P$	$99.5 < P$
Cubic feet per hour conveyed	$99.5 < P$	$99.5 < P$	$99.5 < P$
Pounds per revolution conveyed	$99.5 < P$	$99.5 < P$	$99.5 < P$
Pounds per hour per square inch of opening area	$99.5 < P$	$99.5 < P$	$99.5 < P$
Percent total sample weight damaged	$99.5 < P$	$99.5 < P$	$99.5 < P$
Percent oil-bearing material damaged	$99.5 < P$	$99.5 < P$	$99.5 < P$
Percent decorticated in damaged seed	$P < 70$	$99.5 < P$	$P < 70$
Percent fragments in damaged seed	$99.5 < P$	$99.5 < P$	$99.5 < P$
Percent chipped in damaged seed	$70 < P < 75$	$99.5 < P$	$90 < P < 95$

*(These probabilities were obtained from a split-plot factorial analysis of variance of each attribute)

TABLE VI

PROBABILITIES OF "SIGNIFICANT" DIFFERENCES AMONG THE SOURCES OF VARIATION FOR THE SHEAR-PLANE ANGLE VERSUS AUGER SPEED TESTS

Attributes studied	Source of variation*		
	Shear-plane angles	Speeds	Speeds x shear-plane angles
Pounds per hour conveyed	$99.5 < P$	$99.5 < P$	$99.5 < P$
Cubic feet per hour conveyed	$99.5 < P$	$99.5 < P$	$99.5 < P$
Pounds per revolution conveyed	$99.5 < P$	$99.5 < P$	$99.5 < P$
Pounds per hour per square inch of opening area	$99.5 < P$	$99.5 < P$	$99.5 < P$
Percent total sample weight damaged	$99.5 < P$	$99.5 < P$	$99.5 < P$
Percent oil-bearing material damaged	$99.5 < P$	$99.5 < P$	$99.5 < P$
Percent decorticated in damaged seed	$99.5 < P$	$99.5 < P$	$97.5 < P < 99$
Percent fragments in damaged seed	$99.5 < P$	$99.5 < P$	$99.5 < P$
Percent chipped in damaged seed	$99.5 < P$	$99.5 < P$	$99.5 < P$

*(These probabilities were obtained from a split-plot factorial analysis of variance of each attribute)

the shear-plane angle versus auger speed study. The complete analyses of variance for the opening height test are shown in Appendix A and the complete analyses of variance for the shear-plane test are shown in Appendix B.

Table VII is a comparison of the speed means computed for each attribute for the $5\frac{3}{16}$ inch opening height test and the 72.91 degree shear-plane angle test.

In order to obtain a better understanding of the relationships which existed among the various attributes and the variables under investigation, a multiple regression analysis was performed. The objective of this analysis was to obtain regression equations which would approximate the functional relationship between the attributes measured and the independent variables. The procedure for this type of analysis is discussed in many statistical texts. An application of this type of analysis is discussed by Dickens and Mason (22). The mathematical model used to approximate the relationships was as follows:

$$Y = a + b_1X_1^{\,1} + b_2X_1^{\,2} + \ldots + b_cX_1^{\,c} + d_1X_2^{\,1} + d_2X_2^{\,2} + \ldots + d_eX_2^{\,e}$$

$$+ fX_1X_2$$

where:

Y is the estimate of the attribute in question; X_1 and X_2 are independent variables; a is the value of Y when X_1 and $X_2 = 0$; b_1, b_2, .. b_c and d_1, d_2, .. d_e are partial regression coefficients; c and e may have values of 1, 2, or 3; and f is a partial regression coefficient which provides a measure of the interaction between X_1 and X_2. With the aid of a high speed digital computer it was possible to compute the

TABLE VII

COMPARISON OF OPENING HEIGHT TEST TO SHEAR-PLANE TEST

Attributes	Test*	Auger speeds						
		300	450	600	750	900	1050	1200
Pounds per hour	5-3/16	7780	10224	11463	10645	10060	9732	8659
	72.91°	8147	11287	12754	13049	12920	11432	11613
Cubic feet per hour	5-3/16	252.86	332.28	373.81	347.23	334.12	317.48	282.77
	72.91°	265.47	367.34	418.49	423.67	420.45	377.30	376.93
Pounds per revolution	5-3/16	0.426	0.377	0.324	0.239	0.188	0.154	0.120
	72.91°	0.449	0.417	0.367	0.293	0.241	0.182	0.161
Pounds per hour per square inch	5-3/16	86.79	114.06	127.88	118.76	112.22	108.56	96.60
	72.91°	90.88	125.91	142.28	145.57	144.14	127.53	129.55
Percent total sample weight damaged	5-3/16	1.46	1.58	1.37	1.65	1.66	1.86	2.40
	72.91°	1.68	1.50	1.58	1.58	1.57	1.76	1.61
Percent oil bearing material damaged	5-3/16	1.47	1.59	1.38	1.65	1.67	1.87	2.41
	72.91°	1.68	1.50	1.58	1.58	1.57	1.77	1.62
Percent decorticated	5-3/16	11.39	10.68	13.34	10.36	10.56	11.38	12.61
	72.91°	6.91	7.72	7.52	7.78	8.17	7.89	10.44
Percent fragments	5-3/16	5.83	5.25	6.45	6.79	8.22	9.58	11.36
	72.91°	3.88	3.83	3.52	4.36	4.56	5.11	5.39
Percent chipped	5-3/16	82.78	84.07	80.22	82.85	81.23	79.05	76.02
	72.91°	89.22	88.45	88.96	87.86	87.27	87.01	84.17

*Values presented for the 5-3/16 inch test were the means obtained from 3 replications at that opening height. Values presented for the 72.91° test were the means obtained from 3 replications for that shear-plane angle.

coefficients a, b, d, and f for all levels and combinations of c and e by the least squares method. In addition, the multiple correlation coefficients for each equation form were computed and compared. The equations which had high correlation coefficients and gave calculated values of Y which compared favorably with the observed values of Y were solved for several levels of X_1 and X_2 which were within the experimental limits. These solutions were plotted as response surfaces or isograms. The response surfaces plotted for the opening height versus auger speed tests are shown in Figures 15-21 and those plotted for the shear-plane angle versus auger speed tests are shown in Figures 22-27. Attribute treatment means, speed means, opening height means, and shear-plane angle means used in the multiple regression analyses are shown in Appendices A and B.

Because there was a negligible difference in the relationship of pounds per hour and cubic feet per hour conveyed, cubic feet per hour was not presented graphically. There was also little or no difference in percent total sample weight damaged and percent oil-bearing material damaged. Therefore, the percent oil-bearing material damaged was not presented graphically. One additional attribute, pounds per hour per square inch of opening area (which was similar to pounds per hour), was omitted from graphical presentation for the shear-plane angle versus auger speed tests. The equations and correlation coefficients for those attributes not presented graphically are as follows:

$$\text{Lb./hr.} = 1226.22 + 803.269\ H - 70.9425\ H^2 + 8.2246\ S - 0.0105869\ S^2 + 1.80292\ HS$$

$R = 0.9847$

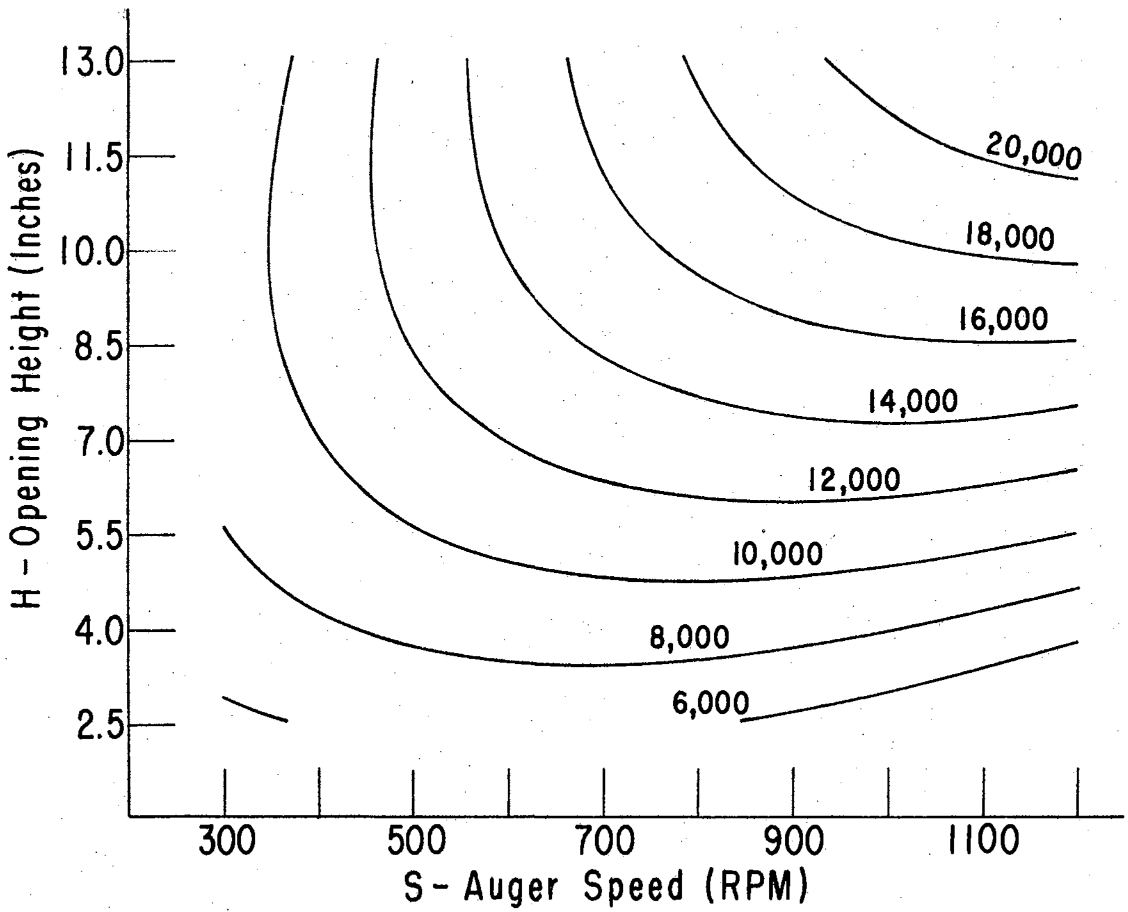


Figure 15. Pounds Conveyed Per Hour as a Function of Opening Height and Auger Speed

$$\text{Lb./revolution} = 0.324 + 0.0393\ H - 0.0018146\ H^2 - 0.00037298\ S + 0.00001422\ HS$$

R = 0.9801

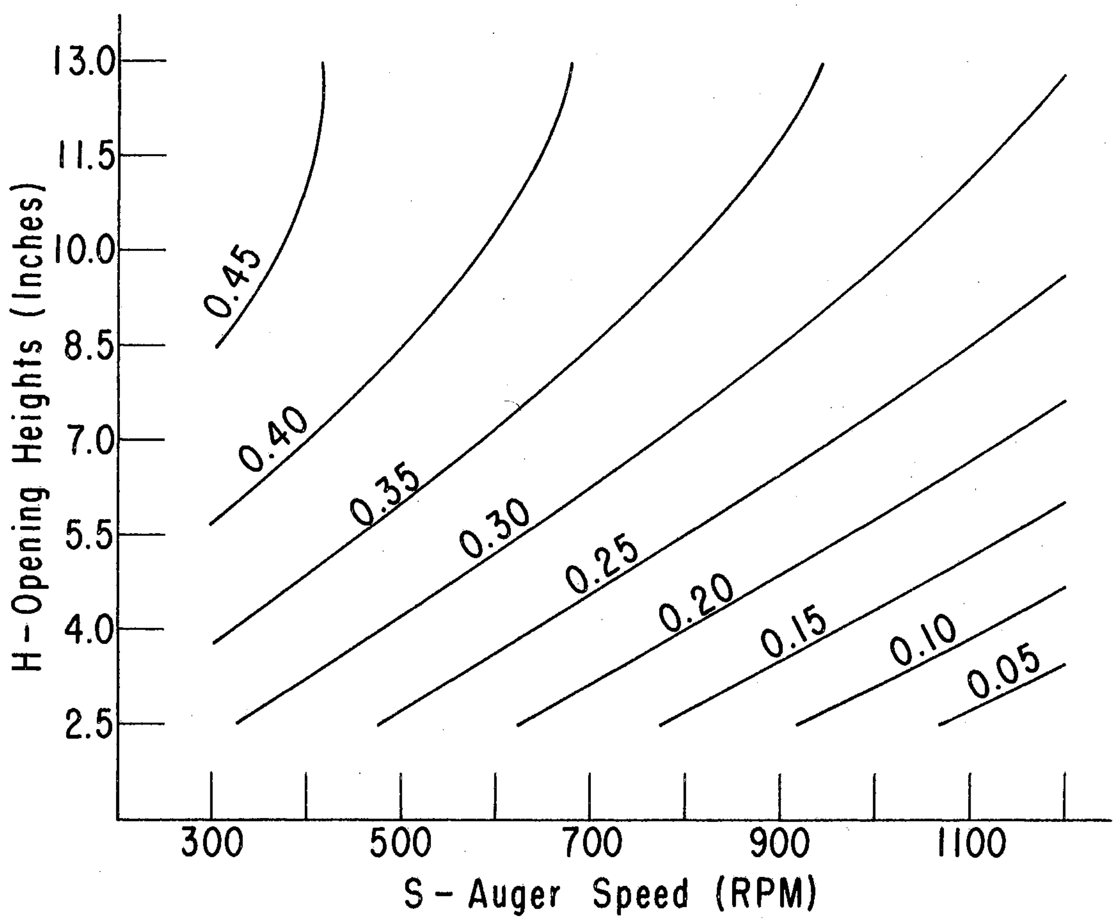


Figure 16. Pounds Conveyed Per Revolution as a Function of Opening Height and Auger Speed

$$\text{Lb./hr./sq. in.} = 69.33 - 13.625\,H + 0.4326\,S - 0.00062498\,S^2 + 0.000000239\,S^3 + 0.011722\,HS$$

R = 0.9563

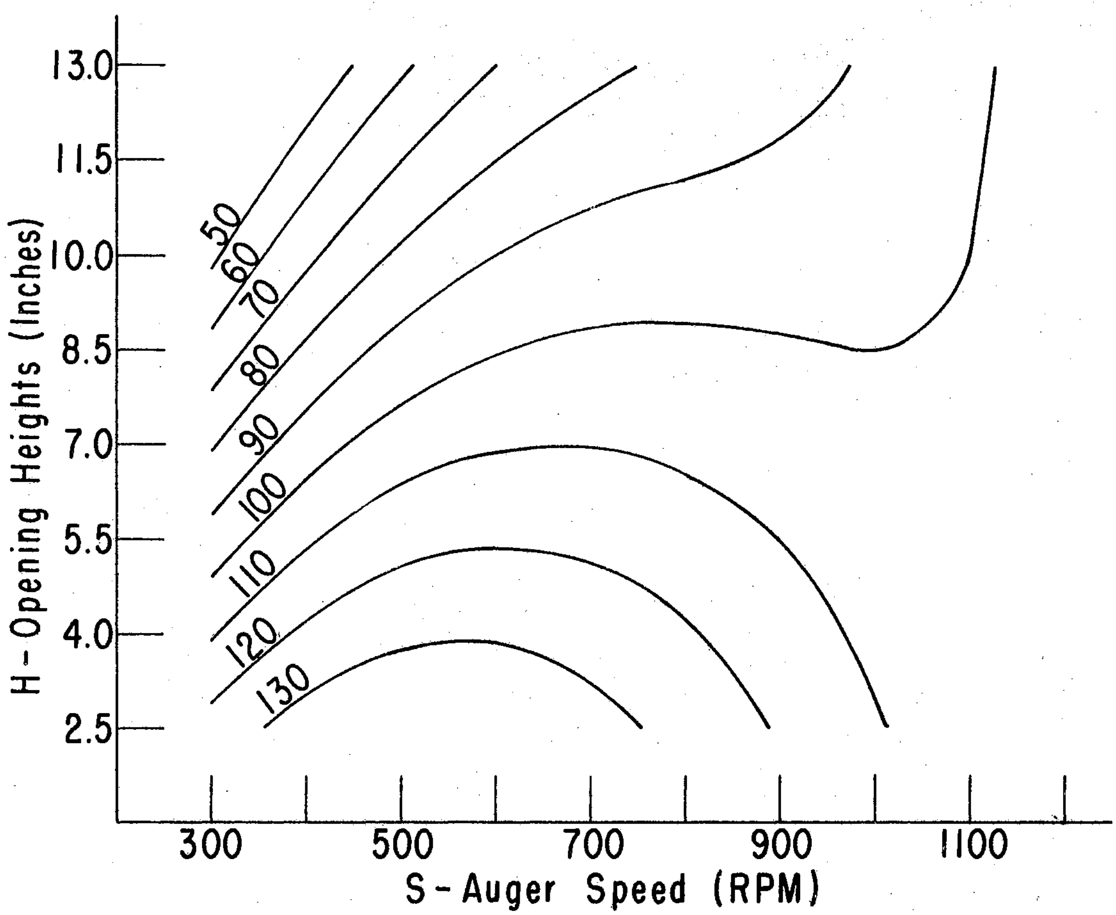


Figure 17. Pounds Conveyed Per Hour Per Square Inch of Entrance Opening Area as a Function of Opening Height and Auger Speed

Percent damaged = 1.46 + 0.00712 H − 0.00004187 S + 0.00000083179 S^2 − 0.00007043 HS

R = 0.9161

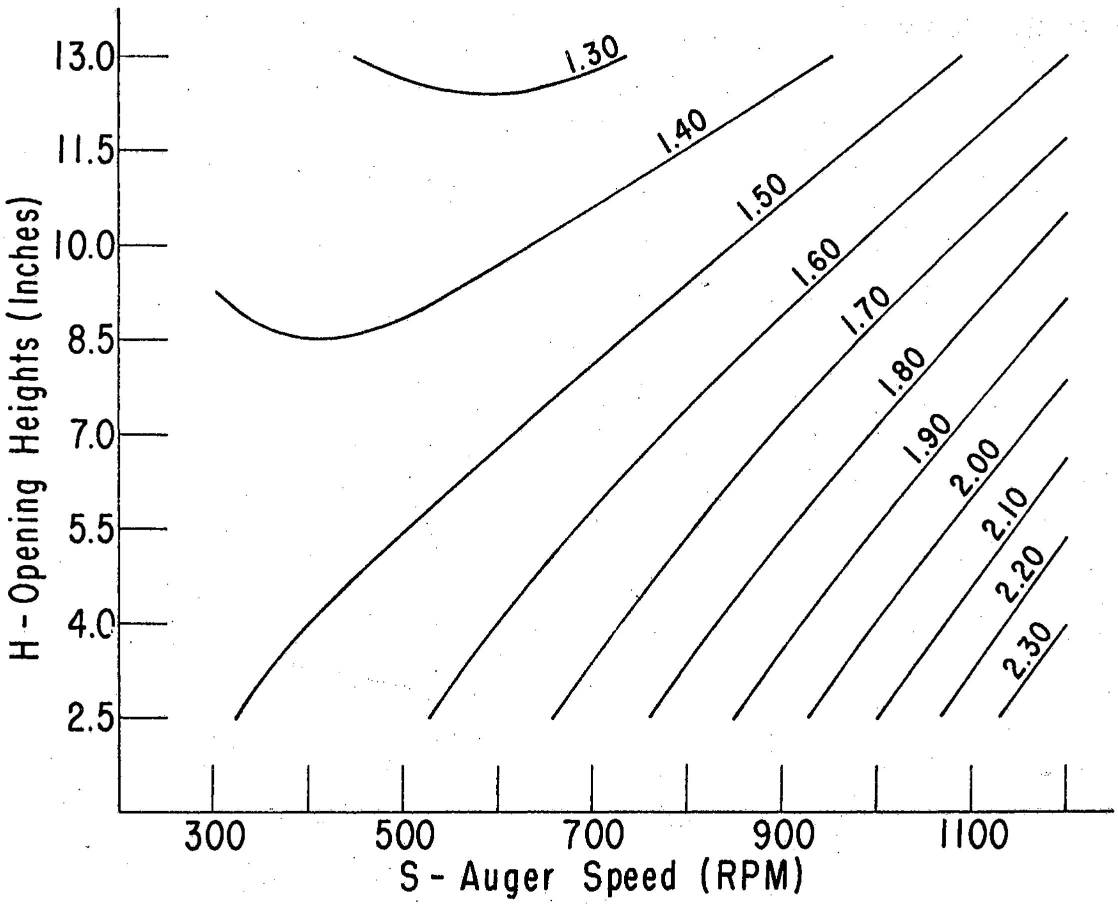


Figure 18. Percent of Total Sample Weight Damaged as a Function of Opening Height and Auger Speed

$$\text{Percent decorticated} = 11.95 - 0.3179\,H + 0.029066\,H^2 - 0.0034683\,S + 0.000004741\,S^2 - 0.0001787\,HS$$

