A PRECISION PLANTER WITH FLUID LOGIC CIRCUITRY

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PREFACE

The work reported in this thesis illustrates the capability of using fluid logic synthesis techniques with fluidic sensing and logic control for specific problems encountered in Agricultural Engineering. Much personal benefit has been gained from this work and my graduate program. I am indebted to many people especially at Oklahoma State University, for their contributions.

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NOMENCLATURE

b	Number of replications
C_t	Actual seed count
D	Coefficient of discrepancy
i	Seed sequence number
K	Best starting position for seed spacing measurement
L	Sampling Length
MP	Seed metering percent used as index of metering unit capabilities
N	Total seed count
N_c	Number of seed cells per row for one drum revolution
N_s	Number of spaces between seeds. (Add space between beginning point and first seed to the space between last seed and end point to obtain the same number of spaces as number of seeds).
p(EP)	Probability of having extra seeds in primary seed cells
p(ES)	Probability of having extra seeds in secondary seed cells
p(P)	Probability of missing a seed in the primary seed source
p(PS)	Probability of missing a seed in primary and secondary seed source simultaneously
p(S)	Probability of missing a seed in the secondary seed source
p(P or S)	Probability of planting a seed from either the primary or secondary source
r	Number of rows of drum

R_d	Number of drum revolutions in sample
R_v	Relative variance
s	Number of RPM settings
S_p	Mean spacing
SR	Percent seed rupture
S^2max	Variance when all spaces are 0 except one which is equal to the test length, i.e. L^2/N_s
$S^2observed$	Measured variance
V_s	Seed velocity in feet per minute
X_i	Observed seed position
X_o	Distance between any two adjacent seeds
σ	Standard deviation

CHAPTER I

INTRODUCTION

Planting is one of the most crucial operations in crop production. A prerequisite in obtaining maximum yield and quality of product is the establishment of a uniform stand. For most crops there is a spacing which optimizes plant competition for nutrients, moisture and light and provides maximum yield and quality of product from a given area of land (10, 19, 24). Obtaining desired plant stands from a minimum seeding rate also contributes toward minimizing production costs.

The device used to plant seeds must satisfy certain criteria if these planting goals are to be obtained. A planter must be able to meter seeds uniformly and place them in the seedbed with uniform spacings between seeds. Since only a limited time period is available for which field conditions are optimum for seedling emergence, the planter must perform these functions at a rate which will allow rapid coverage of the crop production area.

Numerous studies have been made on principles for metering seeds and placing them in the seedbed accurately. However, little attention has been given to automatic control of seed metering. For accurate spacings, capability is needed to sense presence or absence of individual seeds before being planted and to provide "back-up" seeds to plant where there would normally be a "miss".

Pneumatic sensing and logic techniques can provide one method to insure metering accuracy. Several fluidic sensing methods are available for sensing at high rates presence or absence of small objects. Pneumatic logic elements which have frequency response of several hundred Hertz are also available, and can be combined in circuits to obtain programming capability. Pneumatic output devices are available to interface between logic networks, and power circuits, and the combination of these elements provide potential to use pneumatics for sensing, logic, and control in a metering device (17, 18).

Fluidics is a term which identifies elements that do not contain any moving parts and utilize the dynamics of a fluid to perform their functions. Fluidic elements operate at low pressures and require continuous flow of fluid for operation. Other types of logic elements are generally identified as "moving-parts" elements and sometimes are grouped according to the type of internal movement of the element. These types of elements do not require continuous flow of fluid and can operate at high pressures. Moving parts elements are frequently used as the interface between fluidic logic circuits and power control circuits because of their high pressure capability.

Fluid logic techniques have been developed which permit logic circuits to be synthesized from a description of desired circuit inputs and outputs. These techniques offer a means to develop logic circuits to provide compensation for errors in a seed metering device. The logic circuit synthesized from these techniques can be constructed with either fluidic or moving part elements.

Scope of the Research

The purpose of this research was to investigate the feasibility of using fluid logic synthesis techniques in conjunction with fluidic sensing and logic devices to sense presence or absence of seeds in a metering unit and to dispense seeds from a "back-up" source when seeds were missing. Primary interest has been focused on development of a functional circuit, and optimization of air pressures and consumption in the circuit has not been undertaken. Commercial components were then used to perform the desired function and are identified in Appendix A.

Objectives of the Research

1. Develop a metering unit utilizing principles of fluidics and fluid logic for dispensing acid-delinted cottonseed one at a time at a rate of at least 135 seeds per second.
2. Investigate methods of placing individual acid-delinted cottonseed in a seed furrow, and develop a seed ejecting unit which accurately spaces seeds along the furrow.

CHAPTER II

LITERATURE REVIEW

Published information was surveyed to obtain information useful in fulfilling the objectives of this research. Important principles relating to seed metering, seed conveyance, spacing analysis techniques, logic synthesis techniques, and pneumatic sensing, logic and control devices are summarized below. A thorough summary of the classical logic synthesis technique is given since it is used in this research.

Seed Metering

Commercial row crop planters may be classified according to metering principles as cell, finger, and pneumatic types. The cell has been the predominant type and has many variations. This type generally consists of a plate with cells which are filled by seeds as it rotates inside a seed hopper. The two most common variations of the cell type planters have vertical and horizontal plates.

Akyurt and Taub (1) have tested accuracy of several vertical and horizontal plate planters for planting sugar beet seed. They stated that cell filling of horizontal plate planters was more favorable than on vertical ones, whereas the planting precision of vertical plate planters was superior to horizontal ones. Increased planting precision was attributed to reduced falling distance from plate to furrow in vertical plate planters. They found that cell depth was the most important factor in influencing number of empty cells, and that maximum metering rate was approximately 25 cells per second.

Roth and Porterfield (51) studied some of the basic characteristics of a horizontal plate seed metering device. The following factors were given as possibly affecting a horizontal plate metering device:

1. Relative size of seed and cell
2. Relative shape of seed and cell
3. Orientation of seed to cell
4. Relative speed of seed and cell
5. Distance cell travels while exposed to seed
6. Time interval cell is exposed to seed
7. Type of cutoff and knockout devices used
8. Depth of seed above seed plate
9. General shape of seed
10. Variation in seed size and shape
11. Surface characteristics of seed
12. Density of seed

They concluded that after a certain plate cell speed was reached, cell fill decreased with increasing speeds. Cell clearance affected the maximum speed for which cell metering percentage remained at 100, and an increase in cell clearance made metering accuracy less sensitive to speed changes. They also found that for a given time of cell exposure to the seed, a short exposure distance and slow cell speed resulted in increased cell fill.

Wanjura and Hudspeth (53) have studied the metering and seed pattern characteristics of a horizontal edgedrop plate planter using acid delinted cottonseed. They found that metering percentage varied due to plates, plate speed and hoppers. They concluded that spacing between seeds was random and unsuitable for cultural systems where precise seed spacing is desired.

Other studies (3, 4) of cell type planters have shown similar results. Metering accuracy is variable and attributable to many factors. This has led to the development of other planting principles.

Several plateless-finger type metering devices have been developed and one has been produced commercially (15, 34). In the commercial unit, a mechanical finger grasps seeds as it rotates through them and delivers them to a paddle rotor which ejects the seeds. The plateless planter was developed primarily for corn, and metering accuracy is less subject to seed size variations as compared to cell-plate type planters. Field tests including the plateless planter indicate that the stand distribution is about the same as for plate type planters (26).

A more recent commercial development is the pneumatic planter shown in Figure 1 (27). It utilizes a large seed drum which contains several rows of cells containing small orifices. A blower maintains a positive air pressure inside the drum, and seed are fed into the bottom of the seed drum by a chute maintaining a constant seed level within the drum. Seeds close off the orifices as the drum rotates, and the differential pressure between inside and outside the drum causes seeds to be held in the cells until reaching the discharge point. A rubber roller closes the orifice at the top of the drum thus cutting the air pressure differential between inside and outside of the drum. This permits the seed to fall into a manifold which delivers the seed to a tube where the seed is conveyed to the seed furrow pneumatically.

Little information has been published on function of the I H

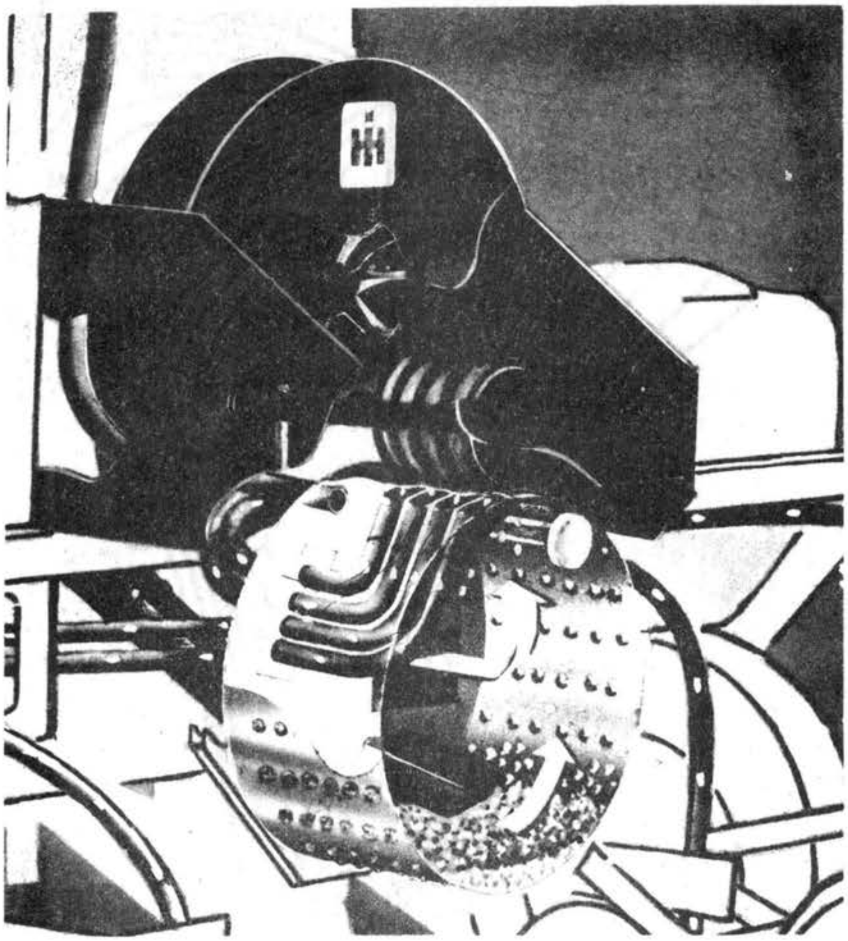


Figure 1. International Harvester Cyclo Planter

Cyclo planter, but Horne (26) has included it in a study of accuracy of seed placement of corn planters. He measured actual seed spacings in farmer's fields and compared these to the theoretical spacing for settings according to the operator's manual. Measurements were made from an initial seed called a "zero-in" seed.

For a theoretical spacing of 19.1 cm (7.5 in) Horne (26) found that only 0 to 1.4% of the seeds were located exactly on the mark where they were supposed to be located. Approximately one-third of the seeds were within 25.4 mm (1 in) of the mark, about 60 percent within 50.8 mm (2 in), and about 90 percent within 76.2 mm (3 in). From 3 to 6 percent were recorded as double drops and 4 to 17 percent were recorded as misses. Horne (26) rated performance of dropping seed within 50.8 mm (2 in) of the predetermined mark as excellent performance.

In addition to commercial metering devices, many metering devices have been studied experimentally. Vacuum, step, centrifugal and fluidic metering type devices have been developed to increase accuracy in metering single seeds. These techniques offer unique alternatives as compared to the traditional cell type planters.

Vacuum metering techniques have been studied by several researchers (10, 11, 12). Wanjura and Hudspeth (56) designed and tested a vacuum metering technique for acid-delinted cottonseed. A vacuum wheel, with mechanical assist in lifting, improved metering accuracy as compared to the conventional cell type planter. One of the primary disadvantages of the vacuum systems was that the air entering the system cannot be easily filtered and contamination could cause malfunctions.

A step planter based on the cell-plate principle was designed and tested by Jimenez and Buchele (28). The design included five metering plates in series which placed five seeds at once in a step fashion. This permitted slower velocity of seed cells in the hopper and longer exposure time for filling cells, but the unbalance of the stepping mechanism limited planting speeds to a maximum of 2.51 kilometers per hour (1.5 mph). Unless some counter balancing could be achieved, this slow speed would result in inadequate field capacity for a commercial unit.

The importance of the force of gravity in filling horizontal seed cells has been emphasized by Khan and McColly (29). They developed and tested a high speed centrifugal seed planter. It utilized two rotating seed rings, and the entire unit and seeds were rotated. The outer ring contained one cell which would line up with a cell in the inner ring once each revolution. One seed would be ejected from the unit each revolution. Centrifugal force exerted on the seeds was greater than the force which could be exerted by gravity. This improved cell fill when compared to a conventional cell-plate planter operating at high speeds. The maximum seeding rate tested was approximately 26 seeds per second for the centrifugal and approximately 18 seeds per second for the conventional plate planters.

Rohrbach and Holmes (47) have shown that an air jet eminating from an orifice at the center of the closed end of a cylindrical cavity causes a single spherical object to be drawn into and retained in the cavity. Rohrbach and Kim (49) have used this phenomenon to develop a pure fluidic seed metering device. Seed shape and surface characteristics may be critical for operation, and reported testing has been only on round smooth objects. Seeding rates which have been reported are very low at 24 seeds per minute.

The above fluidic seed metering device can apparently monitor its seeding output and make corrections for errors, but the performance of this feature has not been reported. In the other metering unit tested by Rohrbach and Kim (49), fluidics was used to control metering within certain limits over a period of time but no attempt was made to provide make-up seeds for individual misses.

Zagotta et al. (57) have patented a fluidic grain planting control which alternately provides vacuum and positive pressure output. Seeds are attracted to radial pickup fingers by vacuum and discharged by positive pressure.

Seed Conveyance

Most planters use a tube to convey the seed from the metering unit to the seed furrow, and gravitational force causes the seed to drop through the tube. Other methods used in commercial planters include rotary valves and pneumatics.

Several studies have shown that the type and shape of tube can affect the accuracy in spacing of seeds in the seed furrow. Bainer (3) showed that smooth straight tubes increased spacing accuracy when compared to spiral ribbon tubes. Morton and Buchele (39) decreased spacing variations by shortening the seed tube. Akyurt and Taub (1) concluded that vertical cell type planters were more accurate in sowing precision than horizontal cell type planters because of the reduced height of fall.

Autrey and Schroeder (2) have tested a trajectory seed tube which permits the seed to drop in a parabolic arc. This was found to reduce dispersion of hill dropped seed. Wanjura and Hudspeth (55) found that a straight tube 19.5 mm (.75 in) in diameter and angled backward on a 30 degree angle produced less lateral scatter and shorter skips than larger straight tubes when planting acid delinted cottonseed.

Brandt and Fabian (9) discussed the operation of a rotary valve used in hill dropping seeds. Seeds accumulate until they are picked up by a pocket on the rotary valve and delivered to the seed furrow. This valve is vertical and was capable of ejecting seeds with zero velocity relative to the seed furrow. By giving seeds a velocity equal and opposite the direction of travel, bouncing and scattering of seeds in the seed furrow was minimized.

The pneumatic planter utilizes air to convey seeds through smooth plastic pipe from the metering drum to the seed furrow (27). Little information is available on the effect of pipe bends and configuration on the dispersion of seeds as they are delivered to the seed furrow or on possible seed damage during conveyance and impact with the soil.

Kirk and McLeod (32) used a pneumatic apparatus to accelerate cottonseed for studying rupture from impact on a steel plate. The 12.7 mm (.5 in) horizontal brass pipe used in the test resulted in a seed velocity which was 0.71 times the air velocity. Rupture was found to be

$$SR = 4.77 \times 10^{-16} (V_s)^{4.38} \quad (1)$$

Tests were made at air velocities of 914.4 to 2438.4 meters per minute (3,000 to 8,000 fpm).

Chand and Ghosh (14) have analytically described the dynamics of particles under pneumatic conveyance. They derived a general equation for velocity of particles from physical properties of the system, and verified it through experiments. The following factors were considered:

1. Gravity
2. Friction between particles and wall
3. Friction between particles
4. Impact between particles and the wall
5. Impact between particles
6. Air velocity profile in tube
7. Shape, size and density of particles

Relationship between particle velocity and air velocity was shown to be linear for a straight horizontal pipe.

In their experimental centrifugal planter, Khan and McColly (29) used the centrifugal force generated to eject seeds at high velocities. No field testing was reported, but it was suggested that the seed would be ejected at velocities high enough to embed it in the seed furrow and reduce scattering.

Brown (12) designed and tested a seed delivery system providing zero seed velocity for use with a finger-type planter. This design consisted of a paddle wheel which accepted seeds from a finger seed metering mechanism and delivered them to a rotor ejecting unit. A paddle wheel delivered seed to a rotor and maintained the accuracy of the metering unit. The rotor accelerated the seed to give it zero velocity relative to the seed furrow. This method improved uniformity of seed spacing as compared to a conventional finger-type planter operating at high speeds.

Spacing Analysis Techniques

Several techniques have been suggested and used to evaluate the regularity of spacings of seeds or seedlings. There is no agreement as to the best method, and all single indexes appear to have deficiencies.

Brooks and Baker (11) have discussed several methods and present some indexes for describing spacing variability. A coefficient of variability was defined as the standard deviation of spacings divided by the mean spacing. The square of the coefficient of variability was defined as a normalized variance as follows:

$$\left(\frac{\sigma}{S_p}\right)^2 = \frac{1}{NS_p^2} \quad (X_o - S_p)^2 \tag{2}$$

A coefficient of discrepancy was defined as follows:

$$D = \sqrt{\frac{1}{NS_p^2} \quad \Sigma[X_i - (is_p + K)]^2} \tag{3}$$

A dispersion coefficient was defined as the standard deviation plus the addition of one-third of the Chi-square criterion. The Chi-square criterion was added to penalize the spacings for clusters of seeds, and the proper weighting factor was expected to be verified through experience.

Porterfield (44) has shown how the above indexes vary when theoretical spacings are different with sample length being constant. He derived a statistic termed relative variance which does not vary in range for a given sample length regardless of the change in theoretical spacings. Relative variance was defined as:

$$R_v = \left(1 - \frac{S^2 \text{ observed}}{S^2_{max}}\right) 100 \tag{4}$$

Expanded in terms of individual variables it becomes:

$$R_v = \frac{L^2 N_s - N_s \Sigma X_o^2}{L^2 (N_s - 1)} \quad (100) \tag{5}$$

The relative variance varies between 0 and 100 with 0 being worst possible spacing and 100 being perfect spacing distribution.

Rohrbach et al. (46) have developed a Monte Carlo Planter Model to evaluate field planting. This model incorporates independent random variables, one of which is error in seed placement. A histogram of field plant spacings is constructed from which the standard deviation of the drop error is determined. Two methods were proposed for determining standard deviation of the drop error, with the suggestion that further study is needed on each. The sample sizes used in their study varied from 250 to 1000 observations, but size of sample required is a function of histogram shape.

Logic Synthesis Techniques

The mathematician George Boole, presented the first practical system of logic in algebraic form. His logic system has been developed into what is today called Boolean algebra, and permits logic problems to be solved in a manner similar to conventional algebra. Boolean algebra is a binary algebra and the two discrete values, 0 and 1, can represent off and on conditions of physical systems. The primary logic functions are AND (·), OR (+), and NOT (-). A summary of the postulates and theorems of Boolean algebra are given in Table 1.

TABLE I

SEVERAL BOOLEAN ALGEBRA POSTULATES AND THEOREMS

NOT Function

$\overline{1} = 0$	$\overline{0} = 1$
$(\overline{X}) = \overline{X}$	$\overline{(\overline{X})} = X$

AND Function

$1 \cdot 1 = 1$	$0 \cdot 0 = 0$
$0 \cdot 1 = 0$	$1 \cdot 0 = 0$
$X \cdot X = X$	$X \cdot \overline{X} = 0$

$$X \cdot Y \cdot Z = X \cdot (Y \cdot Z) = (X \cdot Y) \cdot Z$$

OR Function

$1 + 1 = 1$	$0 + 0 = 0$
$1 + X = 1$	$1 + 0 = 1$
$\overline{X} + X = 1$	$0 + X = X$

$$X + X = X$$

$$X + Y + Z = (X + Y) + Z = X + (Y + Z)$$

Combinations of Functions

$X + XY = X$	$X \cdot (X + Y) = X$
$X + \overline{X}Y = X + Y$	$X \cdot (\overline{X} + Y) = XY$
$XY + X\overline{Y} = X$	$(X + Y) \cdot (X + \overline{Y}) = X$
$\overline{XYZ} = \overline{X} + \overline{Y} + \overline{Z}$	$\overline{X + Y + Z} = \overline{X}\,\overline{Y}\,\overline{Z}$

$$XY + YZ + \overline{X}Z = XY + \overline{X}Z$$

$$(X + Y) \cdot (Y + Z) \cdot (\overline{X} + Z) = (X + Y) \cdot (\overline{X} + Z)$$

$$XY + \overline{X}Z = (X + Z) \cdot (\overline{X} + Y)$$

$$(X + Y) \cdot (\overline{X} + Z) = (XZ + \overline{X}Y)$$

These and other theorems can be used to reduce the complexity of Boolean expressions for circuit design.

Other Boolean equation simplification methods include map and tabular methods (21, 22, 40). Karnaugh maps are diagrams on which the values of the various groups of the switching function may be easily displayed. The maps exhibit basic patterns which permit the simplest Boolean expression to be read directly. The Karnaugh map completely describes a Boolean equation, but practice is required to recognize the simplest expression which can be obtained.

A tabular method can also be used to simplify Boolean Equations and is discussed by Fitch (21) and Foster and Parker (22). This method provides a means of obtaining minimum expressions by determining "prime implicants". A table using 0's and 1's are used to combine terms by repeated use of the theorem $XY + X\overline{Y} = X$. "Prime implicants" are the resulting irreducible terms.

The concepts of Boolean algebra have been used by Fitch (21) and several co-workers to develop techniques to synthesize circuit equations in fluid logic problems. The classical synthesis technique developed is based on the Huffman-Moore model. This model permits information concerning the conditions of a system to be recorded and used in obtaining a circuit solution. The steps required in the classical synthesis technique are shown in the flow diagram of Figure 2.

The primitive flow table is constructed from a word statement of the problem and depicts the various states the network must satisfy for the specified inputs and outputs. The columns of the primitive flow table are formed by all possible combinations of the input

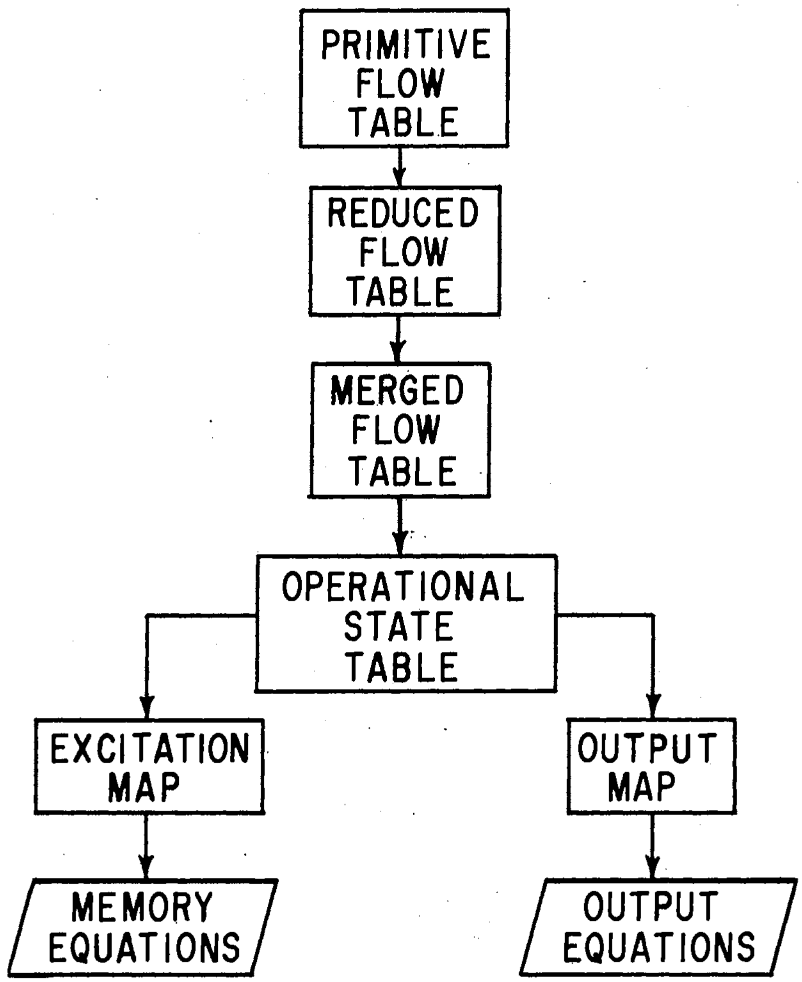


Figure 2. Classical Logic Synthesis Technique

signals and the desired output signals. Stable states identify output signals corresponding to a given input signal of a sequence, and only one stable state is permitted per row of the primitive flow table. Stable states are circled for identification, and the possible transitions from one stable state to another caused by changing input signals are indicated by uncircled numbers. Desired outputs are indicated for each stable state, so the primitive flow table describes operation of the circuit for given sequences of inputs.

In constructing the primitive flow table, no effort is made to eliminate redundant statements or duplications. A reduced flow table is obtained by eliminating stable states which are equivalent. The requirements for establishing equivalency between two stable states are:

1. They are in the same column
2. They have the same output state
3. The states in each column of both rows must be the same or equivalent.

Table reduction and merging processes are done to minimize the number of rows in the final table so that the number of memory or secondary elements are minimized in the circuit.

The merging process consists of combining rows of the reduced flow table, and more than one stable state can be assigned to each row. Output states are ignored in this process, and the general rules for merging two rows are:

1. The state number in each column is the same in both rows, or
2. A state number in one row coincides with an optional term or blank space in the same column, or

3. Optional terms are contained in both rows within corresponding columns.

Choices sometimes exist as to which rows should be merged, and Fitch (21) discusses methods for obtaining optimum merger for these conditions.

An operational state table is constructed after a merged flow table is obtained and specifies the number of memory elements required for the circuit. The operational state table must exhibit an adjacency relationship between stable states and their associated unstable states. This requires that all sequences of operation described by the reduced flow table must be achieved by changing only one input or memory signal at a time. Transitions from changing inputs will be across rows, and those from changing memory signals will be down columns. If the merged table does not exhibit the adjacency relationship, the methods given by Fitch (21) can be used to rearrange the rows and establish it.

The Boolean equations describing signals needed to set and reset the memory elements can be obtained by preparing an excitation map, and equations for the outputs are obtained by preparing output maps. These maps are Karnaugh maps equivalent to the operational state table except that the map entries are the desired conditions of the memory elements or output signals.

An excitation map is prepared by entering the desired condition of the memory element according to its stable state of the operations table. Unstable states in the operations table are assigned the condition of the memories of the next desired stable state. The equations describing the memory signals are obtained from the excitation map.

Output maps are constructed similar to excitation maps. The output signal condition for each stable state is entered in the map in the same manner as the excitation maps, but unstable state conditions are decided by the following rules:

1. Between two stable states having the same output condition, all unstable states involved in the transition must be assigned the same corresponding output state.
2. The output state corresponding to an unstable state is optional when the output state is changed between two stable states.

A circuit can be implemented when the memory and output equations are obtained. Elements are combined starting with the memory equations which are of the form:

$$Y = S + Y(\overline{R}) \qquad (6)$$

This is interpreted as having an output Y when a signal, S, turns the memory on or sets the memory, or when Y is already on and there is not a reset signal, R. The set signal to be connected to a memory can be taken directly from the Boolean expression, but the reset signal is not directly usable from the Boolean expression. The theorem for obtaining a complement must be used to obtain the reset signal which is to be connected to the memory, i.e. $(\overline{\overline{R}}) = R$.

Other techniques have been developed in an attempt to reduce the complexity of the classical techniques (16, 38, 39). Maroney (37) has discussed the evolution of three Digital Control Network Synthesis techniques (DICONESYN I, II, AND III). These methods develop prepared-path networks by total signal augmentation. The flow diagram in Figure 3, illustrates the process which must be followed using these

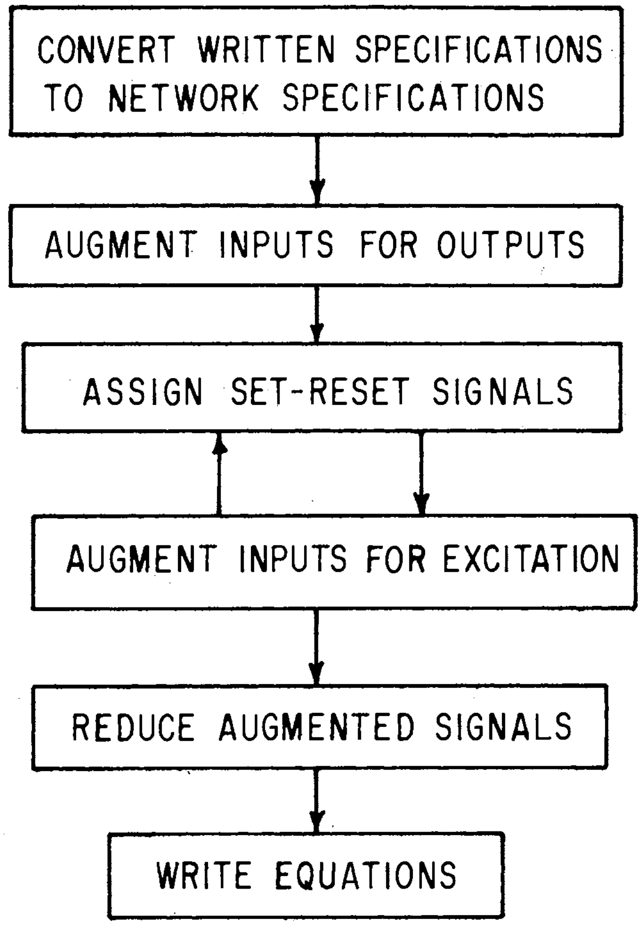


Figure 3. DICONESYN III Network Synthesis Procedures

techniques which are less complex in some respects, but an understanding of the classical technique helps insure their proper use. For this reason, only the classical technique has been described in detail.

Pneumatic Sensing, Logic and Control Devices

Fluidic Sensors

Many unique fluidic sensing devices have recently been developed. They include not only detection of presence, position and dimensions of objects, but also such parameters as temperature, flow rate, acceleration, angular velocity, and direction. Some sensors require use with other logic elements for proper operation.

Fluidic sensors are able to detect objects without touching them. These sensors operate on the following principles:

1. Back pressure
2. Converging cone
3. Diverging cone
4. Vortex
5. Interruptible jet
6. Accoustic beam

Belsterling (7), and Bermel and Stasch (8) have discussed the characteristics of each type. Back pressure and interruptible jet sensors have the desirable characteristics needed for sensing small objects at high speeds.

The operation of a back pressure sensor is illustrated in Figure 4. When no object is in the vicinity of the sensor, output pressure will be low, but when an object is close enough to restrict the flow of fluid from the exhaust orifice, the output pressure increases.

Rosenbaum and Cant (50) tested a back pressure sensor for a pneumatic tape reader and showed that it functioned satisfactorily even at frequencies of 300 HZ. Testing was done with 1.78 mm (0.07 in) diameter holes drilled on the periphery of a disc and spaced at .51 mm (.02 in) pitch. Back pressure sensors are commercially available, but it is simple to construct and is often built into the machine which uses it.

Operation of an interruptible jet sensor is illustrated in Figure 5. When no object is between the transmitting and receiving nozzles, an output signal will be generated at the receiver. An object passing between the transmitter and receiver will interrupt the jet and no signal will be generated at the receiver. A variation of this is illustrated in Figure 6 and is sometimes termed an impacting jet sensor. A constant purge to prevent contamination is incorporated in the receiver, but the operation is the same as the interruptible jet sensor. The interruptible and impacting jet sensors are available commercially and generally have a higher frequency response than back pressure sensors.

Kim and Rohrbach (31) have shown that small objects being conveyed in a pipe can be sensed fluidically. The pressure drop as the particle passes a point can be predicted on the basis of Reynolds number and diameter ratio of the object and pipe. Standard fluidic devices can detect this pressure drop if the proper ratios of the three variables are selected.

Fluidic Logic Elements

Fluidic devices can be divided into the categories of analogue

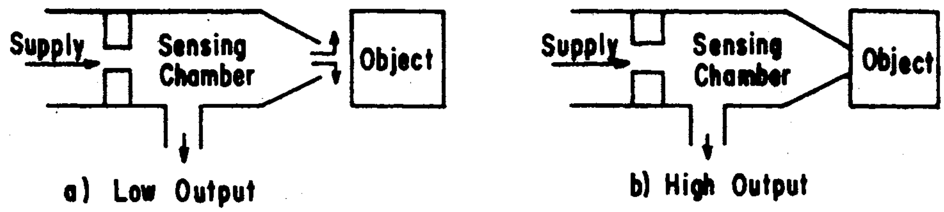


Figure 4. Back Pressure Sensor

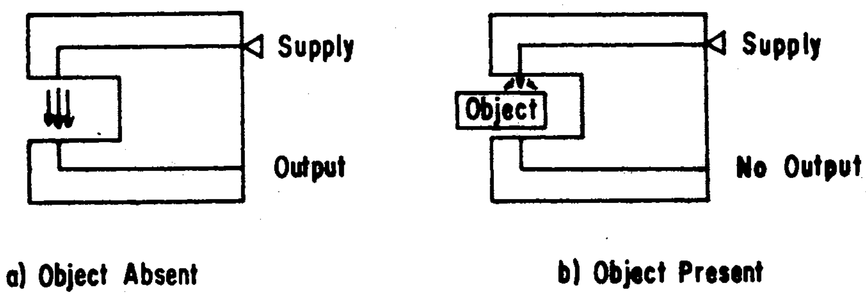


Figure 5. Interruptable Jet Sensor

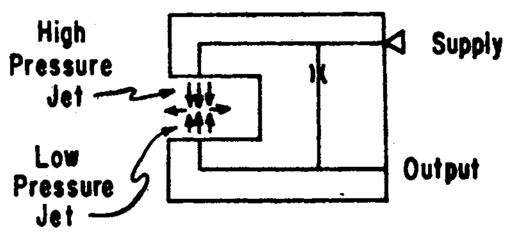


Figure 6. Impacting Jet Sensor

and digital elements. Analogue devices modulate the output in proportion to differences in control signals, whereas, digital devices switch the output signal when control signal reaches a given level. Digital devices give two discrete output signals (0 and 1) and are relatively immune from control signal variation. Digital devices were of primary interest in this research and are reviewed below.

There are three primary types of digital devices - wall-attachment, turbulence amplifiers, and transverse impact modulators. Chang (13) and others (7, 22) have discussed the important characteristics of each type. The wall-attachment devices provide a variety of elements for different logic functions, but the other two are used as NOR gates which is a basic building block for other logic functions. Wall-attachment devices can operate over a wider range of supply pressures than the other types and have fast frequency response. These characteristics suggest that the wall-attachment devices are most suitable for the circuitry in this research.

Wall-attachment devices utilize the Coanda effect in performing their logic functions. The Coanda effect is the phenomenon where a power jet issuing from a nozzle attaches to a wall in the vicinity of the nozzle. The attachment is caused by a low pressure region generated near the wall. If a control signal is injected into the low pressure region, the stream will detach from the wall. Switching time for digital wall-attachment devices is on the order of 1 millisecond and frequency response of 200 HZ is easily obtained. These devices are capable of decision making, memory, signal shaping, and signal amplification. Logic networks can easily be constructed from this choice of components.

Decision making elements are monostable amplifiers which have a normal output state. They can be switched by a proper combination of control signals but return to the normal output state when this combination is not present. OR/NOR and AND/NAND elements are common decision making elements, and their operation is illustrated in Figures 7 and 8.

The OR/NOR element (Figure 7) normally has an output at the O_2 port, but when a control signal is present at control ports C_1 or C_2, the output switches to the O_1 port. When the control signal is removed, the output returns to its normal O_2 port. The AND/NAND element (Figure 8) operates in a similar manner except both control signals must be present simultaneously for switching to occur. The Boolean equations given in the illustrations describe the combination of control signals required for an output to occur at given ports.

Memory elements are bistable devices with two stable output states. The output can rest in either state until a command to change states is received. This permits information to be stored for later use or remembered. The FLIP-FLOP is a basic fluidic memory element and is illustrated in Figure 9. When pressure is first applied to the supply port, the air flow may choose either output at random if no control signal is present. If output is at O_1 as shown, a momentary control signal at C_2 will cause the output to switch to O_2. It will remain in this state until a signal is applied to the C_1 control port which will cause the output to change back to O_1.

The Schmitt Trigger is an extremely pressure sensitive switch with an adjustable set-point, and possesses a narrow switching bandwidth. It can be used in combination with back pressure sensors to provide a

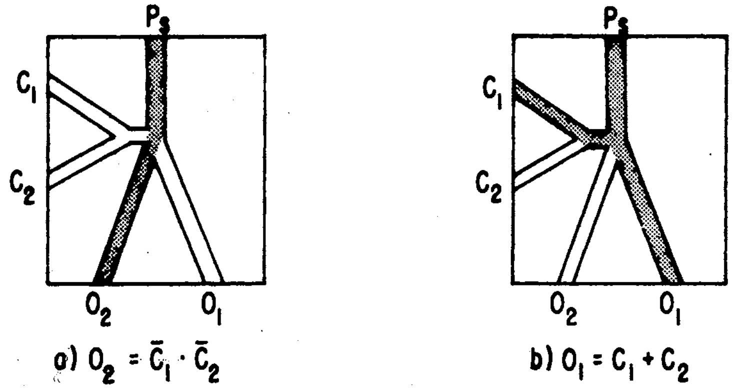


Figure 7. Schematic Drawing of OR-NOR Fluidic Element
a) No control signals actuated
b) Control signal at C_1 and/or C_2

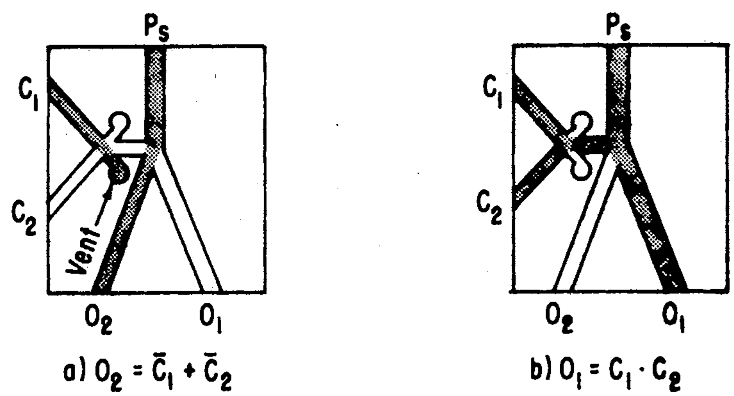


Figure 8. Schematic Drawing of AND-NAND Fluidic Element
a) One control signal absent
b) Control signal at C_1 and C_2

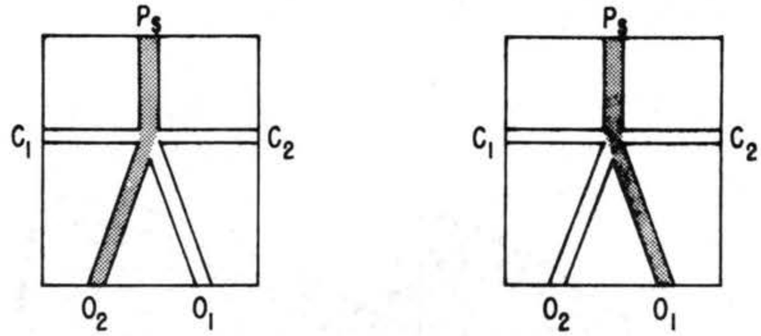
sensitive adjustable sensor. As illustrated in Figure 10, a constant pressure level (bias pressure) can be connected to control port C_2 and the back pressure sensor connected to control port C_1. When pressure signal C_1 is greater than pressure signal C_2, the output is at the O_1 port, and conversely, when pressure signal C_2 is greater than pressure signal C_1, the output is at the O_2 port. The bias pressure can be adjusted to provide a switch which operates around the set-point with little regard as to whether the control signal is increasing or decreasing.

The Digital Amplifier is a device used to increase the power output of other digital components. As shown in Figure 11, either control signal C_1 or C_2 must be present at all times, but both should not be present simultaneously. A control signal at C_1 provides an amplified output at O_1, and a control signal at C_2 provides amplified output at O_2.

Moving Parts Elements

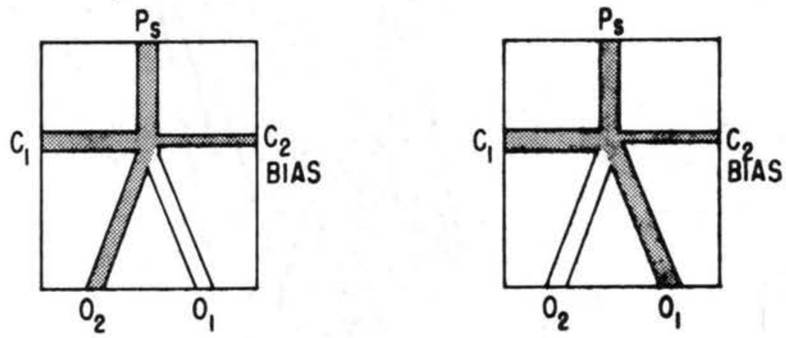
Power circuits generally require flow and pressures higher than those generated in logic control networks (35). The conversion of low level outputs of the logic control network to useable level requires special interface valves. Interface valves contain moving parts and common valve types such as diaphragm, spool, and poppet valves are used.

The diaphragm poppet valve is a common type of fluidic to pneumatic interface valve. Control pressures of several centimeters of water can actuate this valve, and since there is no sliding parts to cause fricitional wear, operating life expectancy is in excess of 100



a) $O_2 = C_2 + O_2 \cdot (\bar{C}_1)$ b) $O_1 = C_1 + O_1 \cdot (\bar{C}_2)$

Figure 9. Schematic Drawing of FLIP-FLOP Fluidic Element. Control Signals May be Momentary Signals



a) $O_2 = C_1 < C_2$ b) $O_1 = C_1 > C_2$

Figure 10. Schematic Drawing of Schmitt Trigger Fluidic Element. The Bias Pressure Provides a Fixed Reference Pressure for Switching and Provides an Adjustable Set Point

million cycles. Frequency response of this type valve approaches 100 HZ.

A diaphragm poppet valve is illustrated in Figure 12. A low pressure control signal closes the small bleed orifice and the resulting pressure increase in the intermediate chamber causes the poppet to switch in a snap action. Release of the control pressure opens the bleed orifice and allows the poppet to return to its original position.

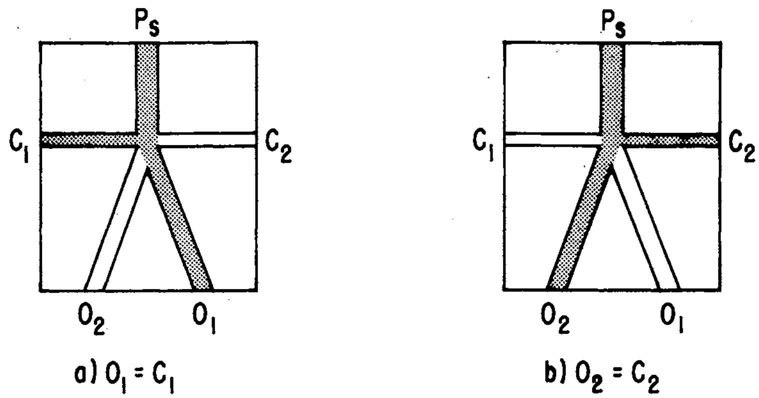


Figure 11. Schematic Drawing of Digital Amplifier Fluidic Element. Control signals must be continuous and one signal must be present at all times

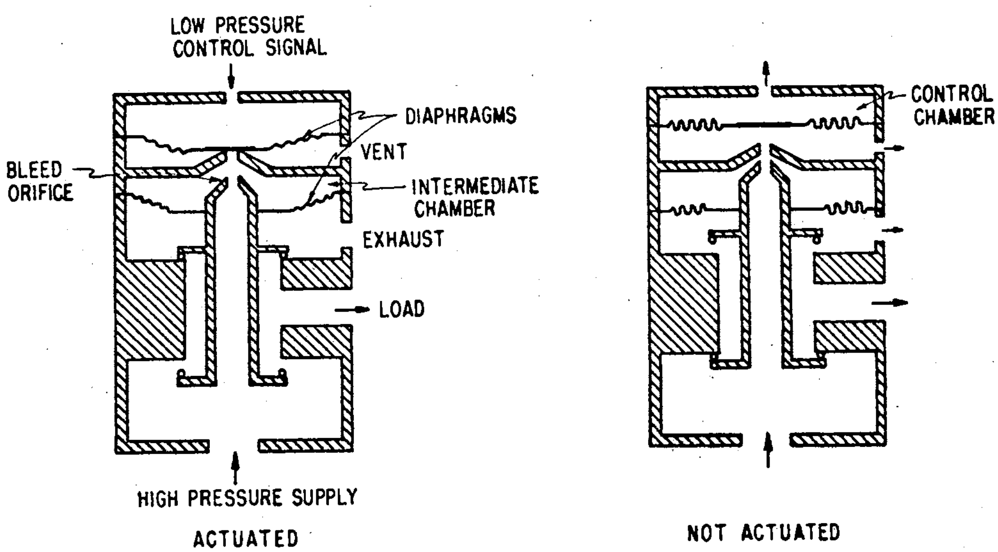


Figure 12. Interface Valve

CHAPTER III

LOGIC CIRCUIT DESIGN AND TESTING

Seed Metering Problem

A general control network is illustrated in Figure 13. The logic network receives input signals as a result of the action of the power system, and correlates these signals to provide output signals for further action of the power circuit. The input signals are generated to identify initiation and completion of actions of the power circuit, and output signals actuate valves in the power system.

The following functions were identified as the objectives of a digital logic circuit for seed metering:

1. Sense presence or absence of a seed in a primary metering source.
2. Eject a seed from a primary source if seed is present in primary.
3. Eject a seed from a secondary source if seed is absent from primary source.
4. Meter seeds uniformly in proportion to forward travel.

Performing these functions could increase the probability of planting a seed. If the probability of missing a seed in the primary source is p(P) and the probability of missing a seed in the secondary source is p(S), then the probability of both sources missing a seed simultaneously, p(PS), is:

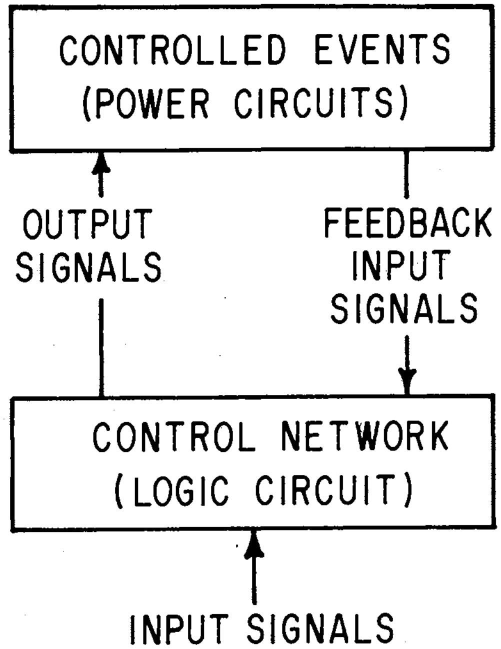


Figure 13. General Control Network

$$p(PS) = p(P) \cdot p(S) \tag{7}$$

The probability of planting a seed from either the primary or secondary is:

$$p(P \text{ or } S) = [1 - p(PS)] \tag{8}$$

If both primary and secondary sources are assumed to miss seeds 10 percent of the time, then by combining the two sources with logic circuitry, the probability of planting a seed could be increased to 99 percent (25).

The pneumatic planting principles utilized in the International Harvester Cyclo planter (27) possesses several unique characteristics which make it compatible with the objectives of this study. The schematic drawing in Figure 14 shows how sensing and logic control might be used on the metering drum of the IH Cyclo planter. Derivation of the logic circuit here assumes use of the IH Cyclo planter as a means of presenting seeds for sensing.

Input-Output Signals

Two input signals are required for the logic circuit to perform the functions described in the seed metering problem. One signal must be generated by an encoding device to control spacing in proportion to ground travel, and another must be generated to indicate presence or absence of seeds in the primary seed cells.

Two output signals must be developed by the logic circuit to eject seeds; one for the primary and one for the secondary seed cells. The output signals are to be delayed so that the seed ejection point is outside the seed sensing area. This is to prevent a seed being ejected from a primary seed cell, and then being sensed absent thus giving an output signal to eject a seed from the secondary cell also. The design of the spacing encoder can provide this delay as well as seed spacing in proportion to forward travel.

For the circuit derivation, the spacing encoder was assumed to be divided into open and closed segments in proportion to the spacing of holes on the periphery of the seed drum. The beginning of the closed segment represents the start of the eject signal and the beginning of the open segment stops the eject signal. Sensing presence or absence of seeds is assumed to occur in the open segment of the encoder.

The relative position of the encoder, seed cells, sensors and seed ejectors is shown in Figure 15. From this figure, a determination

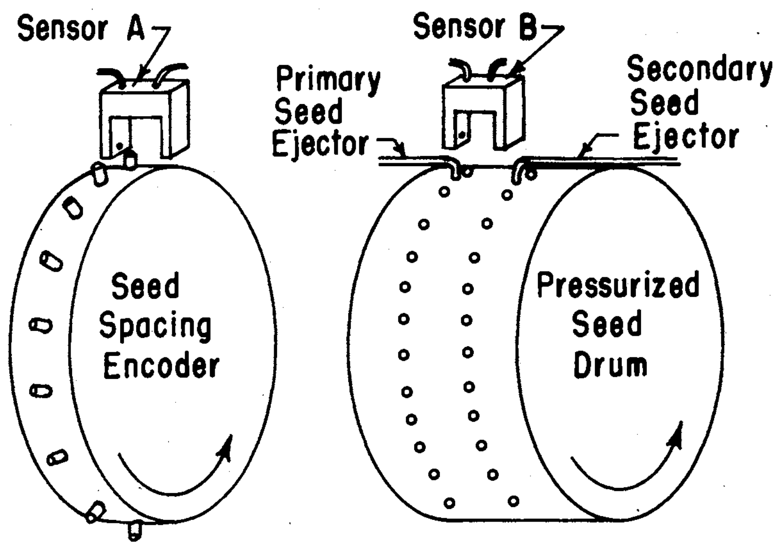


Figure 14. Schematic Drawing of Encoder and Seed Drum with Sensing and Seed Ejecting Arrangements

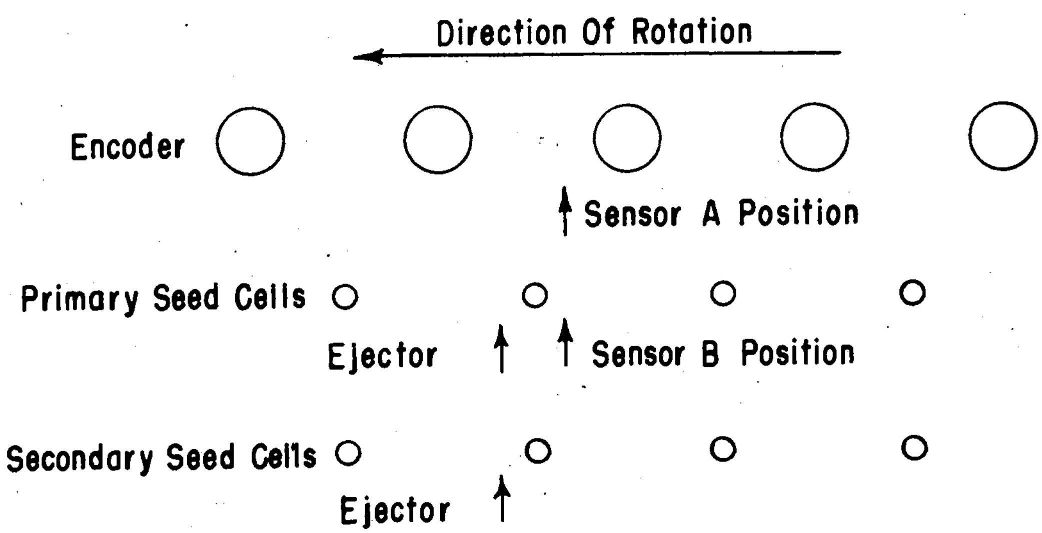


Figure 15. Relative Position of Sensors, Seed Cells, and Ejectors Used in Determining Sensor Signals for Logic Circuit Design

was made of the combination of signals produced from sensor A located on the encoder and sensor B located over the primary seed cell row of the drum. There are two possible sequences of signals generated by sensors A and B, one sequence when a seed is present in a primary seed cell and a different sequence if a seed is absent from a primary seed cell. Using the initial position of the seed drum and encoder relative to sensors A and B as shown in Figure 15 and the characteristics of an interacting jet sensor, the following sequences of signals will be generated for sensors A and B:

1. Seeds present in primary cells; 11, 01, 11, 01....
2. Seeds missing from primary cells; 11, 10, 11, 01, 11, 10, 11, 01....

Derivation of Circuit Equations

The Classical Logic Synthesis technique developed by Fitch (21) and summarized in Chapter II is used to derive the Boolean equations for a logic circuit to perform the functions of the seed metering problem.

Primitive Flow Table

The primitive flow table describing the two possible sequences of input signals for seed metering is shown in Table II. The flow table is developed by first considering the sequence when a seed is present in the primary seed cell. Stable state 1 is entered under the input column 11 representing the initial conditions of sensors A and B. As input signals change, new stable states must be identified. The second condition of input signals is 01 so a transition from stable state 1 to stable state 2 is made by entering an unstable state 2 on the same row as stable state 1 and a stable state 2 on the next row, both under the 01 column. Since a seed was present in a primary cell, it is desired to eject the seed at this point. This is done by identifying Z_1 as the output signal to eject a seed from a primary seed cell and placing a 1 in the Z_1 column to indicate that the output is on for this combination of inputs in the sequence. A seed has now been sensed and ejected, and the next conditions of the sensors are 11 so the transition can be back to the initial stable state and the sequence is complete.

TABLE II

PRIMITIVE FLOW TABLE
FOR SEED METERING

Sensor Signals AB				Outputs	
00	01	11	10	Z_1	Z_2
	2	(1)	3	0	0
	(2)	1		1	0
		4	(3)	0	0
	5	(4)		0	0
	(5)	1		0	1

From the initial stable state, consider the case where a seed is missing from a primary seed cell. The next conditions of the sensors are 10, and the transition is made by entering an unstable state 3 on the first row and a stable state 3 on the third row. From stable state 3 the next conditions of the sensors are 11, but since a sequence has not been completed a new stable state 4 is entered under the 11 column on the fourth row. The next conditions of the sensors are 01 and it is desired to eject a seed from a secondary seed cell. This is done by making a transition to a stable state 5 and entering a 1 in the Z_2 output column which represents the ejection signal for a seed from a secondary seed cell. The next conditions of the sensors are 11 so the transition is made back to the initial stable state, and a sequence for a seed missing in a primary seed cell has been completed.

Since output signals are desired only to eject seeds for the two conditions described, 0's are entered in all other output positions to specify that the outputs are off for those conditions. The primitive flow table now specifies both sequences of input signals, and completely describes the logic required for the seed metering problem.

Testing the stable states for equivalencies according to the requirements given in Chapter II, it is found that no redundancies exist and the primitive flow table cannot be reduced.

Merged Flow Table

The reduced flow table can be merged to obtain a table with only three rows as shown in Table III. This is accomplished by merging rows 1 and 2, and rows 3 and 4. No other mergers are possible if the rules for merging outlined in Chapter II are followed. The significance of the merged table is seen in the development of the Operations State Table which determines the number of memory elements for the circuit.

TABLE III

MERGED FLOW TABLE FOR SEED METERING

Sensor Signals AB			
00	01	11	10
	(2)	(1)	3
	5	(4)	(3)
	(5)	1	

<u>Operational State Table</u>

The operational state table must exhibit an adjacency relationship between stable states and their associated unstable states. This requires changes from one row to another row to exhibit only one change in a memory element at a time. In Table IV the operations state table for seed metering shows how the adjacency relationship is satisfied by assigning memory elements so that only one memory signal is changed at a time. It should be noticed that an unstable state 1 was added in the fourth row of the table which did not exist in the merged table.

This was necessary to achieve the transition from row three back to row one and change only one memory signal at a time.

TABLE IV

OPERATIONS STATE TABLE
FOR SEED METERING

Memory Elements	Sensor Signals AB			
Y_1 Y_2	00	01	11	10
00		(2)	(1)	3
01		5	(4)	(3)
11		(5)	1	
10			1	

Excitation and Output Maps

Excitation maps may be developed for individual memory elements or combined in a single map. The method of presentation here uses individual maps which are more easily interpreted. The conditions of the memory elements in the operations table for the different stable states are shown in Table V. The excitation map for the memory elements is developed by repeating the operations table except the condition of the memory for the respective stable state is entered instead of entering the state number. All unstable states receive the condition of their respective stable state as shown in Table VI. States which are of no significance to the problem are indicated by (-) and represent "don't care" conditions which can be interpreted as either a 0 or 1.

The desired output conditions for the respective stable states are shown in Table VII. These conditions are entered in a table in a manner similar to the excitation maps. The condition entered for unstable states must be determined according to the rules given in Chapter II. The output maps for Z_1 and Z_2 are shown in Table VIII.

Boolean equations which completely describe the logic which the circuit is to perform are obtained from the excitation and output maps. These equations are shown below each map in Tables VI and VIII.