$R = 0.6623$

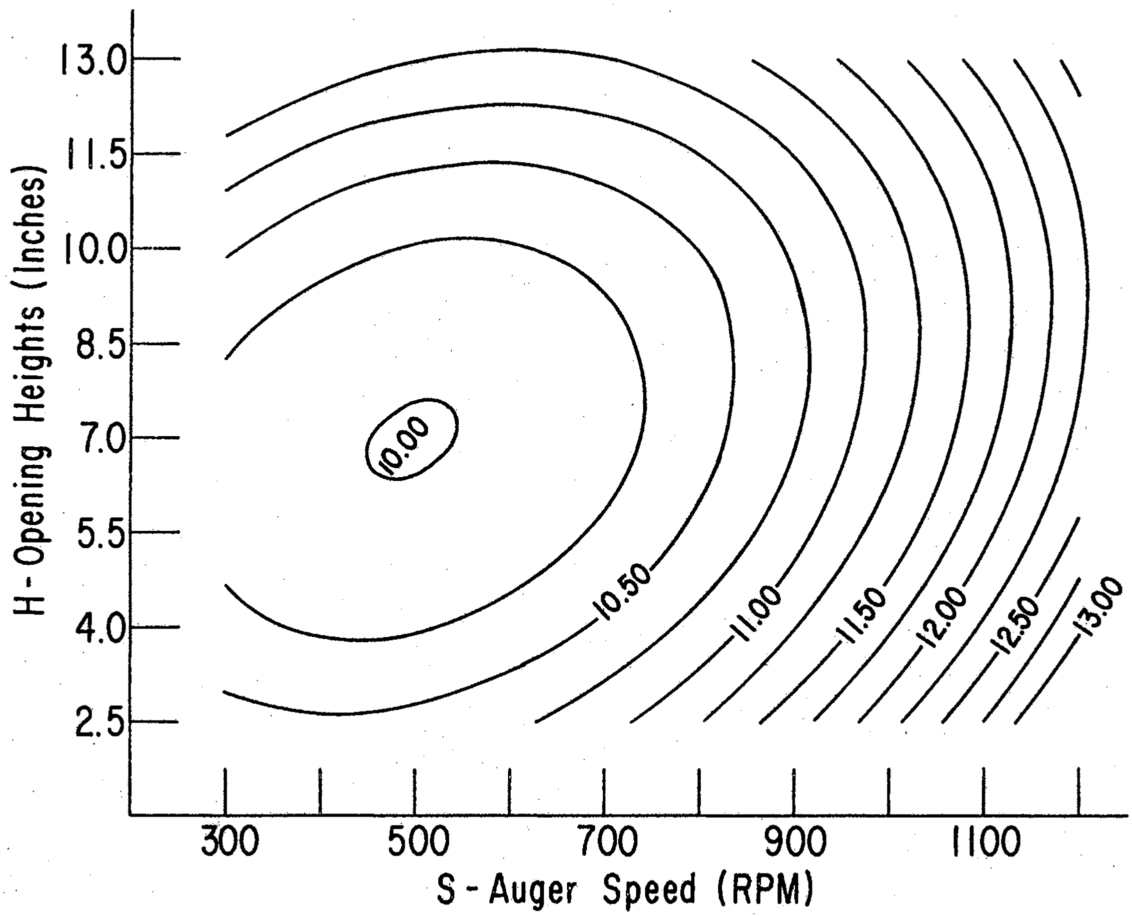


Figure 19. Percent Decorticated Seed in Damaged Material as a Function of Opening Height and Auger Speed

$$\text{Percent fragments} = 4.66 - 0.1359\,H + 0.02546\,H^2 + 0.004334\,S + 0.0000034427\,S^2 - 0.0006269\,HS$$

$R = 0.9501$

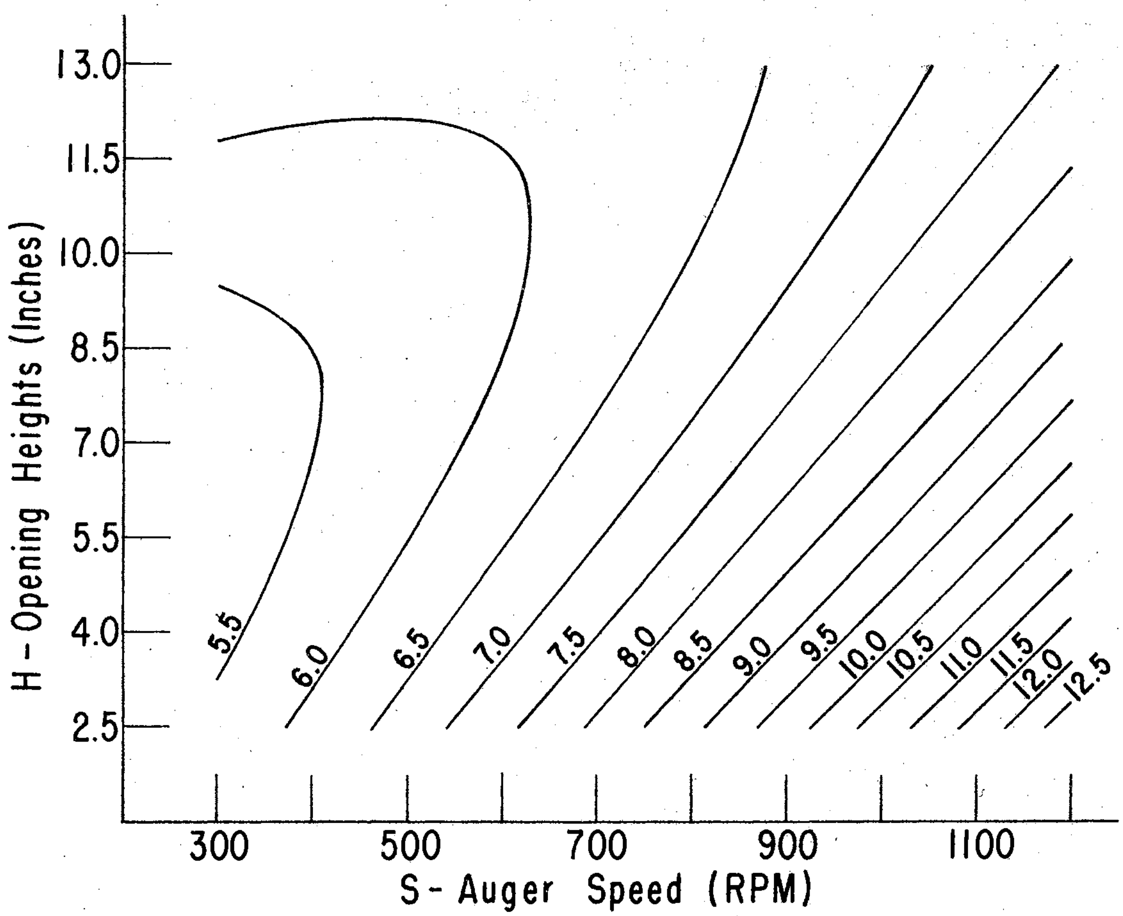


Figure 20. Percent Fragments in Damaged Material as a Function of Opening Height and Auger Speed

$$\text{Percent chipped} = 83.39 + 0.4540\ H - 0.054533\ H^2 - 0.0008628\ S - 0.0000081851\ S^2 + 0.00080547\ HS$$

$R = 0.9113$

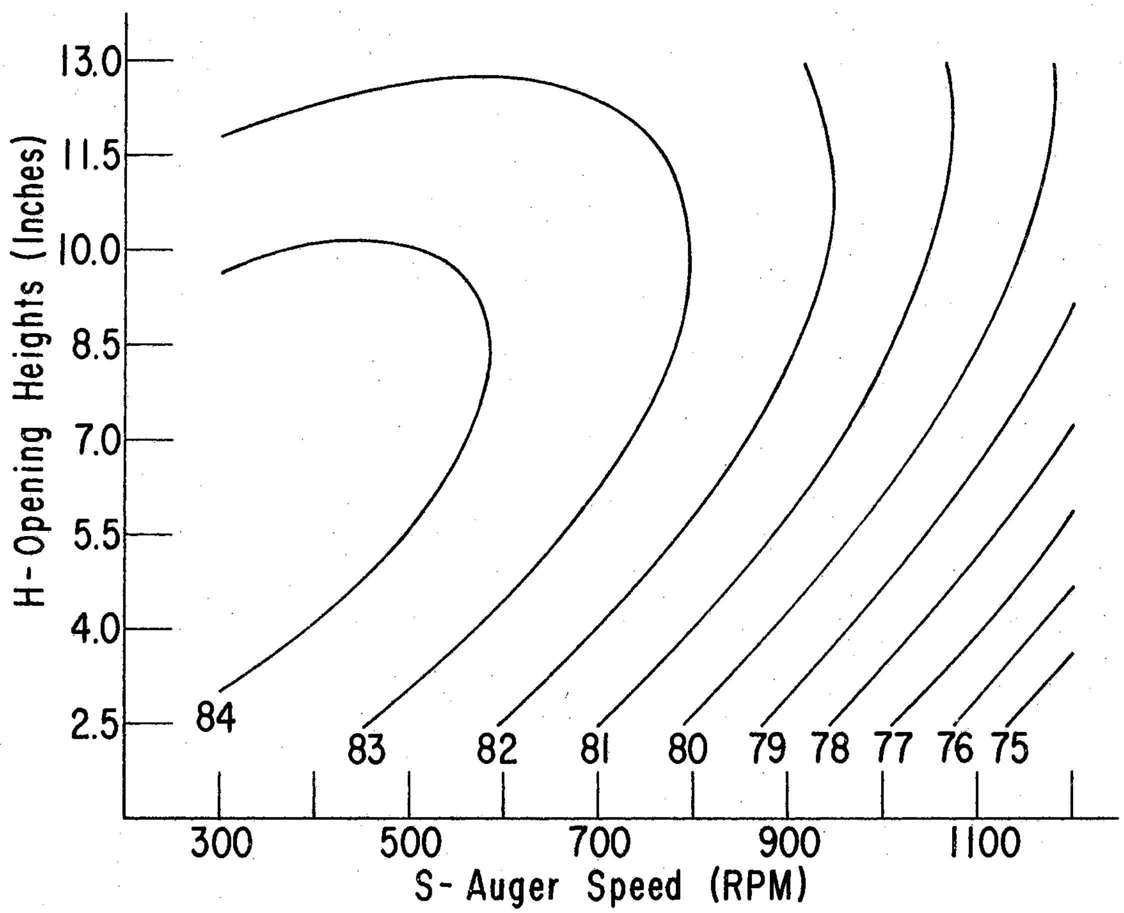


Figure 21. Percent Chipped Seed in Damaged Material as a Function of Opening Height and Auger Speed

$$\text{Lb./hr.} = -7497.13 + 108.2639\,\beta - 0.6046\,\beta^2 + 55.3059\,S - 0.058872\,S^2 + 0.0000199496\,S^3 - 0.0196682\,\beta S$$

$R = 0.9696$

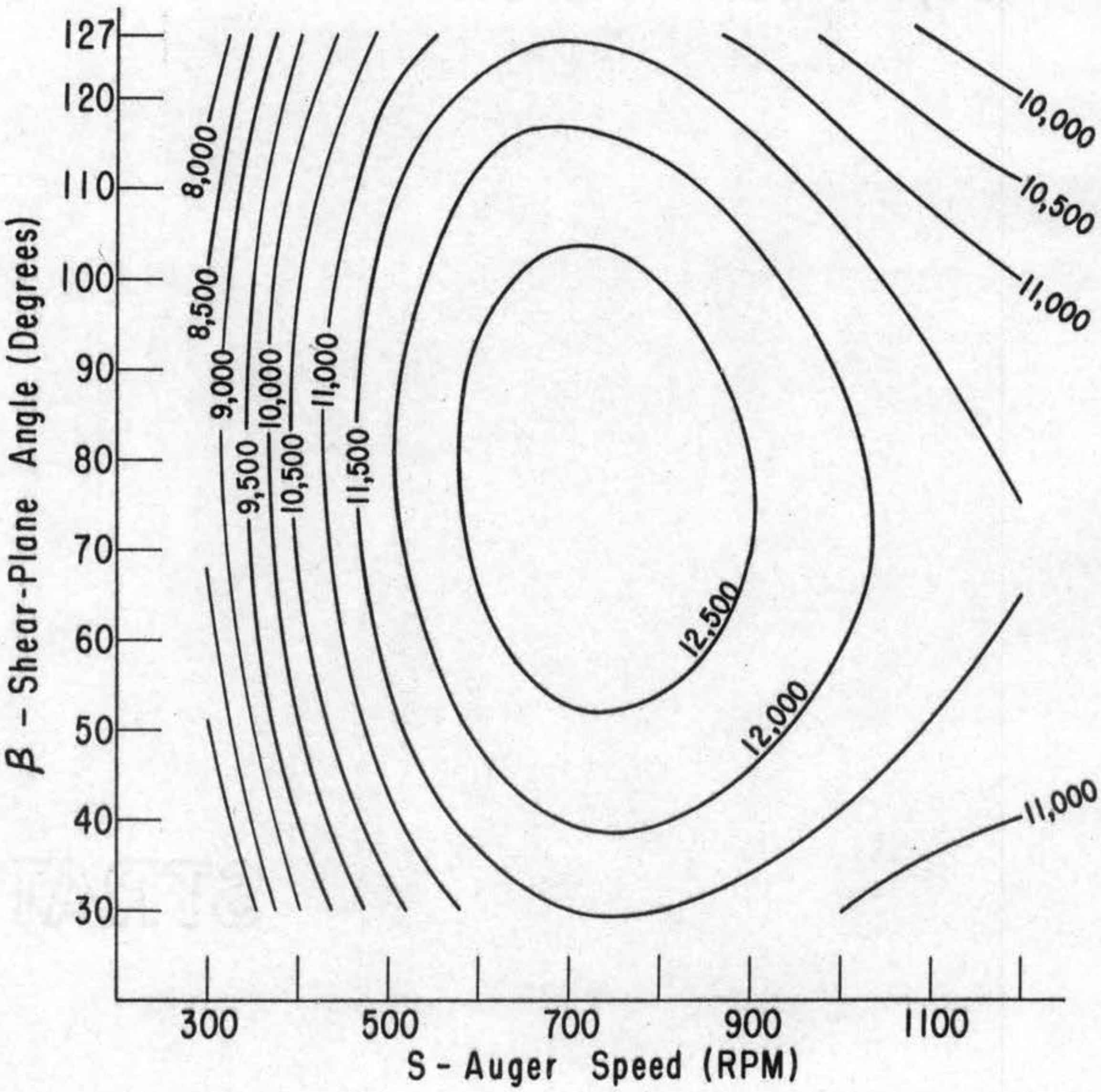


Figure 22. Pounds Conveyed Per Hour as a Function of Shear-Plane Angle and Auger Speed

$$\text{Lb./revolution} = 0.419 + 0.002818\,\beta - 0.000014308\,\beta^2 - 0.000281\,S - 0.0000006952\,\beta S$$

R = 0.9902

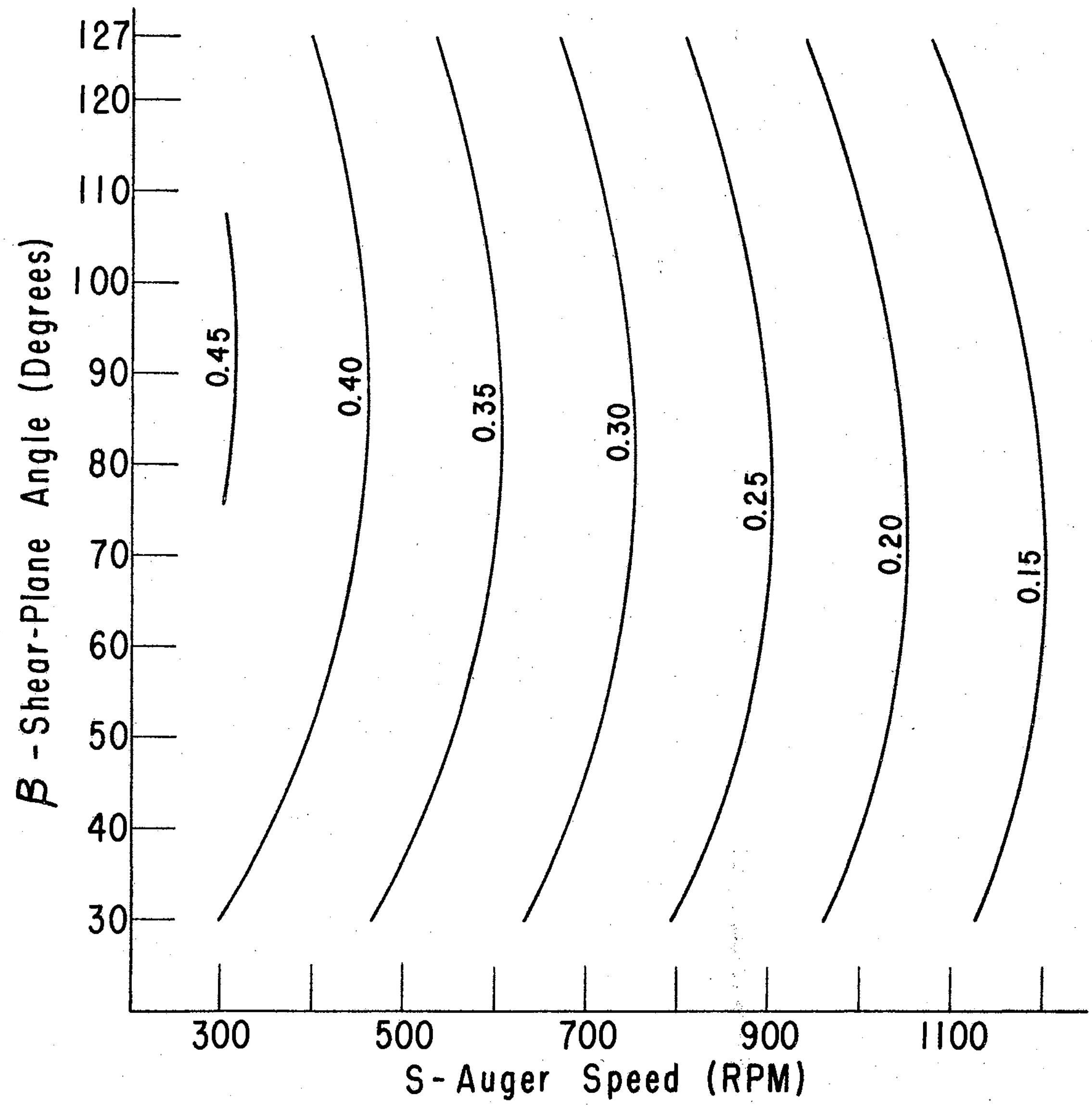


Figure 23. Pounds Conveyed Per Revolution as a Function of Shear-Plane Angle and Auger Speed

$$\text{Percent damaged} = 4.93 - 0.1356\beta + 0.0016044\,\beta^2 - 0.0000055667\,\beta^3 + 0.0007053\,S + 0.0000008519\,S^2 - 0.00001671\,\beta S$$

$R = 0.9652$

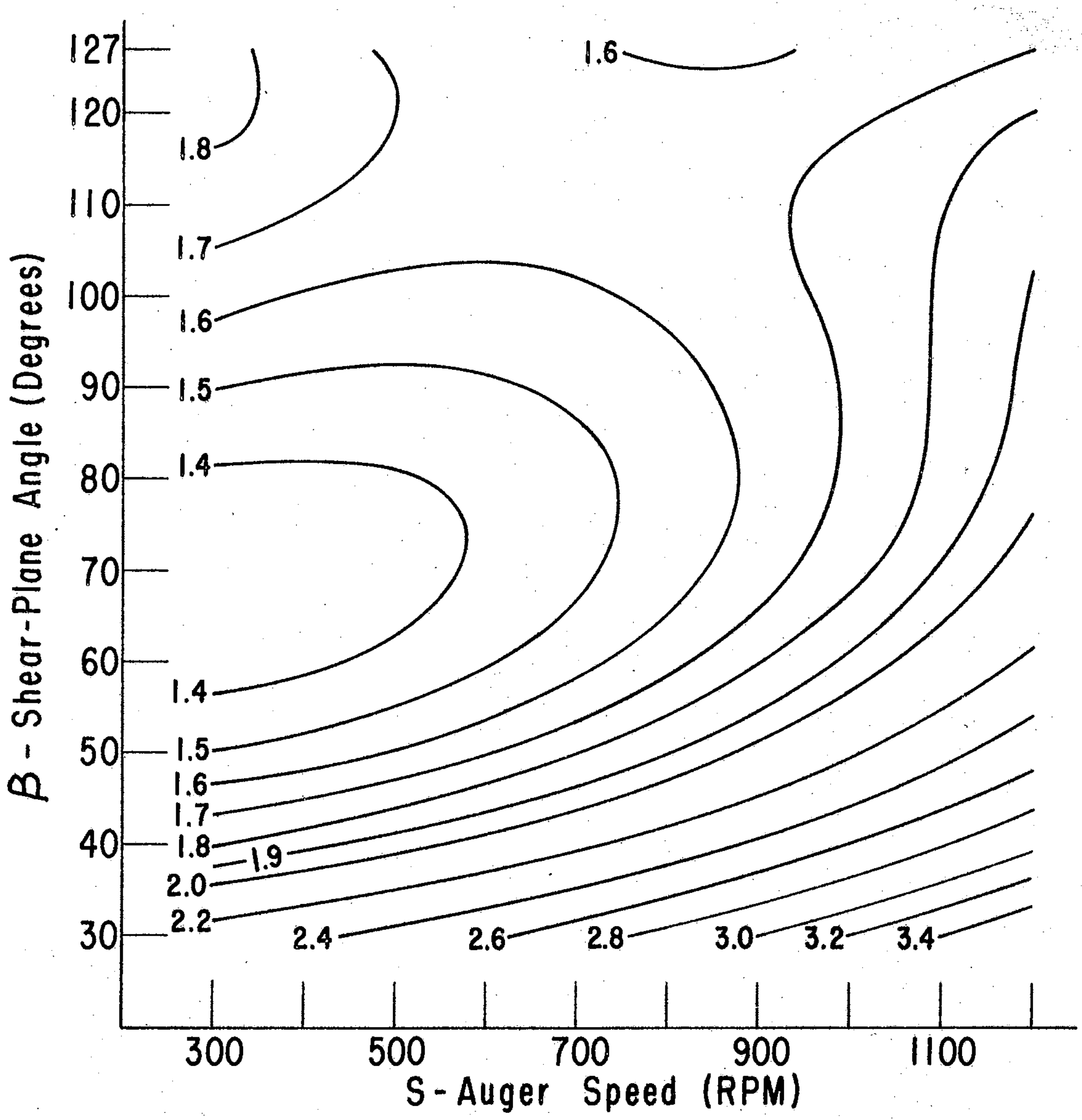


Figure 24. Percent of Total Sample Weight Damaged as a Function of Shear-Plane Angle and Auger Speed

$$\text{Percent decorticated} = 19.49 - 0.3185\,\beta + 0.0017857\,\beta^2 + 0.006555\,S - 0.00004255\,\beta S$$