TABLE V

CONDITIONS OF MEMORY ELEMENTS

Stable State	Memory Element Y_1	Y_2
1	0	0
2	0	0
3	0	1
4	0	1
5	1	1

TABLE VI

EXCITATION MAPS FOR
SEED METERING

Memory Y_1

Memory Elements Y_1 Y_2	Sensor Signals AB 00	01	11	10
00	-	0	0	0
01	-	1	0	0
11	-	1	0	-
10	-	-	0	-

$Y_1 = Y_2 \bar{a}$

Memory Y_2

Memory Elements Y_1 Y_2	Sensor Signals AB 00	01	11	10
00	-	0	0	1
01	-	1	1	1
11	-	1	0	-
10	-	-	0	-

$Y_2 = \bar{b} + Y_2 (\bar{Y}_1 + \bar{a})$

TABLE VII

CONDITIONS OF OUTPUTS

Stable State	Output Signal Z_1	Z_2
1	0	0
2	1	0
3	0	0
4	0	0
5	0	1

TABLE VIII

OUTPUT MAPS FOR
SEED METERING

Output Z_1

Memory Elements $Y_1\ Y_2$	Sensor Signals AB 00	01	11	10
00	-	1	0	0
01	-	0	0	0
11	-	0	0	-
10	-	-	0	-

$Z_1 = \overline{Y}_2\ \overline{a}$

Output Z_2

Memory Elements $Y_1\ Y_2$	Sensor Signals AB 00	01	11	10
00	-	0	0	0
01	-	-	0	0
11	-	1	0	-
10	-	-	0	-

$Z_2 = Y_1\ \overline{a}$

Circuit Implementation

The logic circuit is implemented by starting with the memory elements. Each memory element requires two signals - a set signal and a reset signal. These two signals can be obtained from the Boolean equations for the circuit, but modification is needed to obtain the actual signals connected.

The set signal to be connected can be obtained directly from the equations, but to obtain the reset signal, the complementing theorem must be used as explained in Chapter II. The modified Boolean expressions required for connecting the circuit are shown in Table IX. Elements can be combined to generate the set and reset signals for the memory elements and the logic output signals required in the seed metering problem.

TABLE IX

CIRCUIT DESIGN EQUATIONS

	Memory Elements Set	Reset	Outputs
Y_1	$\bar{a}Y_2$	$a + \bar{Y}_2$	$Z_1 = \bar{a}\bar{Y}_2$
Y_2	$\bar{b}$	aY_1	$Z_2 = \bar{a}Y_1$

A circuit to implement the logic for the seed metering problem is shown in Figure 16. All elements used in this logic circuit are fluidic wall attachemnt digital devices. The elements are all active elements because each individual element receives constant air supply from a common source and outputs from the individual elements are used only as control signals. Signals from sensors are amplified by using OR-NOR elements, and these amplified signals are used in the rest of the circuit.

Different types of logic elements are used in this network, but it is possible to use only one type of element such as the OR-NOR element to perform all the logic functions. OR-NOR elements are used in this circuit to generate the AND logic function as well as OR function. FLIP-FLOP elements are used as memory elements, and one AND element is used for an AND logic function. Actual elements connected according to the diagram are shown in Figures 17 and 18. A manifold supplies the same air pressure to all elements used in the circuit.

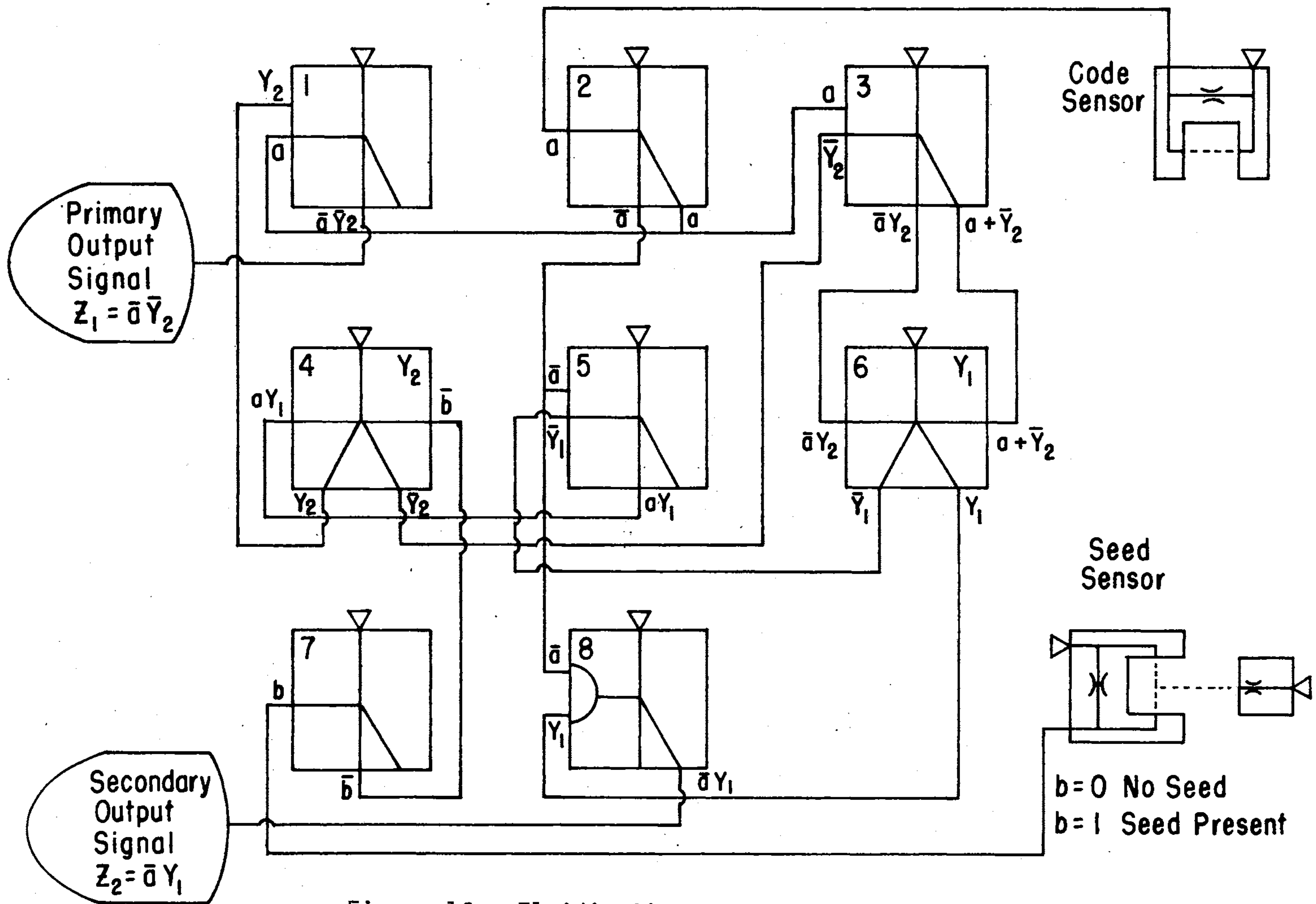


Figure 16. Fluidic Circuitry for Seed Metering

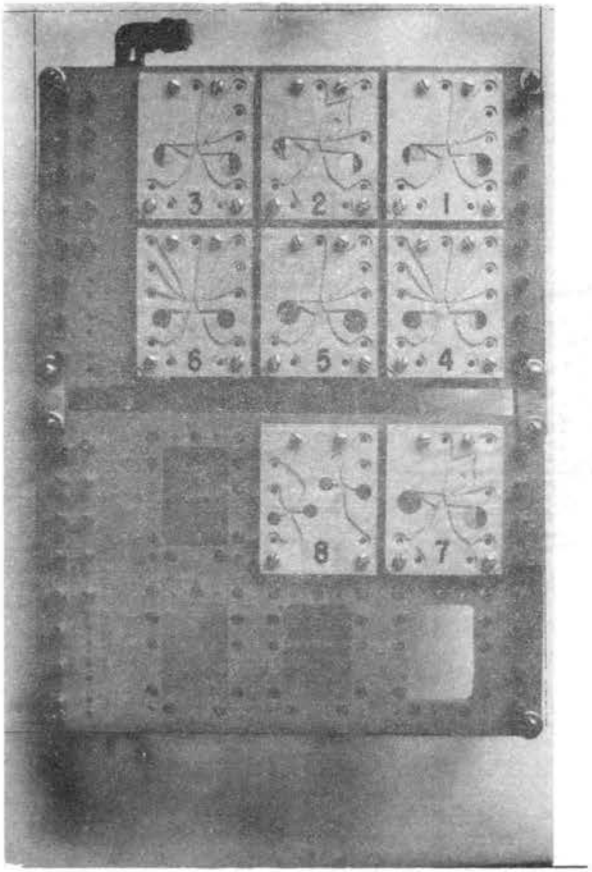


Figure 17. Fluidic Elements Connected in Manifold Forming Logic Circuit for Seed Metering

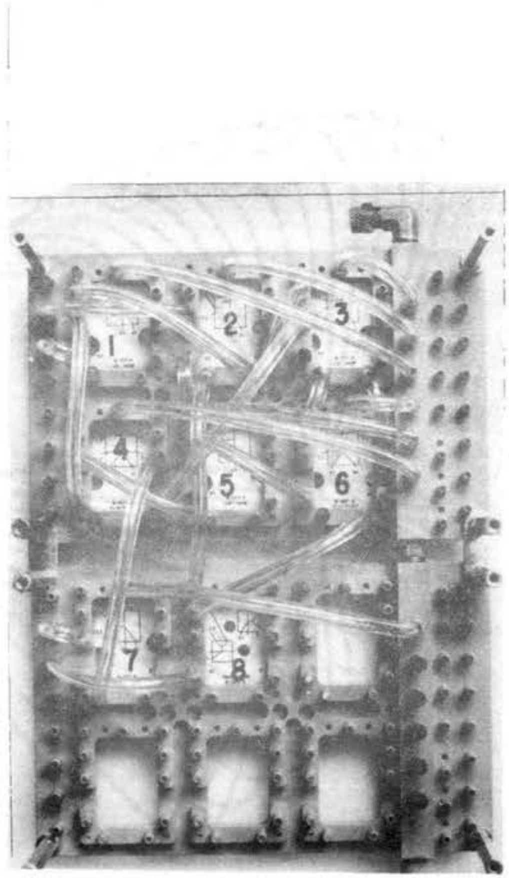


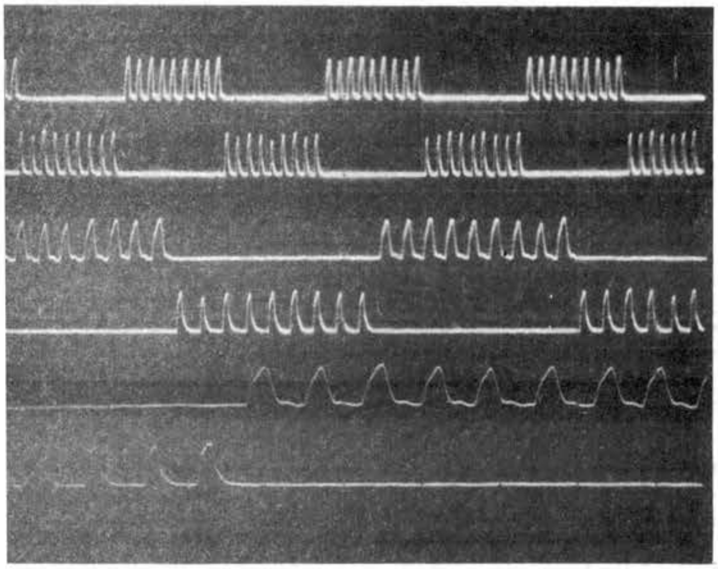
Figure 18. Tubing Connections of Individual Elements in Manifold

Circuit Testing

To test the circuitry for sensing and frequency response capabilities, a disc with 3.18 mm (1/8 in) diameter holes spaced 12.7 mm (1/2 in) on the circumference was used to simulate seed cells. Strain gage pressure transducers and associated signal conditioning enabled output signals to be traced on an oscilloscope and photographed. The output signals for three different oscilloscope sweep rates are shown in Figure 19. The compensating feature of the circuit was tested by closing nine successive holes and then leaving nine successive holes open. This simulated nine seeds present in the primary seed cells and then nine seeds absent in the primary cells.

This simulated testing revealed that the circuit was reliable up to a frequency response of approximately 100 Hertz. Delay times in signal transmission caused malfunctioning of the circuit before the objective of 135 Hertz was reached. This along with the fact that interface valves cannot respond this fast revealed that more than one circuit would be required. The testing verified that the network functioned satisfactorily at frequencies above 68 Hertz which would be the maximum if dual circuits were used in metering seeds.

Time Scale



Z_1

0.1 sec/cm

Z_2

Z_1

0.05 sec/cm

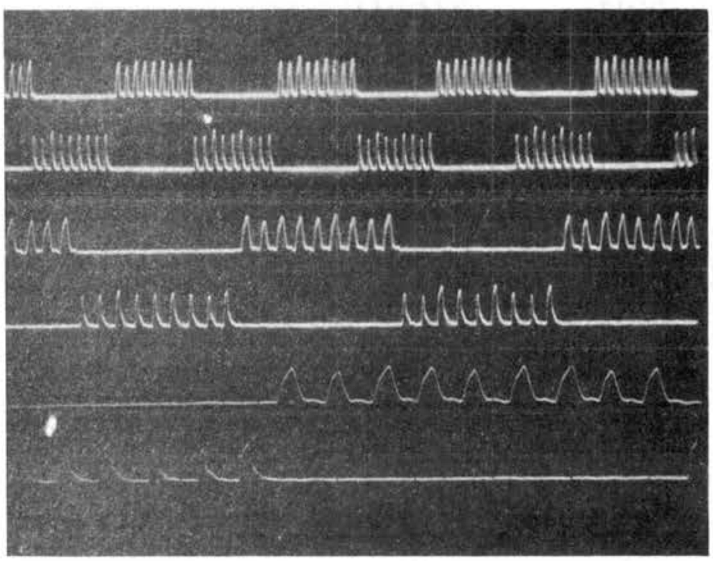
Z_2

Z_1

0.02 sec/cm

Z_2

a) Simulating approximately 70 seeds per second



Z_1

0.1 sec/cm

Z_2

Z_1

0.05 sec/cm

Z_2

Z_1

0.02 sec/cm

Z_2

b) Simulating approximately 88 seeds per second

Figure 19. Output Signals from Seed Metering Logic Circuitry Simulating Nine Seeds Present in Primary Cells and Then Nine Absent from Primary Cells

CHAPTER IV

EXPERIMENTAL APPARATUS AND PROCEDURES

Planting Equipment

An International Harvester 400 Cyclo planter was used in this research. The metering unit was equipped with a field improvement kit for leveling seeds within the drum. All furrow openers, wheels, and other miscellaneous equipment were removed and the seed metering unit mounted on a stand for use in the laboratory.

The planter blower was powered at the manufacturers recommended speed by an electric motor. An electric motor with a variable speed transmission was used to drive the seed drum and obtain different seeding rates. A micrometer dial on the variable speed transmission permitted drum RPM settings for different seeding rates to be identified and repeated.

The maximum drum RPM recommended by the manufacturer for the metering unit was 30 RPM. A 144 hole seed drum was desirable at this speed in order to accomplish the maximum seeding rate stated in the objective of this research. A 144 hole cottonseed drum was not available, but a 144 hole sorghum seed drum was made available by the manufacturer. This drum was equipped with a special clear end which permitted observations of seed cells inside the drum. In addition to the 144 hole sorghum drum, a 96 hole cottonseed drum was used in this research.

The seed drums contained six rows of seed cells, but only the center four rows were used for metering. The other two rows were taped closed and used for attaching coding markers used with logic circuitry. Rows were identified by numbering the rows starting with the row nearest the end with the gasket air seal.

Metering Tests

Description of Treatments

Primary purpose of metering tests was to determine the capabilities of the metering unit modified with logic circuitry. Metering tests were made before modification to establish a predicted metering percent for the modified unit.

Metering tests were conducted in several separate series of tests. The treatments for each series of tests are described in Table X. Six replications were made for each treatment in each series. Samples were taken so that metering percent could be analyzed with a split plot statistical design with the partition of degrees of freedom shown in Table XI. This design enabled metering percent for each row to be determined very accurately and also gave information on the effect of drum speed and any interaction effect.

B-Redlan Sorghum seed was used for tests with the 144 hole sorghum drum, and three sizes of Lankart 57 acid delinted cottonseed were used with the 96 hole cottonseed drum. The sorghum seed was cleaned in a seed sizer which contained round hole screens and a blower for removing light trash. The sorghum seed used in metering tests passed through a 5.56 mm (14/64 in) screen but was caught over a 3.57 mm (9/64 in) screen. Cottonseed used in the tests was separated into three size groups as follows:

TABLE X

DESCRIPTION OF METERING TESTS

Test Series	No. of Cells in Seed Drum	Seed	Metering Method
PS3	144	B-Redlan Sorghum	Unmodified
PS4	144	B-Redlan Sorghum	Modified with Logic Circuitry
PS5	144	B-Redlan Sorghum	Modified with Logic Circuitry
PS6	144	B-Redlan Sorghum	Modified with Logic Circuitry
PC1	96	Lankart 57 acid delinted cottonseed; Through 5.95 mm (15/64 in), Over 5.56 mm (14/64 in) screen	Unmodified
PC2	96	Lankart 57 acid delinted cottonseed; Over 5.95 mm (15/64 in) screen	Unmodified
PC3	96	Lankart 57 acid delinted cottonseed; Ungraded	Unmodified
PC4	96	Lankart 57 acid delinted cottonseed; Through 5.95 mm (15/64 in), Over 5.56 mm (14/64 in) screen	Modified with Logic Circuitry
PC5	96	Lankart 57 acid delinted cottonseed; Over 5.95 mm (15/64 in) screen	Modified with Logic Circuitry
PC6	96	Lankart 57 acid delinted cottonseed; Ungraded	Modified with Logic Circuitry

1. Ungraded
2. Through 5.95 mm (15/64 in), over 5.56 mm (14/64 in) screen
3. Over 5.95 mm (15/64 in) screen

TABLE XI

STATISTICAL DESIGN

Source	Degrees Freedom
Replication	(b-1)
Drum Speed	(s-1)
Error (A)	(b-1) (s-1)
Row	(r-1)
Row X Drum Speed	(r-1) (s-1)
Error (b)	s(b-1) (r-1)

where: b = Number of replications
s = Number of RPM settings
r = Number of rows of drum

Three drum speeds were selected for testing and the theoretical seeding rates for each are shown in Table XII. The highest seeding rate per row for the 144 hole drum was selected to be one-half the maximum seeding rate stated in the objectives of this research. The forward speeds for 25 mm (0.984 in) seed spacings are also shown in Table XII. The seeding rate per row and speeds for the unit modified with logic circuitry would be doubled, but the number of seed rows

TABLE XII

DESCRIPTION OF SEEDING RATES FOR METERING TESTS*

RPM Code	Seed Drum RPM	144 Hole Seed Drum			96 Hole Seed Drum		
		Theoretical Seeding Rates (Seeds/Sec/Row)	Forward Speed For 25 mm Spacings		Theoretical Seed Seeding Rates (Seeds/Sec/Row)	Forward Speed For 25 mm Spacings	
			KM/HR	MI/HR		KM/HR	MI/HR
1	14.17	34	3.06	1.90	22.7	2.04	1.27
2	21.25	51	4.59	2.85	34.0	3.06	1.90
3	28.33	68	6.12	3.80	45.3	4.08	2.53

* Seeding rates and speeds are doubled when modified with logic circuitry.

would be reduced from 4 to 1.

Sampling Procedures

The sampling unit shown in Figure 20 was constructed to sample from the ends of the seed conveyance tubing while the seed metering unit is in a steady-state operating condition. A slide arrangement in the sampling unit allowed seeds to be sent in one of two paths. These paths were formed from plastic netting that permitted air to escape freely as well as absorb some of the energy in stopping the high velocity seeds. One path was the sampling path and led to plastic bags. The other path captured seeds when sampling was disengaged.

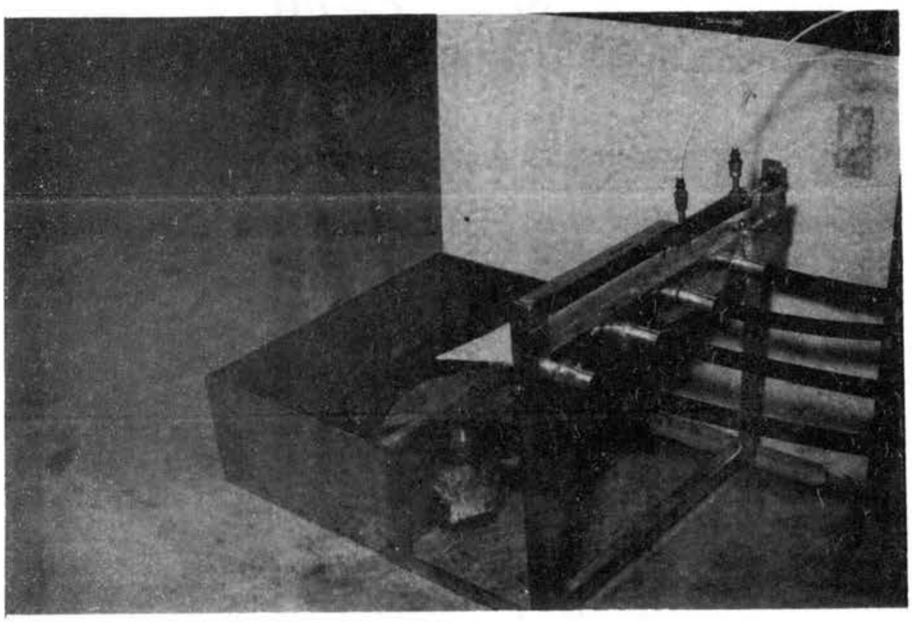


Figure 20. Semi=automatic Sampling Unit Used in Seed Metering Tests

The slide mechanism was operated by a double acting air cylinder. Fluidic sensors, logic elements, and interface valves allowed the cylinder to be actuated by a marker on the seed drum. The semi-automatic sampling circuit is shown in Figure 21. A manual over-ride of the circuit enabled manual counting of drum revolutions, but the marker on the drum controlled actuation when manual over-ride was released.

The dial setting of the seed drum drive unit was set for each test while the motor of the unit was off, and each setting was always made by approaching the setting from the same direction. A steady-state operating condition for each dial setting was obtained before sampling in all tests.

Drum revolutions and beginning and ending of sampling was recorded on an oscillograph recorder. A snap action switch mounted on the slide mechanism enabled beginning and ending of sampling to be recorded as an event. The drum revolution marker was recorded by using a pressure transducer to record the output of the fluidic sensor. These two tracers were used to determine speed of the drum. In some tests, the fluidic sensor indicating missed seeds on one row was monitored and also recorded on the oscillograph.

Logic Circuit for Metering

Several modifications were required to adapt the seed metering unit to use logic circuitry. The rubber rollers normally used in ejecting (Figure 22) seeds were replaced by pneumatic ejectors. These ejectors were mounted on a bracket which permitted adjustment of ejecting position in relation to sensors as shown in Figure 23.

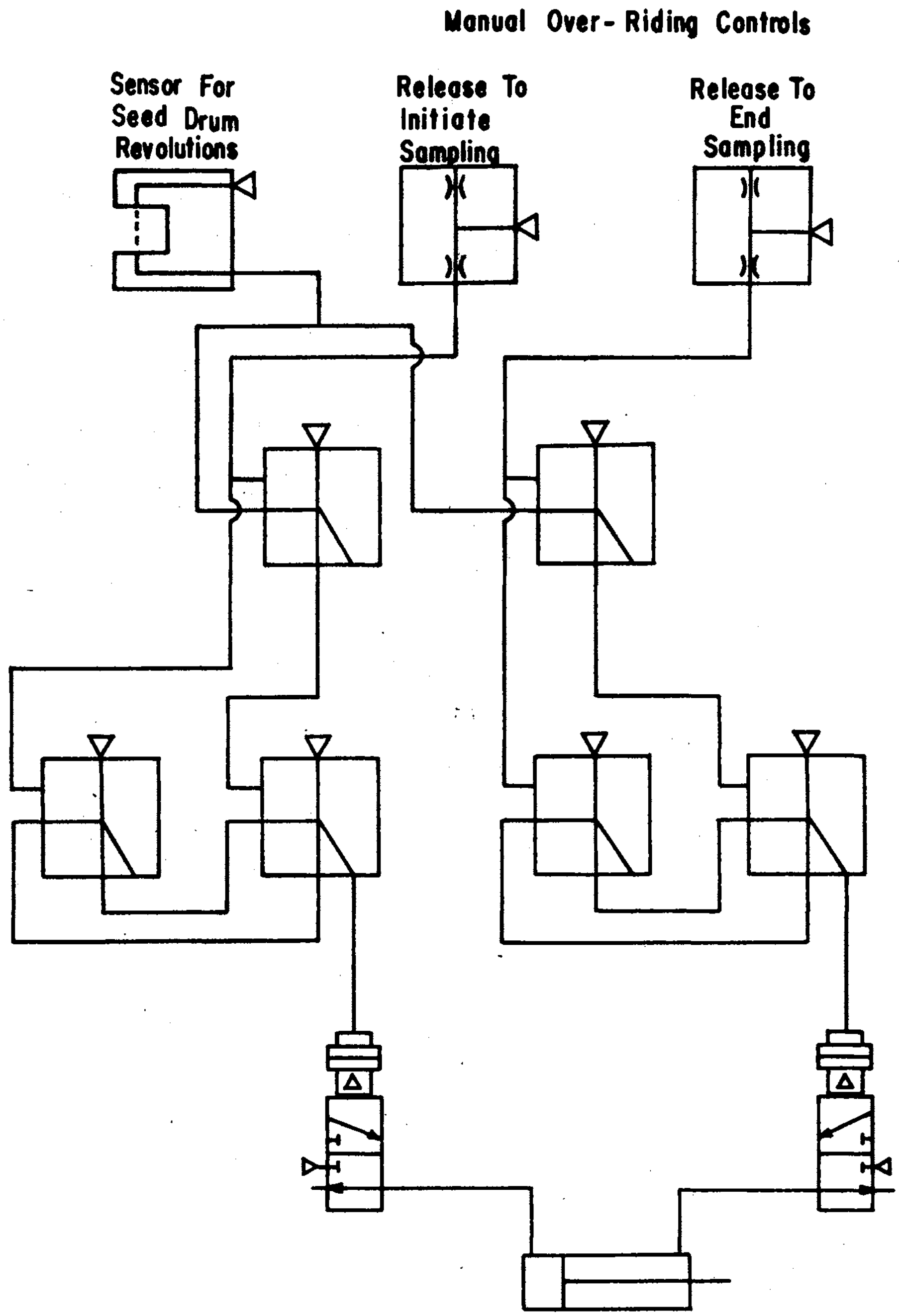


Figure 21. Schematic Diagram of Circuit for Semi-automatic Sampling

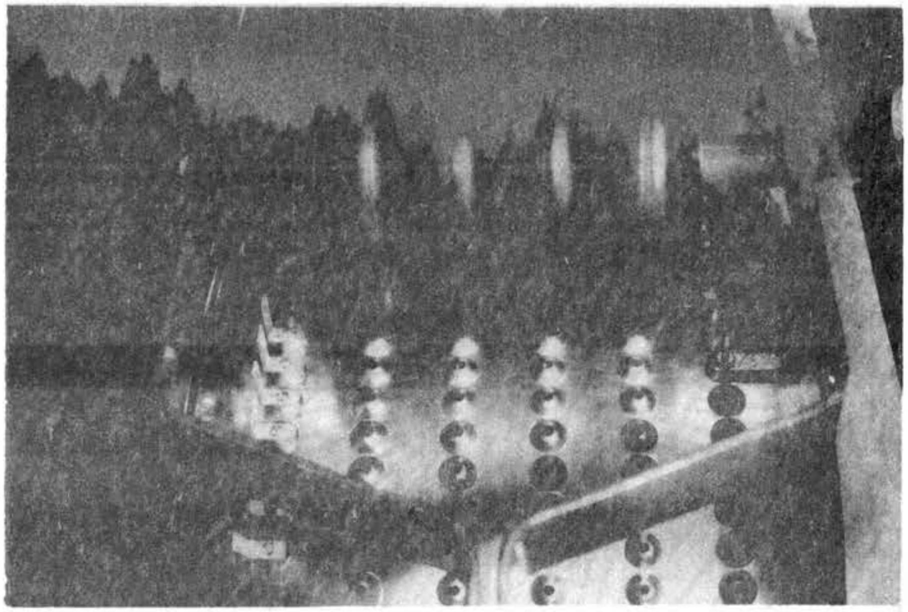


Figure 22. Rubber Roller Ejectors Which are Normally Used on Seed Metering Unit

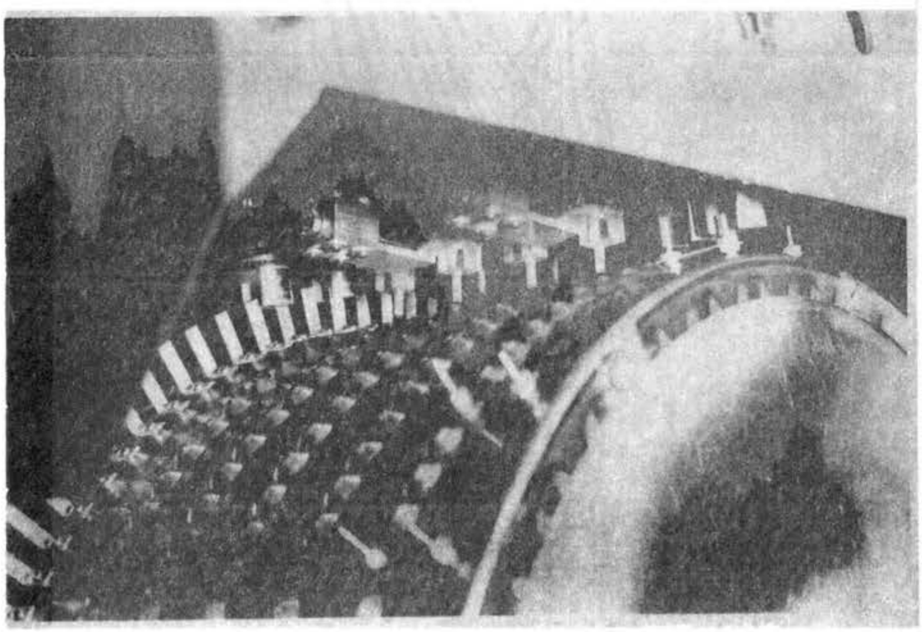


Figure 23. Pneumatic Ejectors and Sensors Used in Logic Controlled Seed Metering

The two extra rows of the seed drum were used for attaching coding markers for fluidic sensing. One row was used to form the spacing encoder. Twenty-five percent of the holes of the primary rows were randomly taped closed (Table XIII) to assure ejection of at least 25 percent of the seeds from the secondary circuit. The other extra row was used for markers to indicate where holes were taped closed in the primary row. These markers are shown on the 96 hole drum in Figure 24.

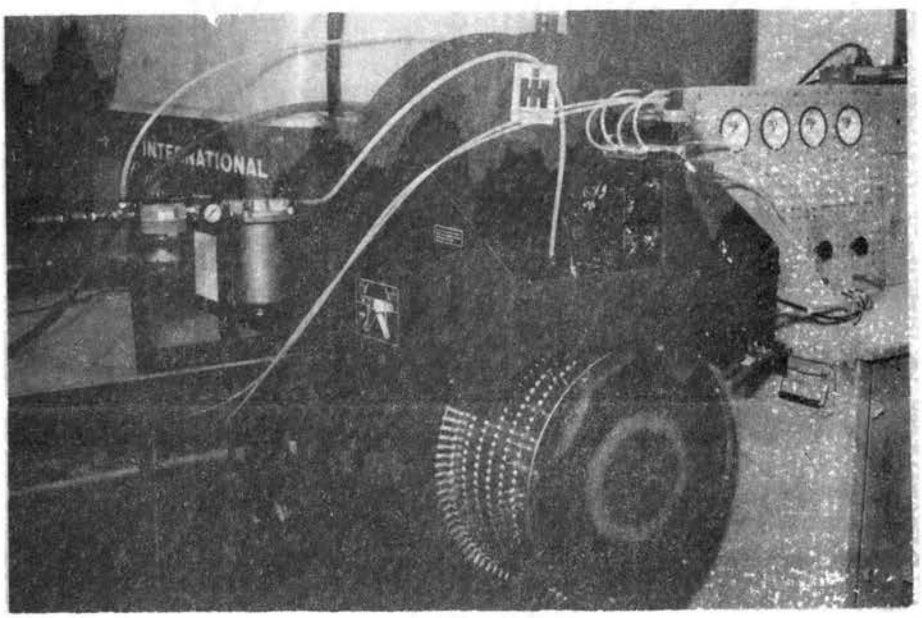


Figure 24. Coding Markers Mounted on 96 Hole Cottonseed Drum

The logic circuitry including the sensor for sensing markers indicating taped holes is shown in Figure 25. Only one circuit is shown but two independent circuits were used. The sensing and ejection for the two circuits positioned one-half the distance between two cell holes

TABLE XIII

TAPED SEED CELLS IN DRUMS

144 Hole Drum	96 Hole Drum
1*	1*
10	4
14	8
17	10
19	14
22	18
23	21
27	25
30	30
33	34
37	42
39	43
45	44
46	56
51	57
61	60
69	62
77	63
81	66
87	70
88	79
89	82
90	91
93	95
97	
104	
107	
108	
117	
119	
132	
133	
136	
137	
139	
141	

* Clockwise from drum seam

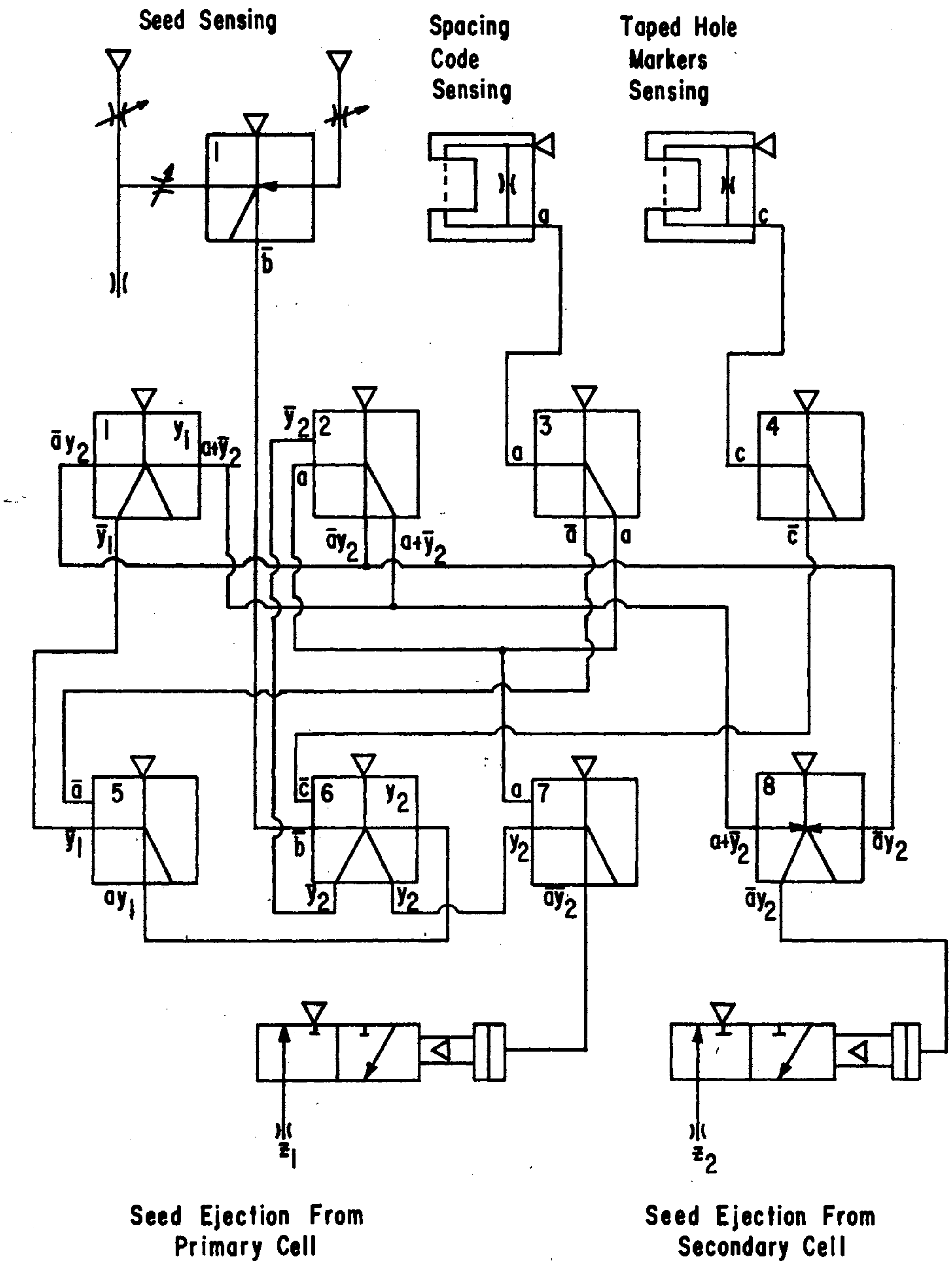


Figure 25. Circuitry for Seed Metering

with respect to each other, and seeds were ejected from the two circuits alternately.

This circuit differs in several respects to the one used in simulated testing and shown in Figure 16. Seed sensing was accomplished by using a Schmitt Trigger element instead of an interruptable jet sensor. Irregular shaped seeds do not provide a perfect seal in the holes of the seed drum and air leaks around the seeds through the holes at a reduced rate. The adjustable bias pressure of the Schmitt Trigger permits a switching point to be selected which can distinguish between the reduced flow when a seed is present and that when a seed is absent from a cell.

The Z_2 output signal was changed from $\bar{a}Y_1$ to $\bar{a}Y_2$. Both of these are correct signals, but the $\bar{a}Y_2$ signal turns on slightly before the $\bar{a}Y_1$ signal as can be seen in the Karnaugh maps of Table VIII. This increased the length of the input signal to the interface valves and assisted high frequency operation. The input signal to the Z_2 interface valve was amplified by a digital amplifier which also assisted in high frequency operation.

Seed Conveyance Tests

Description of Treatments

The effect of the pneumatic conveyance system on seed distribution was studied on row number four of the planter. Three conveyance configurations were the primary treatments. For each primary treatment, other treatments were two ejection methods, two air conveyance velocities, and three seeding rates.

The primary treatments were identified as follows:

Configuration 1; Manifold plus 20.93 mm (.824 in) inside diameter plastic tubing with one 90° bend.

Configuration 2; Manifold plus 20.93 mm (.824 in) inside diameter plastic tubing with two 90° bends.

Configuration 3; Planter manifold only, 19.55 mm (.75 in) inside diameter.

Pertinent dimensions of the configurations are shown in Figure 26.

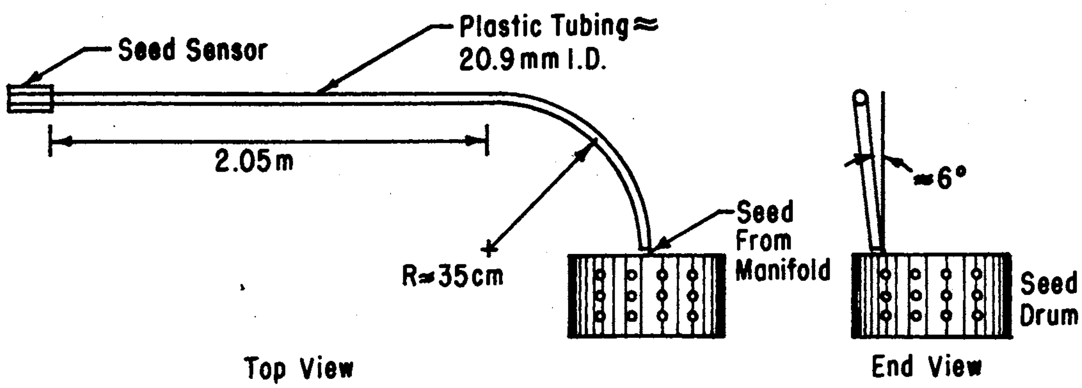
One size of Lankart 57 acid delinted cottonseed was used in all conveyance tests. The seed passed through a 5.95 mm (15/64 in) screen but was retained by a 5.56 mm (14/64 in) screen.

One ejection method was the standard rubber rollers used on the commercial Cyclo planter. The other ejection method was pneumatic ejection using interface valves controlled by fluidic sensing of coding markers. These two ejection units are shown in place over the seed drum in Figures 22 and 27.

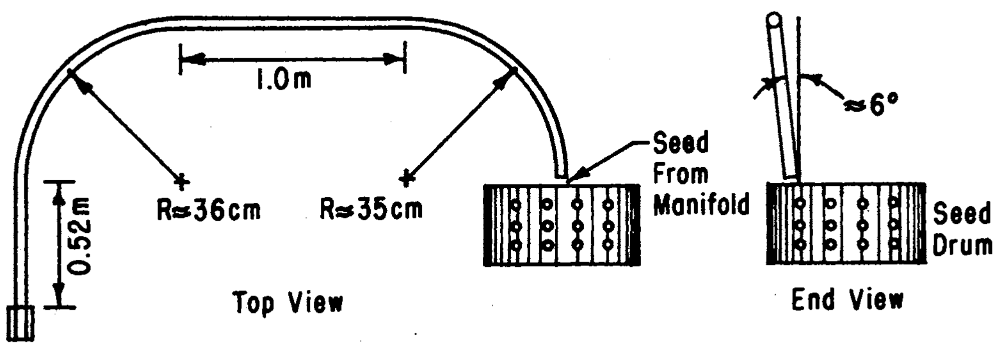
High and low air velocities were used for each combination of configuration and ejection method. High and low air velocities were obtained by varying the intake opening of the blower. Maximum and minimum intake opening positions were used to obtain different air velocities.

Sampling Procedures

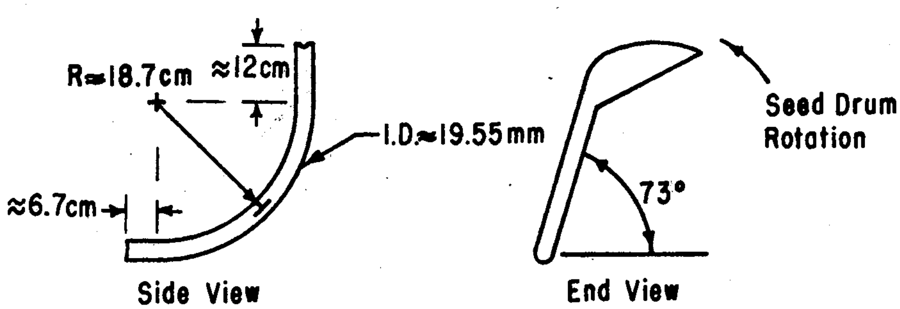
An International Harvester electronic seed monitoring unit was used to sense seed distribution and seed velocity at its exit of the conveyance tubing. The sensors were made as a unit to mount directly to the tubing and operate on the photocell principle. A voltage signal was generated by each seed as it passed through the sensor. The voltage



a) Configuration 1



b) Configuration 2



c) Configuration 3

Figure 26. Schematic Diagrams of Conveyance Configurations Tested

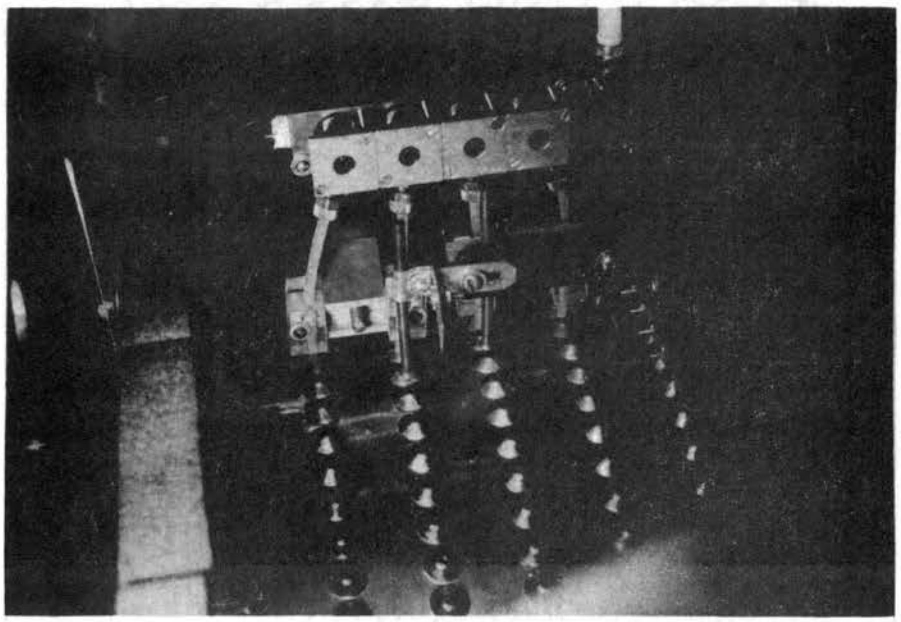


Figure 27. Pneumatic Ejectors Used with Logic Controlled Seed Metering

signal was used as the input to an oscilloscope, and the oscilloscope traces were photographed to provide a permanent record. A single sensor was used in tests for seed distribution, and two sensors mounted 30 cm (.984 in) apart were used for seed velocity measurement.

In seed distribution tests five samples were taken for each combination of treatments and these were replicated four times. Two replications were made at one oscilloscope sweep rate and two at a different rate. The rates were a compromise between the number of seeds desired per sample and the interval between individual seeds.

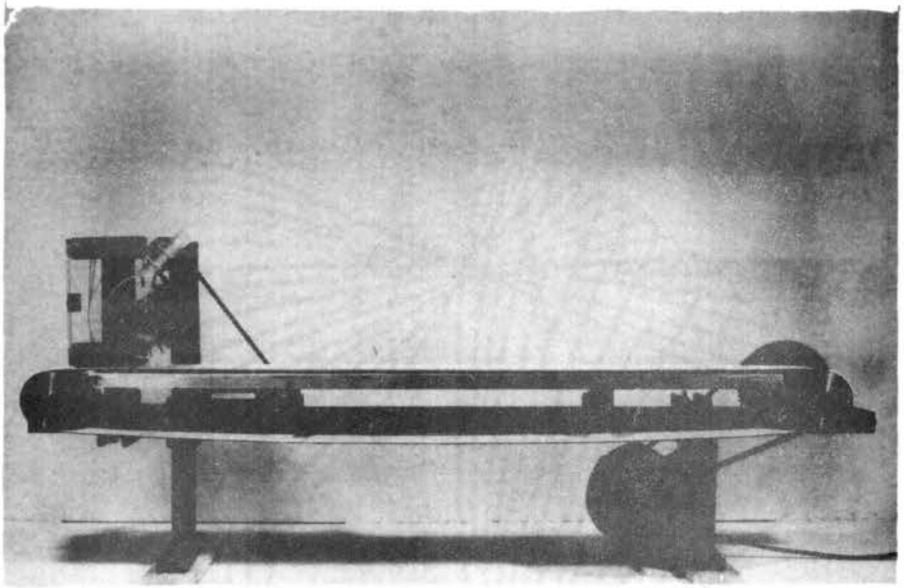
Air velocity profiles were determined for the different treatments at the exit point of the tube using a 1.59 mm (1/16 in) static pitot tube. Profiles were made in vertical and horizontal planes by taking eight measurements in four equal concentric areas and the center.

Seed Spacing Tests

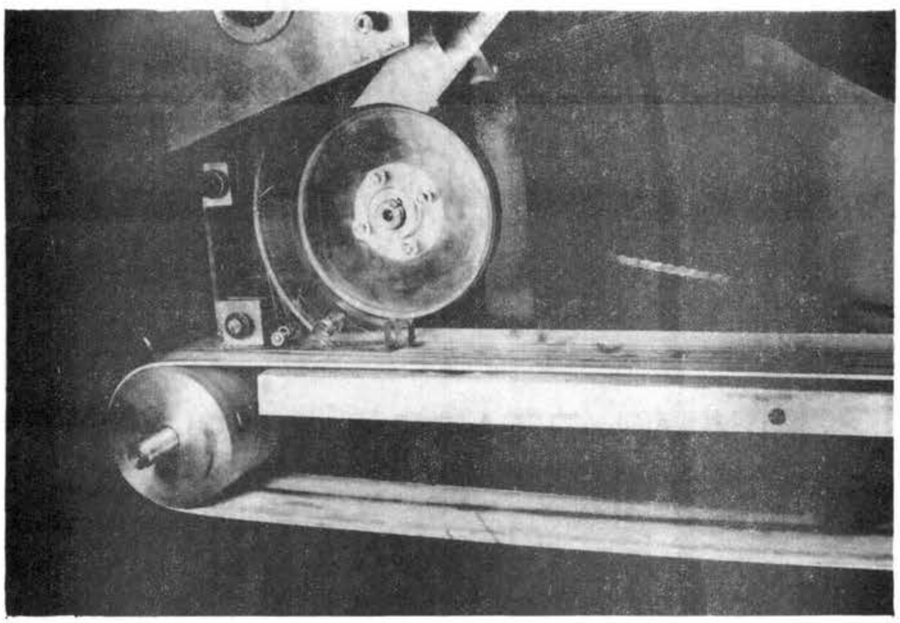
Equipment

A manifold was constructed to merge the seeds from the dual logic circuits on the seed drum into a single row. Seed spacings for the single merged row were observed by two methods. Distribution of seeds exiting the manifold were obtained by photographs of electronic seed sensor signals, and seeds placed on a conveyor belt were photographed.

The velocity of seeds exiting the manifold was slowed and matched to the velocity of the conveyor belt. A wheel covered with rubber weather stripping received seeds from the conveyance tube and placed them on the belt as shown in Figure 28. A section of tubing constructed of screen wire allowed air to escape between the manifold exit and the conveyor belt unit. The conveyor belt was driven by a variable speed



a) Conveyor unit



b) Seed receiving and delivery wheel used in tests

Figure 28. Belt Conveyor Used for Seed Spacing Tests

motor so that ground speed could be simulated.

Description of Treatments

The treatments used in observations with the electronic sensor were three seeding rates and two air velocity levels. Air velocity was controlled by blower intake opening as in previous tests. Four replications of each combination of treatments were made.

For photographing seeds on the conveyor belt, three seeding rates were used, but only the high air velocity was used. Speed of the conveyor belt was matched to the seeding rate so that a theoretical spacing on the belt was 25 mm (0.984 in) for all seeding rates.

Sized Lankart 57 acid delinted cottonseed was used for all treatments. The seed passed through a 5.95 mm (15/64 in) screen but was retained by a 5.56 mm (14/64 in) screen.

Sampling Procedures

For distribution using the electronic sensor, five samples were taken for each combination of treatments and these were replicated four times. Oscilloscope photographs were obtained as described in previous tests.

To photograph seeds on the conveyor belt, an electronic strobe light was used to stop the motion of the belt. The camera shutter was opened in a darkened room and a single flash of approximately three microsecond duration exposed the film and effectively stopped seed motion.

Air velocity profiles at the manifold exit were obtained as described in previous tests.

CHAPTER V

PRESENTATION AND DISCUSSION OF RESULTS

Seed Metering

Measurements obtained for seed metering tests included the following on all tests:

1. Seed drum revolutions during sampling
2. Sampling time
3. Seed count for each row
4. Seed weight for each row

In tests that did not include logic circuitry metering, sensors were placed over one row to record the number of cells with no seeds. Original data for each series of tests are presented in Appendix B.

Metering percent, seed drum RPM, and number of seeds per gram were calculated for each sample and an analysis of variance made on each. The Statistical Analysis System, (SAS), (50), computer program was used for the analysis of variance using the replicated split plot design described in Chapter IV.

Metering percent for each row was of primary interest, and it was calculated from the original data as follows:

$$MP = \frac{C_t}{(N_c)\ (R_d)} \quad 100 \qquad (9)$$

Means and least significant differences (LSD) were obtained from the analysis of variance and are presented in Tables XIV through XVII.

TABLE XIV

METERING PERCENT MEANS - SORGHUM SEED
144 HOLE DRUM

	PS3 Series (6 Replications)					Predicted Value for Logic Circuit Metering			PS6 Series (6 Replications)		
Drum RPM Code	Row of Seed Drum 1	2*	3*	4	RPM Code Means	Fluidic Circuit 1	2	RPM Code Means	Fluidic Circuit 1	2	RPM Code Means
1	99.2	74.5	73.5	98.5	86.4	99.8	99.6	99.7	98.5	97.5	98.0
2	98.8	74.0	74.0	98.3	86.3	99.7	99.6	99.7	99.3	98.7	99.0
2.5	----	----	----	----	----	----	----	----	96.8	94.2	95.5
3	98.7	73.8	74.0	98.4	86.2	99.7	99.6	99.7	69.7	73.7	71.7
Row Means	98.9	74.1	73.8	98.4	86.3	99.7	99.6	99.7	91.1	91.0	91.0
	LSD (.05 Significance Level) Row Means: 0.456 RPM Code x Row Means: 0.456 RPM Code Means: 0.430								LSD (.05 Significance Level) Circuit Means: 0.789 RPM Code x Circuit Means: 0.789 RPM Code: 3.193		

*25% of holes taped closed in Rows 2 and 3

TABLE XV

METERING PERCENT MEANS - ACID DELINTED COTTONSEED**
96 HOLE DRUM

	PC1 Series (6 Replications)					Predicted Values for Logic Circuit Metering			PC4 Series (6 Replications)		
Drum RPM Code	Row of Seed Drum 1	2*	3*	4	RPM Code Means	Fluidic Circuit 1	2	RPM Code Means	Fluidic Circuit 1	2	RPM Code Means
1	104.0	75.3	74.2	102.3	89.0	101.3	100.6	101.0	102.8	101.2	102.0
2	103.7	75.5	75.7	102.2	89.3	101.4	101.3	101.4	102.5	102.3	102.4
3	103.3	75.7	75.8	102.2	89.3	101.5	101.4	101.5	101.3	100.3	100.8
Row Means	103.7	75.5	75.2	102.2	89.2	101.4	101.1	101.3	102.2	101.3	101.8
	LSD (.05 Significance Level) Row Means: 0.630 RPM Code x Row Means: 0.630 RPM Code Means: 0.562								LSD (.05 Significance Level) Circuit Means: 0.780 RPM Code x Circuit Means: 0.982 RPM Code Means: 0.822		

*25% of holes taped closed in Rows 2 and 3

**Through 5.95 mm (15/64 in), Over 5.56 mm (14/64 in) screen

TABLE XVI

METERING PERCENT MEANS - ACID DELINTED COTTONSEED**
96 HOLE DRUM

	PC2 Series (6 Replications)					Predicted Values for Logic Circuit Metering			PC5 Series (6 Replications)		
Drum RPM Code	Row of Seed Drum				RPM Code Means	Fluidic Circuit		RPM Code Means	Fluidic Circuit		RPM Code Means
	1	2*	3*	4		1	2		1	2	
1	104.5	75.7	75.3	104.3	90.0	101.8	101.4	101.6	102.7	102.0	102.3
2	103.0	76.5	75.8	103.3	89.7	102.3	101.6	102.0	102.7	102.5	102.6
3	103.3	75.7	76.0	102.7	89.4	101.5	101.7	101.6	100.3	99.2	99.8
Row Means	103.6	75.9	75.7	103.4	89.7	101.8	101.6	101.7	101.9	101.2	101.6
	LSD (.05 Significance Level) Row Means: 0.508 RPM Code x Row Means: 0.508 RPM Code Means: 0.742								LSD (.05 Significance Level) Circuit Means: 0.745 RPM Code x Circuit Means: 0.745 RPM Code Means: 0.794		

*25% of holes in rows 2 and 3 taped

**Over 5.95 mm (15/65 in) screen

TABLE XVII

METERING PERCENT MEANS - ACID DELINTED COTTONSEED**
96 HOLE DRUM

	PC3 Series (6 Replications)					Predicted Values for Logic Circuit Metering			PC6 Series (6 Replications)		
Drum RPM Code	Row of Seed Drum 1	2*	3*	4	RPM Code Means	Fluidic Circuit 1	2	RPM Code Means	Fluidic Circuit 1	2	RPM Code Means
1	106.2	76.8	75.0	104.2	90.5	103.4	101.1	102.2	103.2	102.3	102.8
2	105.5	76.5	76.2	103.0	90.3	102.9	102.0	102.4	102.8	102.8	102.8
3	104.0	76.0	76.0	102.7	89.7	102.0	101.7	101.8	101.0	101.0	101.0
Row Means	105.2	76.4	75.7	103.3	90.2	102.7	101.5	102.1	102.3	102.1	102.2

PC3 Series — LSD (.05 Significance Level)
- Row Means: 0.644
- RPM Code x Row Means: 0.644
- RPM Code Means: 0.509

PC6 Series — LSD (.05 Significance Level)
- Circuit Means: 0.743
- RPM Code x Circuit Means: 0.743
- RPM Code Means: 0.892

*25% of holes in rows 2 and 3 taped

**Ungraded

The analysis of variance for drum RPM showed that at the 95 percent significance level, no differences in RPM were measured between replications in all tests. Means of the seed drum RPM, LSD's, and theoretical seeding rate per row, are given in Table XVIII for the different series of tests.

The number of seeds per gram was used only as a check on actual seed count. Significant differences were measured due to row and RPM effect, but variances were small and the overall mean provided a way to check seed count. If a large discrepancy existed between the actual seed count and the calculated count, the sample was recounted. The overall means of seeds per gram for the different series of tests are also recorded in Table XVIII.

Means of metering percent for tests before adding logic circuit modifications were used to predict metering percent for the unit modified by adding logic circuitry. The two center rows were used as the primary rows, and since 25 percent of these holes were taped closed, the maximum metering percent for them could be only 75 percent assuming one seed per cell.

An indication of the ability of the metering unit to meter one seed per cell is obtained from the rows where missing seeds were sensed. The number of seeds sensed as missing plus the number of seeds metered in the sample should be equal to 100 percent for one seed per cell. If more than one seed per cell is being metered, this value will be greater than 100 percent. The means of metering percent including misses are shown in Table XIX for the rows measured.

Sorghum seed appears to be metered very accurately at one seed per cell, whereas slightly more than one cottonseed is metered per cell.