$\underline{R = 0.9826}$

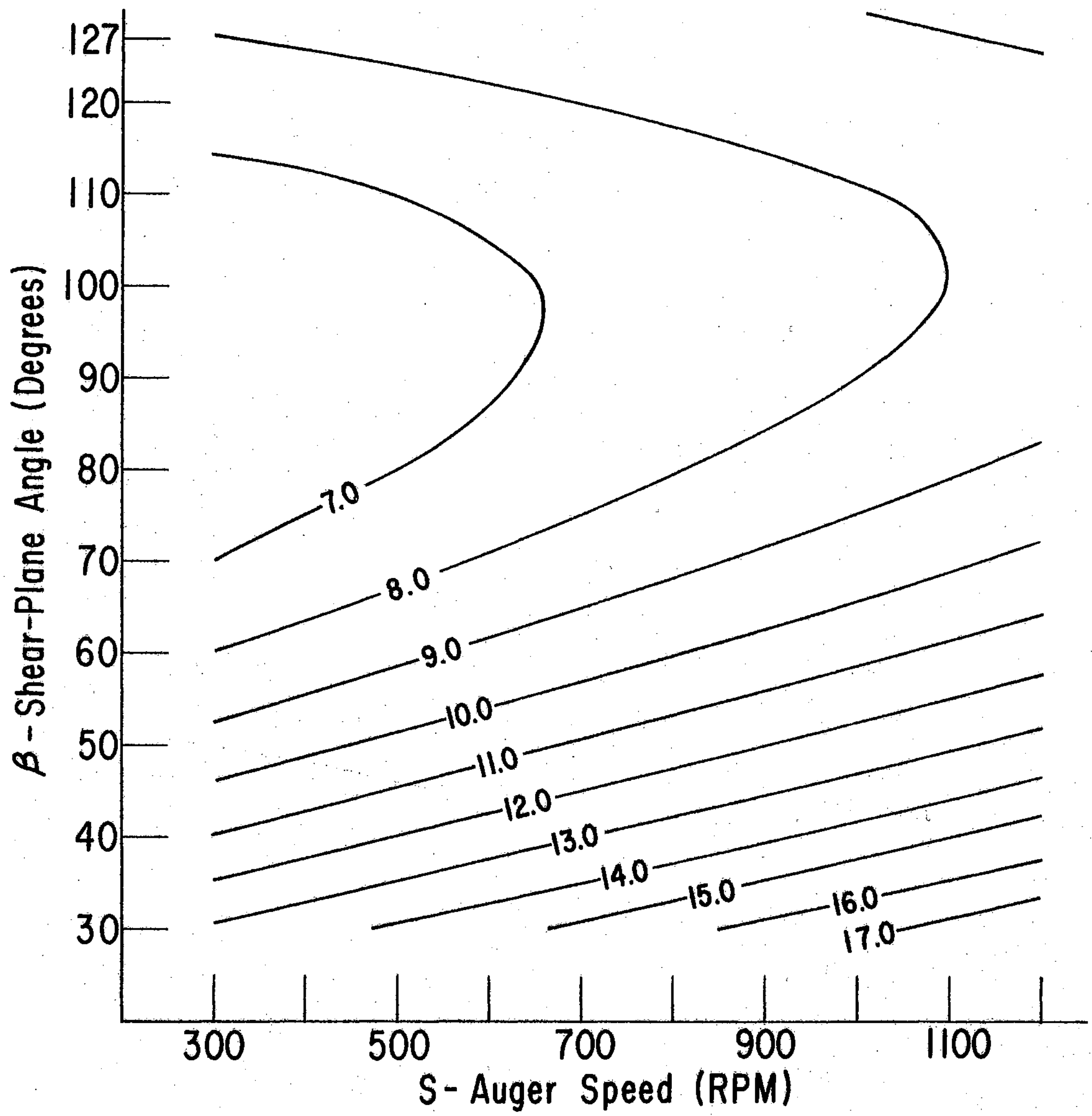


Figure 25. Percent Decorticated Seed in Damaged Material as a Function of Shear-Plane Angle and Auger Speed

Percent fragments $= 16.38 - 0.3252\,\beta + 0.0018448\,\beta^2 + 0.00682\,S - 0.000052238\,\beta S$

R = 0.9803

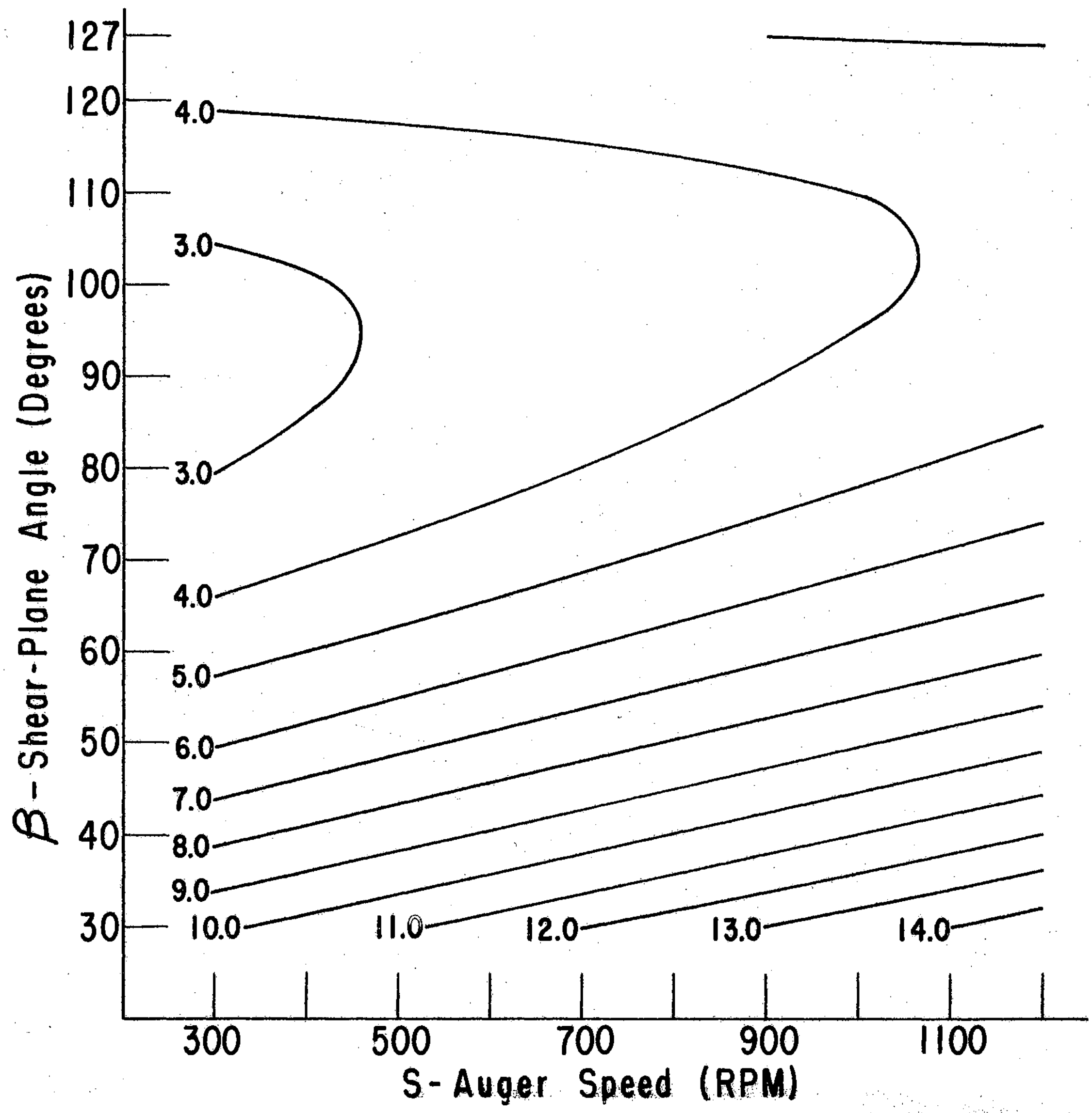


Figure 26. Percent Fragments in Damaged Material as a Function of Shear-Plane Angle and Auger Speed

Percent chipped = $64.13 + 0.6437\beta - 0.0036304\beta^2 - 0.01337\ S + 0.00009478\ \beta S$

R = 0.9844

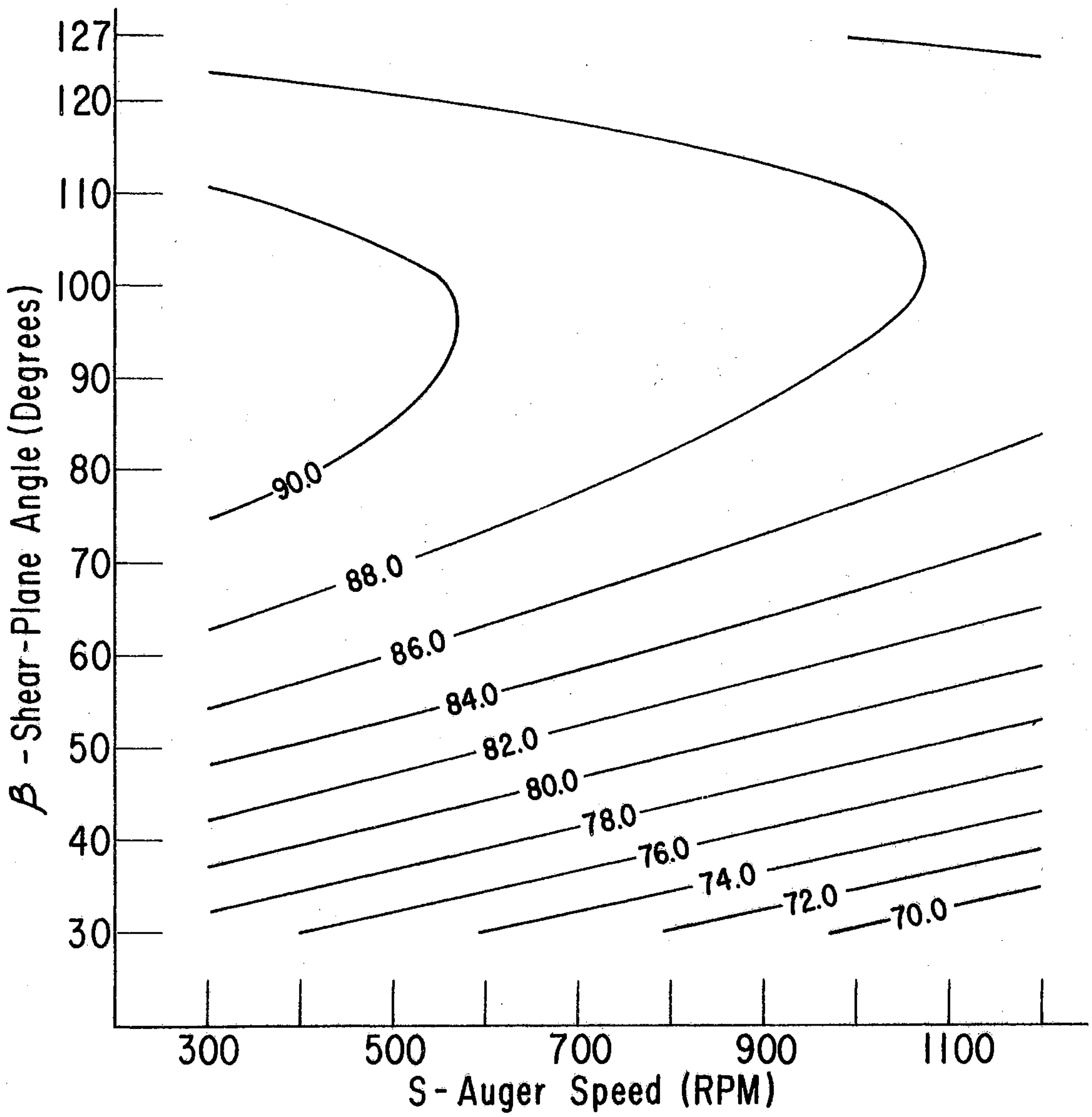


Figure 27. Percent Chipped Seed in Damaged Material as a Function of Shear-Plane Angle and Auger Speed

Opening height versus auger speed tests*:

$$\text{Cubic feet per hour} = 79.01 + 17.757\ H - 1.745\ H^2 + 0.1951\ S - 0.0002886\ S^2 + 0.05849\ HS\ .$$

$R = 0.9738$.

$$\text{Percent oil-bearing material damaged} = 1.47 + 0.00735\ H - 0.00004\ S + 0.000000836\ S^2 - 0.000071\ HS.$$

$R = 0.9161$.

Shear-plane angle versus auger speed tests**:

$$\text{Cubic feet per hour} = -239.84 + 3.4277\ \beta - 0.019205\ \beta^2 + 1.8082\ S - 0.0019278\ S^2 + 0.00000065416\ S^3 - 0.000632\ \beta S\ .$$

$R = 0.9684$.

$$\text{Pounds per hour per square inch opening area} = -83.65 + 1.2077\ \beta - 0.006744\ \beta^2 + 0.617\ S - 0.00065685\ S^2 + 0.0000002226\ S^3 - 0.0002194\ \beta S\ .$$

$R = 0.9696$.

$$\text{Percent oil-bearing material damaged} = 4.96 - 0.1366\ \beta + 0.0016174\ \beta^2 - 0.000005612\ \beta^3 + 0.0007\ S + 0.00000087\ S^2 - 0.00001688\ \beta S\ .$$

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*The symbol "H" is opening height in inches, "S" is the speed in RPM, and the "R's" are correlation coefficients.

**The symbol "β" is the shear-plane angle (Figure 7) in degrees and "S" is the speed in RPM.

$R = 0.9651$.

In addition to data previously mentioned, Appendix A contains original and summarized data for each observation of the entrance opening height versus auger speed test. The original and summarized data for each observation of the shear-plane angle versus auger speed test is presented in Appendix B.

Appendix C contains Electro-Mechanical Selector calibration data and Appendix D presents data collected in the analysis of the cleaned castor seed to determine the percentage of damaged seed prior to conveying.

CHAPTER VII

DISCUSSION OF RESULTS

The speed, opening height, and shear-plane angle means show the general trends obtained from the tests. The analysis of variance for the entrance opening height versus auger speed test shows that opening height was significant at the 99.5 percent level for all attributes except percent decorticated and percent chipped seed. Opening height was not significant at the 70 percent level for percent decorticated, but was significant at the 70 percent level for percent chipped seed. Auger speed was found to be significant at the 99.5 percent level for all attributes tested. The interaction term, (speed x opening height) was significant at that level for all attributes except percent decorticated and percent chipped seed. It was not significant at the 70 percent level for percent decorticated, but was significant at the 90 percent level for percent chipped seed. For the shear-plane angle versus auger speed tests the analysis of variance shows that both shear-plane angle and auger speed were significant at the 99.5 percent level for all attributes studied. The interaction term, (auger speed x shear-plane angle) was significant at the 99.5 percent level for all attributes except percent decorticated seed. For this attribute, the interaction term was significant at the 97.5 percent level.

Table VII (page 52) which compares results of the $5\frac{3}{16}$ inch opening height test to results of the 72.91 degree shear-plane angle test shows that the rate of conveying for the shear-plane test was higher than for the 5 3/16 inch opening height. Pounds per revolution and pounds per hour per square inch of opening area were also greater for the shear-plane test. The seed damage for the shear-plane test was not lower for all auger speeds than the seed damage for the 5 3/16 inch opening height. However, the mean damage for the 72.91 degree shear-plane (Table III, page 47) was lower than the mean damage for the 5 3/16 inch opening height (Table I, page 45). Possibly of more importance is the fact that percent decorticated and percent fragments were much less for the 72.91 degree shear-plane angle test than for the 5 3/16 inch opening height test. The comparison of these tests is made on the basis of equal entrance opening areas. If the 5 3/16 inch test is considered to have a shear-plane angle of 180 degrees, the trends established by the shear-plane angles as shown by Table III are continued.

The response surfaces in Figures 15, 16, and 17 (pp. 54-56) show the effect of opening height and auger speed on rate of conveying. The rate was expressed in terms of pounds per hour in Figure 15. This surface shows that for the smaller opening heights an increase in auger speed caused an increase in the rate of conveying to the point where a maximum rate was reached and that a further increase in auger speed caused a decrease in rate of conveying. This maximum rate of conveying was reached at a lower auger speed for the smaller opening heights than for the larger opening heights. For opening heights greater than approximately nine inches, a maximum rate of conveying was not reached at the maximum speed of 1200 RPM. For the largest opening height tested, which was approximately 13 inches, the slope of the response surface was steeper for the lower auger speeds than for the higher auger speeds. Increasing the entrance opening height for auger speeds in the range of 300 to 500 RPM caused an increase in rate of conveying up to a height of about $8\frac{1}{2}$ inches. As the entrance opening height was increased further, however, no increase in rate of conveying resulted for these auger speeds. For higher auger speeds, increasing the entrance opening height from $2\frac{1}{2}$ to 13 inches caused an increase in rate of conveying throughout the entire range. At these higher auger speeds, the slope of the response surface was steeper for the smaller opening heights than for the larger opening heights.

Figure 16 (page 55) shows the effect of entrance opening height and auger speed on the pounds conveyed per revolution of the auger. This attribute was affected by the load on the conveyor flighting and by the rotation of seed within the conveyor. This response surface clearly indicates that the largest amount of seed was conveyed per revolution of the auger at low auger speeds and large opening heights. It can be seen that the response surface slope was steeper for high speeds and small opening heights than for low speeds and large opening heights. A careful study of this response surface helps to explain the shape of the response surface for pounds per hour. For example: At the opening height of 13 inches, increasing the auger speed from 400 RPM to 800 RPM decreased the pounds conveyed per revolution from approximately 0.45 to 0.375. Since the increase in auger speed was much greater than the reduction in pounds per revolution, the rate of conveying (pounds per hour) increased. However, for the $2\frac{1}{2}$ inch opening height, increasing the auger speed from 400 RPM to 800 RPM decreased the pounds per revolution from approximately 0.28 to 0.14. Since doubling the speed decreased the pounds conveyed per revolution by one-half, the pounds per hour conveyed did not change.

Figure 17 (page 56) shows the effect of opening height and auger speed upon the pounds conveyed per hour per square inch of entrance opening area. This response surface slope was steep for the lower auger speeds, but flattened out at the higher auger speeds. Increasing the entrance opening height for the lower auger speeds caused the pounds per hour per square inch to decrease. This indicates that as the opening height was increased the entrance area increased faster than the pounds per revolution conveyed, as shown in Figure 16 (page 55). The net result was a decrease in pounds per hour per square inch. Since the response surface was relatively flat at the higher auger speeds, this indicates that the pounds conveyed per revolution of the auger increased sufficiently fast at the high speed to offset the rapid increase in entrance opening area.

Figure 18 (page 57) is the response surface for the percent of total sample weight damaged. This surface shows that more damage was caused with high auger speeds and small opening heights than with low auger speeds and large opening heights. The slope of the surface was much steeper for the small opening heights and high auger speeds than for the low auger speeds and large opening heights. The damaged seed in this attribute consisted of decorticated seed, fragments, and chipped seed.

Figure 19 (page 58) is the response surface for the percent decorticated seed in the damaged seed. The multiple regression equation from which this surface was plotted had a correlation coefficient of only 0.6623. However, since the analysis of variance indicated that speed was a significant source of variation for percent decorticated, the contour of the response surface in the speed plane should be fairly reliable. From this standpoint, the response surface indicates that low auger speeds had little effect, and high auger speeds had a greater effect on the percent of decorticated seed.

Figure 20 (page 59) is the response surface for the percent of fragments in the damaged seed. This response surface is very similar to that for percent of total sample weight damaged in that high auger speeds and small opening heights caused more fragments than low auger speeds and large opening heights. Again the slope of the response surface was much steeper for high auger speeds and small opening heights than for low auger speeds and large opening heights. The effects of opening height and auger speed were highly significant for the percent of fragments.

Figure 21 (page 60) is the response surface for the percent of chipped seed in the damaged seed. This response surface is similar to Figure 18 and Figure 20, with the exception that high auger speeds and small opening heights caused a smaller percent chipped seed than low auger speeds and large opening heights. This pattern should have been expected in view of the fact that decorticated seed, fragments, and chipped seed were added together to obtain the total amount of damaged seed. The level of significance for opening height was between 0.70 and 0.75 percent.

Figures 22 and 23 (pages 61 and 62) are response surfaces showing the effect of shear-plane angle and auger speed on rate of conveying. Figure 22 is the response surface for pounds per hour conveyed. A peak rate of conveying occurred at approximately 750 RPM and an 80 degree shear-plane angle. This angle was nearly the same as the shear-plane angle for housing number 4. This was the housing for which a line drawn perpendicular to the auger pitch angle bisected the angle at the upper point of the angular opening. The slope of this response surface was greatest on the low auger speed side of the peak. The slope of the response surface in the angular plane was about the same for angles larger or smaller than 80 degrees.

Figure 23 is the response surface for pounds conveyed per revolution. This surface indicates that shear-plane angle was of less importance than auger speed. Here again the pounds per revolution conveyed increased with an increase in shear-plane angle up to a maximum at approximately 80 degrees, and then decreased slightly as the angle was increased further. The slope of the response surface in the speed plane was fairly uniform with the largest pounds per revolution conveyed at the lowest auger speed.

Figure 24 (page 63) shows the effect of shear-plane angle and auger speed on the percent of total sample weight damaged. This response surface indicates that the largest percentage of damage occurred at the smallest shear-plane angle and the highest auger speed. For the lower speeds, the minimum damage occurred at a shear-plane angle of approximately 70 to 75 degrees. As the shear-plane angle was increased beyond 75 degrees, the percent of damaged seed increased slightly. The irregular shape of the response surface in the neighborhood of 110 to 120 degrees shear-plane angle and 500 to 900 RPM auger speed shows that small changes in angle or speed in this range did not greatly effect the percent of damaged seed. For the auger speed of 800 RPM, the shear-plane angle causing the least damage was approximately 80 degrees. This could have been due to increased rotation of the seed at the auger inlet which resulted in a different angle of approach of the seed to the shear-plane.

For the low auger speeds, the shear-plane angle causing the least damage was almost the same as the shear-plane angle of housing number 4. For high auger speeds, however, the damage decreased with an increase in shear-plane angle until the angle reached approximately 90 degrees. At this point, a further increase in shear-plane angle had little effect on seed damage.

Figures 25, 26, and 27 (pp. 64-66) are response surfaces for percent decorticated, percent fragments, and percent chipped seed in the damaged seed. These response surfaces are very similar in shape. For low auger speeds, the percent decorticated and percent fragments decreased as the shear-plane angle was increased to approximately 90 to 95 degrees. A further increase in shear-plane angle caused an increase in these attributes. For high auger speeds, the point of minimum damage shifted slightly to a larger shear-plane angle in the neighborhood of 100 to 105 degrees. The slopes of these response surfaces were steeper at high auger speeds and small shear-plane angles than elsewhere throughout the range of speed and angle. Figure 27, which is the response surface for percent chipped seed in the damaged seed, has the same general shape as percent decorticated and percent fragments except that the slopes are reversed.

CHAPTER VIII

CONCLUSIONS

1. Effect of auger speed and entrance opening height on capacity:
    (a) Increasing the auger speed increased the capacity of the conveyor up to a maximum. Further increases in speed caused a decrease in capacity. The auger speed at which the maximum rate of conveying was obtained was dependent upon the entrance opening height.
    (b) Increasing the auger speed decreased the amount of seed conveyed per revolution of the auger.
    (c) Increasing the entrance opening height increased the rate of conveying to where the rate of conveying leveled off. A further increase in opening height had little effect on rate.
    (d) Increasing the entrance opening height increased the amount of seed conveyed per revolution of the auger.
2. Effect of auger speed and entrance opening height on the percent of castor seed damaged:
    (a) Increasing the auger speed increased the seed damage. The damaged seed also contained a larger percentage of decorticated seed and fragments at high auger speeds than at low auger speeds.