TABLE XVIII

MEANS FOR MEASURED SEED DRUM RPM AND NUMBER OF SEEDS PER GRAM OF SEED USED IN METERING TESTS

Test Series	RPM Code	Measured RPM	LSD's RPM Means (.05 Significance Level	Theoretical Seeding Rate Seeds/Sec/Row	Mean Number of Seeds Per Gram
PS3	1	14.13*	0.056	33.9	34.09
	2	21.30		51.1	
	3	28.28		67.9	
PS6			0.081		34.38
	1	14.18		34.0	
	2	21.37		51.3	
	2.5	24.88		59.7	
	3	28.33		68.0	
PC1			0.056		8.41
	1	14.17		22.7	
	2	21.32		34.1	
	3	28.25		45.2	
PC2			0.030		7.63
	1	14.20		22.7	
	2	21.38		34.2	
	3	28.30		45.3	
PC3			0.030		8.42
	1	14.20		22.7	
	2	21.38		34.2	
	3	28.30		45.3	
PC4			0.087		8.39
	1	14.30		22.9	
	2	21.40		34.2	
	3	28.32		45.3	
PC5			0.070		7.70
	1	14.30		22.9	
	2	21.38		34.2	
	3	28.37		45.4	
PC6			0.038		8.50
	1	14.30		22.9	
	2	21.40		34.2	
	3	28.43		45.5	

*Means of 6 replications

TABLE XIX

METERING PERCENT MEANS*

Test Series	Row Measured	RPM Setting	Metering Percent
PS3	3		
		1	100.3
		2	100.9
		3	100.9
PC1	4		
		1	102.3
		2	102.2
		3	102.3
PC2	4		
		1	104.3
		2	103.5
		3	103.0
PC3	4		
		1	104.5
		2	103.2
		3	102.8

*Adjusted for Misses

Very few misses occur with either seed, but approximately three percent of the time more than one cottonseed is metered per cell. The shape of the respective seeds probably account for their differences. Sorghum has a more spherical and uniform shape allowing only one seed in a cell, whereas the shape of cottonseed apparently allows two seeds to be caught in a cell occasionally.

Since more than one seed was sometimes being metered, the theory given by equations 1 and 2 of Chapter III were used to derive equations to calculate predicted metering percentages for the four possible cases. The cases and the equations for calculating metering percent for each are given below:

Case I: Metering percents of primary and secondary are less than the maximum for one seed per cell.

$$MP = [1.0 - p(P) \cdot p(S)]100 \qquad (10)$$

Case II: Metering percents of primary and secondary are greater than the maximum for one seed per cell.

$$MP = [1.0 + p(ES) \cdot (0.25) + p(EP)] \cdot 100 \qquad (11)$$

Case III: Metering percents for the primary is greater but that for the secondary is less than the maximum for one seed per cell.

$$MP = [1.0 + p(EP) + p(S) \cdot (0.25)] \cdot 100 \qquad (12)$$

Case IV: Metering percent for the primary is less but that for the secondary is greater than the maximum for one seed per cell.

$$MP = [1.0 + p(ES) \cdot p(P)] \cdot 100 \qquad (13)$$

In Tables XIV through XVII, the predicted values for logic circuit metering can be compared to the measured values. The actual values of metering percent are very close to the predicted values except on the 144 hole drum at the highest drum RPM tested. An intermediate drum speed was added to this test to show where the metering percent began to drop.

This reduction in metering percent can be explained by the response characteristics of the interface valves. The output of the interface valves lags the input by approximately seven milliseconds as shown in the test of Figure 29. At the maximum seeding rate, input signals to the interface valve are generated approximately 14.75 milliseconds apart. This is almost the same as the turn on and turn off time of the valve, so malfunction of the valve would be expected.

Two solutions to this problem exist. One solution would be to utilize three independent logic circuits instead of two and alternate outputs. The other solution is to use a valve with faster frequency response characteristics. Although some commercial valves are advertised with three millisecond response, the ones tested for the seed ejection problem could not do this in sustained operation.

A diaphragm pressure amplifier valve illustrated in Figure 30 was constructed to show that frequency response in the range of interest is possible in an interface valve. The test shown in Figure 29 shows that a response of approximately three milliseconds was obtained from this valve. The input signal is inverted for comparison purposes, but the output signal is present when the control signal is off in this valve.

The capabilities of sensing and logic control are evident when considering the fact that at least 25 percent of the seeds in these tests have come from the secondary cells. Rapid sensing and logic

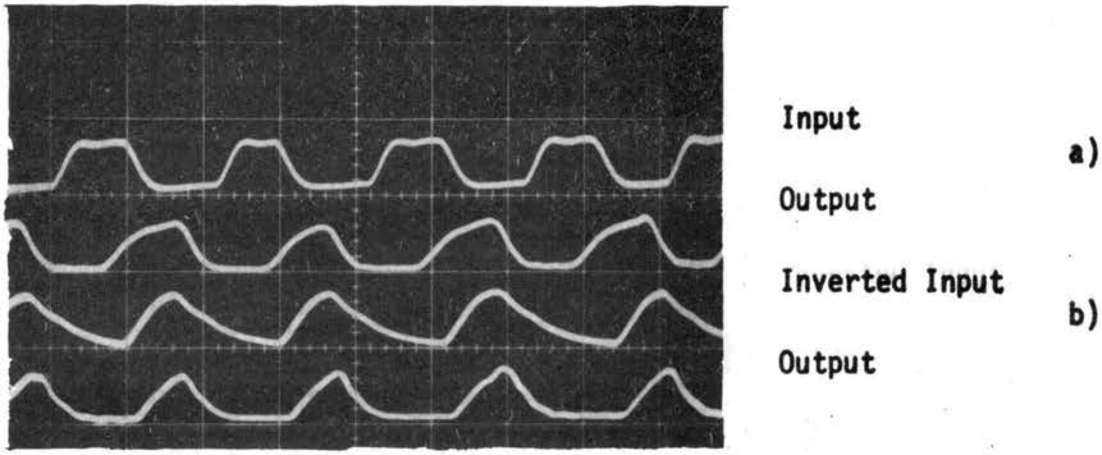


Figure 29. Response Characteristics of Interface Valves. Trace Sweep Rate was 10 Msec Per Cm on Grid Screen
a) Commercial Valve
b) Laboratory Constructed Valve

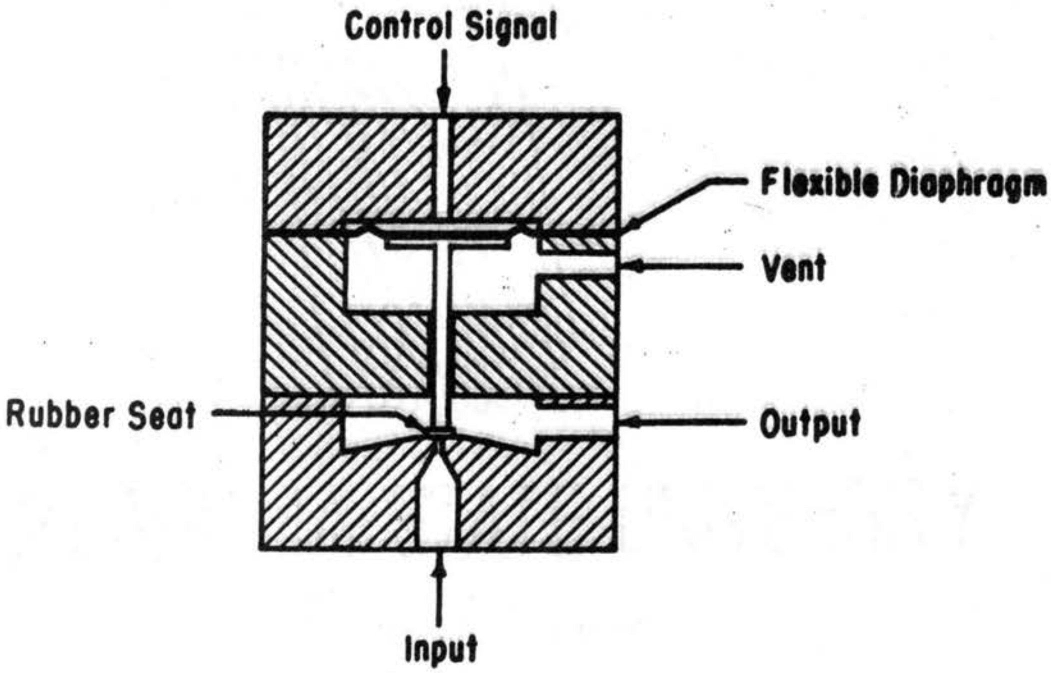


Figure 30. Diaphragm Pressure Amplifier Valve

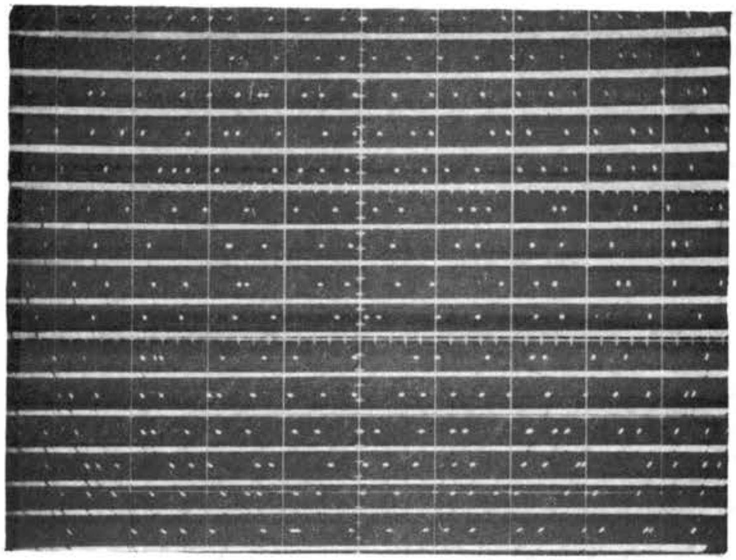
decisions are capable of being made entirely with pneumatic elements.

Seed Conveyance Tests

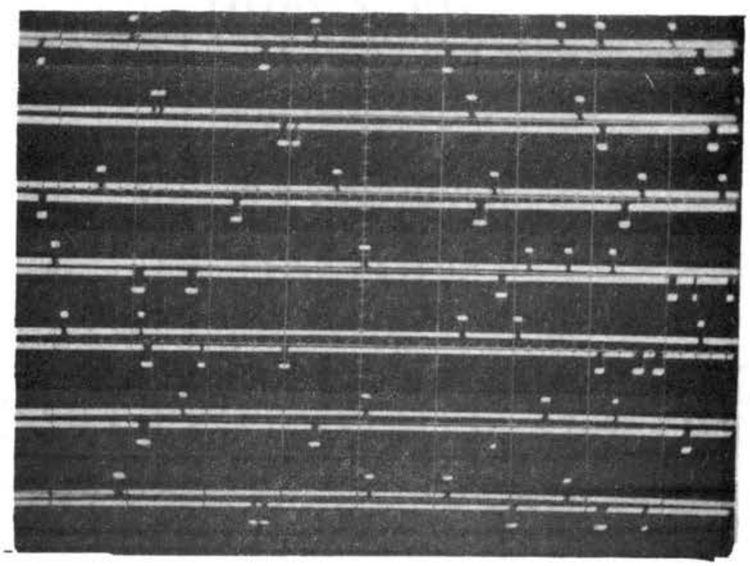
Seed distribution data were obtained from photographs of sensor signals on an oscilloscope. Examples of photographs are shown in Figure 31. Eighty millimeters as outlined by the oscilloscope grid screen was used as the sample length. Each seed was recorded as the distance from the sensed signal to the zero grid line. Distances were estimated to the nearest 0.5 mm. For analysis, the distance from the zero grid line and the first seed was added to the distance between the last seed signal and the 80 mm grid line and this sum was considered as one space. Data for each series of seed conveyance tests are presented in Appendix C.

Relative variance and measured seeding rates were calculated for each sample by use of a computer program. The means of five samples in each test were tabulated for comparison of treatments and given in Table XX. Measured seeding rates from the samples are recorded in Table XXI and can be compared to theoretical seeding rates. Only small differences are apparent for the configuration treatments. Little difference was measured between configuration 1 and 2. The additional bend in the conveyance tubing apparently does not add to spacing variations. Configuration three consisting of manifold only has slightly less variations in distribution than the other configurations.

Several factors could cause these variations. The differences in velocity in the cross section of the tubing could contribute to variations. Air velocity profiles at the exit for each configuration are shown in Figure 32. These profiles show that large differences in air



a) Seed Spacing Distribution Tests



b) Seed Velocity Tests

Figure 31. Examples of Photographs of Sensor Signals in Conveyance Tests

TABLE XX

RELATIVE VARIANCES OF SEED DISTRIBUTION AT EXIT

Seed Metering Rate Seeds/ Sec/Row	Repli- cation	Configuration 1				Configuration 2				Configuration 3			
		Roller Ejector		Air Ejector		Roller Ejector		Air Ejector		Roller Ejector		Air Ejector	
		Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity
22.7	1	98.22*	98.18	97.81	98.37	97.91	98.44	97.95	97.91	99.19	99.10	99.23	99.15
	2	98.24	97.97	98.32	98.25	98.32	98.64	98.13	97.90	99.15	99.30	99.15	99.38
	3	96.75	97.37	96.73	96.03	94.04	95.85	96.26	97.16	98.20	98.54	98.61	98.59
	4	96.17	96.29	95.03	95.54	97.62	96.28	94.72	96.35	98.11	98.36	98.33	98.70
34.0	1	96.16	97.05	96.51	95.72	96.77	96.94	96.52	96.94	98.76	98.55	97.95	98.39
	2	97.54	95.70	95.83	96.98	96.94	96.22	96.22	96.24	98.56	98.93	98.36	99.10
	3	87.94	92.00	90.92	93.03	93.53	89.79	88.51	87.97	98.23	95.98	93.95	95.97
	4	90.29	86.74	93.24	90.15	90.40	94.05	88.14	90.12	97.57	96.76	96.79	93.66
45.3	1	97.08	97.21	97.00	96.87	97.10	96.75	95.94	96.30	98.71	98.46	97.91	98.05
	2	97.95	97.63	95.66	97.03	96.85	96.43	96.42	96.66	98.86	98.91	97.55	97.58
	3	83.38	90.40	90.99	88.51	94.79	87.84	87.19	91.62	95.89	96.84	93.84	92.52
	4	93.04	91.17	90.07	89.77	91.94	91.67	85.15	90.58	96.69	97.45	92.15	95.79

*Means of five samples each

TABLE XXI

MEASURED SEEDING RATES FROM SAMPLES

Seed Metering Rate Seeds/ Sec/Row	Replication	Configuration 1				Configuration 2				Configuration 3			
		Roller Ejector		Air Ejector		Roller Ejector		Air Ejector		Roller Ejector		Air Ejector	
		Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity
22.7	1	23*	23	24	23	25	23	23	24	27	25	25	25
	2	23	24	25	24	23	23	24	24	26	25	25	25
	3	23	23	26	24	24	24	24	25	24	26	27	24
	4	23	25	24	25	25	23	23	24	25	24	25	25
34.0	1	34	37	31	35	33	37	37	32	37	37	35	37
	2	33	37	35	36	33	36	38	35	37	37	37	36
	3	35	37	36	41	36	34	33	35	37	40	36	41
	4	37	31	37	33	34	39	34	33	35	36	39	35
45.3	1	44	49	43	43	43	46	41	45	47	49	43	45
	2	47	45	42	43	45	43	42	40	47	50	45	46
	3	45	46	46	46	45	41	40	53	47	50	49	51
	4	47	49	50	55	49	44	40	43	47	47	46	51

*Means of five samples each (seeds per second)

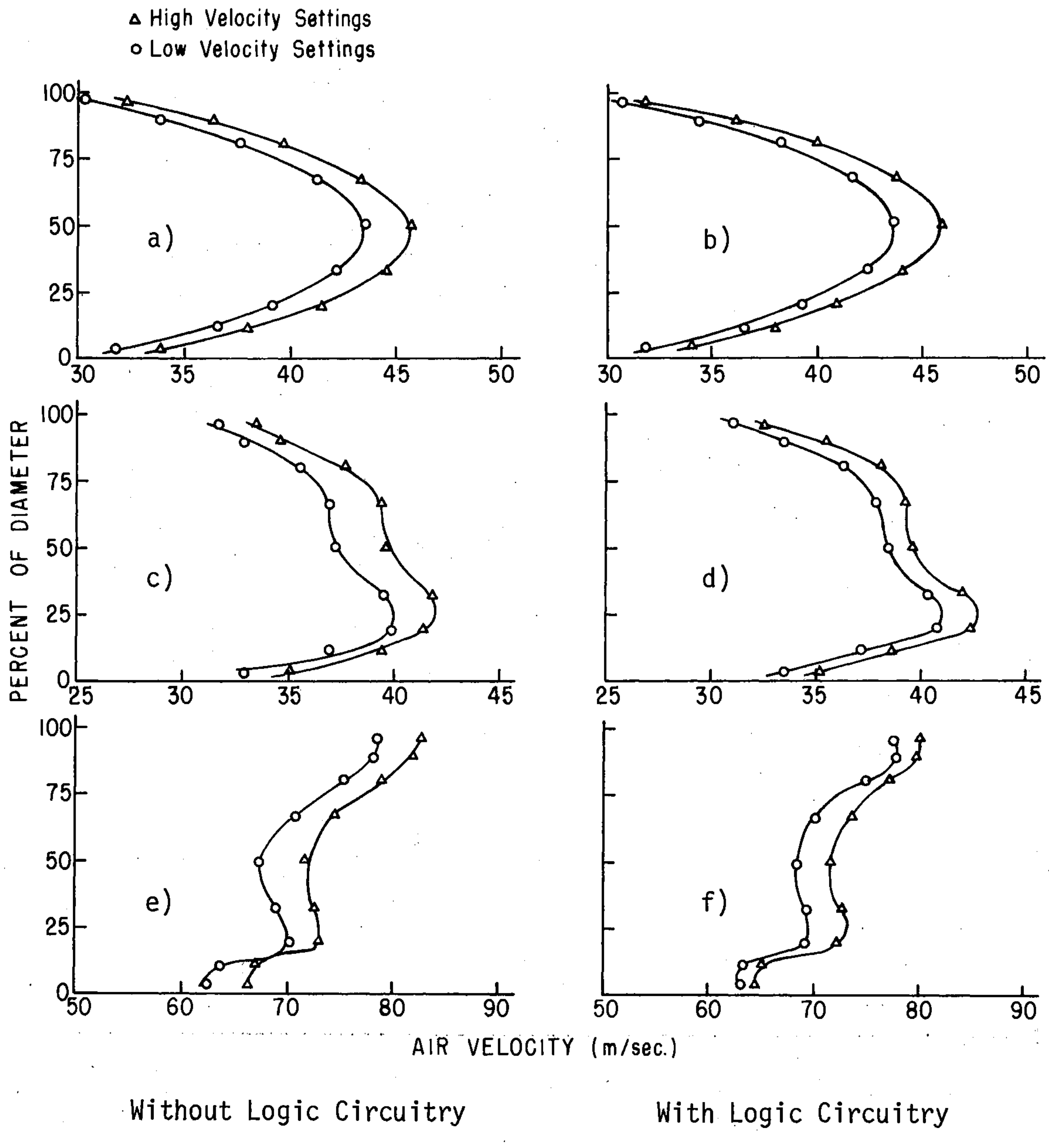


Figure 32. Average of Horizontal and Vertical Velocity Profiles at Configuration Exit
(a & b) Configuration 1
(c & d) Configuration 2
(e & f) Configuration 3

velocities exist in different zones of the tubing.

Another factor is the irregularity in seed shape. As the seed was transmitted through the tubing, velocity variations and rubbing on side walls undoubtedly caused changes in seed orientation with respect to the transmission direction. Since the seed was irregularly shaped, the drag coefficient would change and affect the seed velocity. Differing seed velocities would affect the distribution at the exit of the tubing. Sized seed was used to minimize this effect.

Cottonseed exit velocities and associated 95 percent confidence limits are shown in Table XXII for the different treatments. These velocities were calculated from the time interval for seeds to pass between two sensors spaced 30 cm apart and do not represent instantaneous velocities. Seed velocities were fairly constant for all samples, and most 95 percent confidence limits were within ± 5 percent of the mean.

Seed velocities were higher for the pneumatic ejector than for the roller ejector, but can be explained by differences in air velocities in the tubing. This is attributed to the difference in the number of seed cells closed by seeds with the two ejection methods. With the roller ejector, all four rows had empty cells for approximately one half of the drum; whereas, with the pneumatic ejector, only one row had empty cells for approximately one half of the drum. This caused slightly different static pressures in the drum and different air velocities at the same blower opening for the two ejection methods.

The 95 percent confidence intervals of seed velocities overlap for metering rate in all treatments, so the range of metering rates used in these tests did not affect seed velocity. However, configuration

TABLE XXII

COTTONSEED EXIT VELOCITIES*

Seed Metering Rate	95% Conf. Limits	Configuration 1				Configuration 2				Configuration 3			
		Roller Ejector		Air Ejector		Roller Ejector		Air Ejector		Roller Ejector		Air Ejector	
		Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity
	Lower	16.05	17.71	17.97	18.93	14.08	15.03	12.58	15.80	16.17	16.58	15.85	17.21
22.7	Mean	16.67	18.23	18.58	19.74	14.71	15.71	14.10	16.85	16.92	17.37	16.82	17.89
	Upper	17.33	18.79	19.24	20.62	15.40	16.47	16.03	18.05	17.75	18.24	17.92	18.62
	Lower	15.91	17.36	17.96	19.38	13.73	13.83	14.07	14.36	15.86	17.14	16.23	16.24
34.0	Mean	16.41	17.78	18.49	19.88	14.55	15.02	14.90	15.56	16.51	17.73	16.98	17.05
	Upper	16.94	18.23	19.06	20.41	15.46	16.45	15.84	16.96	17.23	18.37	17.81	17.93
	Lower	15.70	18.22	18.34	18.07	13.41	14.71	14.10	14.99	15.74	16.62	16.56	16.83
45.3	Mean	16.22	18.93	18.83	18.91	14.01	15.14	14.78	15.55	16.20	17.16	16.92	17.29
	Upper	16.72	19.69	19.36	19.82	14.67	15.59	15.53	16.15	16.69	17.75	17.29	17.77
MEANS		16.43	18.31	18.63	19.51	14.42	15.29	14.60	15.99	16.54	19.42	16.91	17.41
Average Air Velocities		36.7	38.7	37.0	38.6	35.8	37.9	36.4	38.0	70.9	74.5	70.9	73.2
Ratio Avg. Seed Vel. To Avg. Air Velocity		.45	.47	.50	.51	.40	.40	.40	.42	.23	.23	.24	.24

*Meters per second

affects seed velocity, with configuration 2 having lower velocity than configurations 1 and 3. The bend near the exit in configuration 2 apparently causes seed velocity to be reduced slightly. This effect is apparently almost constant for all seeds because otherwise seed distribution would be affected.

Average air velocities were determined in separate tests and not simultaneously with seed velocity tests. However, the air velocities are recorded for the different treatments in Table XXII and the approximate ratio of average seed velocity to average air velocity determined. These ratios are almost constant for each configuration, but vary with configuration. This follows the work of Chand (14) that particle velocity varies linearly with air velocity for a particular conveyance shape. The low ratio of seed velocity to air velocity in configuration 3 suggests that seeds may still be accelerating when leaving the manifold when no tubing is attached.

Little difference in relative variance was measured between ejection methods. The roller ejector depends on gravity to cause seeds to drop into the manifold and enter the air stream in the conveyance tube. Due to the circular cell motion at the time of seed ejection, the seed follows an approximate parabolic path into the manifold.

The pneumatic ejectors apply a force in addition to gravity in ejecting the seeds. This force is caused by the ejection air pressure acting over the area of the seed cell opening. Observations of seeds leaving the cells with a strobe light when no manifold was attached, showed that seeds follow an almost linear path when ejected pneumatically. The direction of the path was not constant, and these differences were thought to be caused by differences in seed shape and timing of ejection air pulse.

The ejection point for the pneumatic ejectors had to be located closer to the center of the manifold than the point where seed were ejected by the roller. Observations with a strobe light showed that when pneumatic ejectors were located at the same ejection point as the rollers, seed bounced out of the manifold over the approach edge. This occurred primarily at the low drum RPM setting and losses could be reduced some by a reduction in air pressure. Relocation of ejectors reduced loss of seeds from the manifold, (Table XXIII), but bouncing within the manifold probably still occurred.

Seed Spacing Tests

Original Data for seed distribution at manifold exit and for seeds placed on conveyor belt are given in Appendix D. Data for seed distribution were determined from photographs of sensor signals on the oscilloscope and represent distances to signals from a zero grid line on the oscilloscope screen. Eighty mm sample distance was used.

Data for seeds placed on conveyor belt were obtained from photographs and represent distances in centimeters. The same fifty centimeters of sample distance as indicated by a rule over the conveyor belt was used as the sample distance for all tests. The first value represents the zero point for beginning sample and the final value represents the final point for ending sample. Estimated centers of seeds were measured to the nearest 0.5 cm as indicated on the rule, and duplication of values indicate more than one seed on the belt at that point. Examples of seed distribution on the belt are shown in Figure 33.

TABLE XXIII

METERING PERCENT MEANS - SORGHUM SEED
144 HOLE DRUM

(PS4)	Air Ejector With Ejection Point Same As For Rollers		(PS5)	Air Ejector With Relocated Ejector Position	
Drum RPM	Circuit		Drum RPM	Circuit	
	1	2		1	2
14.20	88.88*	84.63	14.18	98.63	96.13
21.29	97.00	90.50	21.26	99.63	98.75
	LSD (.05 significance level)			LSD (.05 significance level)	
	Circuit Means:	0.751		Circuit Means:	0.655
	RPM x Circuit Means:	0.751		RPM x Circuit Means:	0.655
	RPM Means:	0.974		RPM Means:	0.383

*Means of 8 replications

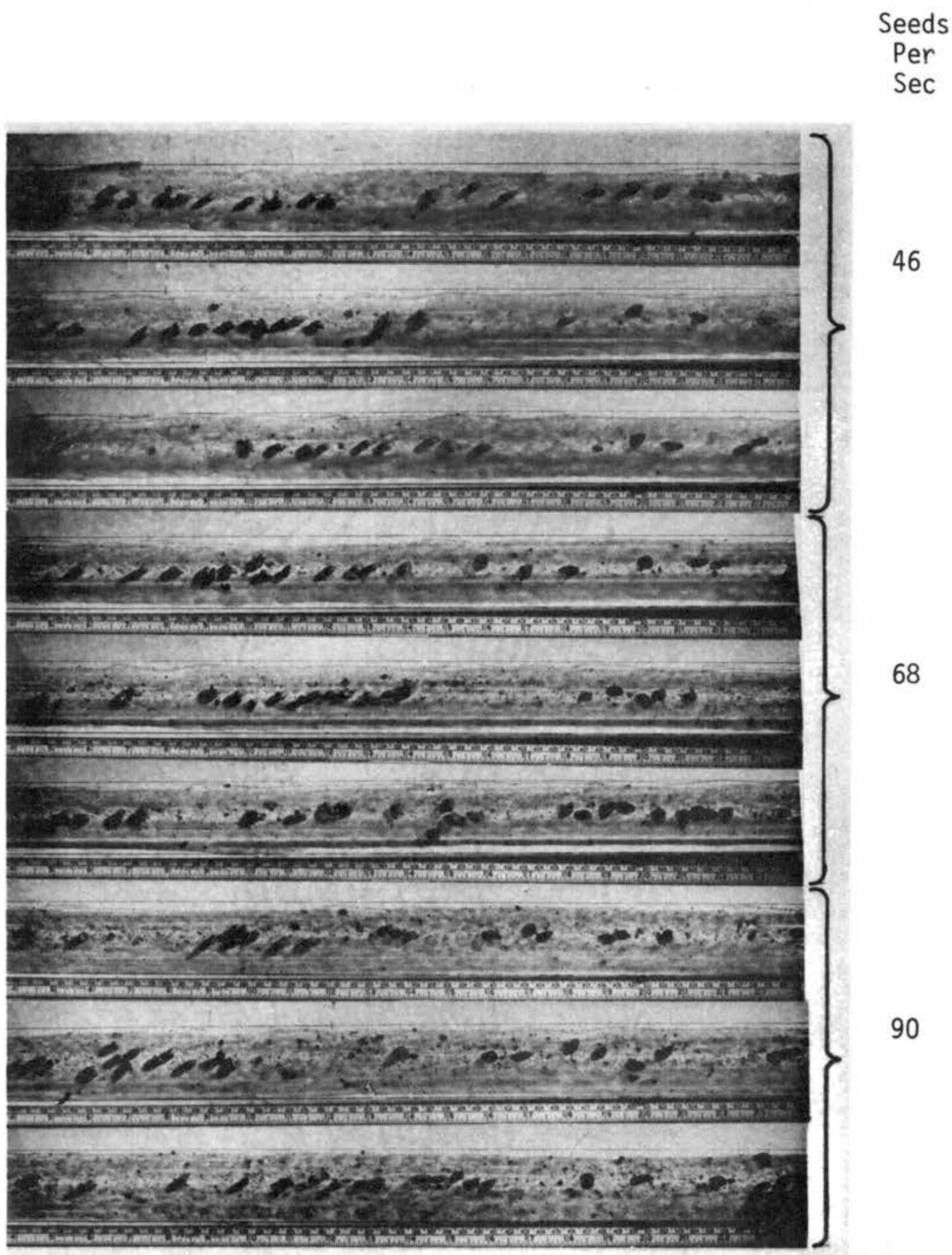


Figure 33. Examples of Seed Distribution on Conveyor Belt for Three Seeding Rates

Relative variances and measured seeding rates are shown in Table XXIV for seeds at exit of manifold used to integrate 4 seed drum rows into one row. Relative variances of the lowest seeding rate included in the test appear to be slightly higher than the other two seeding rates. This indicates that distribution is more uniform at the lower seeding rate. As seeding rate increases, any bouncing or disturbance in the manifold would be expected to be more detrimental to spacings because of the smaller time interval between seeds.

The measured seeding rates determined from sensor signals are also shown in Table XXIV. The measured seeding rates compare closely with the theoretical seeding rate except at the highest seeding rate tested. The measured seeding rate was 10 to 15 percent below the expected rate.

If two seeds pass through the sensor with no separation between them, they are sensed as one seed. Where two sensors were used in measurement of seed exit velocities for the merging manifold, this was observed to happen at high seeding rates. A single signal observed from the first sensor sometimes became two signals in the second sensor. Generally when this occurred, the first signal was longer than normal indicating two seeds may have been in contact coming from the manifold. At the high seeding rate this was believed to be the primary reason for the discrepancy between measured and theoretical values.

Approximate air velocity profiles at the exit of the manifold are shown in Figure 34. Seed velocities at the exit of the manifold and the ratio of seed velocity to average air velocities are shown in Table XXV. The profiles show small variations in velocity measurements in different areas. Some of these variations may be due to location of reading points as indicated by difference in centerline velocity of

TABLE XXIV

RELATIVE VARIANCES AND SEEDING RATES AT MANIFOLD EXIT IN SPACING TESTS WITH LOGIC CIRCUIT METERING*

Theoretical Seeding Rate	Replication	Relative Variances		Measured Seeding Rate in Seeds/Sec	
		Low Air Velocity	High Air Velocity	Low Air Velocity	High Air Velocity
46	1	96.67	97.27	49	46
	2	97.09	95.04	48	42
	3	96.01	97.22	45	50
	4	96.78	96.46	40	48
68	1	95.05	93.55	61	69
	2	93.34	95.60	59	64
	3	92.45	94.41	69	75
	4	96.07	93.10	68	72
90	1	94.80	90.24	78	75
	2	95.42	93.89	83	83
	3	95.60	95.06	71	78
	4	94.02	94.35	73	81

*Cottonseed through 5.95 mm (15/64 in), over 5.56 mm (14/64 in) screen

TABLE XXV

COTTONSEED EXIT VELOCITIES FROM MANIFOLD MERGING SEED FROM TWO INDEPENDENT CIRCUITS INTO ONE ROW

Theoretical Seeding Rate Seeds/Sec.	Mean and 95% Confidence Limits	Cottonseed Exit Velocity m/sec	
		Low Air Velocity	High Air Velocity
46	Lower	12.73	13.96
	Mean	13.39	14.37
	Upper	14.11	14.80
68	Lower	13.34	13.56
	Mean	13.97	14.08
	Upper	14.65	14.65
90	Lower	13.46	13.98
	Mean	13.85	14.36
	Upper	14.25	14.76
Means		13.74	14.27
Average Air Velocity M/Sec		88.68	92.03
Ratio of Seed to Air Velocity		.155	.155

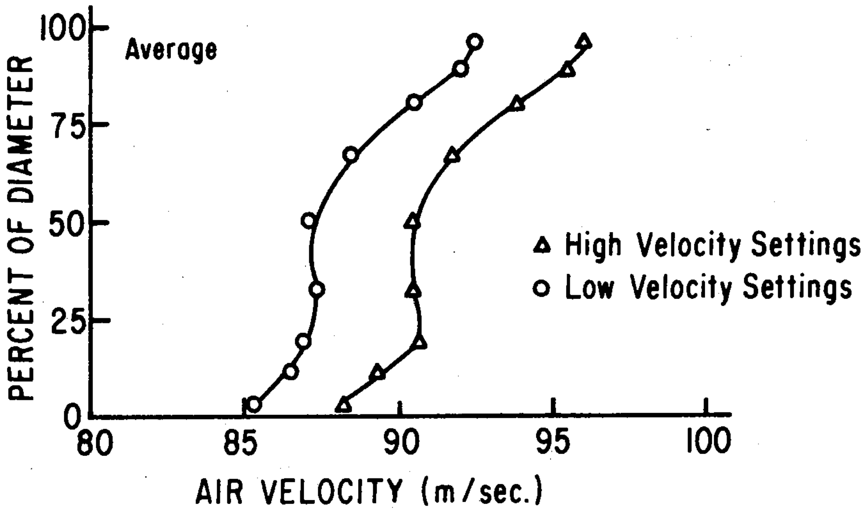


Figure 34. Average of Horizontal and Vertical Velocity Profiles at Exit of Seed Merging Manifold

the two profiles. The outlet was not a perfect circle which made reference points difficult to establish, and small variations are more important because of the small diameter of the exit.

The velocity distribution in the rest of the manifold was not obtained and could be a factor in causing seeds to group. However, the primary factor in causing grouping was thought to be bouncing of seed caused by hitting side walls as they were merged and brought to the exit. Seeds could be observed to occasionally ricochete violently inside the manifold after ejection.

Relative variances and mean seed spacings determined from photographs of seeds placed on the conveyor belt are shown in Table XXVI. The relative variances of seed spacings on the belt were approximately the same as those at the exit of the manifold. The additional path and seed wheel which matched seed velocity to the belt velocity could have

TABLE XXVI

RELATIVE VARIANCES AND SPACING FOR SEEDS PLACED ON CONVEYOR BELT IN SPACING TESTS

Theoretical Seeding Rate (seeds/sec)	Replication	Relative Variances	Mean Spacing (CM)
46	1	95.88	2.66
	2	95.70	2.45
	3	96.69	2.32
68	1	95.93	2.34
	2	96.78	2.56
	3	95.61	2.51
90	1	96.45	2.50
	2	94.43	2.84
	3	94.62	2.54

rearranged the distribution of seeds which exited the manifold, but the final seed distribution on the belt was apparantly no worse than that at the manifold exit.

The theoretical spacing of seeds was 2.5 cm, and the observed mean spacing on the belt was very close to the theoretical spacing. Differences between observed and theoretical spacings could be attributed to skips, grouping of seeds, and variations in belt speed.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND SUGGESTIONS FOR FURTHER STUDY

Summary

Research undertaken was related to the application of logic techniques and fluidic sensing and control to planting seeds. The following objectives were established for this research:

1. Develop a metering unit utilizing principles of fluidics and fluid logic for dispensing acid delinted cottonseed one at a time at a rate of at least 135 seeds per second.
2. Investigate methods of placing individual acid delinted cottonseed in a seed furrow, and develop a seed ejecting unit which accurately spaces seeds along the furrow.

All research was done in the Agricultural Engineering Research Laboratory and was divided into four phases. The first phase consisted of deriving logic circuit, selecting the sensing and logic elements to implement the circuit, and testing the circuit to provide a "backup" seed source for seeds missing from the primary source.

In the second phase, an International Harvester 400 Cyclo planter was modified to eject seeds using two independent logic circuits and four pneumatic interface valves. Each circuit sensed presence or absence of seeds in a primary row on the IH Cyclo seed metering drum, and if no seed was present, a seed was ejected from a secondary row.

The circuits were positioned to alternate outputs in order to achieve a high combined seeding rate. Capabilities of using pneumatic sensing and logic circuitry for control of seed metering were also studied in this phase of the research.

Seed metering percent was used as the criterion for evaluating the function of the logic controlled unit. A predicted metering percent was determined from tests of the unmodified unit for three seed drum speeds and compared to the modified unit. Tests were made with sorghum and three sizes of cottonseed.

The third phase of the research was an investigation of the pneumatic transport of acid delinted cotton seed from the metering unit to the exit point. Seeds were sensed at the exit of the conveyance tubing with an International Harvester Air Planter Monitor. Treatments included three conveyance configurations, two ejection methods and two air velocities. Relative variance was used to compare the measured seed distribution from the different treatments.

The fourth and final phase of the research was an investigation of the distribution of cottonseed from the logic circuit where the primary and secondary rows of both circuits were merged into one row. Distribution of seeds placed on a conveyor belt by a wheel that matched seed velocity to belt velocity was also studied. Three seeding rates of cottonseed were used in the tests.

Conclusions

1. The Classical Synthesis Technique was useful in developing a logic circuit to meter seeds where provisions were made for a "backup" seed source to fill potentially vacant spaces.

2. Fluidic sensors and logic elements were combined into a logic circuit capable of deciding and signaling from which source seed were to be ejected, and the circuit functioned satisfactorily at simulated seeding rates up to approximately 100 seeds per second.
3. Moving parts interface valves were required to amplify logic signals sufficiently to eject seeds from the IH Cyclo seed metering drum, and maximum ejection rate for an individual valve without malfunction was found to be 60 seeds per second.
4. In tests with Sorghum seed, metering percent of the IH Cyclo planter modified with logic circuitry was very close to predicted values except at the maximum seeding rate of 136 seeds per second. Where at least 25 percent of the seeds were missing from primary seed cells because of taped holes, the "backup" technique allowed metering percent to be maintained from 94 to 99 percent up to a rate of 120 seeds per second. At a seeding rate of 136 seeds per second, interface valves began to malfunction and seeding rate was approximately 72 percent.
5. In tests with three sizes of acid delinted cottonseed, metering percent of the IH Cyclo planter modified with logic circuitry was very close to the predicted values for all seeding rates tested. Seeding rates tested were 46, 68, and 90 seeds per second.
6. The IH Cyclo planter is an excellent metering unit and was capable of metering the seeds tested one at a time with very few misses. With cottonseed, from 1 to 5 percent more seeds were metered per cell than theoretically expected and this was attributed to seed shape. No important advantage was obtained by using the logic circuitry. However, the concepts and principles tested by taping

25 percent of the seed cells may be applicable for other seeds or other situations.

7. The conveyance of seeds from the metering unit for placing them in a seed furrow introduced spacing variations. Seeds were released from the cells with equal intervals of time from one to the next, but seeds exiting the manifold and two configurations of tubing did not exit with equal intervals of time between them.
8. Exit velocities of cottonseed were found to exceed 13 meters per second for three conveyance configurations.
9. Little difference in seed distribution was measured for cottonseed exiting three conveyance configurations with two ejecting methods, two air velocities, and three seeding rates.
10. Seed spacings measured at the exit of the manifold was slightly less variable than when conveyed through additional tubing.

Suggestions for Further Study

Further investigations are recommended for achieving uniform spacings in the seed furrow for high seeding rates. Individual seeds were uniformly metered, but some method is needed to maintain this uniformity and precisely control spacings of seeds delivered to the seed furrow.

It is also recommended that investigations be made on locating sensors very near the seed furrow and use logic circuitry to control spacing uniformity. The metering principles used in the IH Cyclo planter provide excellent metering characteristics and addition of sensing and logic control of metering apparently is not needed at that point. However, many of the logic circuit principles and techniques used in this study should apply to controlling seed spacing.

Information is needed on the effect of impact of seeds with soil in the seed furrow. High exit seed velocities were measured in this study, and any future studies should consider the effect of this on seed germination and emergence.

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APPENDIXES

APPENDIX A

IDENTIFICATION OF EQUIPMENT USED IN THIS RESEARCH

APPENDIX A

LOGIC CIRCUIT AND SAMPLING COMPONENTS

Identification	Company	Part Number
OR/NOR	Corning	191453
AND/NAND	Corning	191455
FLIP-FLOP	Corning	191454
SCHMITT TRIGGER	Corning	191456
DIGITAL AMPLIFIER	Corning	191460
MANIFOLD	Corning	191722
VARIABLE RESTRICTOR	Clippard	MNV-1
INTERFACE VALVE	Creative Automation Technique	146-1
INTERFACE VALVE	KAY Pneumatics	KV28/043UP-HP
CYLINDER	Clippard	

PLANTING EQUIPMENT

Identification	Company	Part or Serial No.
400 IH Cyclo Planter	International Harvester	0970000U006232*
Field Improvement Package	International Harvester	8007449R91
Cyclo Air Planter Monitor	International Harvester	15386 HP
144 Hole Sorghum Seed Drum	International Harvester	58435C91
96 Hole Cottonseed Drum	International Harvester	94969R91

INSTRUMENTATION

Identification	Company	Model No.
Oscillograph	Sanborn	321
Oscilloscope (Dual beam)	Tektronix	502A
Pressure Transducer	Statham	PM822
Pressure Transducer	Statham	PM872
Strobotac	Gen. Radio Co.	1531A

APPENDIX B

APPENDIX B-1

THEORETICAL SEED COUNT = 576

REP NO	RPM CODE	DRUM ROW	SAMPLING TIME (SEC)	RECORDED MISSES	SEED COUNT
1	1	1	16.92		572
1	1	2	16.92		425
1	1	3	16.92	8	429
1	1	4	16.92		561
1	2	1	11.27		569
1	2	2	11.27		424
1	2	3	11.27	20	421
1	2	4	11.27		558
1	3	1	8.48		567
1	3	2	8.48		425
1	3	3	8.48	9	429
1	3	4	8.48		561
2	1	1	16.94		573
2	1	2	16.94		433
2	1	3	16.94	12	420
2	1	4	16.94		568
2	2	1	11.27		568
2	2	2	11.27		422
2	2	3	11.27	5	429
2	2	4	11.27		564
2	3	1	8.48		572
2	3	2	8.48		425
2	3	3	8.48	8	422
2	3	4	8.48		569
3	1	1	16.97		573
3	1	2	16.97		431
3	1	3	16.97	6	425
3	1	4	16.97		571
3	2	1	11.25		565
3	2	2	11.25		427
3	2	3	11.25	6	430
3	2	4	11.25		570
3	3	1	8.48		571
3	3	2	8.48		427
3	3	3	8.48	7	425
3	3	4	8.48		564

REP NO	RPM CODE	DRUM ROW	SAMPLING TIME (SEC)	RECORDED MISSES	SEED COUNT
4	1	1	16.96		573
4	1	2	16.96		428
4	1	3	16.96	6	422
4	1	4	16.96		565
4	2	1	11.28		570
4	2	2	11.28		431
4	2	3	11.28	8	426
4	2	4	11.28		567
4	3	1	8.48		571
4	3	2	8.48		422
4	3	3	8.48	19	423
4	3	4	8.48		566
5	1	1	17.09		575
5	1	2	17.09		427
5	1	3	17.09	13	428
5	1	4	17.09		569
5	2	1	11.28		570
5	2	2	11.28		430
5	2	3	11.28	11	429
5	2	4	11.28		573
5	3	1	8.50		574
5	3	2	8.50		430
5	3	3	8.50	5	435
5	3	4	8.50		568
6	1	1	16.99		573
6	1	2	16.99		434
6	1	3	16.99	6	420
6	1	4	16.99		570
6	2	1	11.28		569
6	2	2	11.28		421
6	2	3	11.28	6	424
6	2	4	11.28		570
6	3	1	8.49		559
6	3	2	8.49		419
6	3	3	8.49	5	427
6	3	4	8.49		571

APPENDIX B-2

THEORETICAL SEED COUNT = 576

REP NO	RPM CODE	DRUM ROW	SAMPLING TIME (SEC)	RECORDED MISSES	SEED COUNT
1	1	1	25.35		598
1	1	2	25.35		438
1	1	3	25.35		434
1	1	4	25.35	0	583
1	2	1	16.85		597
1	2	2	16.85		427
1	2	3	16.85		440
1	2	4	16.85	1	583
1	3	1	12.76		593
1	3	2	12.76		433
1	3	3	12.76		438
1	3	4	12.76	1	588
2	1	1	25.35		592
2	1	2	25.35		441
2	1	3	25.35		428
2	1	4	25.35	0	587
2	2	1	16.85		598
2	2	2	16.85		435
2	2	3	16.85		433
2	2	4	16.85	0	595
2	3	1	12.74		586
2	3	2	12.74		434
2	3	3	12.74		439
2	3	4	12.74	1	594
3	1	1	25.45		595
3	1	2	25.45		429
3	1	3	25.45		422
3	1	4	25.45	1	588
3	2	1	16.90		587
3	2	2	16.90		436
3	2	3	16.90		441
3	2	4	16.90	1	577
3	3	1	12.75		597
3	3	2	12.75		438
3	3	3	12.75		431
3	3	4	12.75	3	590

REP NO	RPM CODE	DRUM ROW	SAMPLING TIME (SEC)	RECORDED MISSES	SEED COUNT
4	1	1	25.45		599
4	1	2	25.45		433
4	1	3	25.45		425
4	1	4	25.45	1	585
4	2	1	16.95		597
4	2	2	16.95		439
4	2	3	16.95		433
4	2	4	16.95	1	585
4	3	1	12.76		602
4	3	2	12.76		435
4	3	3	12.76		445
4	3	4	12.76	0	586
5	1	1	25.35		598
5	1	2	25.35		433
5	1	3	25.35		430
5	1	4	25.35	0	596
5	2	1	16.90		601
5	2	2	16.90		438
5	2	3	16.90		432
5	2	4	16.90	0	597
5	3	1	12.70		599
5	3	2	12.70		437
5	3	3	12.70		430
5	3	4	12.70	0	587
6	1	1	25.40		610
6	1	2	25.40		434
6	1	3	25.40		428
6	1	4	25.40	0	597
6	2	1	16.90		597
6	2	2	16.90		433
6	2	3	16.90		437
6	2	4	16.90	1	591
6	3	1	12.72		585
6	3	2	12.72		438
6	3	3	12.72		436
6	3	4	12.72	0	589

APPENDIX B-3

THEORETICAL SEED COUNT = 576

REP NO	RPM CODE	DRUM ROW	SAMPLING TIME (SEC)	RECORDED MISSES	SEED COUNT	REP NO	RPM CODE	DRUM ROW	SAMPLING TIME (SEC)	RECORDED MISSES	SEED COUNT
1	1	1	25.30		607	4	1	1	25.35		609
1	1	2	25.30		432	4	1	2	25.35		439
1	1	3	25.30		431	4	1	3	25.35		438
1	1	4	25.30	0	601	4	1	4	25.35	1	605
1	2	1	16.85		597	4	2	1	16.85		586
1	2	2	16.85		441	4	2	2	16.85		439
1	2	3	16.85		439	4	2	3	16.85		432
1	2	4	16.85	0	601	4	2	4	16.85	0	593
1	3	1	12.72		602	4	3	1	12.74		591
1	3	2	12.72		436	4	3	2	12.74		433
1	3	3	12.72		436	4	3	3	12.74		435
1	3	4	12.72	2	592	4	3	4	12.74	0	593
2	1	1	25.30		601	5	1	1	25.35		604
2	1	2	25.30		443	5	1	2	25.35		433
2	1	3	25.30		432	5	1	3	25.35		434
2	1	4	25.30	0	599	5	1	4	25.35	0	598
2	2	1	16.85		593	5	2	1	16.85		598
2	2	2	16.85		441	5	2	2	16.85		435
2	2	3	16.85		440	5	2	3	16.85		442
2	2	4	16.85	1	600	5	2	4	16.85	0	591
2	3	1	12.71		598	5	3	1	12.72		593
2	3	2	12.71		445	5	3	2	12.72		429
2	3	3	12.71		443	5	3	3	12.72		432
2	3	4	12.71	1	585	5	3	4	12.72	3	589
3	1	1	25.35		587	6	1	1	25.35		606
3	1	2	25.35		434	6	1	2	25.35		439
3	1	3	25.35		435	6	1	3	25.35		433
3	1	4	25.35	0	597	6	1	4	25.35	1	603
3	2	1	16.85		594	6	2	1	16.90		586
3	2	2	16.85		445	6	2	2	16.90		436
3	2	3	16.85		434	6	2	3	16.90		436
3	2	4	16.85	0	597	6	2	4	16.90	2	590
3	3	1	12.71		588	6	3	1	12.73		596
3	3	2	12.71		438	6	3	2	12.73		437
3	3	3	12.71		435	6	3	3	12.73		436
3	3	4	12.71	0	598	6	3	4	12.73	2	590

APPENDIX B-4

THEORETICAL SEED COUNT = 576

REP NO	RPM CODE	DRUM ROW	SAMPLING TIME (SEC)	RECORDED MISSES	SEED COUNT
1	1	1	25.40		616
1	1	2	25.40		454
1	1	3	25.40		436
1	1	4	25.40	2	603
1	2	1	16.85		607
1	2	2	16.85		448
1	2	3	16.85		448
1	2	4	16.85	1	600
1	3	1	12.74		601
1	3	2	12.74		438
1	3	3	12.74		435
1	3	4	12.74	0	596
2	1	1	25.35		615
2	1	2	25.35		437
2	1	3	25.35		430
2	1	4	25.35	1	596
2	2	1	16.85		607
2	2	2	16.85		437
2	2	3	16.85		443
2	2	4	16.85	0	595
2	3	1	12.71		600
2	3	2	12.71		437
2	3	3	12.71		441
2	3	4	12.71	1	591
3	1	1	25.30		612
3	1	2	25.30		442
3	1	3	25.30		432
3	1	4	25.30	0	602
3	2	1	16.85		615
3	2	2	16.85		444
3	2	3	16.85		433
3	2	4	16.85	0	591
3	3	1	12.74		597
3	3	2	12.74		438
3	3	3	12.74		436
3	3	4	12.74	3	598
4	1	1	25.35		615
4	1	2	25.35		449
4	1	3	25.35		429
4	1	4	25.35	2	608
4	2	1	16.90		611
4	2	2	16.90		433
4	2	3	16.90		442
4	2	4	16.90	0	593
4	3	1	12.71		608
4	3	2	12.71		435
4	3	3	12.71		441
4	3	4	12.71	1	594
5	1	1	25.30		602
5	1	2	25.30		434
5	1	3	25.30		439
5	1	4	25.30	1	591
5	2	1	16.85		597
5	2	2	16.85		443
5	2	3	16.85		439
5	2	4	16.85	3	590
5	3	1	12.70		595
5	3	2	12.70		431
5	3	3	12.70		439
5	3	4	12.70	1	584
6	1	1	25.35		604
6	1	2	25.35		437
6	1	3	25.35		429
6	1	4	25.35	2	595
6	2	1	16.85		613
6	2	2	16.85		439
6	2	3	16.85		427
6	2	4	16.85	0	596
6	3	1	12.71		594
6	3	2	12.71		444
6	3	3	12.71		429
6	3	4	12.71	1	586

APPENDIX B-5

THEORETICAL SEED COUNT FOR SUM OF
PRIMARY AND SECONDARY = 576

REP NO	RPM CODE	LOGIC CIRCUIT	SAMPLING TIME (SEC)	SEED COUNT PRIMARY	SEED COUNT SECONDARY
1	1	1	16.85	339	178
1	1	2	16.85	338	144
1	2	1	11.30	398	159
1	2	2	11.30	382	138
2	1	1	16.90	337	179
2	1	2	16.90	335	157
2	2	1	11.25	405	153
2	2	2	11.25	366	144
3	1	1	16.95	344	179
3	1	2	16.95	344	143
3	2	1	11.25	405	153
3	2	2	11.25	391	137
4	1	1	16.90	346	158
4	1	2	16.90	352	137
4	2	1	11.25	390	170
4	2	2	11.25	374	140
5	1	1	16.90	355	156
5	1	2	16.90	344	142
5	2	1	11.25	401	157
5	2	2	11.25	391	145
6	1	1	16.95	346	163
6	1	2	16.95	350	142
6	2	1	11.30	403	157
6	2	2	11.30	378	139
7	1	1	16.90	339	161
7	1	2	16.90	349	132
7	2	1	11.20	407	157
7	2	2	11.20	381	143
8	1	1	16.90	357	152
8	1	2	16.90	337	151
8	2	1	11.25	402	153
8	2	2	11.25	381	137

APPENDIX B-6

THEORETICAL SEED COUNT FOR SUM OF
PRIMARY AND SECONDARY = 576

REP NO	RPM CODE	LOGIC CIRCUIT	SAMPLING TIME (SEC)	SEED COUNT PRIMARY	SEED COUNT SECONDARY
1	1	1	16.95	428	143
1	1	2	16.95	413	142
1	2	1	11.25	431	141
1	2	2	11.25	435	139
2	1	1	16.95	431	140
2	1	2	16.95	420	140
2	2	1	11.30	434	148
2	2	2	11.30	431	140
3	1	1	17.00	426	141
3	1	2	17.00	422	138
3	2	1	11.25	430	142
3	2	2	11.25	440	137
4	1	1	16.95	420	143
4	1	2	16.95	408	140
4	2	1	11.25	430	142
4	2	2	11.25	427	143
5	1	1	16.95	429	141
5	1	2	16.95	414	135
5	2	1	11.25	433	144
5	2	2	11.25	422	142
6	1	1	17.00	427	142
6	1	2	17.00	415	139
6	2	1	11.30	433	142
6	2	2	11.30	423	140
7	1	1	16.90	421	143
7	1	2	16.90	413	143
7	2	1	11.30	430	143
7	2	2	11.30	427	138
8	1	1	16.90	432	139
8	1	2	16.90	412	139
8	2	1	11.25	430	145
8	2	2	11.25	430	136

APPENDIX B-7

THEORETICAL SEED COUNT FOR SUM OF
PRIMARY AND SECONDARY = 576

REP NO	RPM CODE	LOGIC CIRCUIT	SAMPLING TIME (SEC)	SEED COUNT PRIMARY	SEED COUNT SECONDARY
1	1	1	16.95	414	156
1	1	2	16.95	418	136
1	2	1	11.15	416	153
1	2	2	11.15	414	150
1	2.5	1	9.63	413	135
1	2.5	2	9.63	414	105
1	3	1	8.44	294	45
1	3	2	8.44	312	47
2	1	1	17.00	413	156
2	1	2	17.00	420	138
2	2	1	11.25	412	158
2	2	2	11.25	420	145
2	2.5	1	9.61	412	153
2	2.5	2	9.61	417	129
2	3	1	8.49	330	71
2	3	2	8.49	381	60
3	1	1	16.90	427	141
3	1	2	16.90	421	145
3	2	1	11.20	408	164
3	2	2	11.20	428	135
3	2.5	1	9.66	401	160
3	2.5	2	9.66	411	126
3	3	1	8.48	357	83
3	3	2	8.48	370	63
4	1	1	16.95	419	147
4	1	2	16.95	410	152
4	2	1	11.20	412	162
4	2	2	11.20	415	155
4	2.5	1	9.65	406	147
4	2.5	2	9.65	404	141
4	3	1	8.47	325	84
4	3	2	8.47	367	67
5	1	1	16.95	422	145
5	1	2	16.95	418	149
5	2	1	11.25	402	169
5	2	2	11.25	424	153
5	2.5	1	9.64	404	156
5	2.5	2	9.64	416	133
5	3	1	8.49	332	67
5	3	2	8.49	370	69
6	1	1	16.95	419	146
6	1	2	16.95	418	147
6	2	1	11.25	416	160
6	2	2	11.25	413	155
6	2.5	1	9.66	409	158
6	2.5	2	9.66	409	147
6	3	1	8.46	340	78
6	3	2	8.46	381	62

APPENDIX B-8

THEORETICAL SEED COUNT FOR SUM OF
PRIMARY AND SECONDARY = 576

REP NO	RPM CODE	LOGIC CIRCUIT	SAMPLING TIME (SEC)	SEED COUNT PRIMARY	SEED COUNT SECONDARY
1	1	1	25.20	446	148
1	1	2	25.20	428	149
1	2	1	16.80	437	153
1	2	2	16.80	412	183
1	3	1	12.71	439	150
1	3	2	12.71	404	167
2	1	1	25.15	438	154
2	1	2	25.15	426	153
2	2	1	16.80	438	150
2	2	2	16.80	409	175
2	3	1	12.71	432	153
2	3	2	12.71	413	157
3	1	1	25.20	435	158
3	1	2	25.20	428	159
3	2	1	16.80	442	153
3	2	2	16.80	415	180
3	3	1	12.67	431	151
3	3	2	12.67	420	164
4	1	1	25.25	439	155
4	1	2	25.25	430	152
4	2	1	16.80	444	155
4	2	2	16.80	406	183
4	3	1	12.66	430	139
4	3	2	12.66	419	161
5	1	1	25.20	437	155
5	1	2	25.20	435	152
5	2	1	16.80	433	150
5	2	2	16.80	405	181
5	3	1	12.82	431	149
5	3	2	12.82	420	165
6	1	1	25.20	432	156
6	1	2	25.20	426	157
6	2	1	16.80	437	154
6	2	2	16.80	414	182
6	3	1	12.67	437	155
6	3	2	12.67	410	167