(b) Decreasing the entrance opening height increased seed damage. This increase was more pronounced for high auger speeds than for low auger speeds.

(c) Changing the entrance opening height did not have a significant effect on the percentage of decorticated seed in the damaged seed, although small opening heights did result in a larger percentage of fragments and, consequently, a smaller percentage of chipped seed than large opening heights. These effects were more pronounced at high auger speeds.

3. Effect of auger speed and shear-plane angle on capacity:

(a) Increasing the auger speed caused a rapid increase in the rate of conveying until a maximum was obtained at approximately 750 RPM. A further increase in speed lowered the rate of conveying.

(b) Increasing the auger speed decreased the amount of seed conveyed per revolution.

(c) Increasing the shear-plane angle increased the rate of conveying up to an angle of approximately 80 degrees. A further increase in shear-plane angle decreased the rate of conveying. The shear-plane angle resulting in the maximum rate of conveying corresponded closely to the shear-plane angle present when the shear-plane orientation was such that a seed traveling perpendicular to the periphery of the auger flighting bisected the angle formed by the upper point of the entrance opening.

(d) The maximum amount of seed was delivered per revolution of the auger for a shear-plane angle of approximately 80 degrees.

4. Effect of auger speed and shear-plane angle on seed damage:

   (a) Increasing the auger speed caused an increase in seed damage for shear-plane angles up to approximately 100 degrees. Beyond this shear-plane angle, speed was of little importance.

   (b) Increasing the auger speed caused an increase in the percent decorticated and percent fragments in the damaged seed and a decrease in the percent chipped seed. These differences were more pronounced for small shear-plane angles than for large shear-plane angles.

   (c) Increasing the shear-plane angle for auger speeds in the range of 300 to 900 RPM resulted in a decrease in seed damage until a minimum was reached at approximately 70 to 80 degrees. Further increase in the shear-plane angle for these speeds resulted in a slight increase in seed damage. The angle giving the minimum seed damage corresponded closely to the shear-plane angle present when the shear-plane orientation was such that a seed traveling perpendicular to the periphery of the auger flighting bisected the angle formed by the upper point of the entrance opening. Increasing the shear-plane angle for auger speeds from 900 to 1200 RPM resulted in decreased seed damage until an angle of approximately 90 degrees was reached. At this point, the damage leveled off and a further increase in angle had little effect on seed damage.

(d) The percent of decorticated seed and percent of fragments was a minimum at a shear-plane angle of approximately 100 degrees and increased to either side of this angle. The percent of chipped seed was a maximum at a shear-plane angle of approximately 100 degrees.

5. Comparison of 5 3/16 inch opening height to 72.91 degree shear-plane angle:

(a) The rate of conveying, pounds per revolution, and pounds per hour per square inch of opening area were greater for the 72.91 degree shear-plane test than for the 5 3/16 inch opening height test at all auger speeds.

(b) The mean seed damage was less for the 72.91 degree shear-plane test than for the 5 3/16 inch opening height test.

(c) The percent decorticated and percent fragments were less for the 72.91 degree shear-plane test than for the 5 3/16 inch opening height test at all auger speeds.

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APPENDIX A

ENTRANCE OPENING HEIGHT VERSUS AUGER SPEED DATA

DATA SHEET A-I

ATTRIBUTE MEANS FOR MULTIPLE REGRESSION ANALYSIS OF OPENING HEIGHT VERSUS AUGER SPEED TEST

Opening Height (Inches)	Auger Speed (RPM)	Pounds per Hour	Cubic Feet per Hour	Pounds per Revolution	Pounds per Hour per Sq. In. Opening Area	Percent Total Sample Weight Damaged	Percent Oil-bearing Material Damaged	Separation of Damaged Seed into Fractions: Percent Decorticated	Percent Fragments	Percent Chipped
2.59375	306	5751	187.17	0.314	128.31	1.64	1.65	9.33	5.45	85.21
2.59375	459	6952	229.87	0.253	155.11	1.51	1.51	10.47	5.76	83.76
2.59375	597	6486	211.08	0.181	144.72	1.48	1.48	9.90	7.45	82.65
2.59375	754	5622	182.82	0.124	125.43	1.73	1.74	10.22	8.43	81.34
2.59375	898	5024	163.87	0.093	112.10	1.89	1.90	11.46	10.20	78.34
2.59375	1048	4445	144.91	0.071	99.17	2.33	2.34	12.72	11.11	76.18
2.59375	1203	4637	153.43	0.064	103.47	2.54	2.56	14.65	12.64	72.71
5.18750	305	7780	252.86	0.426	86.79	1.46	1.47	11.39	5.83	82.78
5.18750	452	10224	332.28	0.377	114.06	1.58	1.59	10.68	5.25	84.07
5.18750	590	11463	373.81	0.324	127.88	1.37	1.38	13.34	6.45	80.22
5.18750	742	10645	347.23	0.239	118.76	1.65	1.65	10.36	6.79	82.85
5.18750	892	10060	334.12	0.188	112.22	1.66	1.67	10.56	8.22	81.23
5.18750	1051	9732	317.48	0.154	108.56	1.86	1.87	11.38	9.58	79.05
5.18750	1198	8659	282.77	0.120	96.60	2.40	2.41	12.61	11.36	76.02
7.78125	304	8212	266.40	0.449	61.07	1.36	1.37	10.44	6.17	83.39
7.78125	456	11321	369.25	0.414	84.20	1.51	1.52	8.68	6.22	85.10
7.78125	607	14023	257.20	0.386	104.29	1.58	1.58	11.06	6.16	82.78
7.78125	760	14021	457.40	0.308	104.28	1.65	1.66	8.33	7.17	84.50
7.78125	902	14628	476.16	0.271	108.79	1.78	1.79	9.45	8.09	82.46
7.78125	1049	14577	476.77	0.232	108.41	1.54	1.54	11.73	9.41	78.87
7.78125	1203	15538	507.29	0.215	115.56	1.88	1.89	11.14	8.55	80.31
10.37500	305	7960	262.04	0.434	44.40	1.45	1.46	10.70	5.32	83.98
10.37500	457	11008	367.88	0.402	61.40	1.34	1.34	10.10	5.76	84.14
10.37500	607	15272	504.16	0.420	85.19	1.39	1.39	10.29	5.94	83.77
10.37500	754	16497	540.40	0.365	92.01	1.50	1.51	10.60	5.15	84.25
10.37500	899	16253	540.09	0.302	90.66	1.62	1.62	12.37	6.02	81.60
10.37500	1054	20160	662.95	0.319	112.45	1.52	1.52	11.64	7.22	81.13
10.37500	1203	17762	581.85	0.246	99.07	1.77	1.77	11.49	7.49	81.02
12.96875	302	8104	264.96	0.447	36.16	1.24	1.25	10.73	5.49	83.77
12.96875	451	12689	412.94	0.470	56.62	1.06	1.07	11.33	7.24	81.43
12.96875	603	16074	529.16	0.444	71.73	1.37	1.37	10.25	5.73	84.02
12.96875	756	17188	560.47	0.379	76.70	1.42	1.43	12.16	6.18	81.65
12.96875	898	18909	618.88	0.351	84.38	1.54	1.54	10.32	6.72	82.97
12.96875	1049	20008	652.42	0.318	89.29	1.44	1.44	12.50	7.98	79.51
12.96875	1200	23557	765.91	0.327	105.12	1.61	1.62	13.11	7.95	78.95

DATA SHEET A-II

SUMMARY OF DATA FROM OPENING HEIGHT VERSUS AUGER SPEED TEST - BLOCK I

			Rate of Conveying				Seed Damage				
									Separation of Damaged Seed into Fractions		
Opening Height (Inches)	Actual Auger Speed (RPM)	Seed Density (Lb. per cu. ft.)	Pounds per Hour	Cubic Feet per Hour	Pounds per Revolution	Pounds per Hour per Sq. In. Opening Area	Percent Total Sample Weight Damaged	Percent Oil-bearing Material Damaged	Percent Decorticated	Percent Fragments	Percent Chipped
CHECK 1		29.3125					1.298	1.303	12.297	5.093	82.610
2.59375	309	30.7813	6000	194.92	0.32415	133.87	1.528	1.532	12.981	5.593	81.426
2.59375	456	29.8438	7038	235.83	0.25707	157.03	1.311	1.315	12.195	6.871	80.934
2.59375	620	30.5313	6648	217.74	0.17857	148.33	1.466	1.470	11.457	7.576	80.967
2.59375	755	30.8125	5701	185.02	0.12579	127.20	1.663	1.669	12.662	8.697	78.641
2.59375	891	30.3750	5556	182.91	0.10390	123.96	1.565	1.571	14.888	9.975	75.137
2.59375	1048	30.7813	4734	153.79	0.07526	105.62	2.260	2.267	15.150	12.107	72.743
2.59375	1197	30.6250	4511	147.30	0.06279	100.65	2.449	2.458	16.619	14.302	69.079
5.18750	303	30.5313	8163	267.36	0.44944	91.06	1.289	1.292	9.713	6.051	84.236
5.18750	460	30.5625	11429	373.96	0.41451	127.50	1.359	1.364	12.919	3.606	83.475
5.18750	571	30.5625	11429	373.96	0.33333	127.50	1.357	1.361	11.657	6.460	81.883
5.18750	760	30.7188	11111	361.70	0.24361	123.95	1.443	1.445	11.422	6.837	81.741
5.18750	896	30.6250	10084	329.27	0.18762	112.49	1.641	1.646	10.638	8.663	80.699
5.18750	1050	30.7188	9959	324.20	0.15810	111.10	1.813	1.820	11.485	10.601	77.914
5.18750	1192	30.7500	9023	293.43	0.12618	100.66	2.208	2.214	12.807	12.632	74.561
7.78125	313	31.1875	9375	300.60	0.50000	69.72	1.140	1.142	12.352	7.293	80.355
7.78125	462	30.7500	11940	388.29	0.43103	88.80	1.248	1.250	10.618	7.027	82.355
7.78125	629	30.4375	13714	450.56	0.36364	101.99	1.373	1.376	16.054	7.688	76.258
7.78125	753	30.5625	14634	478.82	0.32389	108.84	1.282	1.284	10.028	9.202	80.770
7.78125	896	30.7500	17143	557.50	0.31898	127.50	1.375	1.378	12.082	8.789	79.129
7.78125	1052	30.2500	13636	450.78	0.21598	101.41	1.474	1.479	11.574	11.919	76.507
7.78125	1206	30.2500	13559	448.23	0.18744	100.84	1.836	1.843	10.789	10.894	78.317
10.37500	310	30.8750	8664	280.62	0.46512	48.33	1.571	1.574	9.439	5.391	85.170
10.37500	452	30.1875	11538	382.21	0.42553	64.36	1.244	1.246	10.735	6.429	82.836
10.37500	617	30.6563	15584	508.35	0.42105	86.93	1.100	1.101	12.640	7.223	80.137
10.37500	765	30.6875	15686	511.15	0.34188	87.49	1.393	1.397	13.298	6.078	80.624
10.37500	893	30.5625	16667	545.34	0.31104	92.97	1.462	1.467	13.132	6.071	80.797
10.37500	1053	31.0313	22857	736.58	0.36166	127.49	1.572	1.576	10.730	6.737	82.533
10.37500	1218	30.2813	16327	539.18	0.22346	91.07	1.828	1.834	12.278	8.362	79.360
12.96875	304	30.8438	8362	271.11	0.45872	37.31	1.137	1.139	10.932	6.291	82.777
12.96875	459	30.9063	13115	424.35	0.47619	58.52	1.040	1.041	10.657	7.505	81.838
12.96875	614	30.6875	16327	532.04	0.44346	72.86	1.142	1.145	10.305	7.351	82.344
12.96875	768	30.7813	17391	564.99	0.37736	77.60	1.345	1.348	14.534	7.282	78.184
12.96875	905	30.7188	21818	710.25	0.40201	97.36	1.325	1.328	13.225	8.092	78.683
12.96875	1055	30.6875	20000	651.73	0.31596	89.25	1.375	1.379	10.850	8.829	80.321
12.96875	1198	30.9375	25000	808.08	0.34783	111.56	1.502	1.508	13.578	8.828	77.594

DATA SHEET A-II (Continued)

SUMMARY OF DATA FROM OPENING HEIGHT VERSUS AUGER SPEED TEST - BLOCK II

			Rate of Conveying				Seed Damage				
Opening Height (Inches)	Actual Auger Speed (RPM)	Seed Density (Lb. per cu. ft.)	Pounds per Hour	Cubic Feet per Hour	Pounds per Revolution	Pounds per Hour per Sq. In. Opening Area	Percent Total Sample Weight Damaged	Percent Oil-bearing Material Damaged	Separation of Damaged Seed into Fractions: Percent Decorticated	Percent Fragments	Percent Chipped
CHECK 2		30.9688					1.053	1.056	14.800	4.333	80.867
2.59375	302	30.5313	5811	190.33	0.32103	129.65	1.222	1.224	9.620	6.384	83.996
2.59375	461	30.3750	7038	231.70	0.25445	157.03	1.291	1.293	11.923	6.672	81.405
2.59375	592	30.5625	6593	215.72	0.18570	147.10	1.182	1.185	10.748	8.869	80.383
2.59375	756	30.6250	5543	181.00	0.12225	123.67	1.587	1.590	9.988	10.317	79.695
2.59375	901	30.8438	4829	156.56	0.08937	107.74	2.122	2.131	11.059	11.146	77.795
2.59375	1044	30.7188	4554	148.25	0.07273	101.61	2.264	2.276	12.253	10.211	77.536
2.59375	1204	30.1563	4898	162.42	0.06777	109.28	2.284	2.295	15.076	12.979	71.945
5.18750	305	30.5625	7385	241.64	0.40404	82.39	1.284	1.285	17.098	7.799	75.103
5.18750	461	31.0000	10084	325.29	0.36430	112.49	1.244	1.246	14.063	7.665	78.272
5.18750	599	30.7813	10959	356.03	0.30488	122.26	1.063	1.065	17.880	8.362	73.758
5.18750	724	30.5000	10345	339.18	0.23810	115.41	1.584	1.588	12.833	8.298	78.869
5.18750	893	29.1875	10300	352.89	0.19231	114.90	1.342	1.346	13.482	9.597	76.921
5.18750	1053	30.5313	10213	334.51	0.16168	113.93	1.719	1.724	13.092	9.450	77.458
5.18750	1202	30.7500	8955	291.22	0.12415	99.90	2.179	2.185	14.903	10.979	74.118
7.78125	298	30.5000	7619	249.80	0.42553	56.66	1.023	1.026	12.936	7.267	79.797
7.78125	439	30.4688	10860	356.43	0.41237	80.77	1.334	1.338	9.254	6.570	84.176
7.78125	610	30.4063	13260	436.09	0.36232	98.62	1.511	1.514	9.211	6.836	83.953
7.78125	766	30.6250	13793	450.38	0.30030	102.58	1.790	1.796	8.009	6.416	85.575
7.78125	907	30.5313	13333	436.70	0.24510	99.16	1.807	1.811	9.528	8.940	81.532
7.78125	1050	30.8125	15894	515.83	0.25221	118.21	1.311	1.314	14.896	8.354	76.750
7.78125	1203	30.9375	17266	558.09	0.23923	128.41	1.605	1.609	13.717	8.600	77.683
10.37500	301	30.2813	7921	261.58	0.43860	44.18	1.164	1.166	13.585	5.708	80.707
10.37500	469	29.7813	10959	367.98	0.38911	61.13	1.311	1.319	8.543	5.799	85.658
10.37500	615	29.3750	13793	469.55	0.37383	76.94	1.085	1.088	12.989	7.856	79.155
10.37500	766	30.4688	16783	550.83	0.36496	93.61	1.262	1.266	12.076	5.828	82.096
10.37500	911	29.6250	15190	512.74	0.27778	84.73	1.162	1.165	17.719	8.455	73.826
10.37500	1054	29.9375	21622	722.24	0.34188	120.60	1.153	1.155	15.820	8.966	75.214
10.37500	1201	30.7813	17910	581.85	0.24845	99.90	1.458	1.461	14.225	8.787	76.988
12.96875	301	30.3750	7843	258.21	0.43478	35.00	1.102	1.104	14.482	5.986	79.532
12.96875	437	30.8438	13187	427.54	0.50251	58.84	0.989	0.990	17.660	8.031	74.309
12.96875	613	30.2813	16000	528.38	0.43478	71.40	1.269	1.274	14.396	5.884	79.720
12.96875	762	30.6563	17391	567.29	0.38023	77.60	1.206	1.210	15.961	6.415	77.624
12.96875	899	30.1250	17391	577.29	0.32258	77.60	1.464	1.468	10.618	7.120	82.262
12.96875	1049	30.5625	19512	638.43	0.31008	87.07	1.298	1.302	17.647	8.864	73.489
12.96875	1205	30.2813	21429	707.66	0.29630	95.62	1.435	1.438	16.804	8.778	74.418

DATA SHEET A-II (Continued)

SUMMARY OF DATA FROM OPENING HEIGHT VERSUS AUGER SPEED TEST - BLOCK III

Opening Height (Inches)	Actual Auger Speed (RPM)	Seed Density (Lb. per cu. ft.)	Rate of Conveying: Pounds per Hour	Rate of Conveying: Cubic Feet per Hour	Rate of Conveying: Pounds per Revolution	Rate of Conveying: Pounds per Hour per Sq. In. Opening Area	Seed Damage: Percent Total Sample Weight Damaged	Seed Damage: Percent Oil-bearing Material Damaged	Separation of Damaged Seed into Fractions: Percent Decorticated	Separation of Damaged Seed into Fractions: Percent Fragments	Separation of Damaged Seed into Fractions: Percent Chipped
CHECK 3		30.4063					1.929	1.936	4.522	3.274	92.204
2.59375	306	30.8750	5442	176.26	0.29674	121.42	2.182	2.190	5.400	4.381	90.219
2.59375	459	30.5313	6780	222.07	0.24600	151.27	1.919	1.926	7.303	3.747	88.950
2.59375	578	31.1250	6218	199.78	0.17937	138.73	1.781	1.785	7.502	5.896	86.602
2.59375	750	30.8125	5621	182.43	0.12484	125.41	1.947	1.955	8.024	6.285	85.691
2.59375	902	30.8125	4688	152.15	0.08658	104.60	1.984	1.990	8.430	9.471	82.099
2.59375	1051	30.5000	4047	132.69	0.06418	90.29	2.465	2.479	10.751	11.002	78.247
2.59375	1208	29.9063	4503	150.57	0.06213	100.47	2.901	2.915	12.244	10.650	77.106
5.18750	306	31.2188	7792	249.59	0.42463	86.93	1.814	1.818	7.370	3.629	89.001
5.18750	434	30.7813	9160	297.58	0.35149	102.19	2.145	2.150	5.060	4.467	90.473
5.18750	599	30.6563	12000	391.44	0.33389	133.87	1.697	1.701	10.470	4.520	85.010
5.18750	742	30.7500	10480	340.81	0.23529	116.91	1.916	1.921	6.836	5.229	87.935
5.18750	887	30.5938	9796	320.20	0.18416	109.28	1.997	2.005	7.546	6.394	86.060
5.18750	1050	30.7188	9023	293.73	0.14327	100.66	2.047	2.051	9.557	8.576	81.767
5.18750	1201	30.3438	8000	263.65	0.11105	89.25	2.821	2.836	10.127	10.482	79.391
7.78125	302	30.7188	7643	248.81	0.42194	56.84	1.922	1.928	6.042	3.937	90.021
7.78125	467	30.7500	11163	363.02	0.39841	83.02	1.962	1.968	6.178	5.064	88.758
7.78125	582	31.1250	15094	484.95	0.43197	112.26	1.846	1.854	7.916	3.958	88.126
7.78125	760	30.7813	13636	443.00	0.29895	101.41	1.883	1.886	6.946	5.887	87.167
7.78125	903	30.8750	13408	434.27	0.24752	99.72	2.165	2.171	6.731	6.555	86.714
7.78125	1045	30.6250	14201	463.71	0.22650	105.62	1.826	1.836	8.709	7.951	83.340
7.78125	1199	30.6250	15789	515.56	0.21954	117.43	2.199	2.207	8.923	6.156	84.921
10.37500	305	29.9063	7295	243.93	0.39841	40.69	1.625	1.631	9.079	4.854	86.067
10.37500	449	29.7813	10526	353.44	0.39063	58.71	1.450	1.455	11.024	5.050	83.926
10.37500	590	30.7500	16438	534.57	0.46404	91.69	1.987	1.992	5.227	2.749	92.024
10.37500	732	30.4375	17021	559.21	0.38760	94.94	1.851	1.859	6.427	3.535	90.038
10.37500	892	30.0625	16901	562.20	0.31596	94.27	2.227	2.238	6.269	3.546	90.185
10.37500	1055	30.1875	16000	530.02	0.25284	89.25	1.822	1.828	8.379	5.968	85.653
10.37500	1190	30.5000	19048	624.52	0.26667	106.25	2.016	2.023	7.971	5.326	86.703
12.96875	302	30.5313	8108	265.56	0.44743	36.18	1.492	1.496	6.779	4.206	89.015
12.96875	456	30.4063	11765	386.93	0.43011	52.50	1.165	1.167	5.673	6.182	88.145
12.96875	583	30.1563	15894	527.05	0.45455	70.92	1.689	1.696	6.052	3.951	89.997
12.96875	738	30.5625	16783	549.14	0.37879	74.89	1.712	1.717	5.995	4.853	89.152
12.96875	891	30.7813	17518	569.11	0.32787	78.17	1.829	1.837	7.105	4.942	87.953
12.96875	1044	30.7500	20513	667.09	0.32733	91.54	1.644	1.650	9.009	6.261	84.730
12.96875	1196	31.0000	24242	782.00	0.33784	108.17	1.899	1.904	8.933	6.242	84.825

DATA SHEET A-III

ORIGINAL DATA FROM OPENING HEIGHT VERSUS AUGER SPEED TEST - BLOCK I

Opening Height (Inches)	Auger Speed Wanted (RPM)	Time to Convey 40 Pounds (Minutes)	Number Revolutions for 40 Pounds	Seed Sample Analysis Data: Seed Density (Lb. per cu. ft.)	Total Sample Weight (Pounds)	Clipper Cleaner Fractions: Cleaned Seed (Pounds)	Clipper Cleaner Fractions: Fragments of Seed (Grams)	Selector Reject of Cleaned Seed: Decor-ticated (Grams)	Selector Reject of Cleaned Seed: Chipped Seed (Grams)	Selector Reject of Cleaned Seed: Unhulled Seed (Grams)
CHECK 1				29.3125	56.3438	56.2188	16.9	40.5	108.7	125.7
2.59375	300	0.400	123.4	30.7813	56.2500	56.1563	21.8	50.2	125.9	135.7
2.59375	450	0.341	155.6	29.8438	56.5469	56.4531	23.1	40.7	107.9	139.4
2.59375	600	0.361	224.0	30.5313	56.5625	56.4688	28.5	42.8	120.8	143.7
2.59375	750	0.421	318.0	30.8125	57.1719	56.9844	37.5	54.2	134.5	110.5
2.59375	900	0.432	385.0	30.3750	56.5000	56.3125	40.0	59.3	119.5	127.3
2.59375	1050	0.507	531.5	30.7813	56.3906	56.1875	70.0	87.0	166.8	114.2
2.59375	1200	0.532	637.0	30.6250	56.7031	56.3750	90.1	103.9	172.6	88.2
5.18750	300	0.294	89.0	30.5313	56.5156	56.4375	20.0	31.9	110.4	112.8
5.18750	450	0.210	96.5	30.5625	57.1250	57.0156	12.7	45.2	116.6	130.7
5.18750	600	0.210	120.0	30.5625	56.5781	56.4844	22.5	40.3	113.1	126.5
5.18750	750	0.216	164.2	30.7188	56.2969	56.2969	25.2	41.8	119.5	121.7
5.18750	900	0.238	213.2	30.6250	56.4688	56.3281	36.4	44.4	134.5	131.3
5.18750	1050	0.241	253.0	30.7188	56.4375	56.2344	49.2	52.9	143.4	144.8
5.18750	1200	0.266	317.0	30.7500	56.8281	56.6406	71.9	72.4	168.3	130.2
7.78125	300	0.256	80.0	31.1875	58.8906	58.7656	22.2	37.3	97.0	63.8
7.78125	450	0.201	92.8	30.7500	56.5625	56.5000	22.5	33.7	104.6	86.8
7.78125	600	0.175	110.0	30.4375	56.8281	56.7031	27.2	56.4	107.0	75.9
7.78125	750	0.164	123.5	30.5625	56.2500	56.1563	30.1	32.6	104.8	81.0
7.78125	900	0.140	125.4	30.7500	60.3906	60.2500	33.1	45.2	118.2	75.3
7.78125	1050	0.176	185.2	30.2500	56.3281	56.1250	44.9	43.3	114.3	90.2
7.78125	1200	0.177	213.4	30.2500	57.0938	56.8594	51.8	50.9	147.7	117.2
10.37500	300	0.277	86.0	30.8750	58.5781	58.5000	22.5	39.1	141.0	76.6
10.37500	450	0.208	94.0	30.1875	57.5938	57.5469	20.9	34.6	106.8	85.6
10.37500	600	0.154	95.0	30.6563	61.0625	60.9688	22.0	38.2	96.8	56.3
10.37500	750	0.153	117.0	30.6875	56.7813	56.7031	21.8	47.3	114.7	143.7
10.37500	900	0.144	128.6	30.5625	57.8906	57.7656	23.3	50.0	123.0	149.3
10.37500	1050	0.105	110.6	31.0313	57.2500	57.1250	27.5	43.5	133.6	86.6
10.37500	1200	0.147	179.0	30.2813	56.9688	56.8438	39.5	57.6	148.7	154.5
12.96875	300	0.287	87.2	30.8438	56.4219	56.3594	18.3	31.6	95.5	86.4
12.96875	450	0.183	84.0	30.9063	56.4844	56.4219	20.0	28.2	86.5	49.8
12.96875	600	0.147	90.2	30.6875	57.5000	57.3750	21.9	30.5	97.3	56.2
12.96875	750	0.138	106.0	30.7813	56.4844	56.4063	25.1	49.7	106.9	82.0
12.96875	900	0.110	99.5	30.7188	57.3594	57.2656	27.9	45.3	107.6	103.0
12.96875	1050	0.120	126.6	30.6875	57.9063	57.7500	31.9	38.9	115.1	85.1
12.96875	1200	0.096	115.0	30.9375	56.8594	56.6719	34.2	52.2	119.2	104.3

DATA SHEET A-III (Continued)

ORIGINAL DATA FROM OPENING HEIGHT VERSUS AUGER SPEED TEST - BLOCK II

				Seed Sample Analysis Data						
						Clipper Cleaner Fractions		Selector Reject of Cleaned Seed		
Opening Height (Inches)	Auger Speed Wanted (RPM)	Time to Convey 40 Pounds (Minutes)	Number Revolutions for 40 Pounds	Seed Density (Lb. per cu. ft.)	Total Sample Weight (Pounds)	Cleaned Seed (Pounds)	Fragments of Seed (Grams)	Decor-ticated (Grams)	Chipped Seed (Grams)	Unhulled Seed (Grams)
CHECK 2				30.9688	68.5781	68.4375	14.2	48.1	105.1	63.3
2.59375	300	0.413	124.6	30.5313	60.7656	60.6719	21.5	32.2	112.2	60.0
2.59375	450	0.341	157.2	30.3750	58.8750	58.8125	23.0	40.8	111.3	110.8
2.59375	600	0.364	215.4	30.5625	56.5781	56.4531	26.9	32.4	96.7	92.8
2.59375	750	0.433	327.2	30.6250	59.1250	58.9375	43.9	42.2	134.5	54.5
2.59375	900	0.497	447.6	30.8438	59.8281	59.5469	64.2	63.2	177.7	116.6
2.59375	1050	0.527	550.0	30.7188	57.6875	57.3594	60.5	72.1	182.2	116.5
2.59375	1200	0.490	590.2	30.1563	58.4531	58.0625	78.6	90.6	172.8	82.4
5.18750	300	0.325	99.0	30.5625	58.3594	58.2656	26.5	57.7	101.2	46.7
5.18750	450	0.238	109.8	31.0000	60.0938	59.9844	26.0	47.3	105.3	47.1
5.18750	600	0.219	131.2	30.7813	59.2813	59.1875	23.9	50.7	83.6	66.9
5.18750	750	0.232	168.0	30.5000	59.5469	59.3594	35.5	54.5	133.8	56.2
5.18750	900	0.233	208.0	29.1875	56.6719	56.5156	33.1	46.2	105.2	93.1
5.18750	1050	0.235	247.4	30.5313	57.3906	57.2031	42.3	58.2	137.5	68.0
5.18750	1200	0.268	322.2	30.7500	61.0938	60.8594	66.3	89.3	177.5	71.3
7.78125	300	0.315	94.0	30.5000	59.3281	59.1406	20.0	35.3	87.1	55.7
7.78125	450	0.221	97.0	30.4688	59.1094	58.9688	23.5	32.9	119.4	115.0
7.78125	600	0.181	110.4	30.4063	60.8281	60.7500	28.5	38.1	138.8	109.5
7.78125	750	0.174	133.2	30.6250	59.5156	59.3750	31.0	38.4	164.0	129.4
7.78125	900	0.180	163.2	30.5313	60.1875	60.0313	44.1	46.7	159.5	99.4
7.78125	1050	0.151	158.6	30.8125	62.2188	62.0469	30.9	54.7	112.6	79.3
7.78125	1200	0.139	167.2	30.9375	63.8750	63.7188	40.0	63.3	143.3	80.5
10.37500	300	0.303	91.2	30.2813	56.7344	56.6719	17.1	40.4	95.9	95.6
10.37500	450	0.219	102.8	29.7813	59.4219	59.2344	20.5	30.0	120.1	225.7
10.37500	600	0.174	107.0	29.3750	58.2031	58.0625	22.5	36.9	89.9	82.5
10.37500	750	0.143	109.6	30.4688	62.3281	62.2500	20.8	42.8	116.2	145.0
10.37500	900	0.158	144.0	29.6250	58.5625	58.4844	26.1	54.3	90.4	125.0
10.37500	1050	0.111	117.0	29.9375	62.5000	62.3906	29.3	51.3	97.5	79.0
10.37500	1200	0.134	161.0	30.7813	60.0469	59.9688	34.9	56.1	121.3	113.4
12.96875	300	0.306	92.0	30.3750	58.1406	58.0469	17.4	41.8	91.7	40.4
12.96875	450	0.182	79.6	30.8438	61.3594	61.2969	22.1	48.2	81.1	46.0
12.96875	600	0.150	92.0	30.2813	60.7969	60.6719	20.6	50.0	110.7	128.8
12.96875	750	0.138	105.2	30.6563	59.5781	59.3906	20.9	51.6	100.3	90.4
12.96875	900	0.138	124.0	30.1250	60.7031	60.5781	28.7	42.5	131.5	121.9
12.96875	1050	0.123	129.0	30.5625	63.2344	63.0469	33.0	65.2	108.5	65.4
12.96875	1200	0.112	135.0	30.2813	63.3594	63.2344	36.2	68.8	121.7	106.8

DATA SHEET A-III (Continued)

ORIGINAL DATA FROM OPENING HEIGHT VERSUS AUGER SPEED TEST - BLOCK III

				Seed Sample Analysis Data						
						Clipper Cleaner Fractions		Selector Reject of Cleaned Seed		
Opening Height (Inches)	Auger Speed Wanted (RPM)	Time to Convey 40 Pounds (Minutes)	Number Revolutions for 40 Pounds	Seed Density (Lb. per cu. ft.)	Total Sample Weight (Pounds)	Cleaned Seed (Pounds)	Fragments of Seed (Grams)	Decor-ticated (Grams)	Chipped Seed (Grams)	Unhulled Seed (Grams)
CHECK 3				30.4063	55.8594	55.7344	16.0	21.9	178.7	148.6
2.59375	300	0.441	134.8	30.8750	53.5000	53.3906	23.2	28.4	189.5	142.8
2.59375	450	0.354	162.6	30.5313	53.9688	53.8750	17.6	34.0	165.7	154.3
2.59375	600	0.386	223.0	31.1250	53.9531	53.8594	25.7	32.5	149.7	78.0
2.59375	750	0.427	320.4	30.8125	54.0313	53.8594	30.0	38.0	162.2	128.0
2.59375	900	0.512	462.0	30.8125	53.3906	53.1875	45.5	40.2	156.4	86.0
2.59375	1050	0.593	623.2	30.5000	53.5000	53.1719	65.8	63.8	185.6	140.0
2.59375	1200	0.533	643.8	29.9063	53.8750	53.6094	75.5	86.2	216.8	185.9
5.18750	300	0.308	94.2	31.2188	53.9375	53.8594	16.1	32.5	156.6	99.3
5.18750	450	0.262	113.8	30.7813	55.4531	55.3750	24.1	27.1	193.6	119.3
5.18750	600	0.200	119.8	30.6563	56.3281	56.2344	19.6	45.1	146.2	107.7
5.18750	750	0.229	170.0	30.7500	56.5469	56.4375	25.7	33.4	171.4	109.0
5.18750	900	0.245	217.2	30.5938	55.5938	55.4063	32.2	37.7	171.9	106.3
5.18750	1050	0.266	279.2	30.7188	55.0000	54.8750	44.3	48.4	165.6	95.8
5.18750	1200	0.300	360.2	30.3438	54.9531	54.6094	73.7	70.7	221.4	140.0
7.78125	300	0.314	94.8	30.7188	54.4844	54.3750	18.7	28.5	169.6	125.9
7.78125	450	0.215	100.4	30.7500	55.4688	55.3750	25.0	30.3	173.8	141.7
7.78125	600	0.159	92.6	31.1250	57.0313	56.8906	18.9	37.5	166.9	157.0
7.78125	750	0.176	133.8	30.7813	57.4844	57.3906	28.9	33.8	169.7	97.3
7.78125	900	0.179	161.6	30.8750	57.9531	57.7969	37.3	38.0	195.7	101.1
7.78125	1050	0.169	176.6	30.6250	58.9063	58.6250	38.8	42.2	161.3	120.5
7.78125	1200	0.152	182.2	30.6250	59.7656	59.6094	36.7	52.8	200.8	152.4
10.37500	300	0.329	100.4	29.9063	53.9531	53.8281	19.3	35.8	135.7	155.7
10.37500	450	0.228	102.4	29.7813	56.0000	55.8594	18.6	40.3	122.6	132.2
10.37500	600	0.146	86.2	30.7500	57.3125	57.2188	14.2	26.8	188.5	110.3
10.37500	750	0.141	103.2	30.4375	59.3125	59.1563	17.6	31.8	177.8	152.2
10.37500	900	0.142	126.6	30.0625	58.8906	58.7344	21.1	37.0	212.8	182.1
10.37500	1050	0.150	158.2	30.1875	59.2188	59.0313	29.2	40.7	166.2	112.0
10.37500	1200	0.126	150.0	30.5000	60.3594	60.2031	29.4	43.7	189.8	123.9
12.96875	300	0.296	89.4	30.5313	53.4063	53.2969	15.2	24.3	127.6	100.9
12.96875	450	0.204	93.0	30.4063	55.7031	55.6563	18.2	16.6	102.9	70.3
12.96875	600	0.151	88.0	30.1563	57.1563	57.0156	17.3	26.3	156.3	137.7
12.96875	750	0.143	105.6	30.5625	58.6406	58.5469	22.1	27.1	161.0	130.5
12.96875	900	0.137	122.0	30.7813	58.5156	58.3438	24.0	34.2	169.4	127.0
12.96875	1050	0.117	122.2	30.7500	59.5313	59.3906	27.8	39.7	149.2	134.4
12.96875	1200	0.099	118.4	31.0000	62.1250	61.9531	33.4	47.4	180.0	84.3

DATA SHEET A-IV

ANALYSES OF VARIANCE FOR OPENING HEIGHT VERSUS AUGER SPEED TEST

ATTRIBUTE 1. POUNDS PER HOUR CONVEYED

Source of variation	df	ss	ms	F	P
Total	104	2666300000	25637500		
Main Plots	14	1654727000	118194790		
Blocks	2	8011000	4005500	10.231	$99 < P < 99.5$
Opening heights	4	1643584000	410896000	1049.543	$99.5 < P$
Main plot error	8	3132000	391500		
Sub-plots	34	2575228000	75742000		
Speeds	6	471865000	78644167	59.036	$99.5 < P$
Speeds x opening heights	24	459779000	19157458	14.381	$99.5 < P$
Sub-plot error	60	79929000	1332150		

DATA SHEET A-IV (Continued)

ATTRIBUTE 2. CUBIC FEET PER HOUR CONVEYED

Source of variation	df	ss	ms	F	P
Total	104	2844480	27350.769		
Main plots	14	1777326	126951.86		
Blocks	2	7344	3672.	11.264	$99 < P < 99.5$
Opening Heights	4	1767374	441843.5	1355.347	$99.5 < P$
Main plot error	8	2608	326.		
Sub-plots	34	2758271	81125.618		
Speeds	6	506915	84485.833	66.475	$99.5 < P$
Speeds x opening heights	24	483982	20165.917	15.867	$99.5 < P$
Sub-plot error	60	76257	1270.95		

DATA SHEET A-IV (Continued)

ATTRIBUTE 3. POUNDS PER REVOLUTION CONVEYED

Source of variation	df	ss	ms	F	P
Total	104	1.4743040	.014176		
Main plots	14	.715156	.051082571		
Blocks	2	.0045839	.00229195	21.645	99.5 < P
Opening heights	4	.709725	.17743125	1675.658	99.5 < P
Main plot error	8	.0008471	.0001058875		
Sub-plots	34	1.4302070	.042064912		
Speeds	6	.659154	.109859	170.500	99.5 < P
Speed x opening heights	24	.061328	.0025553333	3.966	99.5 < P
Sub-plot error	60	.03866	.000644333		

DATA SHEET A-IV (Continued)

ATTRIBUTE 4. POUNDS PER HOUR PER SQUARE INCH OF OPENING AREA

Source of variation	df	ss	ms	F	P
Total	104	73802.400	709.63846		
Main plots	14	33820.300	2415.7357		
Blocks	2	571.90000	285.95000	13.339	99.5 <P
Opening heights	4	33076.900	8269.2250	385.736	99.5 <P
Main plot error	8	171.50000	21.437500		
Sub-plots	34	69607.800	2047.2882		
Speeds	6	13651.700	2275.2833	39.556	99.5 <P
Speed x opening heights	24	22879.200	953.30000	16.573	99.5 <P
Sub-plot error	60	3451.200	57.52000		

DATA SHEET A-IV (Continued)

ATTRIBUTE 5. PERCENT TOTAL SAMPLE WEIGHT DAMAGED

Source of variation	df	ss	ms	F	P
Total	104	16.915670	.16265067		
Main plots	14	8.6238900	.61599214		
Blocks	2	5.3800900	2.6900450	76.7734	$99.5 < P$
Opening heights	4	2.9634900	.74087250	21.1144	$99.5 < P$
Main plot error	8	.28031000	.035038750		
Sub-plots	34	9.6632600	.28421353		
Speeds	6	4.7189700	.78649500	29.6416	$99.5 < P$
Speed x opening heights	24	1.9808000	.082533333	3.1105	$99.5 < P$
Sub-plot error	60	1.5920100	.02653350		

DATA SHEET A-IV (Continued)

ATTRIBUTE 6. PERCENT OIL-BEARING MATERIAL DAMAGED

Source of variation	df	ss	ms	F	P
Total	104	17.116330	.16458010		
Main plots	14	8.7181900	.62272786		
Blocks	2	5.4415200	2.7207600	77.1902	99.5 < P
Opening heights	4	2.9946900	.74867250	21.2404	99.5 < P
Main plot error	8	.28198000	.035247500		
Sub-plots	34	9.7810100	.28767676		
Speeds	6	4.7776600	.79627667	29.6414	99.5 < P
Speed x opening heights	24	2.0086600	.083694167	3.1156	99.5 < P
Sub-plot error	60	1.6118200	.02686366		

DATA SHEET A-IV (Continued)

ATTRIBUTE 7. PERCENT DECORTICATED IN DAMAGED SEED

Source of variation	df	ss	ms	F	P
Total	104	1080.9630	10.393875		
Main plots	14	724.92400	51.780286		
Blocks	2	592.13900	296.06950	22.3449	99.5 < P
Opening heights	4	26.785000	6.6962500	0.5054	P < 70
Main plot error	8	106.00000	13.250000		
Sub-plots	34	178.01400	5.2357059		
Speeds	6	71.517000	11.919500	3.4919	99.5 < P
Speed x opening heights	24	79.712000	3.3213333	0.9730	P < 70
Sub-plot error	60	204.81000	3.4135000		

DATA SHEET A-IV (Continued)

ATTRIBUTE 8. PERCENT FRAGMENTS IN DAMAGED SEED

Source of variation	df	ss	ms	F	P
Total	104	555.13660	5.3378519		
Main plots	14	221.57680	15.826914		
Blocks	2	127.20950	63.604750	35.0599	99.5 < P
Opening heights	4	79.853900	19.963475	11.0042	99.5 < P
Main plot error	8	14.513400	1.8141750		
Sub-plots	34	364.43540	10.718688		
Speeds	6	212.93050	35.488417	43.4745	99.5 < P
Speed x opening heights	24	71.651000	2.9854583	3.6573	99.5 < P
Sub-plot error	60	48.978300	.81630500		

DATA SHEET A-IV (Continued)

ATTRIBUTE 9. PERCENT CHIPPED IN DAMAGED SEED

Source of variation	df	ss	ms	F	P
Total	104	2517.1800	24.203654		
Main plots	14	1517.9900	108.42786		
Blocks	2	1259.7900	629.89500	34.458	99.5 < P
Opening heights	4	111.96000	27.990000	1.5312	70 < P < 75
Main plot error	8	146.24000	18.280000		
Sub-plots	34	810.49000	23.837941		
Speeds	6	507.86000	84.643333	16.8949	99.5 < P
Speed x opening heights	24	190.67000	7.9445833	1.5857	90 < P < 95
Sub-plot error	60	300.66000	5.0100000		

APPENDIX B

SHEAR-PLANE ANGLE VERSUS AUGER SPEED DATA

DATA SHEET B-I

ATTRIBUTE MEANS FOR MULTIPLE REGRESSION ANALYSIS OF SHEAR-PLANE ANGLE VERSUS AUGER SPEED TEST

Shear-Plane Angle (Degrees)	Auger Speed (RPM)	Pounds per Hour	Cubic Feet per Hour	Pounds per Revolution	Pounds per Hour per Sq. In. Opening Area	Percent Total Sample Weight Damaged	Percent Oil-bearing Material Damaged	Separation of Damaged Seed into Fractions		
								Percent Decorticated	Percent Fragments	Percent Chipped
27.97	304	6829	222.74	0.375	76.19	2.25	2.26	13.49	10.52	76.00
27.97	440	9219	303.78	0.349	102.85	2.43	2.43	13.70	10.01	76.30
27.97	594	11168	370.29	0.314	124.59	2.40	2.41	14.35	11.07	74.58
27.97	743	11321	370.42	0.254	126.29	2.90	2.92	14.72	11.32	73.96
27.97	897	10315	338.59	0.192	115.07	3.22	3.24	15.94	13.66	70.40
27.97	1054	10595	351.46	0.168	118.19	3.43	3.45	18.02	13.63	68.35
27.97	1201	9813	322.07	0.136	109.47	4.22	4.25	18.64	15.96	65.40
36.37	305	7812	258.01	0.427	87.15	1.95	1.95	12.43	8.59	78.97
36.37	457	10143	335.55	0.370	113.15	2.12	2.12	12.97	10.12	76.92
36.37	614	12043	393.62	0.327	134.35	2.30	2.31	14.04	10.70	75.26
36.37	741	11672	380.62	0.263	130.21	2.38	2.38	14.96	11.89	73.15
36.37	899	11753	384.16	0.218	131.12	2.71	2.72	15.17	11.97	72.86
36.37	1055	11485	372.50	0.181	128.13	2.89	2.91	16.64	13.42	69.93
36.37	1194	10787	354.24	0.151	120.33	3.37	3.40	16.93	14.25	68.82
50.22	305	7819	258.59	0.428	87.22	1.61	1.61	9.42	5.94	84.64
50.22	445	10867	355.67	0.407	121.23	1.59	1.59	10.88	6.69	82.43
50.22	585	12085	396.53	0.344	134.82	1.76	1.76	9.49	7.09	83.42
50.22	755	12482	412.48	0.275	139.24	1.81	1.81	11.60	8.08	80.32
50.22	896	12801	423.38	0.238	142.80	1.85	1.85	11.70	8.11	80.19
50.22	1055	12635	411.43	0.200	140.96	2.12	2.13	12.05	7.29	80.66
50.22	1201	11509	379.54	0.160	128.39	2.27	2.28	13.05	9.00	77.95
72.91	303	8147	265.47	0.449	90.88	1.68	1.68	6.91	3.88	89.22
72.91	451	11287	367.34	0.417	125.91	1.50	1.50	7.72	3.83	88.45
72.91	578	12754	418.49	0.367	142.28	1.58	1.58	7.52	3.52	88.96
72.91	743	13049	423.67	0.293	145.57	1.58	1.58	7.78	4.36	87.86
72.91	893	12920	420.45	0.241	144.14	1.57	1.57	8.17	4.56	87.27
72.91	1045	11432	377.30	0.182	127.53	1.76	1.77	7.89	5.11	87.01
72.91	1200	11613	376.93	0.161	129.55	1.61	1.62	10.44	5.39	84.17
102.27	306	8344	273.78	0.454	93.08	1.65	1.65	6.21	3.16	90.63
102.27	442	10658	347.52	0.402	118.89	1.41	1.41	7.45	4.08	88.47
102.27	596	11785	383.63	0.329	131.47	1.74	1.75	6.99	3.79	89.22
102.27	743	12368	402.33	0.278	137.97	1.56	1.56	7.89	4.09	88.02
102.27	892	11562	377.42	0.216	128.98	1.70	1.70	7.67	4.16	88.17
102.27	1054	11361	373.58	0.180	126.74	1.91	1.92	6.99	3.98	89.03
102.27	1202	10903	356.36	0.151	121.63	1.76	1.76	8.83	4.58	86.60
126.60	305	8305	271.40	0.454	92.65	1.71	1.71	7.48	3.59	88.93
126.60	457	10586	347.36	0.386	118.10	1.56	1.56	8.27	4.68	87.05
126.60	591	11523	378.15	0.325	128.55	1.57	1.57	8.25	4.86	86.89
126.60	735	11412	374.04	0.259	127.31	1.54	1.55	8.41	5.02	86.57
126.60	889	10667	347.02	0.200	119.00	1.69	1.70	9.66	5.10	85.25
126.60	1050	10271	337.69	0.163	114.58	1.90	1.91	8.82	4.99	86.20
126.60	1204	9693	317.05	0.134	108.13	1.78	1.79	9.36	5.09	85.55