APPENDIX B-9

THEORETICAL SEED COUNT FOR SUM OF
PRIMARY AND SECONDARY = 576

REP NO	RPM CODE	LOGIC CIRCUIT	SAMPLING TIME (SEC)	SEED COUNT PRIMARY	SEED COUNT SECONDARY
1	1	1	25.20	428	161
1	1	2	25.20	432	160
1	2	1	16.80	442	152
1	2	2	16.80	405	185
1	3	1	12.70	435	151
1	3	2	12.70	415	158
2	1	1	25.25	430	158
2	1	2	25.25	434	156
2	2	1	16.80	442	149
2	2	2	16.80	421	177
2	3	1	12.70	433	142
2	3	2	12.70	420	155
3	1	1	25.25	442	155
3	1	2	25.25	425	159
3	2	1	16.80	443	150
3	2	2	16.80	416	165
3	3	1	12.70	421	151
3	3	2	12.70	414	163
4	1	1	25.20	440	147
4	1	2	25.20	424	157
4	2	1	16.85	436	153
4	2	2	16.85	418	173
4	3	1	12.65	434	149
4	3	2	12.65	424	140
5	1	1	25.25	447	150
5	1	2	25.25	440	159
5	2	1	16.87	443	149
5	2	2	16.87	423	165
5	3	1	12.69	428	147
5	3	2	12.69	426	152
6	1	1	25.25	441	145
6	1	2	25.25	421	163
6	2	1	16.85	437	151
6	2	2	16.85	426	169
6	3	1	12.69	435	143
6	3	2	12.69	408	156

APPENDIX B-10

THEORETICAL SEED COUNT FOR SUM OF
PRIMARY AND SECONDARY = 576

REP NO	RPM CODE	LOGIC CIRCUIT	SAMPLING TIME (SEC)	SEED COUNT PRIMARY	SEED COUNT SECONDARY
1	1	1	25.25	435	161
1	1	2	25.25	436	154
1	2	1	16.85	445	154
1	2	2	16.85	433	162
1	3	1	12.67	438	146
1	3	2	12.67	427	153
2	1	1	25.25	443	156
2	1	2	25.25	433	155
2	2	1	16.85	437	155
2	2	2	16.85	429	162
2	3	1	12.66	430	155
2	3	2	12.66	431	152
3	1	1	25.20	430	154
3	1	2	25.20	432	148
3	2	1	16.80	434	153
3	2	2	16.80	432	161
3	3	1	12.65	427	155
3	3	2	12.65	429	152
4	1	1	25.25	442	158
4	1	2	25.25	427	148
4	2	1	16.80	436	150
4	2	2	16.80	430	165
4	3	1	12.65	421	154
4	3	2	12.65	427	144
5	1	1	25.25	445	156
5	1	2	25.25	441	157
5	2	1	16.80	442	145
5	2	2	16.80	422	173
5	3	1	12.66	438	144
5	3	2	12.66	433	155
6	1	1	25.25	441	151
6	1	2	25.25	444	161
6	2	1	16.80	448	153
6	2	2	16.80	425	162
6	3	1	12.67	438	142
6	3	2	12.67	433	157

APPENDIX C

C-1 ORIGINAL DATA FOR CONFIGURATION 1 SEED CONVEYANCE TESTS

C-2 ORIGINAL DATA FOR CONFIGURATION 2 SEED CONVEYANCE TESTS

C-3 ORIGINAL DATA FOR CONFIGURATION 3 SEED CONVEYANCE TESTS

APPENDIX C-1

ROLLER EJECTOR - LOW AIR VELOCITY SETTING

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 1															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.5	2.0	1.0	10.0	1.0	1.0	0.5	1.5	2.5	0.5	3.0	4.0	1.0	4.5	1.0
	4.0	7.0	3.5	11.0	7.0	3.5	9.0	4.0	9.0	2.5	4.5	10.0	7.5	6.5	3.0
	10.0	12.5	14.5	18.0	13.0	6.5	10.0	9.5	10.5	6.5	12.5	13.0	12.0	19.5	12.0
	12.0	19.5	17.0	19.0	15.5	15.0	12.5	15.0	19.0	12.5	14.0	19.0	22.0	20.5	15.0
	16.0	21.0	18.5	25.5	20.0	23.5	20.0	23.0	22.0	26.0	20.0	23.0	22.5	21.0	21.0
	19.5	27.0	29.0	27.5	27.0	26.5	24.0	31.0	29.0	30.5	23.0	25.5	31.5	32.5	25.5
	23.5	32.0	31.5	31.0	32.5	34.5	28.5	35.5	39.0	32.0	27.0	30.5	33.5	42.5	28.0
	30.0	36.0	34.5	37.5	33.0	45.0	36.5	36.5	40.0	46.0	35.0	32.0	35.0	44.0	35.5
	33.0	36.5	39.5	41.0	38.5	50.5	45.0	50.0	44.5	50.0	39.5	37.0	36.5	48.5	36.5
	37.0	43.0	41.5	47.0	42.0	51.0	53.0	57.0	53.5	55.5	43.0	40.0	41.0	58.0	41.5
	46.5	50.0	45.5	52.0	45.5	55.5	60.0	63.5	73.5	56.5	50.5	43.5	50.5	59.5	45.5
	47.0	51.0	53.5	56.0	48.5	61.0	63.0	64.5	75.0	59.5	53.5	47.5	53.5	63.5	50.5
	51.0	58.5	55.5	61.0	52.0	74.0	70.5	71.5	76.0	62.5	55.0	48.5	60.0	68.0	53.0
	54.5	62.0	59.5	66.0	59.0	80.0	71.0	80.0	78.5	80.0	59.5	54.5	62.0	80.0	58.0
	58.0	67.0	62.5	67.5	66.5	80.0	80.0		80.0		64.0	62.0	66.0		67.5
	59.5	73.5	68.0	77.0	68.5						66.0	67.5	66.5		68.0
	67.5	78.5	71.5	78.5	70.0						71.0	74.0	67.5		74.0
	74.0	80.0	76.5	80.0	73.0						72.5	76.5	78.5		75.0
	75.0		80.0		79.0						80.0	77.5	80.0		76.0
	77.5				80.0							78.0			80.0
	80.0											80.0			

REP 2															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.0	0.0	4.5	2.5	1.5	8.5	3.5	5.0	4.0	4.5	0.0	2.5	4.0	5.5	5.0
	4.5	1.5	12.5	6.0	5.0	17.0	9.0	10.5	14.0	9.0	2.5	3.5	5.0	6.0	9.0
	6.5	5.5	17.0	10.0	5.5	21.5	20.0	19.0	16.0	10.0	10.5	4.0	13.5	14.5	15.0
	11.5	9.0	22.0	13.5	11.0	23.5	24.5	20.5	33.0	17.5	13.5	10.0	19.5	20.0	16.0
	13.0	12.0	27.0	19.0	11.5	27.0	25.5	30.0	35.0	25.0	15.0	17.0	28.0	22.0	22.5
	17.5	23.5	29.0	23.5	19.0	28.0	34.0	37.5	39.0	33.0	19.5	18.5	31.5	28.0	30.5
	24.5	26.5	34.5	26.5	30.0	36.5	41.0	39.5	49.0	42.5	27.5	19.5	34.0	28.5	31.5
	28.5	32.0	40.5	30.5	33.5	43.5	46.5	47.5	54.0	54.0	31.5	24.5	36.0	35.0	37.5
	32.0	36.0	44.5	37.0	37.0	47.5	54.5	48.0	60.5	61.0	35.0	30.0	37.5	35.5	40.5
	37.0	41.0	47.5	38.5	38.0	52.5	61.0	59.0	63.5	65.0	40.0	32.0	44.5	39.0	42.0
	40.5	43.0	52.0	39.5	43.5	54.0	62.0	64.0	68.5	70.5	50.5	37.5	50.5	48.0	49.0
	47.0	47.0	61.0	46.0	46.5	64.0	71.0	65.5	77.5	72.0	53.0	42.0	52.5	50.5	50.5
	49.5	56.5	63.5	48.5	54.5	71.5	73.0	75.5	80.0	79.0	55.5	46.5	57.5	52.0	52.5
	57.0	57.5	64.0	52.5	57.5	79.5	80.0	80.0		80.0	62.5	48.0	61.0	60.0	56.5
	57.5	62.5	64.5	57.5	65.5	80.0					69.0	56.5	64.0	63.5	60.0
	58.5	68.5	73.5	59.5	71.0						72.0	58.0	64.5	66.5	65.5
	63.5	73.0	77.0	64.5	72.0						73.5	65.0	70.5	67.0	69.0
	68.5	76.5	80.0	70.0	80.0						76.0	70.5	72.0	75.5	73.5
	74.0	80.0	80.0	70.5	80.0						80.0	78.0	76.5	77.5	76.5
	79.5			79.0								80.0	80.0	78.5	80.0
	80.0			80.0										80.0	

APPENDIX C-1 (Continued)

ROLLER EJECTOR - LOW AIR VELOCITY SETTING

RPM CODE			1					2					3		
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 3															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.5	10.5	1.0	7.5	0.0	12.0	11.5	9.5	4.5	27.5	26.5	33.5	3.0	11.0	8.5
	15.0	21.5	13.5	18.0	8.0	22,0	34.0	14.5	19.0	35.5	31.5	35.5	9.0	31.5	9.5
	19.5	28.0	25.0	21.5	23.5	50.5	47.5	25.0	33.5	36.5	51.0	36.5	39.0	41.5	18.0
	29.0	34.0	30.0	30.5	24.5	51.5	50.5	52.0	56.5	62.5	55.0	55.5	53.5	42.5	19.0
	31.5	51.0	33.0	42.5	32.0	52.5	70.0	53.0	67.0	72.5	69.0	80.0	57.0	51.0	34.5
	40.0	53.5	47.5	52.0	40.5	80.0	80.0	65.0	69.0	80.0	71.0		63.5	67.0	49.5
	45.5	66.0	55.0	55.5	53.5			80.0	70.5		80.0		69.0	79.5	55.0
	62.5	68.5	65.0	66.5	62.5				80.0				79.5	80.0	74.0
	71.5	78.0	72.0	70.5	65.0								80.0	80.0	77.0
	72.5	80.0	80.0	80.0	80.0								80.0		80.0
	80.0		80.0												
REP 4															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	7.0	10.5	11.0	4.0	4.5	30.0	22.0	21.0	14.5	7.5	4.0	2.5	3.5	0.0	7.0
	11.5	11.0	15.5	10.0	13.0	46.5	37.0	21.5	34.5	12.5	18.0	4.0	24.0	12.0	12.0
	21.0	30.5	36.0	23.0	22.0	62.5	52.0	44.5	41.5	31.5	39.5	25.0	36.5	23.5	17.0
	26.0	39.0	37.5	28.0	34.5	63.5	53.0	48.0	55.5	48.0	41.5	32.0	37.5	33.5	48.0
	30.0	43.5	43.5	35.0	50.5	80.0	61.5	62.5	68.5	59.5	43.5	33.0	52.5	45.5	50.0
	44.0	46.0	49.5	43.5	52.0		75.0	77.0	69.5	69.5	69.5	46.5	61.5	53.0	65.5
	50.0	60.5	65.5	58.5	54.5		75.5	80.0	76.0	80.0	70.5	53.5	75.0	60.0	80.0
	59.5	66.5	77.5	64.0	65.0		80.0		80.0		80.0	66.5	79.0	69.5	
	68.5	77.0	80.0	65.0	68.5							72.5	80.0	80.0	
	79.5	80.0		80.0	75.5							80.0			
	80.0			80.0	80.0										

APPENDIX C-1 (Continued)

ROLLER EJECTOR - HIGH AIR VELOCITY SETTING

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 1															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4.5	1.0	7.0	5.5	5.0	9.0	3.0	3.0	6.0	2.0	1.5	0.5	8.0	1.0	1.5
	10.0	5.0	8.0	7.0	9.5	14.5	8.0	4.5	12.5	11.0	11.0	6.0	10.0	4.5	6.0
	16.0	10.5	17.0	14.0	13.0	22.0	21.0	5.0	19.0	12.0	18.5	12.5	12.0	15.0	14.0
	19.0	12.0	18.0	19.0	19.0	22.5	29.5	9.5	20.5	19.0	19.0	13.0	19.0	16.5	14.5
	24.5	16.5	27.0	20.0	24.5	23.5	33.0	12.5	31.5	25.5	21.0	15.5	23.5	22.0	21.5
	27.5	24.5	29.0	22.0	25.0	35.5	34.0	17.0	32.0	33.0	21.5	20.5	24.0	27.0	25.5
	30.0	28.0	32.5	30.0	29.0	38.0	45.5	29.0	37.0	39.0	23.0	25.5	35.5	28.0	27.0
	37.5	33.0	34.5	34.5	35.0	41.5	48.0	33.5	54.0	42.5	34.5	28.0	38.0	33.0	30.5
	38.5	37.5	36.5	35.5	39.0	48.5	52.0	38.0	54.5	45.5	35.5	29.0	40.0	34.5	31.5
	43.5	43.5	46.0	43.0	44.0	54.0	54.5	39.5	59.0	50.0	39.5	42.0	46.0	39.0	37.0
	45.5	47.5	50.0	45.5	47.0	62.5	58.0	48.0	65.0	58.0	42.0	44.5	50.5	41.5	37.5
	50.5	52.0	57.5	49.0	53.0	67.5	67.5	49.0	72.5	60.5	45.5	46.0	52.5	54.0	43.0
	52.5	58.0	60.0	55.0	57.5	79.0	79.5	51.0	77.5	67.5	49.0	51.5	56.0	55.0	44.0
	57.5	58.5	65.5	58.5	59.5	80.0	80.0	56.5	80.0	71.0	53.0	54.5	63.5	58.0	49.5
	67.0	67.0	66.0	63.5	63.0		80.0	60.0		76.5	59.0	59.5	67.0	60.0	52.5
	71.5	68.0	71.0	66.5	68.0			66.0		80.0	61.0	60.5	68.0	67.5	54.5
	72.0	71.5	77.0	68.0	74.0			75.5			63.5	68.0	73.0	69.5	62.0
	80.0	77.5	79.0	75.0	76.0			80.0			70.0	70.0	74.0	72.5	63.0
		80.0	80.0	79.0	80.0			80.0			73.0	75.0	79.0	78.5	72.0
				80.0							80.0	78.0	80.0	80.0	73.0
												80.0			80.0
												80.0			80.0
REP 2															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.5	4.0	1.5	0.5	1.0	4.0	0.5	1.5	9.0	3.0	3.0	1.0	3.5	3.5
	2.0	4.5	9.0	6.0	6.5	9.0	8.5	7.0	3.5	9.5	5.0	8.5	4.5	5.5	17.5
	4.5	10.5	11.0	15.5	7.0	11.0	12.5	9.0	9.5	15.0	13.5	10.0	8.0	11.5	20.0
	10.5	13.0	16.5	17.5	9.0	20.0	21.5	15.5	11.0	21.0	22.0	16.0	9.5	13.5	28.0
	11.5	21.0	21.0	18.0	18.0	30.0	22.0	20.0	24.0	21.5	23.5	17.5	13.5	17.5	31.0
	21.5	21.5	25.5	19.0	25.0	34.0	31.0	27.0	24.5	36.0	24.0	20.0	19.0	19.5	38.0
	22.5	28.5	29.0	22.0	29.5	42.5	31.5	30.5	28.0	36.5	33.0	22.0	27.0	23.5	41.0
	29.5	39.0	32.0	25.5	33.0	46.0	32.0	43.0	38.5	42.5	35.5	26.0	30.5	27.0	50.5
	35.5	40.5	41.5	27.0	36.0	51.0	34.5	51.0	46.5	46.0	37.5	31.0	31.5	34.0	53.5
	43.0	44.0	42.0	28.0	41.0	52.0	45.0	52.0	50.0	48.0	38.5	36.0	39.0	38.0	57.0
	44.5	50.5	45.0	32.0	42.0	55.5	46.0	65.5	56.0	64.0	46.0	42.5	44.5	42.5	66.0
	47.5	55.5	51.5	34.0	49.5	58.0	57.0	70.0	68.0	65.0	49.0	48.5	45.5	46.5	70.5
	52.5	56.0	54.5	39.0	54.5	67.5	58.0	80.0	74.0	67.0	55.5	50.0	50.5	54.0	72.0
	53.5	62.5	59.5	44.0	56.5	73.0	70.5	80.0	80.0	70.5	57.5	56.0	55.5	55.5	80.0
	61.0	71.0	63.0	50.5	63.0	79.5	71.0		80.0	72.5	64.0	60.0	56.5	57.0	
	62.5	72.0	67.0	57.5	68.5	80.0	79.5			80.0	65.5	61.0	67.5	66.0	
	67.5	73.0	73.5	65.5	69.5		80.0				75.0	63.5	71.5	69.5	
	75.5	79.0	74.0	67.0	74.0						76.0	73.5	74.5	70.5	
	77.5	80.0	79.0	72.5	78.0						76.5	74.5	80.0	71.5	
	80.0		80.0	76.0	80.0						80.0	79.5		77.5	
				78.0								80.0		80.0	
				80.0											

APPENDIX C-1 (Continued)

ROLLER EJECTOR - HIGH AIR VELOCITY SETTING

RPM CODE			1					2					3		
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 3															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	5.0	8.0	9.0	6.5	6.0	2.5	25.0	5.5	1.0	14.0	11.0	6.5	14.5	9.5
	7.5	18.0	13.5	28.0	11.0	7.5	6.5	29.5	17.0	10.5	28.5	24.0	12.5	20.5	17.5
	24.5	23.5	16.5	35.5	21.5	24.0	23.5	44.0	31.5	14.0	36.5	26.0	20.5	26.5	33.5
	31.0	34.5	19.0	44.0	25.0	43.0	41.0	47.0	50.0	43.0	46.0	40.0	24.5	37.0	37.0
	37.5	39.5	25.0	50.0	38.0	60.0	56.0	77.0	57.5	45.0	49.0	42.0	28.5	43.0	57.0
	52.0	46.5	32.5	61.5	42.5	63.5	80.0	78.5	77.0	48.0	51.5	71.0	55.0	52.5	80.0
	53.0	59.0	40.0	76.5	48.5	80.0		80.0	80.0	67.0	62.0	75.0	58.5	62.5	
	62.0	64.5	48.0	80.0	59.5					80.0	80.0	76.0	59.5	68.5	
	71.5	77.0	57.0		73.0							80.0	78.0	80.0	
	74.5	80.0	71.0		74.0								80.0		
	80.0		75.0		80.0										
			80.0												
REP 4															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	12.5	3.0	2.5	7.0	2.0	6.0	9.0	5.0	25.5	8.5	3.5	18.0	13.5	3.5	11.0
	13.5	4.5	14.5	9.0	14.0	22.0	17.0	10.0	42.5	14.0	22.5	27.0	17.5	12.5	20.5
	22.0	16.5	17.5	21.5	28.0	28.0	26.0	33.5	44.5	25.0	46.5	29.5	18.5	22.5	30.0
	28.5	23.0	26.5	29.5	32.0	45.5	50.0	43.0	63.5	36.5	47.5	32.0	37.5	27.5	31.0
	46.5	35.5	33.5	43.5	37.5	59.5	53.5	44.0	80.0	80.0	52.0	51.5	45.0	48.0	45.5
	56.5	41.5	39.0	44.5	47.5	80.0	75.5	71.0			54.5	61.0	56.0	49.0	51.0
	72.0	43.5	54.0	53.0	51.0		80.0	80.0			80.0	70.5	70.5	51.5	74.5
	74.0	46.5	61.5	66.5	55.0							71.0	74.5	67.0	77.0
	80.0	61.0	73.0	77.5	61.5							80.0	75.5	80.0	80.0
		65.5	76.5	78.0	72.0								80.0		
		74.0	80.0	80.0	78.0										
		75.0			80.0										
		80.0													

APPENDIX C-1 (Continued)

AIR EJECTOR - LOW AIR VELOCITY SETTING

RPM CODE			1					2					3		
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 1															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.5	3.0	0.5	4.5	4.5	2.5	7.0	1.5	1.5	6.0	3.0	1.5	7.5
	8.5	2.5	1.0	5.0	1.5	12.0	8.5	5.5	14.5	9.0	10.5	12.5	7.0	4.5	9.5
	10.0	7.0	6.5	10.5	2.5	16.5	16.5	18.5	23.5	11.5	15.5	13.5	11.5	5.0	12.5
	13.0	11.5	20.5	14.0	9.0	31.0	25.0	23.5	27.0	12.5	20.5	18.0	22.0	13.5	16.5
	20.0	17.5	21.5	18.5	16.5	34.5	31.0	25.5	38.5	17.5	25.0	23.0	23.5	22.0	24.5
	21.0	19.0	22.5	20.5	17.5	39.5	34.5	43.0	41.5	21.0	35.5	24.5	25.5	23.5	27.5
	27.5	25.5	23.5	26.5	22.0	51.5	41.0	48.5	46.0	36.0	41.5	29.5	27.0	31.5	40.5
	31.5	26.5	30.5	30.0	28.0	56.5	44.0	49.5	50.5	40.0	44.5	34.0	39.5	32.5	41.0
	35.5	32.5	36.0	35.5	31.0	58.5	58.0	57.0	59.0	41.0	55.0	45.0	40.5	36.0	42.0
	41.5	33.0	42.0	39.5	34.5	59.5	64.5	61.5	59.5	47.5	56.0	45.5	51.0	38.0	46.5
	42.5	37.0	48.5	48.0	41.5	75.5	75.5	62.5	68.0	55.0	56.5	49.5	53.0	40.0	52.0
	47.0	40.5	49.0	51.5	45.0	80.0	76.0	69.5	78.5	63.5	67.5	51.5	57.5	45.5	53.0
	52.5	41.5	52.5	58.0	53.5		80.0	72.0	80.0	72.5	71.0	55.5	62.5	50.0	54.0
	54.5	51.5	56.0	61.0	56.0			80.0		73.0	73.0	61.5	69.0	51.0	56.5
	58.5	52.5	64.5	68.5	56.5			80.0		80.0	79.0	64.5	70.5	60.5	66.5
	66.0	55.0	65.5	72.0	61.0						80.0	71.5	72.5	65.0	73.5
	69.0	64.0	72.5	75.0	64.0							77.0	80.0	67.0	75.0
	71.5	65.0	74.0	80.0	66.0							80.0		72.5	79.0
	78.5	71.5	80.0		72.5									73.0	80.0
	80.0	73.5			75.0									73.5	
		74.5			80.0									77.0	
		79.5												80.0	
		80.0													
REP 2															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.5	2.5	1.5	0.0	2.0	1.5	9.0	0.5	1.0	0.0	2.5	4.0	4.0	1.5	0.0
	1.5	4.0	2.5	5.0	6.0	4.5	10.0	18.0	5.5	15.5	9.5	9.5	5.0	5.5	9.0
	9.0	13.0	5.0	7.0	14.5	9.5	12.5	19.5	15.5	19.0	20.5	12.5	18.0	7.5	10.0
	14.0	15.5	11.0	14.0	16.0	11.0	21.5	20.5	19.5	27.5	23.0	15.0	19.5	9.5	12.5
	15.0	22.0	13.5	18.0	20.5	22.5	24.5	27.5	22.5	28.5	29.5	30.5	22.0	13.5	23.0
	17.0	27.0	17.5	24.0	25.0	27.0	27.0	28.5	29.5	32.5	35.5	32.0	23.0	21.5	25.0
	25.5	31.0	18.0	27.5	29.0	37.5	34.5	39.5	33.5	51.5	38.5	33.5	25.0	22.5	32.5
	33.0	38.0	28.5	30.0	31.5	41.5	43.0	46.5	45.5	53.5	41.0	43.0	35.0	35.0	33.5
	34.5	41.0	32.5	38.0	33.0	42.5	49.0	49.0	47.5	66.5	43.5	48.0	35.5	37.0	34.5
	41.5	45.5	34.5	40.5	34.0	48.5	50.0	56.5	52.0	69.5	45.0	49.5	43.5	38.5	41.0
	43.5	52.5	37.0	43.0	44.0	56.5	59.5	58.5	55.0	74.0	58.5	50.5	46.0	42.5	49.5
	47.5	56.0	42.5	46.5	50.0	57.5	68.5	65.0	58.5	74.5	61.5	57.0	48.0	43.0	52.5
	55.0	62.0	45.0	49.5	54.5	68.0	73.5	72.5	67.0	80.0	63.5	58.0	53.0	44.0	55.0
	57.5	66.5	53.5	55.0	55.5	73.0	80.0	73.5	70.0		74.0	61.5	62.5	55.0	68.0
	60.0	70.0	54.5	60.0	56.5	77.0		80.0	79.5		78.0	66.5	63.5	58.5	69.0
	62.0	71.5	58.5	64.5	62.0	80.0		80.0	80.0		80.0	68.5	67.0	59.0	70.0
	66.0	77.5	62.5	68.0	67.0							69.5	79.5	66.0	80.0
	66.5	80.0	66.0	72.0	70.0							80.0	80.0	75.0	
	74.5	80.0	70.0	74.5	74.5									80.0	
	78.0		76.0	80.0	80.0										
	79.0		78.0		80.0										
	80.0		80.0												

APPENDIX C-1 (Continued)

AIR EJECTOR - LOW AIR VELOCITY SETTING

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 3															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5.5	5.5	1.0	2.5	6.0	4.0	4.0	7.0	10.5	22.5	7.5	12.5	2.0	0.5	15.5
	13.5	14.5	9.5	7.5	12.0	22.5	37.5	13.0	11.0	33.0	33.5	37.0	29.5	13.5	16.0
	17.5	18.5	18.5	15.0	24.0	41.0	40.5	24.0	19.5	63.5	34.5	39.5	36.5	18.5	30.5
	21.5	31.0	26.5	23.5	25.0	48.0	63.5	29.0	38.0	73.0	53.5	51.5	40.5	45.5	39.0
	29.0	41.5	35.0	25.5	40.0	76.5	80.0	57.0	39.0	80.0	54.5	62.5	49.5	49.5	41.5
	30.5	48.5	45.5	37.5	41.5	78.5		73.0	65.5		77.5	73.5	65.5	59.5	66.5
	47.5	54.0	52.5	41.5	55.0	80.0		80.0	72.0		80.0	76.0	78.5	71.0	68.5
	57.5	55.0	59.0	44.5	67.0			80.0	77.5			80.0	80.0	73.0	74.5
	60.0	77.0	62.5	53.0	74.5				80.0					74.0	80.0
	67.5	80.0	69.5	69.0	80.0									80.0	
	70.5		80.0	71.5	80.0										
	78.0			80.0											
	80.0														
REP 4															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5.0	4.0	2.0	4.5	3.5	2.5	28.0	0.0	2.0	5.0	11.0	1.0	6.0	1.0	7.0
	19.0	14.5	4.5	30.0	13.5	7.5	30.0	20.0	18.0	18.0	24.0	1.5	16.5	18.5	16.5
	23.0	23.5	12.5	32.0	19.5	22.0	45.5	41.5	29.0	31.0	35.5	17.0	22.5	27.5	18.0
	24.0	26.5	22.5	50.0	29.5	25.0	47.0	64.5	56.0	42.0	45.0	45.5	27.5	28.5	44.0
	37.5	43.5	33.0	54.5	36.5	41.5	67.5	80.0	68.5	52.0	48.5	52.5	60.0	29.5	50.0
	44.5	47.5	34.0	60.0	46.0	60.0	80.0		73.5	67.0	58.5	57.5	64.5	45.5	76.5
	49.0	57.5	44.0	67.0	47.5	77.5			78.0	76.5	60.0	61.5	70.0	55.0	80.0
	70.0	70.5	58.0	78.0	60.5	80.0			80.0	80.0	80.0	69.5	77.5	58.5	80.0
	72.0	78.5	62.0	80.0	79.0							80.0	78.5	64.5	
	73.5	80.0	74.5		80.0								80.0	80.0	
	75.5		79.5												
	80.0		80.0												

APPENDIX C-1 (Continued)