DATA SHEET B-II

SUMMARY OF DATA FROM SHEAR-PLANE ANGLE VERSUS AUGER SPEED TEST - BLOCK I

		Rate of Conveying					Seed Damage				
									Separation of Damaged Seed into Fractions		
Shear-Plane Angle (Degrees)	Actual Auger Speed (RPM)	Seed Density (Lb. per Cu. Ft.)	Pounds per Hour	Cubic Feet per Hour	Pounds per Revolution	Pounds per Hour per Sq. In. Opening Area	Percent Total Sample Weight Damaged	Percent Oil-bearing Material Damaged	Percent Decorticated	Percent Fragments	Percent Chipped
CHECK 1		29.1875					1.622	1.626	7.758	4.386	87.856
27.97	304	30.8750	7018	227.30	0.38462	78.29	2.175	2.182	14.147	10.457	75.396
27.97	422	30.8438	9160	296.98	0.36166	102.19	2.651	2.657	13.182	9.916	76.902
27.97	573	30.1875	12060	399.50	0.35088	134.54	2.498	2.509	13.299	9.431	77.270
27.97	730	30.7813	11483	373.05	0.26212	128.10	3.136	3.145	13.809	11.178	75.013
27.97	891	30.7813	10714	348.07	0.20040	119.52	3.219	3.233	16.075	13.342	70.583
27.97	1049	30.5625	11268	368.69	0.17905	125.70	3.686	3.705	16.864	13.399	69.737
27.97	1209	30.9688	10213	329.78	0.14085	113.93	4.625	4.657	17.113	15.171	67.716
36.37	304	30.3750	7595	250.04	0.41580	84.73	1.893	1.899	12.782	9.464	77.754
36.37	466	29.8750	10169	340.38	0.36364	113.44	2.040	2.048	11.432	11.566	77.002
36.37	605	30.6875	12766	416.00	0.35149	142.41	2.045	2.051	12.223	10.653	77.124
36.37	762	30.8125	11823	383.71	0.25873	131.89	2.278	2.285	13.704	12.374	73.922
36.37	909	31.0313	11765	379.13	0.21575	131.25	2.684	2.695	14.174	13.203	72.623
36.37	1050	30.7500	11707	380.72	0.18587	130.60	2.866	2.876	15.564	13.001	71.435
36.37	1197	29.9063	10084	337.19	0.14035	112.49	3.404	3.426	16.562	16.204	67.234
50.22	307	30.1875	7895	261.53	0.42918	88.07	1.808	1.813	8.363	4.906	86.731
50.22	454	30.5625	11594	379.35	0.42553	129.34	1.663	1.666	8.575	5.272	86.153
50.22	596	30.4688	12308	403.95	0.34423	137.30	2.031	2.036	8.084	6.011	85.905
50.22	752	30.2813	12766	421.58	0.28289	142.41	1.886	1.890	9.883	6.541	83.576
50.22	888	30.2188	12000	397.10	0.22523	133.87	2.132	2.136	11.782	8.100	80.118
50.22	1056	30.4688	12371	406.02	0.19531	138.01	2.107	2.110	12.772	7.185	80.043
50.22	1203	29.9375	10860	362.76	0.15049	121.15	2.413	2.421	13.490	10.967	75.543
72.91	303	30.9063	8247	266.84	0.45351	92.00	1.763	1.766	4.647	3.417	91.936
72.91	445	30.9375	11163	360.82	0.41841	124.53	1.621	1.626	6.734	3.151	90.115
72.91	573	30.3750	12903	424.79	0.37523	143.94	1.647	1.651	5.954	3.103	90.943
72.91	729	30.6875	13873	452.07	0.31696	154.76	1.816	1.822	6.151	3.304	90.545
72.91	886	30.3750	13953	459.36	0.26247	155.66	1.752	1.756	7.534	3.938	88.528
72.91	1043	30.5313	11707	383.44	0.18709	130.60	1.892	1.896	6.986	4.280	88.734
72.91	1198	30.8750	11483	371.92	0.15974	128.10	1.588	1.590	10.934	5.063	84.003
102.27	306	30.6875	8219	267.83	0.44743	91.69	1.957	1.961	5.741	2.545	91.714
102.27	437	30.8125	11009	357.29	0.42017	122.81	1.468	1.470	6.585	3.506	89.909
102.27	584	30.7813	11707	380.33	0.33389	130.60	2.029	2.034	5.475	2.662	91.863
102.27	747	30.8125	13043	423.30	0.29112	145.50	1.571	1.572	6.324	4.055	89.621
102.27	887	30.7500	11321	368.16	0.21277	126.29	1.791	1.797	7.621	3.832	88.547
102.27	1056	30.5000	11060	362.62	0.17452	123.38	1.773	1.777	6.231	3.462	90.307
102.27	1194	30.5313	10480	343.25	0.14631	116.91	1.829	1.834	7.097	3.984	88.919
126.60	307	30.4063	8392	276.00	0.45558	93.62	1.724	1.728	6.447	3.551	90.002
126.60	462	30.3750	10435	343.54	0.37665	116.41	1.679	1.682	7.522	4.425	88.053
126.60	592	30.7188	11268	366.81	0.31696	125.70	1.634	1.638	6.488	5.375	88.137
126.60	739	30.5938	11268	368.31	0.25413	125.70	1.465	1.468	7.797	4.647	87.556
126.60	884	30.9063	10762	348.21	0.20284	120.06	1.540	1.543	8.521	5.088	86.391
126.60	1051	30.3438	10213	336.58	0.16194	113.93	1.769	1.776	7.130	4.819	88.051
126.60	1209	30.6563	9524	310.67	0.13132	106.25	1.670	1.674	9.311	6.100	84.589

DATA SHEET B-II (Continued)

SUMMARY OF DATA FROM SHEAR-PLANE ANGLE VERSUS AUGER SPEED TEST - BLOCK II

			Rate of Conveying				Seed Damage				
									Separation of Damaged Seed into Fractions		
Shear-Plane Angle (Degrees)	Actual Auger Speed (RPM)	Seed Density (Lb. per Cu. Ft.)	Pounds per Hour	Cubic Feet per Hour	Pounds per Revolution	Pounds per Hour per Sq. In. Opening Area	Percent Total Sample Weight Damaged	Percent Oil-bearing Material Damaged	Percent Decorticated	Percent Fragments	Percent Chipped
CHECK 2		29.5000					1.295	1.298	8.080	4.465	87.455
27.97	302	30.2188	6593	218.18	0.36430	73.55	2.314	2.324	13.252	10.947	75.801
27.97	448	29.9375	9302	310.71	0.34602	103.77	2.207	2.216	13.368	10.022	76.610
27.97	605	29.9375	10435	348.56	0.28736	116.41	2.328	2.337	13.401	12.810	73.789
27.97	768	30.1875	10480	347.16	0.22753	116.91	2.964	2.981	15.063	12.513	72.424
27.97	900	30.2188	9796	324.17	0.1814[illegible]	109.28	3.355	3.361	14.727	14.540	70.733
27.97	1056	29.4063	10390	353.33	0.16393	115.91	2.913	2.930	18.772	14.066	67.162
27.97	1198	30.0938	9266	307.90	0.12887	103.37	4.155	4.184	17.581	16.993	65.426
36.37	306	30.3438	7895	260.18	0.43011	88.07	2.033	2.041	11.310	7.454	81.236
36.37	440	30.4063	9959	327.53	0.37736	111.10	2.066	2.074	10.962	7.901	81.137
36.37	600	30.5625	11881	388.74	0.33003	132.54	2.209	2.219	12.738	10.130	77.132
36.37	728	30.6250	11429	373.19	0.26178	127.50	2.029	2.037	14.755	12.099	73.146
36.37	911	30.6250	11374	371.40	0.20812	126.89	2.666	2.679	15.009	11.846	73.145
36.37	1062	30.8438	11374	368.76	0.17857	126.89	2.766	2.782	16.501	13.250	70.249
36.37	1196	30.5938	11009	359.84	0.15337	122.81	3.313	3.333	16.560	13.110	70.330
50.22	302	29.9375	7453	248.95	0.41068	83.14	1.657	1.663	8.969	6.158	84.873
50.22	449	30.4688	10526	345.47	0.39063	117.43	1.504	1.508	10.245	6.986	82.769
50.22	580	30.5938	11765	384.56	0.33784	131.25	1.686	1.690	8.540	6.313	85.147
50.22	757	30.2813	12245	404.37	0.26954	136.60	1.830	1.837	10.527	6.551	82.922
50.22	899	29.9063	12766	426.87	0.23669	142.41	1.749	1.755	11.709	8.166	80.125
50.22	1049	30.9375	12903	417.07	0.20492	143.94	2.253	2.259	10.439	5.439	84.122
50.22	1200	30.3750	11483	378.04	0.15949	128.10	2.163	2.175	12.906	5.924	81.170
72.91	301	30.5313	7947	260.29	0.43956	88.65	1.929	1.935	5.110	3.204	91.686
72.91	440	30.7500	11215	364.72	0.42463	125.11	1.503	1.506	6.528	2.850	90.622
72.91	570	30.5938	12245	400.24	0.35778	136.60	1.581	1.585	6.712	3.137	90.151
72.91	771	30.4063	12371	406.86	0.26738	138.01	1.657	1.662	6.718	4.161	89.121
72.91	895	30.6563	12500	407.75	0.23283	139.45	1.533	1.538	6.522	3.560	89.918
72.91	1049	30.5938	11268	368.31	0.17905	125.70	1.826	1.832	7.843	4.142	88.015
72.91	1198	31.0625	12245	394.21	0.17036	136.60	1.734	1.740	8.297	3.432	88.271
102.27	307	30.4063	8362	275.01	0.45455	93.28	1.333	1.336	5.414	3.025	91.561
102.27	454	30.5313	10619	347.81	0.38986	118.46	1.309	1.312	6.768	4.174	89.058
102.27	607	30.6875	11940	389.08	0.32787	133.20	1.452	1.454	6.257	3.807	89.936
102.27	753	30.9063	12000	388.27	0.26560	133.87	1.378	1.382	7.307	3.108	89.585
102.27	887	30.5313	11881	389.14	0.22321	132.54	1.417	1.419	5.786	3.993	90.221
102.27	1049	30.0313	11594	386.06	0.18416	129.34	1.982	1.988	5.841	4.036	90.123
102.27	1206	30.4375	10909	358.41	0.15072	121.70	1.509	1.514	8.293	4.159	87.548
126.60	306	30.8438	8191	265.56	0.44543	91.38	1.502	1.505	5.843	3.618	90.539
126.60	454	30.1250	10213	339.02	0.37453	113.93	1.503	1.508	7.312	4.033	88.655
126.60	581	30.0313	11707	389.83	0.33557	130.60	1.279	1.282	7.007	3.866	89.127
126.60	723	30.2500	11374	376.00	0.26212	126.89	1.580	1.585	6.163	4.493	89.344
126.60	893	30.4063	10526	346.18	0.19646	117.43	1.626	1.631	7.830	3.820	88.350
126.60	1048	30.2500	10256	339.04	0.16313	114.41	1.663	1.670	7.526	5.296	87.178
126.60	1206	30.1563	9677	320.89	0.13378	107.95	1.677	1.681	7.201	4.085	88.714

DATA SHEET B-II (Continued)

SUMMARY OF DATA FOR SHEAR-PLANE ANGLE VERSUS AUGER SPEED TEST - BLOCK III

			Rate of Conveying				Seed Damage				
									Separation of Damaged Seed into Fractions		
Shear-Plane Angle (Degrees)	Actual Auger Speed (RPM)	Seed Density (Lb. per Cu. Ft.)	Pounds per Hour	Cubic Feet per Hour	Pounds per Revolution	Pounds per Hour per Sq. In. Opening Area	Percent Total Sample Weight Damaged	Percent Oil-bearing Material Damaged	Percent Decorticated	Percent Fragments	Percent Chipped
CHECK 3		30.1875					1.370	1.374	8.942	3.430	87.628
27.97	305	30.8750	6877	222.74	0.37594	76.72	2.250	2.259	13.059	10.149	76.792
27.97	450	30.2813	9195	303.65	0.34072	102.58	2.423	2.431	14.537	10.090	75.373
27.97	604	30.3438	11009	362.81	0.30395	122.81	2.385	2.397	16.346	10.962	72.692
27.97	732	30.6875	12000	391.04	0.27322	133.87	2.610	2.621	15.288	10.272	74.440
27.97	900	30.3750	10435	343.54	0.19324	116.41	3.097	3.117	17.021	13.091	69.888
27.97	1057	30.4688	10127	332.37	0.15962	112.97	3.696	3.718	18.410	13.427	68.163
27.97	1195	30.3125	9959	328.54	0.13889	111.10	3.892	3.921	21.224	15.708	63.068
36.37	305	30.1250	7947	263.80	0.43478	88.65	1.911	1.917	13.208	8.859	77.933
36.37	464	30.4063	10300	338.75	0.37037	114.90	2.243	2.249	16.510	10.879	72.611
36.37	637	30.5313	11483	376.11	0.30030	128.10	2.647	2.655	17.156	11.310	71.534
36.37	733	30.5625	11765	384.95	0.26738	131.25	2.821	2.832	16.423	11.185	72.392
36.37	876	30.1563	12121	401.94	0.23068	135.22	2.787	2.774	16.320	10.875	72.805
36.37	1053	30.9063	11374	368.02	0.18002	126.89	3.048	3.063	17.867	14.020	68.113
36.37	1188	30.8125	11268	365.70	0.15810	125.70	3.407	3.429	17.682	13.426	68.892
50.22	305	30.5625	8108	265.29	0.44346	90.45	1.364	1.367	10.918	6.769	82.313
50.22	431	30.6250	10480	342.20	0.40568	116.91	1.603	1.608	13.831	7.803	78.366
50.22	579	30.3750	12183	401.09	0.35088	135.91	1.553	1.558	11.849	8.936	79.215
50.22	756	30.2188	12435	411.50	0.27397	138.72	1.703	1.709	14.401	11.144	74.455
50.22	902	30.5625	13636	446.17	0.25189	152.12	1.661	1.666	11.597	8.063	80.340
50.22	1060	30.7188	12632	411.21	0.19861	140.92	2.006	2.012	12.942	9.231	77.827
50.22	1199	30.6250	12183	397.81	0.16935	135.91	2.229	2.238	12.752	10.101	77.147
72.91	304	30.6250	8247	269.29	0.45249	92.00	1.349	1.353	10.965	5.006	84.029
72.91	469	30.5000	11483	376.49	0.40816	128.10	1.371	1.374	9.892	5.502	84.606
72.91	592	30.4688	13115	430.44	0.36900	146.31	1.504	1.508	9.890	4.330	85.780
72.91	728	31.3125	12903	412.07	0.29542	143.94	1.261	1.262	10.470	5.615	83.915
72.91	898	31.2188	12308	394.25	0.22831	137.30	1.415	1.417	10.464	6.171	83.365
72.91	1042	29.7813	11321	380.14	0.18116	126.29	1.576	1.580	8.826	6.905	84.269
72.91	1203	30.4688	11111	364.67	0.15396	123.95	1.515	1.522	12.094	7.671	80.235
102.27	306	30.3438	8451	278.51	0.45977	94.28	1.646	1.651	7.481	3.899	88.620
102.27	434	30.6563	10345	337.45	0.39683	115.41	1.442	1.446	9.003	4.555	86.442
102.27	598	30.6875	11707	381.49	0.32626	130.60	1.750	1.756	9.229	4.902	85.869
102.27	728	30.5000	12060	395.41	0.27624	134.54	1.736	1.740	10.029	5.103	84.868
102.27	901	30.6250	11483	374.96	0.21231	128.10	1.892	1.897	9.608	4.652	85.740
102.27	1058	30.7188	11429	372.05	0.18002	127.50	1.975	1.981	8.889	4.454	86.657
102.27	1206	30.8125	11321	367.42	0.15649	126.29	1.932	1.936	11.094	5.586	83.320
126.60	301	30.5625	8333	272.65	0.46083	92.96	1.898	1.904	10.157	3.597	86.246
126.60	456	30.9063	11111	359.51	0.40568	123.95	1.501	1.504	9.982	5.574	84.444
126.60	601	30.6875	11594	377.81	0.32154	129.34	1.799	1.803	11.264	5.341	83.395
126.60	744	30.6875	11594	377.81	0.25974	129.34	1.585	1.589	11.283	5.906	82.811
126.60	891	30.9063	10714	346.66	0.20040	119.52	1.913	1.917	12.621	6.381	80.998
126.60	1052	30.6563	10345	337.45	0.16393	115.41	2.279	2.284	11.797	4.847	83.356
126.60	1198	30.9063	9877	319.58	0.13736	110.19	1.998	2.003	11.555	5.099	83.346

DATA SHEET B-III

ORIGINAL DATA FROM SHEAR-PLANE ANGLE VERSUS AUGER SPEED TEST - BLOCK I

						Seed Sample Analysis Data				
						Clipper Cleaner Fractions		Selector Reject of Cleaned Seed		
Shear-Plane Angle (Degrees)	Auger Speed Wanted (RPM)	Time to Convey 40 Pounds (Minutes)	Number Revolutions for 40 Pounds	Seed Density (Lb. per Cu. Ft.)	Total Sample Weight (Pounds)	Cleaned Seed (Pounds)	Fragments of Seed (Grams)	Decor-ticated (Grams)	Chipped Seed (Grams)	Unhulled Seed (Grams)
CHECK 1				29.1875	49.5938	49.5313	16.0	28.2	151.8	191.1
27.97	300	0.342	104.0	30.8750	54.3906	54.1563	56.1	75.7	191.6	111.5
27.97	450	0.262	110.6	30.8438	55.5156	55.3125	66.2	87.8	243.2	121.4
27.97	600	0.199	114.0	30.1875	57.2656	57.0000	61.2	86.1	237.5	175.7
27.97	750	0.209	152.6	30.7813	56.9063	56.6406	90.5	111.6	287.7	137.0
27.97	900	0.224	199.6	30.7813	57.1250	56.7031	11.3	133.8	278.9	96.6
27.97	1050	0.213	223.4	30.5625	57.1406	56.6563	28.0	160.8	315.6	147.9
27.97	1200	0.235	284.0	30.9688	57.6875	56.9531	83.6	206.7	388.2	112.9
36.37	300	0.316	96.2	30.3750	54.7500	54.5469	44.5	60.0	173.2	95.6
36.37	450	0.236	110.0	29.8750	56.5313	56.2500	60.5	59.7	190.8	110.1
36.37	600	0.188	113.8	30.6875	56.9844	56.7500	56.3	64.5	193.1	104.6
36.37	750	0.203	154.6	30.8125	57.4844	57.2031	73.5	81.2	208.0	93.0
36.37	900	0.204	185.4	31.0313	57.5469	57.1719	92.5	99.1	241.0	110.8
36.37	1050	0.205	215.2	30.7500	57.3281	56.9844	96.9	115.8	252.2	108.3
36.37	1200	0.238	285.0	29.9063	57.8750	57.2969	44.8	147.7	284.6	173.9
50.22	300	0.304	93.2	30.1875	54.6719	54.5781	22.0	37.4	184.2	152.9
50.22	450	0.207	94.0	30.5625	56.5781	56.5000	22.5	36.5	174.2	128.0
50.22	600	0.195	116.2	30.4688	57.0625	56.9531	31.6	42.4	213.9	153.0
50.22	750	0.188	141.4	30.2813	57.7188	57.6250	32.3	48.7	195.5	169.1
50.22	900	0.200	177.6	30.2188	57.5625	57.4531	45.1	65.5	211.3	138.0
50.22	1050	0.194	204.8	30.4688	58.2500	58.1719	40.0	71.0	211.1	143.3
50.22	1200	0.221	265.8	29.9375	57.5625	57.3281	69.1	84.8	225.5	161.3
72.91	300	0.291	88.2	30.9063	54.8906	54.8281	15.0	20.4	191.2	118.4
72.91	450	0.215	95.6	30.9375	56.5469	56.4375	13.1	27.9	177.5	133.6
72.91	600	0.186	106.6	30.3750	58.2344	58.1406	13.5	25.8	187.4	141.3
72.91	750	0.173	126.2	30.6875	58.4219	58.2969	15.9	29.5	206.4	154.6
72.91	900	0.172	152.4	30.3750	58.7813	58.7031	18.4	35.1	195.9	152.9
72.91	1050	0.205	213.8	30.5313	57.7031	57.6094	21.2	34.5	208.2	122.0
72.91	1200	0.209	250.4	30.8750	58.4219	58.3594	21.3	45.9	167.4	121.9
102.27	300	0.292	89.4	30.6875	55.3438	55.2813	12.5	28.1	213.4	148.7
102.27	450	0.218	95.2	30.8125	56.1094	56.0469	13.1	24.6	159.1	107.8
102.27	600	0.205	119.8	30.7813	57.5625	57.4844	14.1	28.9	230.5	182.2
102.27	750	0.184	137.4	30.8125	58.1563	58.1094	16.8	26.1	175.9	90.5
102.27	900	0.212	188.0	30.7500	57.5000	57.3438	17.9	35.5	195.9	132.5
102.27	1050	0.217	229.2	30.5000	57.4688	57.3750	16.0	28.7	197.7	115.9
102.27	1200	0.229	273.4	30.5313	58.0938	57.9844	19.2	34.1	203.0	148.6
126.60	300	0.286	87.8	30.4063	54.7344	54.6875	15.2	27.5	182.5	143.9
126.60	450	0.230	106.2	30.3750	56.3906	56.3125	19.0	32.2	179.1	131.8
126.60	600	0.213	126.2	30.7188	56.9844	56.8594	22.7	27.3	176.3	116.7
126.60	750	0.213	157.4	30.5938	57.3281	57.2344	17.7	29.6	158.0	130.6
126.60	900	0.223	197.2	30.9063	57.1250	57.0469	20.3	33.9	163.3	122.8
126.60	1050	0.235	247.0	30.3438	57.1563	56.9688	22.1	32.6	191.3	142.9
126.60	1200	0.252	304.6	30.6563	57.1250	57.0000	26.4	40.2	173.4	118.2

DATA SHEET B-III (Continued)

ORIGINAL DATA FROM SHEAR-PLANE ANGLE VERSUS AUGER SPEED TEST - BLOCK II

						Seed Sample Analysis Data				
						Clipper Cleaner Fractions		Selector Reject of Cleaned Seed		
Shear-Plane Angle (Degrees)	Auger Speed Wanted (RPM)	Time to Convey 40 Pounds (Minutes)	Number Revolutions for 40 Pounds	Seed Density (Lb. per Cu. Ft.)	Total Sample Weight (Pounds)	Cleaned Seed (Pounds)	Fragments of Seed (Grams)	Decor-ticated (Grams)	Chipped Seed (Grams)	Unhulled Seed (Grams)
CHECK 2				29.5000	56.0313	55.9688	14.7	26.5	136.4	173.5
27.97	300	0.364	109.8	30.2188	54.1406	53.8594	62.2	75.1	204.0	142.9
27.97	450	0.258	115.6	29.9375	55.5313	55.2813	55.7	74.2	201.7	186.8
27.97	600	0.230	139.2	29.9375	56.1094	55.8281	75.9	79.2	207.1	173.3
27.97	750	0.229	175.8	30.1875	56.5938	56.1563	95.2	114.4	261.0	166.6
27.97	900	0.245	220.4	30.2188	56.1250	55.8750	24.2	125.5	286.2	181.4
27.97	1050	0.231	244.0	29.4063	57.0938	56.6250	06.1	141.3	240.0	182.0
27.97	1200	0.259	310.4	30.0938	56.8906	56.1875	82.2	188.1	332.3	145.6
36.37	300	0.304	93.0	30.3438	54.5625	54.3750	37.5	56.8	193.6	178.9
36.37	450	0.241	106.0	30.4063	55.7656	55.5625	41.3	57.2	200.9	134.2
36.37	600	0.202	121.2	30.5625	56.6563	56.3594	57.5	72.2	207.4	143.7
36.37	750	0.210	152.8	30.6250	56.8594	56.5469	63.3	77.0	181.3	116.3
36.37	900	0.211	192.2	30.6250	57.5156	57.1406	82.4	104.2	241.0	141.2
36.37	1050	0.211	224.0	30.8438	57.6250	57.1719	95.8	119.1	240.6	141.8
36.37	1200	0.218	260.8	30.5938	58.0625	57.5625	14.4	144.2	290.7	151.7
50.22	300	0.322	97.4	29.9375	54.4375	54.2813	25.2	36.6	164.5	171.0
50.22	450	0.228	102.4	30.4688	56.2344	56.1250	26.8	39.2	150.4	163.6
50.22	600	0.204	118.4	30.5938	56.9688	56.8594	27.5	37.1	175.7	177.2
50.22	750	0.196	148.4	30.2813	57.5625	57.3906	31.3	50.2	187.7	198.0
50.22	900	0.188	169.0	29.9063	58.3594	58.1875	37.8	54.1	175.7	174.5
50.22	1050	0.186	195.2	30.9375	57.9219	57.7969	32.2	61.7	235.9	153.4
50.22	1200	0.209	250.8	30.3750	57.7969	57.5313	33.6	73.1	218.1	200.9
72.91	300	0.302	91.0	30.5313	54.5781	54.4844	15.3	24.4	207.4	174.8
72.91	450	0.214	94.2	30.7500	56.6250	56.5625	11.0	25.1	165.7	100.5
72.91	600	0.196	111.8	30.5938	57.3438	57.2656	12.9	27.5	175.6	152.2
72.91	750	0.194	149.6	30.4063	57.2188	57.0938	17.9	28.8	181.6	138.1
72.91	900	0.192	171.8	30.6563	57.7656	57.6563	14.3	26.1	171.1	145.9
72.91	1050	0.213	223.4	30.5938	57.4063	57.2656	19.7	37.2	198.3	143.8
72.91	1200	0.196	234.8	31.0625	58.5469	58.3750	15.8	38.1	192.5	99.4
102.27	300	0.287	88.0	30.4063	54.6719	54.6250	10.0	17.9	143.4	138.3
102.27	450	0.226	102.6	30.5313	56.5000	56.3906	14.0	22.7	141.5	128.0
102.27	600	0.201	122.0	30.6875	57.0313	56.9844	14.3	23.5	160.0	125.5
102.27	750	0.200	150.6	30.9063	57.1406	57.0469	11.1	26.0	151.6	132.7
102.27	900	0.202	179.2	30.5313	57.2656	57.2500	14.7	21.3	157.3	149.7
102.27	1050	0.207	217.2	30.0313	57.3281	57.1875	20.8	30.0	220.0	150.0
102.27	1200	0.220	265.4	30.4375	57.6250	57.4844	16.4	32.6	163.5	174.9
126.60	300	0.293	89.8	30.8438	54.7656	54.7188	13.5	21.8	160.0	147.2
126.60	450	0.235	106.8	30.1250	56.3594	56.2500	15.5	28.0	161.4	190.0
126.60	600	0.205	119.2	30.0313	57.0625	56.9844	12.8	23.2	139.8	127.7
126.60	750	0.211	152.6	30.2500	56.8125	56.7031	18.3	25.0	172.4	164.0
126.60	900	0.228	203.6	30.4063	56.7813	56.6719	16.0	32.7	175.3	163.4
126.60	1050	0.234	245.2	30.2500	57.0781	56.9063	22.8	32.3	177.8	179.0
126.60	1200	0.248	299.0	30.1563	56.9688	56.8906	17.7	31.1	182.1	182.7

DATA SHEET B-III (Continued)

ORIGINAL DATA FROM SHEAR-PLANE ANGLE VERSUS AUGER SPEED TEST - BLOCK III

						Seed Sample Analysis Data				
						Clipper Cleaner Fractions		Selector Reject of Cleaned Seed		
Shear-Plane Angle (Degrees)	Auger Speed Wanted (RPM)	Time to Convey 40 Pounds (Minutes)	Number Revolutions for 40 Pounds	Seed Density (Lb. per Cu. Ft.)	Total Sample Weight (Pounds)	Cleaned Seed (Pounds)	Fragments of Seed (Grams)	Decor-ticated (Grams)	Chipped Seed (Grams)	Unhulled Seed (Grams)
CHECK 3				30.1875	54.8906	54.8125	11.7	30.4	141.6	187.5
27.97	300	0.349	106.4	30.8750	53.8750	53.6094	55.8	71.7	200.0	118.2
27.97	450	0.261	117.4	30.2813	55.4531	55.2344	61.5	88.4	217.6	171.3
27.97	600	0.218	131.6	30.3438	56.6719	56.3281	67.2	100.0	211.1	141.3
27.97	750	0.200	146.4	30.6875	56.5781	56.2656	68.8	102.2	236.2	130.4
27.97	900	0.230	207.0	30.3750	56.8750	56.3750	04.6	135.7	264.5	136.6
27.97	1050	0.237	250.6	30.4688	56.7344	56.2188	27.7	174.7	307.1	167.5
27.97	1200	0.241	288.0	30.3125	57.2969	56.6250	58.9	214.3	302.2	162.2
36.37	300	0.302	92.0	30.1250	57.0469	56.8594	43.8	65.2	182.5	164.1
36.37	450	0.233	108.0	30.4063	56.3750	56.1406	62.4	94.5	197.3	89.3
36.37	600	0.209	133.2	30.5313	56.7031	56.4375	77.0	116.6	230.7	114.8
36.37	750	0.204	149.6	30.5625	57.2969	56.9688	82.0	120.2	251.4	140.7
36.37	900	0.198	173.4	30.1563	57.3906	57.5938	78.9	118.2	250.2	175.2
36.37	1050	0.211	222.2	30.9063	57.1563	56.7188	10.8	140.9	255.0	135.8
36.37	1200	0.213	253.0	30.8125	58.0781	57.5313	20.5	158.4	292.9	148.8
50.22	300	0.296	90.2	30.5625	54.9375	54.7969	23.0	37.0	132.5	100.2
50.22	450	0.229	98.6	30.6250	56.5781	56.4063	32.1	56.8	152.7	132.3
50.22	600	0.197	114.0	30.3750	57.5156	57.3281	36.2	47.9	152.0	119.5
50.22	750	0.193	146.0	30.2188	57.6094	57.3906	49.6	64.0	157.0	153.6
50.22	900	0.176	158.8	30.5625	58.6094	58.4219	35.6	51.1	168.0	136.0
50.22	1050	0.190	201.4	30.7188	57.1406	56.9531	48.0	67.2	191.7	121.0
50.22	1200	0.197	236.2	30.6250	58.9531	58.6719	60.2	75.8	217.8	140.0
72.91	300	0.291	88.4	30.6250	54.8438	54.7031	16.8	36.7	133.6	113.9
72.91	450	0.209	98.0	30.5000	56.4219	56.3438	19.3	34.6	140.6	138.7
72.91	600	0.183	108.4	30.4688	57.2188	57.0938	16.9	38.5	158.6	122.7
72.91	750	0.186	135.4	31.3125	57.6250	57.5625	18.5	34.4	131.0	79.4
72.91	900	0.195	175.2	31.2188	58.0625	57.9688	23.0	38.9	147.2	83.5
72.91	1050	0.212	220.8	29.7813	57.5313	57.4063	28.4	36.2	164.2	119.2
72.91	1200	0.216	259.8	30.4688	58.2188	57.9688	30.7	48.3	152.1	116.1
102.27	300	0.284	87.0	30.3438	54.9531	54.8594	16.0	30.6	172.3	148.9
102.27	450	0.232	100.8	30.6563	56.7188	56.5938	16.9	33.3	151.9	109.4
102.27	600	0.205	122.6	30.6875	57.0469	56.9063	22.2	41.7	184.2	140.5
102.27	750	0.199	144.8	30.5000	57.5000	57.4063	23.1	45.3	182.0	141.7
102.27	900	0.209	188.4	30.6250	57.6094	57.5000	23.0	47.4	200.8	148.4
102.27	1050	0.210	222.2	30.7188	57.8750	57.7656	23.1	46.0	212.9	173.8
102.27	1200	0.212	255.6	30.8125	58.4219	58.2969	28.6	56.7	202.1	104.9
126.60	300	0.288	86.8	30.5625	54.8906	54.7656	17.0	47.9	193.1	137.4
126.60	450	0.216	98.6	30.9063	56.6406	56.5469	21.5	38.4	154.3	85.2
126.60	600	0.207	124.4	30.6875	56.9063	56.7813	24.8	52.2	183.4	125.9
126.60	750	0.207	154.0	30.6875	57.7031	57.5625	24.5	46.7	162.7	123.4
126.60	900	0.224	199.6	30.9063	57.0625	56.9688	31.6	62.4	190.0	127.1
126.60	1050	0.232	244.0	30.6563	57.4688	57.3906	28.8	70.0	234.6	157.7
126.60	1200	0.243	291.2	30.9063	57.7656	57.6563	26.7	60.4	206.7	132.7

DATA SHEET B-IV

ANALYSIS OF VARIANCE FOR SHEAR-PLANE ANGLE VERSUS AUGER SPEED TEST

ATTRIBUTE 1. POUNDS PER HOUR CONVEYED

Source of variation	df	ss	ms	F	P
Total	125	301291000	2410328		
Main plots	17	48668000	2862823.5		
Blocks	2	1496000	748000	2.743	$75 < P < 90$
Shear-plane angles	5	44445000	8889000	32.596	$99.5 < P$
Main plot error	10	2727000	272700		
Sub-plots	41	284654000	6942780.5		
Speeds	6	223457000	37242833	216.005	$99.5 < P$
Speeds x shear-plane angles	30	16752000	558400	3.239	$99.5 < P$
Sub-plot error	72	12414000	172416.66		

DATA SHEET B-IV (Continued)

ATTRIBUTE 2. CUBIC FEET PER HOUR CONVEYED

Source of variation	df	ss	ms	F	P
Total	125	317475	2539.8		
Main plots	17	48599	2858.7647		
Blocks	2	888	444	1.997	75< P< 90
Shear-plane angles	5	45488	9097.6	40.922	99.5 <P
Main plot error	10	2223	222.3		
Sub-plots	41	300917	7339.439		
Speeds	6	237948	39658	212.343	99.5 <P
Speeds x shear-plane angles	30	17481	582.7	3.120	99.5 <P
Sub-plot error	72	13447	186.76388		

DATA SHEET B-IV (Continued)

ATTRIBUTE 3. POUNDS PER REVOLUTION CONVEYED

Source of variation	df	ss	ms	F	P
Total	125	1.296535	.01037228		
Main plots	17	.03175	.0018676471		
Blocks	2	.0014249	.00071245	2.829	$75 < P < 90$
Shear-plane angles	5	.02780700	.00556140	22.086	$99.5 < P$
Main plot error	10	.0025181	.00025181		
Sub-plots	41	1.283662	.031308829		
Speeds	6	1.241613	.2069355	1668.566	$99.5 < P$
Speed x shear-plane angles	30	.014242	.00047473333	3.828	$99.5 < P$
Sub-plot error	72	.00893	.00012402		

DATA SHEET B-IV (Continued)

ATTRIBUTE 4. POUNDS PER HOUR CONVEYED PER SQUARE INCH OF OPENING AREA

Source of variation	df	ss	ms	F	P
Total	125	37496.3	299.9704		
Main plots	17	6056.3	356.25294		
Blocks	2	186.2	93.1	2.742	$75 < P < 90$
Shear-plane angles	5	5530.6	1106.12	32.581	$99.5 < P$
Main plot error	10	339.5	33.95		
Sub-plots	41	35425.6	864.03902		
Speeds	6	27810.	4635.	216.000	$99.5 < P$
Speeds x shear-plane angles	30	2085.	69.5	3.239	$99.5 < P$
Sub-plot error	72	1545.	21.458333		

DATA SHEET B-IV (Continued)

ATTRIBUTE 5. PERCENT TOTAL SAMPLE WEIGHT DAMAGED

Source of variation	df	ss	ms	F	P
Total	125	52.98742	.42389936		
Main plots	17	35.59418	2.0937753		
Blocks	2	.44475	.222375	1.508	70 < P < 75
Shear-plane angles	5	33.67439	6.734878	45.659	99.5 < P
Main plot error	10	1.47504	.147504		
Sub-plots	41	49.12417	1.1981505		
Speeds	6	8.38472	1.3974533	51.772	99.5 < P
Speeds x shear-plane angles	30	7.06506	.235502	8.725	99.5 < P
Sub-plot error	72	1.94346	.0269925		

DATA SHEET B-IV (Continued)

ATTRIBUTE 6. PERCENT OIL BEARING MATERIAL DAMAGED

Source of variation	df	ss	ms	F	P
Total	125	53.801820	.43041456		
Main plots	17	36.094220	2.1231894		
Blocks	2	.43974	.21987	1.493	70 < P < 75
Shear-plane angles	5	34.18153	6.836306	46.412	99.5 < P
Main plot error	10	1.47295	.147295		
Sub-plots	41	49.92686	1.2177283		
Speeds	6	8.53663	1.4227717	52.205	99.5 < P
Speed x shear-plane angles	30	7.2087	.24029	8.817	99.5 < P
Sub-plot error	72	1.96227	.02725375		

DATA SHEET B-IV (Continued)

ATTRIBUTE 7. PERCENT DECORTICATED SEED IN DAMAGED SEED

Source of variation	df	ss	ms	F	P
Total	125	1805.701	14.445608		
Main plots	17	1528.441	89.908294		
Blocks	2	212.046	106.023	53.452	$99.5 < P$
Shear-plane angles	5	1296.56	259.312	130.735	$99.5 < P$
Main plot error	10	19.835	1.9835		
Sub-plots	41	1503.132	36.661756		
Speeds	6	152.674	25.445667	25.918	$99.5 < P$
Speeds x shear-plane angles	30	53.898	1.7966	1.830	$97.5 < P < 99$
Sub-plot error	72	70.688	.98177777		

DATA SHEET B-IV (Continued)

ATTRIBUTE 8. PERCENT FRAGMENTS IN DAMAGED SEED

Source of variation	df	ss	ms	F	P
Total	125	1765.5274	14.124219		
Main plots	17	1525.7826	89.751918		
Blocks	2	25.7789	12.88945	2.814	75 < P < 90
Shear-plane angles	5	1454.1923	290.83846	63.486	99.5 < P
Main plot error	10	45.8114	4.58114		
Sub-plots	41	1641.5466	40.037722		
Speeds	6	117.9719	19.661983	27.021	99.5 < P
Speed x shear-plane angles	30	69.3824	2.3127467	3.178	99.5 < P
Sub-plot error	72	52.3905	.72764583		

DATA SHEET B-IV (Continued)

ATTRIBUTE 9. PERCENT CHIPPED SEED IN DAMAGED SEED

Source of variation	df	ss	ms	F	P
Total	125	6880.88	55.04704		
Main plots	17	5964.2	350.83529		
Blocks	2	382.94	191.47	21.8548	99.5 < P
Shear-plane angles	5	5493.65	1098.73	125.410	99.5 < P
Main plot error	10	87.61	8.761		
Sub-plots	41	6243.64	152.2839		
Speeds	6	537.33	89.555	30.3205	99.5 < P
Speed x shear-plane angles	30	212.66	7.0886667	2.400	99.5 < P
Sub-plot error	72	166.69	2.953611		

APPENDIX C

ELECTRO-MECHANICAL SELECTOR CALIBRATION DATA

DATA SHEET C-I

BLOCK MEANS

Block	Percent Rejected			
	Undamaged	Decorticated	Chipped	Unhulled
	Opening Height Tests			
1	1.06	98.57	40.02	47.72
2	0.89	100.00	39.06	41.02
3	1.80	99.20	39.89	66.14
Grand Mean	1.25	99.26	39.66	51.63
	Shear-Plane Tests			
1	1.98	99.53	47.27	77.26
2	3.16	99.88	46.34	75.21
3	3.22	100.00	48.49	73.04
Grand Mean	2.79	99.80	47.37	75.17

DATA SHEET C-II

OPENING HEIGHT TESTS - BLOCK 1

Sample No.	Percent Rejected			
	Undamaged	Decorticated	Chipped	Unhulled
137	0.91	100.00	39.13	52.38
147	1.14	90.91	39.62	72.00
131	0.64	100.00	27.27	28.57
154	1.20	100.00	54.79	38.64
152	0.38	100.00	29.69	22.73
142	0.75	100.00	61.97	43.75
135	0.44	100.00	30.77	53.33
121	0.78	100.00	32.20	15.63
132	0.76	100.00	32.31	44.00
124	1.36	100.00	48.57	50.00
125	0.97	87.50	31.15	68.97
126	1.45	100.00	44.23	63.64
143	0.35	100.00	33.33	31.37
135	1.01	100.00	24.53	54.72
153	0.94	70.00	28.09	12.00
141	0.98	100.00	63.33	40.91
146	1.77	100.00	26.23	60.00
134	0.71	100.00	29.63	19.51
123	1.28	100.00	42.55	38.81
156	1.49	100.00	52.27	62.50
145	1.65	100.00	40.00	53.85
144	1.20	100.00	48.48	60.00
157	1.10	100.00	46.67	54.84
127	1.29	100.00	58.82	71.43
115	1.54	100.00	22.92	26.67
112	0.51	100.00	31.37	60.87
Check	0.78	100.00	32.81	60.00
136	1.24	100.00	51.43	24.24
122	1.66	100.00	58.49	67.86
133	0.91	100.00	34.29	58.33
151	0.65	100.00	44.44	47.92
117	0.65	100.00	36.05	42.86
111	1.48	100.00	36.54	54.00
113	1.20	100.00	50.72	58.00
116	1.62	100.00	42.86	57.58
114	1.27	100.00	33.33	46.15
Mean	1.06	98.57	40.02	47.72

DATA SHEET C-II (Continued)

OPENING HEIGHT TESTS - BLOCK 2

Sample No.	Percent Rejected Undamaged	Decorticated	Chipped	Unhulled
253	0.78	100.00	40.00	35.71
221	0.60	100.00	38.46	54.55
235	0.91	100.00	46.91	51.22
227	0.91	100.00	60.78	21.43
224	0.67	100.00	26.03	48.39
247	0.97	100.00	56.90	55.77
234	1.50	100.00	66.67	73.17
215	1.48	100.00	38.46	62.07
255	1.49	100.00	36.17	65.79
216	1.12	100.00	43.02	58.82
232	1.18	100.00	22.97	41.46
226	0.61	100.00	35.29	34.38
233	1.14	100.00	46.38	47.73
Check	0.50	100.00	48.00	03.57
237	0.77	100.00	41.18	48.28
242	1.77	100.00	39.29	60.66
257	0.55	100.00	34.55	04.00
222	0.79	100.00	40.32	45.00
256	0.56	100.00	35.94	26.67
241	0.98	100.00	20.25	32.14
213	0.96	100.00	40.22	28.79
225	2.23	100.00	26.92	19.05
246	0.94	100.00	27.27	22.92
223	1.14	100.00	51.39	72.92
212	1.11	100.00	50.94	50.00
236	0.52	100.00	44.00	22.58
217	0.81	100.00	41.49	92.86
252	0.32	100.00	49.09	30.00
231	0.52	100.00	30.61	26.92
243	0.16	100.00	16.67	17.65
251	0.17	100.00	30.36	00.00
254	0.70	100.00	30.30	35.00
211	0.89	100.00	35.48	38.60
245	0.65	100.00	26.03	56.41
244	0.80	100.00	30.99	57.78
214	0.67	100.00	56.86	34.48
Mean	0.89	100.00	39.06	41.02

DATA SHEET C-II (Continued)

OPENING HEIGHT TESTS - BLOCK 3

Sample No.	Percent Rejected Undamaged	Decorticated	Chipped	Unhulled
352	0.91	100.00	29.46	52.08
355	2.42	100.00	41.94	60.98
354	1.63	100.00	22.12	51.43
356	1.42	72.73	29.52	68.18
336	0.40	100.00	34.96	51.11
316	1.30	100.00	43.75	72.09
351	1.86	100.00	42.86	63.16
311	3.37	100.00	45.54	76.36
353	1.88	100.00	32.32	67.86
322	2.63	100.00	32.99	82.05
357	2.36	100.00	39.58	45.16
315	0.93	100.00	35.05	70.00
335	2.04	100.00	31.31	73.17
346	1.26	100.00	34.31	61.11
326	0.45	100.00	49.10	11.54
337	2.04	100.00	38.04	68.89
Check	2.25	100.00	36.36	94.45
347	0.94	100.00	46.43	92.00
317	1.64	100.00	58.24	53.70
341	1.37	100.00	40.00	50.91
314	1.16	100.00	35.19	71.79
325	1.57	100.00	72.06	82.14
334	1.11	100.00	41.00	60.87
345	2.53	100.00	55.88	67.50
324	2.23	100.00	42.31	82.35
323	1.33	100.00	27.16	90.63
321	1.76	100.00	22.22	55.56
332	2.92	100.00	44.44	77.08
343	1.98	100.00	37.50	78.79
342	2.11	100.00	34.55	44.83
333	2.34	100.00	50.48	66.67
331	2.87	100.00	40.32	69.09
312	2.09	100.00	51.56	74.29
344	2.12	100.00	37.65	60.00
Mean	1.80	99.20	39.89	66.14

DATA SHEET C-III

SHEAR-PLANE TESTS - BLOCK 1

Sample No.	Percent Rejected			
	Undamaged	Decorticated	Chipped	Unhulled
151	3.70	100.00	52.80	89.19
117	2.75	100.00	65.41	60.00
153	6.86	100.00	62.20	93.94
133	2.99	100.00	39.42	100.00
156	2.02	100.00	44.87	89.47
146	2.33	100.00	40.91	100.00
143	3.92	100.00	57.43	88.89
155	2.02	80.00	67.68	92.11
142	2.00	100.00	26.72	100.00
157	1.09	100.00	33.63	58.70
137	2.07	100.00	42.75	69.44
134	2.14	100.00	41.94	56.67
131	1.38	100.00	36.08	72.73
152	1.29	100.00	48.28	37.50
132	2.07	100.00	49.50	83.33
154	1.92	100.00	50.00	87.50
135	1.53	100.00	55.70	75.00
114	2.47	100.00	64.63	67.57
136	1.58	100.00	56.12	59.09
112	2.06	100.00	49.18	69.57
141	2.56	100.00	52.11	100.00
115	1.49	100.00	49.01	61.11
111	1.27	100.00	43.08	68.75
144	1.34	100.00	48.35	72.00
145	1.16	100.00	52.94	89.66
147	1.27	100.00	40.46	83.72
116	1.59	100.00	68.21	77.42
Check	2.14	100.00	31.58	80.43
162	1.91	100.00	63.79	69.23
166	2.23	100.00	43.53	82.05
113	2.42	100.00	44.32	100.00
164	1.89	100.00	36.36	100.00
163	1.56	100.00	43.82	80.77
122	1.25	100.00	41.38	65.00
124	1.26	100.00	40.86	80.00
114	1.65	100.00	44.90	70.00
127	1.37	100.00	34.90	63.59
165	1.49	100.00	45.79	72.22
125	1.61	100.00	50.00	73.68
161	2.29	100.00	33.01	86.67
121	0.89	100.00	47.52	65.71
123	1.08	100.00	43.55	38.89
126	1.43	100.00	48.00	90.48
Mean	1.98	99.53	47.27	77.26

DATA SHEET C-III (Continued)

SHEAR-PLANE TESTS - BLOCK 2

Sample No.	Percent Rejected			
	Undamaged	Decorticated	Chipped	Unhulled
236	6.79	100.00	50.62	93.75
262	4.29	100.00	54.55	88.89
234	4.90	100.00	58.97	81.25
265	3.93	100.00	38.10	93.10
231	3.88	100.00	32.14	62.07
246	4.40	100.00	51.59	86.67
254	3.64	100.00	50.00	82.35
221	3.39	100.00	53.66	83.33
217	1.87	100.00	53.41	85.71
215	2.52	95.00	46.32	71.43
261	2.90	100.00	44.29	83.33
255	2.51	100.00	46.15	79.59
211	4.29	100.00	47.14	48.57
266	3.68	100.00	51.49	69.81
222	3.86	100.00	60.87	63.16
253	2.75	100.00	52.50	72.09
212	3.43	100.00	42.86	63.79
232	1.46	100.00	37.37	82.22
Check	3.06	100.00	34.23	73.17
257	3.84	100.00	42.40	70.21
233	4.82	100.00	53.23	60.00
225	3.34	100.00	54.47	68.09
252	3.67	100.00	47.14	79.69
214	4.07	100.00	56.57	77.78
251	2.90	100.00	43.33	80.00
244	2.72	100.00	27.78	68.18
216	2.27	100.00	37.42	44.29
224	1.46	100.00	46.09	67.50
256	8.14	100.00	50.00	76.92
243	1.33	100.00	40.00	59.32
227	1.44	100.00	47.12	92.86
213	1.96	100.00	45.35	91.67
264	1.94	100.00	58.12	100.00
242	1.79	100.00	38.04	78.13
247	2.50	100.00	35.77	73.53
226	1.65	100.00	51.38	45.45
235	1.57	100.00	46.67	53.57
241	6.35	100.00	68.97	91.43
237	2.28	100.00	34.48	92.31
267	2.47	100.00	39.60	74.55
223	2.12	100.00	48.34	92.31
245	2.03	100.00	41.57	76.67
263	1.46	100.00	32.59	55.17
Mean	3.16	99.88	46.34	75.21

DATA SHEET C-III (Continued)

SHEAR-PLANE TESTS - BLOCK 3

Sample No.	Percent Rejected			
	Undamaged	Decorticated	Chipped	Unhulled
322	2.23	100.00	35.29	64.41
364	4.09	100.00	48.15	74.07
357	1.33	100.00	66.98	92.00
331	1.28	100.00	46.43	65.38
325	6.85	100.00	43.48	76.19
351	3.89	100.00	48.48	66.67
332	3.57	100.00	42.11	86.67
354	2.80	100.00	34.74	76.27
346	2.42	100.00	47.47	63.64
367	2.76	100.00	42.45	72.41
362	3.00	100.00	57.34	74.29
356	3.80	100.00	42.73	95.83
324	3.42	100.00	52.52	88.24
337	2.72	100.00	43.42	91.18
327	3.18	100.00	47.06	65.00
336	2.36	100.00	45.31	51.72
335	2.43	100.00	46.22	53.13
Check	4.11	100.00	59.18	72.09
361	5.74	100.00	55.71	71.43
347	3.19	100.00	39.62	60.00
315	1.79	100.00	65.74	83.67
345	2.80	100.00	44.04	84.00
311	1.63	100.00	59.66	68.89
344	2.71	100.00	50.98	54.35
314	2.79	100.00	63.86	91.67
343	2.31	100.00	34.74	97.22
341	3.23	100.00	42.86	62.96
342	2.67	100.00	48.35	62.50
312	3.43	100.00	48.09	51.85
321	3.18	100.00	42.17	63.64
317	3.64	100.00	66.02	68.57
353	2.81	100.00	53.57	68.00
365	1.98	100.00	27.86	50.00
352	7.96	100.00	43.81	38.24
323	3.29	100.00	49.25	88.00
313	1.95	100.00	46.88	67.65
316	3.28	100.00	52.63	77.14
333	2.32	100.00	33.90	91.18
363	3.34	100.00	41.43	59.26
323	3.11	100.00	55.38	82.35
355	3.50	100.00	47.37	75.00
366	5.33	100.00	62.67	95.83
334	4.08	100.00	58.95	98.15
Mean	3.22	100.00	48.49	73.04

APPENDIX D

ANALYSIS OF CLEANED CASTOR SEED SAMPLES

DATA SHEET D-I

ANALYSIS OF CLEANED CASTOR SEED SAMPLES
(These samples were taken prior to conveyor tests.)

Sample No.	Total Weight (Gm)	Damaged Weight (Gm)	Percent Damaged	Sample No.	Total Weight (Gm)	Damaged Weight (Gm)	Percent Damaged
1	623.1	8.4	1.3	43	600.5	10.2	1.7
2	619.4	11.0	1.8	44	543.6	8.2	1.5
3	591.2	8.6	1.5	45	556.6	7.6	1.4
4	624.3	9.3	1.5	46	633.8	7.4	1.2
5	672.3	12.2	1.8	47	614.1	7.2	1.2
6	589.0	8.6	1.5	48	406.4	4.3	1.1
7	623.5	8.8	1.4	49	558.8	8.7	1.6
8	665.1	9.9	1.5	50	549.0	6.3	1.1
9	554.2	6.5	1.2	51	521.6	11.5	2.2
10	539.5	8.0	1.5	52	643.2	10.5	1.6
11	505.7	8.4	1.7	53	584.3	8.9	1.5
12	601.5	7.6	1.3	54	559.5	6.2	1.1
13	565.3	7.6	1.3	55	402.6	4.7	1.2
14	405.3	6.3	1.6	56	509.4	8.8	1.7
15	626.1	8.9	1.4	57	574.9	11.1	1.9
16	556.7	5.3	1.0	58	560.9	9.0	1.6
17	529.5	8.1	1.5	59	546.4	9.5	1.7
18	584.0	6.9	1.2	60	536.1	8.1	1.5
19	565.8	7.6	1.3	61	593.6	11.7	2.0
20	535.9	8.9	1.7	62	539.8	6.0	1.1
21	560.9	7.2	1.3	63	507.3	7.6	1.5
22	544.6	7.0	1.3	64	536.4	9.4	1.8
23	603.5	7.2	1.2	65	547.6	5.5	1.0
24	504.2	5.2	1.0	66	560.6	5.3	0.9
25	580.1	8.6	1.5	67	573.4	10.5	1.8
26	669.3	8.2	1.2	68	539.3	8.0	1.5
27	471.9	6.1	1.3	69	491.9	7.3	1.5
28	597.2	9.2	1.5	70	559.4	9.0	1.6
29	567.1	10.5	1.9	71	587.8	7.4	1.3
30	555.3	10.0	1.8	72	446.3	6.8	1.5
31	532.4	6.8	1.3	73	580.1	10.0	1.7
32	483.2	7.7	1.6	74	693.1	8.0	1.2
33	578.7	11.3	2.0	75	640.5	11.1	1.7
34	459.1	6.9	1.5	76	558.1	6.1	1.1
35	464.9	8.5	1.8	77	577.4	11.8	2.0
36	620.4	13.3	2.1	78	467.1	7.7	1.6
37	591.5	8.6	1.5	79	498.7	9.2	1.8
38	639.3	10.3	1.6	80	569.8	6.5	1.1
39	557.0	8.1	1.5	81	509.0	6.2	1.2
40	570.3	10.1	1.8	82	461.4	6.7	1.5
41	513.9	8.2	1.6	83	556.2	8.9	1.6
42	544.5	10.3	1.9	84	425.9	10.5	2.5

DATA SHEET D-I (Continued)

Sample No.	Total Weight (Gm)	Damaged Weight (Gm)	Percent Damaged	Sample No.	Total Weight (Gm)	Damaged Weight (Gm)	Percent Damaged
85	514.4	7.1	1.4	130	575.5	11.7	2.0
86	579.8	11.2	1.9	131	573.4	10.0	1.7
87	542.4	12.2	2.2	132	540.6	11.7	2.2
88	549.1	12.3	2.2	133	555.3	12.5	2.3
89	592.0	13.5	2.3	134	546.3	10.7	2.0
90	634.3	13.0	2.0	135	588.0	9.9	1.7
91	659.4	9.5	1.4	136	611.4	10.5	1.7
92	577.4	8.7	1.5	137	592.6	7.5	1.3
93	810.9	12.0	1.5	138	639.7	7.3	1.1
94	835.2	12.1	1.4	139	629.4	7.4	1.2
95	506.7	7.6	1.5	140	617.8	13.5	2.2
96	826.2	12.0	1.5	141	601.8	11.2	1.9
97	577.5	10.3	1.8	142	760.7	15.4	2.0
98	611.7	12.8	2.1	143	671.8	7.5	1.1
99	536.3	7.7	1.4	144	784.1	11.6	1.5
100	542.0	10.5	1.9	145	610.9	6.5	1.1
101	591.2	8.0	1.4	146	736.8	13.6	1.8
102	574.5	8.9	1.5	147	648.5	11.9	1.8
103	563.1	9.0	1.6	148	720.7	10.9	1.5
104	612.1	5.4	0.9	149	663.8	11.8	1.8
105	519.1	6.1	1.2	150	703.0	14.2	2.0
106	524.9	8.1	1.5	151	646.6	11.4	1.8
107	638.7	6.6	1.0	152	714.9	13.8	1.9
108	503.1	9.6	1.9	153	570.7	9.5	1.7
109	517.6	6.2	1.2	154	562.9	11.6	2.1
110	545.4	6.7	1.2	155	595.8	13.3	2.2
111	595.8	11.3	1.9	156	567.8	15.0	2.6
112	604.4	6.3	1.0	157	646.1	12.4	1.9
113	501.4	6.7	1.3	158	741.7	10.0	1.3
114	481.6	7.9	1.6	159	506.5	8.7	1.7
115	548.9	10.0	1.8	160	561.7	12.2	2.2
116	553.4	9.2	1.7	161	487.0	6.0	1.2
117	517.2	9.7	1.9	162	483.8	7.4	1.5
118	582.9	10.9	1.9	163	503.5	7.0	1.4
119	533.1	10.0	1.9	164	659.4	16.4	2.5
120	546.3	12.8	2.3	165	551.3	8.7	1.6
121	553.4	9.3	1.7	166	556.1	10.4	1.9
122	530.9	11.0	2.1	167	569.6	11.7	2.1
123	583.9	7.9	1.4	168	607.8	16.0	2.6
124	632.2	9.2	1.5	169	576.3	16.3	2.8
125	555.5	5.9	1.1	170	624.3	15.6	2.5
126	498.5	8.5	1.7	171	580.2	15.2	2.6
127	552.7	7.8	1.4	172	571.8	10.3	1.8
128	583.0	10.5	1.8	173	641.1	12.5	1.9
129	655.4	13.5	2.1	174	574.0	10.4	1.8

DATA SHEET D-I (Continued)

Sample No.	Total Weight (Gm)	Damaged Weight (Gm)	Percent Damaged
175	577.6	9.6	1.7
176	600.2	8.6	1.4
177	544.1	10.3	1.9
178	589.3	12.5	2.1
179	646.8	10.1	1.6
180	576.4	11.3	2.0
181	591.3	11.4	1.9
182	585.8	12.8	2.2
183	661.5	12.2	1.8
184	628.8	9.7	1.5
185	642.2	16.6	2.6
186	608.7	14.0	2.3
187	600.0	16.2	2.7
188	557.6	10.6	1.9
189	584.0	15.3	2.6
190	622.0	9.2	1.5
191	525.0	8.8	1.7
192	488.2	7.6	1.6
193	635.7	12.9	2.0
194	610.7	8.7	1.4
195	578.4	9.8	1.7
196	633.6	10.8	1.7
197	562.6	10.5	1.9
198	644.3	8.6	1.3
199	638.7	12.5	2.0
200	579.5	15.4	2.7
201	577.6	17.8	3.1
202	582.4	14.7	2.5
203	570.7	11.1	1.9
204	514.3	10.8	2.1
205	642.4	10.4	1.6
206	644.4	13.1	2.0
207	586.4	12.5	2.1
208	534.5	10.4	1.9
Mean			1.68

APPENDIX E

PRELIMINARY TEST DATA

DATA SHEET E-I

EFFECT OF SPEED ON CAPACITY FOR VARIOUS OPENING HEIGHTS

Vertical Opening Height (In)	Speed (RPM)	Time (Sec)	Weight Castor Seed Conveyed (Lb)	Rate of Conveying (Lb/Hr)
1	100	30	2.800	336
1	200	30	5.095	610
1	300	15	3.649	875
1	400	15	3.166	760
1	500	15	3.838	920
1	600	15	5.822	1400
1	700	15	5.123	1230
1	800	15	5.676	1360
1	900	15	4.902	1180
2	29	30	4.766	572
2	100	15	6.874	1650
2	200	10	7.144	2580
2	300	15	16.852	4045
2	350	15	21.235	5096
2	400	15	22.594	5423
2	500	15	24.344	5843
2	600	15	22.032	5288
2	700	15	14.844	3563
3	29	30	6.485	778
3	100	30	22.266	2672
3	200	15	19.954	4789
3	400	10	18.079	6508
3	500	10	19.579	7048
3	600	10	17.985	6475
5	100	30	19.477	2337
5	200	15	20.547	4931
5	400	10	24.547	8742
5	500	5	13.719	9878
5	600	10	26.563	9563
5	700	10	26.203	9433
5	800	10	26.110	9400
5	1000	10	24.516	8826
5	1200	10	24.516	8826
5	1300	10	24.829	8938

DATA SHEET E-I (Continued)

Vertical Opening Height (In)	Speed (RPM)	Time (Sec)	Weight Castor Seed Conveyed (Lb)	Rate of Conveying (Lb/Hr)
7	100	27	12.750	1700
7	200	15	17.704	4249
7	400	10	24.813	8933
7	500	10	28.750	10350
7	600	10	32.640	11750
7	700	10	33.437	12037
7	800	10	34.078	12268
7	900	10	34.578	12448
7	1000	10	33.000	11880
7	1200	10	34.406	12386
7	1300	10	33.750	12150
9	100	15	7.438	1785
9	200	15	17.125	4110
9	300	10	22.375	8055
9	400	10	29.781	10721
9	500	10	34.500	12420
9	600	10	39.031	14051
9	700	10	40.344	14524
9	800	10	40.656	14636
9	900	10	42.359	15250
9	1000	10	42.219	15190
9	1200	10	41.656	15000
10	400	10	22.141	7971
10	600	10	31.844	11464
10	800	10	35.281	12701
10	1000	10	37.281	13421
10	1100	10	35.984	12954
10	1200	10	37.281	13421
10	1300	10	37.625	13545
11	400	10	27.938	10057
11	500	10	34.625	12465
11	600	10	37.063	13343
11	700	10	41.031	14771
11	800	10	40.219	14479
11	900	10	42.688	15368
11	1000	10	43.422	15632
11	1200	10	34.625	12465

DATA SHEET E-II

EFFECT OF OPENING HEIGHT ON CAPACITY AT TWO SPEEDS

Vertical Opening Height (In)	Idle or Empty Speed (RPM)	Actual Loaded Speed (RPM)	Time (Sec)	Weight Castor Seed Conveyed (Lb)	Rate of Conveying (Lb/Hr)
6	800	791	10	30.625	11,025
7	800	789	10	35.750	12,870
8	800	788	10	44.094	15,874
9	800	791	10	46.422	16,712
10	800	790	10	47.203	16,993
11	800	788	10	49.125	17,685
6	1000	985	10	32.766	11,796
7	1000	980	10	37.281	13,421
8	1000	981	10	41.250	14,850
9	1000	980	10	45.656	16,436
10	1000	971	10	48.250	17,370
11	1000	977	10	49.656	17,876

DATA SHEET E-III

HOPPER ORIFICE TEST
(Five replications were made for each height.)

Vertical Opening (In)	Rate (Lb/Hr)	Vertical Opening (In)	Rate (Lb/Hr)
1	4,511	3	34,351
$1\frac{1}{8}$	5,625	4	36,000
$1\frac{1}{4}$	7,732	5	38,461
$1\frac{1}{2}$	12,820	7	40,358
$1\frac{3}{4}$	15,571	9	40,449
2	20,833	11	37,975
		No Tube	38,961

DATA SHEET E-IV

PRELIMINARY RECIRCULATION TEST DATA

	First Circulation		Tenth Circulation	
	1/2 Pitch Length Opening Height	2 1/2 Pitch Lengths Opening Height	1/2 Pitch Length Opening Height	2 1/2 Pitch Lengths Opening Height
Total weight conveyed to scale box; lb.	53.063	67.344	------	------
Time required to convey 40 pounds; min.	0.461	0.098	1.072	0.142
Number of auger revolutions required to convey 40 pounds	555.0	118.2	1299.3	155.6
Computed RPM during 40 pounds	1204	1206	1212	1096
Computed rate for 40 pounds; lb/hr	5206	24490	2239	16901
Computed pounds per auger revolution	0.072	0.338	0.031	0.257
Time required for one recirculation; sec	36.7	9.9	85.3	14.3

DATA SHEET E-V

ANALYSIS OF SUB-SAMPLES FROM RECIRCULATION TEST

		Opening Height					
		1/2 Pitch Length			2 1/2 Pitch Lengths		
Number of Circulations	Sub-Sample Number	Total Weight (Gm)	Damaged Weight (Gm)	Percent Damaged	Total Weight (Gm)	Damaged Weight (Gm)	Percent Damaged
3	A	-----	-----	-----	653.3	16.3	2.50
	B	-----	-----	-----	620.1	14.3	2.31
	C	-----	-----	-----	685.2	18.2	2.66
	Mean	-----	-----	-----			2.49
5	A	523.8	38.5	7.35	717.2	22.8	3.18
	B	530.8	34.4	6.48	743.5	20.0	2.69
	C	554.3	36.1	6.51	738.0	23.4	3.17
	Mean			6.78			3.01
7	A	622.2	57.2	9.19	601.0	19.6	3.26
	B	460.9	42.0	9.11	659.6	21.8	3.31
	C	739.0	57.8	7.82	665.4	22.1	3.32
	Mean			8.71			3.30
9	A	566.3	56.9	10.05	683.5	29.5	4.32
	B	586.5	54.6	9.31	635.0	23.8	3.75
	C	578.6	57.6	9.96	629.6	19.8	3.14
	Mean			9.77			3.74

VITA

Louis Frederick Bouse

Candidate for the Degree

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