AIR EJECTOR - HIGH AIR VELOCITY SETTING

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 1															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2.5	2.5	4.0	1.5	6.5	1.5	9.0	0.5	1.0	0.0	2.5	1.5	0.5	2.5	4.5
	5.0	6.5	7.5	7.0	14.5	4.5	10.0	18.0	5.5	15.5	3.5	8.0	1.5	11.0	5.5
	12.5	7.0	11.5	8.0	19.0	9.5	12.5	20.0	15.0	18.5	6.5	14.0	9.0	11.5	16.5
	15.5	12.0	16.5	13.5	27.0	11.0	22.0	20.5	19.5	27.5	8.0	26.0	10.0	20.5	17.5
	20.0	14.5	21.5	18.0	30.5	23.0	24.5	27.5	22.5	28.0	10.5	33.5	16.0	25.0	24.0
	25.0	15.5	24.0	27.5	36.0	27.5	27.0	28.0	30.0	32.5	14.5	34.5	29.5	34.0	35.0
	30.0	19.5	26.0	29.5	39.0	37.5	34.5	39.5	33.5	51.0	25.0	36.0	32.5	35.0	48.5
	31.0	21.5	35.0	33.0	43.5	41.5	43.0	47.0	45.5	53.5	28.5	43.5	35.0	36.0	50.5
	39.0	25.5	41.5	36.5	44.5	43.0	49.0	49.0	47.5	66.5	38.5	47.5	37.5	44.0	55.0
	41.0	31.0	42.5	41.5	50.5	48.5	50.0	56.5	52.0	69.5	40.0	50.0	41.0	46.5	56.0
	43.0	32.5	47.5	45.0	57.5	56.5	59.5	57.5	55.0	74.0	41.0	52.5	54.0	51.0	58.0
	47.0	38.5	50.5	48.0	58.0	57.5	68.5	65.0	58.5	74.5	43.0	61.5	55.5	54.0	59.0
	52.5	41.0	56.5	52.5	61.5	68.0	73.0	72.5	67.0	80.0	52.5	64.5	58.0	59.5	61.5
	54.0	50.0	60.0	59.0	66.0	73.5	80.0	73.5	70.0		55.5	68.5	65.0	64.0	65.0
	58.0	51.0	71.0	62.5	73.0	77.0		80.0	79.5		57.0	73.0	70.5	67.0	68.5
	66.5	55.5	75.5	64.0	73.5	80.0		80.0	80.0		64.5	75.0	71.5	72.0	80.0
	67.5	63.0	80.0	72.0	77.5						68.0	80.0	75.5	78.5	80.0
	71.5	68.0	80.0	72.5	80.0						73.0	80.0	80.0	78.5	
	76.0	71.0		78.0							78.0				
	80.0	76.5		80.0							80.0				
		78.0													
		80.0													
REP 2															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.5	0.0	3.0	2.5	5.5	4.0	4.5	2.0	5.0	0.5	0.0	0.0	2.0	1.5	2.5
	3.5	2.0	10.0	5.0	6.0	7.0	9.0	9.5	17.5	5.0	9.0	2.0	11.0	10.0	6.5
	11.5	6.0	12.0	5.5	12.5	8.5	9.5	18.0	19.5	9.5	13.5	8.5	12.0	15.0	13.0
	17.0	11.5	20.5	6.5	17.5	19.0	14.0	22.0	20.5	14.5	14.0	11.5	16.0	15.5	14.0
	22.5	17.5	22.0	14.5	21.5	24.0	21.5	25.0	31.5	16.0	20.5	13.0	21.5	16.0	18.0
	24.5	20.0	26.0	15.0	22.0	37.5	27.5	36.5	36.0	22.0	22.5	15.0	25.0	22.5	20.0
	26.0	21.5	26.5	20.0	29.0	38.5	31.0	37.0	37.0	26.0	26.5	19.5	32.5	31.5	25.5
	32.5	23.5	32.5	24.5	35.0	40.0	37.5	45.0	43.0	38.5	35.0	20.5	35.5	36.0	30.0
	36.0	30.5	33.5	30.0	40.0	53.5	45.0	47.0	52.5	41.0	36.5	36.0	41.5	44.0	39.5
	41.0	31.5	36.0	31.5	44.0	59.5	51.0	55.5	58.5	41.5	39.5	40.5	43.5	46.5	44.5
	45.5	38.0	44.0	39.5	46.0	60.0	60.0	56.0	63.0	48.5	41.5	42.5	57.0	55.5	48.5
	47.5	39.0	46.0	46.0	51.5	61.0	64.5	64.0	67.5	55.5	51.5	46.5	59.5	57.5	50.0
	55.0	46.0	52.0	47.5	56.5	63.0	69.0	70.0	70.0	61.0	61.5	51.0	66.5	60.5	52.5
	57.0	51.5	56.0	50.5	58.0	69.5	72.0	80.0	78.5	64.0	62.5	62.0	68.0	71.0	60.5
	61.5	53.0	62.0	57.5	64.0	73.0	78.0		80.0	67.0	65.5	69.5	73.5	72.5	63.0
	64.5	56.0	67.0	62.0	72.5	80.0	80.0			80.0	68.5	77.0	76.0	75.0	64.0
	70.5	61.5	70.0	66.5	73.5						74.5	79.5	77.0	80.0	67.0
	74.0	62.5	73.5	68.5	74.5						80.0	80.0	80.0		78.0
	80.0	70.0	80.0	71.5	77.5										78.5
		75.0		78.0	80.0										80.0
		80.0		80.0											

APPENDIX C-1 (Continued)

AIR EJECTOR - HIGH AIR VELOCITY SETTING

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 3															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5.0	6.5	0.0	0.5	3.0	10.0	14.0	2.0	20.0	1.0	0.5	26.0	11.5	6.0	3.0
	15.0	17.5	6.5	8.0	8.0	19.0	18.5	36.5	22.5	11.0	3.0	27.0	19.5	16.5	8.5
	21.0	27.5	12.0	23.5	22.5	38.5	27.5	44.5	36.0	17.0	7.5	37.0	34.0	25.0	15.0
	36.0	33.5	23.5	36.0	27.0	46.0	43.0	64.0	41.5	19.0	13.0	44.5	39.5	47.0	40.0
	41.0	35.0	32.5	57.5	33.0	58.5	60.0	68.0	54.0	36.5	21.5	57.5	43.0	53.0	46.0
	46.0	43.0	44.5	62.0	47.5	72.0	70.5	80.0	63.0	66.0	30.0	80.0	47.5	57.0	60.5
	48.5	45.5	45.5	66.0	53.5	74.0	80.0		79.0	78.5	40.0		71.0	80.0	69.5
	65.5	62.0	63.0	77.5	66.0	80.0			80.0	80.0	65.5		73.5		77.5
	74.5	66.5	67.0	79.0	69.5				80.0		70.0		80.0		80.0
	80.0	78.5	77.0	80.0	75.0						80.0				80.0
		80.0	80.0		80.0										
REP 4															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.5	1.0	5.5	1.5	6.5	11.5	0.0	6.0	7.0	12.5	4.5	7.5	10.5	0.0	5.5
	3.5	17.0	6.0	14.0	12.0	24.5	22.0	7.5	30.5	31.5	10.0	12.0	15.0	26.0	7.0
	15.5	23.5	15.5	25.5	18.5	25.5	24.5	46.5	54.5	38.0	10.5	13.0	29.0	29.5	23.0
	27.5	26.0	28.0	28.5	32.5	40.5	46.0	50.0	57.0	67.5	18.5	13.5	47.0	41.0	31.0
	29.5	29.0	31.0	29.0	45.0	58.5	47.5	76.5	80.0	74.0	31.5	20.0	53.5	65.0	33.0
	41.5	32.5	51.5	52.5	52.5	75.0	68.5	80.0		80.0	36.0	33.5	58.0	65.5	46.5
	55.0	45.5	64.5	58.0	64.5	80.0	80.0				61.0	69.0	72.5	72.5	52.0
	59.5	54.0	73.5	63.0	69.0						75.0	70.0	75.0	79.0	61.5
	65.0	61.0	79.0	74.0	72.0						77.0	73.5	77.0	80.0	80.0
	76.5	73.0	80.0	79.5	80.0						78.5	80.0	80.0		
	78.0	80.0		80.0							80.0				
	80.0														

APPENDIX C-2

ROLLER EJECTOR - LOW AIR VELOCITY SETTING

REP 1

RPM CODE			1					2					3		
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.5	3.0	0.0	4.0	3.0	6.0	5.0	4.5	0.0	0.5	4.0	7.0	5.5	1.0
	0.5	2.0	8.5	5.0	7.0	6.5	9.0	10.5	6.0	3.0	2.5	4.5	12.5	8.5	5.0
	11.0	11.5	11.0	11.0	10.5	19.0	12.0	20.5	10.5	10.5	9.5	7.5	17.0	15.5	10.0
	13.0	13.0	17.0	12.0	12.0	20.0	21.5	22.0	22.5	14.5	10.5	10.5	21.5	25.5	10.5
	15.0	13.5	19.0	20.5	18.5	30.0	28.5	33.0	29.5	17.5	11.5	11.0	28.0	26.5	14.0
	18.5	24.0	19.5	21.0	21.5	32.0	33.0	37.5	34.0	25.0	17.0	19.5	29.0	35.5	19.0
	26.5	26.0	29.5	25.0	26.0	43.5	36.5	40.0	34.5	32.0	29.5	27.0	40.5	36.5	26.0
	32.0	31.5	34.0	28.5	30.5	50.5	42.5	47.0	39.5	34.0	37.5	31.5	41.5	43.5	28.0
	38.5	34.5	37.5	30.0	34.5	55.5	56.0	49.5	50.5	46.0	41.0	41.0	47.5	48.0	29.5
	41.0	39.5	43.0	36.0	36.5	56.0	57.0	59.5	58.5	55.5	41.5	45.5	55.5	53.0	35.0
	49.0	45.5	47.0	37.0	42.5	61.5	60.0	63.0	72.5	62.5	47.5	46.5	64.0	58.0	45.0
	49.5	48.0	50.5	41.5	47.5	64.0	70.5	71.0	74.0	63.0	50.0	48.5	64.5	62.5	53.0
	54.0	54.0	56.0	44.0	50.5	72.0	71.5	80.0	80.0	69.0	53.0	52.0	67.5	67.0	55.0
	59.0	59.0	60.0	48.5	55.0	80.0	75.0			70.5	58.0	54.0	68.5	69.5	62.0
	59.5	60.0	65.0	55.0	58.5		80.0			74.0	61.0	63.0	71.5	70.5	63.5
	64.0	67.0	69.0	59.0	59.0					80.0	63.5	68.5	80.0	74.5	67.5
	70.0	69.5	71.5	61.5	68.0						68.5	69.0		80.0	76.5
	72.0	72.0	72.0	70.5	72.0						73.0	70.5			79.5
	74.0	74.0	80.0	73.0	74.0						80.0	76.5			80.0
	78.0	79.0		79.5	76.0							80.0			80.0
	80.0	80.0		80.0	80.0										

REP 2

RPM CODE			1					2					3		
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2.0	0.5	1.0	0.0	1.0	3.5	4.5	10.0	5.0	4.0	3.5	5.5	5.5	5.0	3.0
	6.5	5.0	8.0	2.0	8.0	5.0	7.0	18.0	11.0	9.0	4.0	8.0	10.0	7.0	5.5
	13.5	7.0	13.5	5.0	13.0	8.5	10.0	24.0	22.0	10.0	5.0	11.5	13.0	7.5	8.0
	15.5	12.0	19.0	10.5	15.5	11.0	21.0	33.5	22.5	30.0	12.0	16.0	17.0	11.0	16.5
	22.5	13.0	23.5	13.0	17.5	20.0	34.0	36.0	33.5	36.5	13.5	19.0	24.5	18.5	18.5
	24.0	16.0	27.0	17.5	22.5	28.0	40.5	37.5	39.5	38.0	21.5	23.0	25.5	19.0	32.0
	32.5	23.5	29.5	20.5	28.0	31.0	45.5	44.0	51.5	48.0	29.0	26.0	31.0	24.5	33.0
	34.5	28.5	33.5	28.0	32.0	42.5	52.5	47.5	59.0	49.0	36.0	29.5	37.5	31.5	37.5
	36.0	35.0	40.0	29.5	35.5	45.5	59.0	56.0	63.0	52.5	37.5	34.0	39.5	32.5	45.5
	43.0	41.5	43.0	40.0	39.0	49.5	68.0	61.5	65.0	59.5	39.5	38.0	44.0	33.0	46.5
	45.5	45.0	47.0	42.0	49.5	58.0	70.0	75.5	73.5	67.0	44.0	48.0	48.0	44.0	61.0
	51.0	51.0	54.5	45.0	51.0	63.5	75.5	79.5	76.5	69.0	45.5	54.5	57.5	45.5	64.5
	52.5	58.0	60.0	47.5	54.0	67.5	80.0	80.0	80.0	73.0	47.5	59.5	58.0	53.0	73.0
	58.5	59.0	63.0	53.5	57.0	79.0				77.5	55.5	63.0	60.0	54.0	74.5
	60.0	63.5	64.0	59.5	66.0	80.0				78.5	64.5	65.0	65.5	62.5	76.5
	69.0	71.0	69.5	64.0	67.5					80.0	65.0	73.5	71.5	65.5	78.5
	70.0	73.0	77.0	73.0	72.5						68.5	74.5	72.0	72.5	80.0
	75.0	76.0	77.5	77.5	79.5						72.0	75.5	74.5	80.0	
	78.0	79.0	80.0	80.0	80.0						77.0	80.0	80.0		
	80.0	80.0									79.5				
											80.0				

APPENDIX C-2 (Continued)

ROLLER EJECTOR - LOW AIR VELOCITY SETTING

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 3															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	10.0	4.0	8.0	1.5	17.0	4.5	10.0	8.0	0.5	3.0	3.0	9.5	2.0	21.5	0.5
	13.5	13.5	9.0	4.5	18.0	7.0	17.5	33.5	10.0	15.0	18.0	27.5	5.5	22.5	1.0
	21.0	15.5	18.0	20.5	35.0	10.0	34.5	42.5	34.0	21.0	38.0	32.5	19.0	29.5	20.5
	22.5	27.5	40.0	22.5	40.0	21.5	51.5	52.0	48.5	40.0	42.0	43.0	34.0	39.0	34.0
	35.0	42.5	47.0	27.5	44.5	47.5	80.0	72.5	56.0	51.0	42.5	54.5	47.5	60.5	50.0
	45.5	45.5	57.0	37.0	45.5	51.5		80.0	80.0	57.0	69.0	60.0	61.5	74.0	59.5
	50.5	55.0	58.5	49.5	58.0	71.0				76.0	76.0	69.0	67.0	79.5	75.0
	59.5	57.5	68.0	54.5	59.0	76.5				80.0	80.0	78.0	80.0	80.0	80.0
	64.5	70.0	77.5	62.0	70.5	80.0						80.0			
	80.0	80.0	80.0	70.5	80.0										
		80.0		78.0											
				80.0											
REP 4															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.0	3.5	1.0	1.0	2.5	14.5	21.0	7.5	6.0	20.0	0.5	19.5	1.0	5.0	14.5
	7.0	16.0	13.5	7.0	3.5	16.0	29.0	33.5	31.0	42.5	13.5	22.0	15.5	6.0	17.0
	15.0	25.0	21.0	17.5	15.5	21.5	47.5	52.5	54.0	56.5	17.0	39.0	36.0	6.5	25.0
	23.0	27.5	29.5	24.5	18.0	35.5	65.5	56.0	59.5	59.0	28.0	47.5	37.0	18.0	35.0
	34.5	33.5	39.0	26.0	27.5	52.5	66.0	57.0	80.0	71.0	29.5	59.0	60.0	28.5	49.5
	38.5	49.0	46.5	42.5	43.5	55.0	80.0	60.5		80.0	54.0	67.0	61.5	32.0	61.5
	46.0	52.5	51.0	49.5	51.0	73.5		80.0			66.0	80.0	80.0	45.0	67.5
	54.5	61.5	62.5	54.0	60.0	80.0					67.5			50.0	80.0
	63.0	68.0	73.5	65.0	63.0						70.0			70.0	
	80.0	78.0	80.0	73.0	72.5						78.0			79.0	
		80.0		80.0	80.0						80.0			80.0	
					80.0										

APPENDIX C-2 (Continued)

ROLLER EJECTOR - HIGH AIR VELOCITY SETTING

RPM CODE			1					2					3		
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 1															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.0	0.0	1.5	3.5	0.5	0.5	3.5	6.0	4.0	3.0	0.0	2.0	5.0	0.5	4.5
	12.5	2.0	6.0	5.0	6.5	11.0	7.5	13.0	7.0	7.0	3.0	6.5	12.0	2.5	10.5
	14.0	8.5	9.0	8.0	7.5	12.0	18.5	21.5	11.0	8.5	9.0	23.0	13.0	5.5	14.5
	15.0	9.0	12.5	14.5	13.5	15.0	19.0	22.0	20.0	12.5	12.0	23.5	19.0	7.0	24.0
	18.5	14.0	20.0	18.5	18.5	22.0	19.5	25.5	23.5	27.5	17.0	25.5	22.5	10.0	26.5
	21.0	20.5	23.5	21.5	25.0	28.5	26.5	33.0	31.0	30.5	20.5	37.5	31.5	17.5	32.5
	25.5	23.5	29.5	26.5	32.0	39.0	33.0	40.5	32.5	31.0	25.0	42.0	34.5	20.0	33.5
	31.0	26.0	35.5	30.0	34.5	41.5	37.5	45.5	46.0	34.0	29.5	42.5	36.5	21.0	36.5
	32.5	33.5	39.5	32.5	39.0	45.0	49.5	55.5	52.0	40.0	30.0	44.5	44.5	27.0	38.0
	37.0	36.0	42.5	38.0	42.0	47.0	52.0	62.0	61.5	45.0	39.5	46.5	45.0	32.0	44.5
	41.0	38.5	45.5	41.5	50.5	51.5	55.5	63.5	67.0	60.0	40.5	52.0	46.0	41.0	52.5
	45.5	41.5	57.5	46.5	54.0	56.5	57.5	72.5	74.0	63.0	46.5	58.5	52.0	43.0	55.0
	51.0	50.5	59.5	50.5	56.0	57.5	60.5	74.5	77.5	69.5	53.5	66.0	52.5	50.0	60.0
	58.5	52.5	65.0	57.5	62.0	65.0	63.5	80.0	80.0	74.5	55.0	67.5	56.0	54.5	66.0
	62.0	56.5	69.0	63.0	69.5	72.0	64.5			80.0	55.5	72.0	56.5	58.5	68.5
	64.5	67.5	71.0	66.5	75.0	72.5	76.0			80.0	59.5	72.5	57.0	60.5	69.5
	67.5	69.5	78.0	71.5	79.0	79.5	78.0				63.0	77.5	71.0	68.0	71.5
	70.5	73.5	78.5	76.0	80.0	80.0	80.0				64.5	80.0	75.0	71.5	80.0
	77.0	79.0	80.0	80.0							71.5		75.5	79.5	
	78.0	80.0									72.5		80.0	80.0	
	80.0										80.0				
REP 2															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4.5	7.0	2.0	3.0	2.0	2.5	11.5	7.5	0.0	0.0	4.5	0.5	4.5	3.5	1.5
	8.5	11.5	6.0	6.5	5.5	6.0	14.0	9.5	6.0	6.5	8.0	5.0	8.5	4.5	3.5
	12.5	14.5	10.0	11.0	6.5	8.5	19.0	21.5	10.5	10.0	12.5	5.5	20.0	13.0	7.0
	15.0	18.5	13.0	16.0	11.0	22.5	27.5	26.5	24.5	14.5	15.5	11.5	23.0	16.5	15.0
	22.5	19.5	19.0	19.0	17.0	23.0	30.5	34.5	28.5	18.0	20.5	20.0	27.0	20.5	17.0
	24.5	23.5	26.0	22.5	23.0	32.5	32.5	40.0	35.5	26.0	21.5	23.5	28.5	22.5	18.0
	32.0	32.5	30.5	25.5	27.0	33.5	35.0	43.5	39.0	27.5	27.0	28.0	33.5	25.0	30.5
	37.5	33.5	39.5	27.5	29.5	39.5	36.5	48.0	44.5	28.5	28.0	33.5	39.5	30.5	32.5
	43.5	40.0	43.0	39.0	35.5	47.0	49.5	66.0	57.5	36.0	35.0	36.5	48.5	35.5	37.5
	49.5	52.0	45.0	41.5	37.5	49.0	50.5	66.5	59.5	39.5	36.5	42.5	54.0	37.5	43.0
	56.5	56.0	52.5	44.0	40.5	53.0	56.0	72.0	64.0	40.0	57.5	47.5	57.0	53.5	43.5
	61.0	60.5	58.0	46.0	45.0	60.0	59.5	74.0	75.5	46.0	60.0	53.0	60.5	54.5	51.0
	68.0	66.5	60.0	52.0	48.5	69.5	70.5	77.0	79.0	46.5	62.5	56.0	66.0	58.0	54.0
	70.0	70.0	64.0	53.5	50.5	72.5	77.5	80.0	80.0	60.5	63.0	57.5	71.0	60.5	69.0
	75.5	75.0	72.0	58.5	54.0	77.0	80.0			67.0	68.5	59.5	71.5	66.0	73.5
	80.0	79.0	74.0	61.0	59.0	80.0				71.0	75.5	66.5	80.0	69.0	76.0
	80.0	80.0	75.0	66.5	61.0					78.5	77.5	71.0		77.0	79.0
			80.0	72.5	67.0					80.0	80.0	72.5		80.0	80.0
			80.0	79.5	71.5							77.5			
				80.0	74.0							80.0			
					79.0										
					80.0										

APPENDIX C-2 (Continued)

ROLLER EJECTOR - HIGH AIR VELOCITY SETTING

RPM CODE			1					2					3		
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 3															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11.5	0.0	2.5	0.0	7.0	29.0	2.5	22.5	11.5	8.5	10.5	3.5	1.0	7.5	18.0
	13.0	15.5	6.5	6.0	14.5	64.0	7.5	40.0	22.5	10.5	21.0	5.5	15.5	32.0	31.0
	18.0	20.5	15.5	21.0	20.5	75.5	37.5	55.5	34.5	39.5	29.0	22.0	18.0	34.5	56.0
	22.5	23.0	16.0	26.5	34.0	76.5	55.0	58.0	47.5	46.0	52.5	25.0	20.5	41.5	57.5
	39.5	32.5	29.0	36.5	37.5	80.0	72.5	73.0	70.5	50.5	53.5	27.0	57.0	57.0	80.0
	48.0	47.0	37.5	42.5	48.0		74.0	80.0	80.0	76.5	65.5	53.0	60.5	60.5	
	59.5	55.5	40.0	50.0	57.0		80.0			78.0	79.0	54.0	65.0	80.0	
	65.0	59.5	54.0	67.5	64.5					80.0	80.0	70.5	80.0		
	71.5	76.5	70.0	72.0	70.5							76.5			
	80.0	77.5	71.5	80.0	80.0							80.0			
		80.0	77.0												
			80.0												
REP 4															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11.5	0.0	3.5	5.5	4.5	9.5	7.5	20.0	7.5	4.5	23.5	5.5	12.5	16.5	0.5
	29.0	7.0	14.0	11.5	8.0	10.5	11.5	29.0	18.0	19.5	38.0	14.5	23.5	32.0	1.5
	33.5	23.5	33.0	18.5	25.0	23.0	18.5	32.5	32.0	21.5	43.5	31.5	36.0	36.5	3.0
	41.5	33.5	38.5	30.0	35.0	34.0	34.5	51.0	53.0	22.5	54.5	44.0	42.0	40.5	11.0
	52.0	35.5	41.5	38.5	42.0	58.5	45.5	58.0	73.0	51.0	55.5	66.0	45.5	45.0	18.5
	57.5	47.0	47.5	45.5	49.5	63.0	63.5	74.5	80.0	68.5	68.0	68.0	56.5	62.0	44.0
	65.0	55.5	64.0	52.5	51.0	80.0	72.5	79.5		80.0	80.0	80.0	75.5	71.5	45.5
	72.5	63.5	65.5	69.5	68.5		80.0	80.0					80.0	80.0	52.5
	80.0	70.5	72.0	71.5	73.5										55.5
		77.0	80.0	80.0	80.0										80.0
		80.0													

APPENDIX C-2 (Continued)

AIR EJECTOR - LOW AIR VELOCITY SETTING

RPM CODE			1					2					3		
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 1															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2.0	0.5	0.0	3.5	3.5	2.0	1.0	1.5	6.0	1.5	4.0	2.5	7.0	2.5	8.0
	4.0	1.5	6.0	4.0	7.0	2.5	3.5	7.0	11.0	12.0	10.5	6.0	10.0	3.5	8.5
	12.0	4.5	11.0	8.0	13.5	10.0	6.5	19.0	20.5	14.5	18.5	14.5	10.5	12.5	11.0
	14.5	9.0	15.0	14.5	17.5	17.0	9.0	23.5	22.5	22.0	21.0	17.5	17.5	14.5	18.0
	19.5	18.5	23.5	21.0	22.0	22.0	20.0	25.5	31.0	27.5	25.0	23.5	22.0	21.5	21.5
	29.5	20.0	24.5	22.5	31.0	24.5	25.5	28.0	31.5	37.5	26.5	26.5	25.5	24.5	37.0
	30.0	29.0	31.0	30.0	37.5	36.0	26.5	35.0	47.0	44.0	34.5	29.0	27.0	36.0	38.0
	34.0	31.5	36.5	36.5	40.5	37.0	42.0	38.0	56.0	46.0	35.5	30.0	31.0	37.0	40.0
	36.5	36.0	39.0	38.0	46.5	52.0	50.5	45.5	57.0	50.0	44.5	31.0	43.5	39.5	45.0
	43.5	39.5	41.5	46.0	47.5	52.5	52.5	48.0	59.5	55.0	49.5	36.5	44.0	45.0	51.5
	45.0	42.5	44.0	49.0	54.0	57.5	59.0	54.0	72.5	68.5	50.5	51.5	48.0	50.5	60.5
	46.5	52.0	48.0	52.5	58.0	63.5	61.5	58.5	76.0	71.0	54.5	52.5	50.0	54.5	61.5
	53.5	62.0	52.0	57.0	60.5	69.5	63.0	60.0	77.0	75.5	62.0	54.0	57.0	62.0	68.5
	61.0	65.5	60.0	59.0	62.0	75.5	68.5	64.0	80.0	80.0	64.0	65.0	61.5	64.0	70.0
	66.5	66.5	61.5	66.0	70.5	80.0	77.0	69.0		80.0	67.5	69.5	73.5	71.5	80.0
	70.5	71.0	65.5	66.5	71.5		78.0	76.0			69.0	75.0	74.5	74.0	
	73.0	73.5	74.0	71.0	73.0		80.0	78.0			80.0	80.0	76.0	75.5	
	80.0	77.5	79.0	79.5	78.5			80.0					78.5	80.0	
		79.5	80.0	80.0	80.0								79.5		
		80.0											80.0		
REP 2															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2.0	0.5	7.0	0.5	2.0	1.5	4.5	10.0	1.0	5.0	9.0	3.5	6.5	9.0	4.5
	12.5	2.0	8.5	5.0	3.5	12.5	11.0	11.5	7.0	6.0	12.0	13.5	13.0	12.0	8.5
	15.5	6.0	15.5	8.5	7.0	17.5	21.0	21.5	12.5	14.5	13.0	20.5	16.5	13.5	11.0
	17.0	11.5	20.0	9.5	10.5	18.5	23.0	33.0	20.5	20.5	15.0	21.5	17.5	17.5	11.5
	19.5	13.0	21.5	17.5	16.0	26.5	27.0	37.5	23.0	26.0	25.0	29.0	21.5	22.0	14.5
	22.5	21.0	28.0	24.5	17.0	42.0	29.5	39.5	26.5	31.0	27.0	34.0	30.5	23.0	34.0
	26.0	27.5	32.5	25.5	26.0	46.5	30.5	41.5	27.5	32.0	28.0	35.5	37.0	25.5	36.5
	29.5	34.5	35.0	27.5	30.0	54.5	40.5	53.5	30.5	33.5	28.5	37.5	38.5	31.5	39.5
	31.5	36.0	38.0	35.5	34.0	57.0	44.0	64.5	48.0	35.0	42.0	44.5	41.5	35.0	42.5
	38.5	37.0	40.0	39.0	34.5	60.5	51.0	65.0	49.0	38.5	50.0	53.0	46.5	50.0	48.5
	41.5	41.0	51.5	44.0	39.0	61.5	59.5	66.5	50.0	45.0	56.0	55.5	54.0	59.5	59.0
	45.5	44.0	56.0	46.0	46.0	68.5	62.5	69.5	57.5	48.5	63.5	60.5	55.0	63.0	60.5
	48.5	50.5	60.0	52.5	50.0	73.0	72.0	75.5	66.5	53.0	65.5	65.5	59.0	70.0	62.0
	50.0	54.5	67.5	55.0	52.0	76.5	77.5	80.0	67.5	56.0	66.5	73.5	60.0	72.5	67.5
	52.0	57.5	73.0	57.5	56.5	80.0	80.0		72.0	62.5	70.5	79.0	70.0	77.5	68.5
	61.0	60.0	77.5	65.5	63.5				77.0	63.0	76.5	80.0	74.0	78.0	69.0
	62.0	66.0	80.0	73.5	64.0				80.0	65.0	80.0		75.0	80.0	72.5
	66.5	69.0	80.0	75.0	70.5					66.5	80.0		80.0	80.0	78.0
	68.5	72.5		80.0	74.0					69.0					80.0
	72.5	80.0		80.0	76.5					80.0					
	79.5				77.5										
	80.0				80.0										

APPENDIX C-2 (Continued)

AIR EJECTOR - LOW AIR VELOCITY SETTING

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 3															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5.0	1.5	0.0	5.0	4.5	22.0	17.0	15.5	21.5	14.0	0.0	6.0	17.5	3.0	4.5
	9.5	19.5	11.0	19.5	9.0	29.5	18.5	43.5	35.0	18.0	23.0	7.5	26.5	4.0	34.5
	10.0	28.5	19.5	27.5	20.5	36.5	38.0	47.0	44.0	54.0	33.0	36.0	37.0	28.0	40.5
	21.5	36.0	27.5	41.5	30.0	50.5	49.0	48.5	63.0	71.0	52.5	39.5	49.5	36.5	42.0
	38.5	40.0	43.0	48.5	32.5	66.0	50.5	74.0	80.0	80.0	60.0	45.5	52.5	73.0	43.0
	45.5	54.0	43.5	52.0	37.0	80.0	78.5	77.0		80.0	62.0	59.0	67.0	80.0	79.0
	48.5	58.5	54.5	60.0	41.5		80.0	80.0			77.0	60.0	80.0		80.0
	64.5	60.0	60.5	75.5	58.5						80.0	76.0			
	70.0	72.5	69.5	80.0	63.5							80.0			
	80.0	80.0	73.0		73.5										
			77.5		80.0										
			78.0												
			80.0												
REP 4															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.0	10.0	7.0	3.5	4.5	5.0	9.5	14.5	10.5	25.5	17.0	20.5	3.0	8.5	7.5
	4.0	23.0	15.0	16.0	6.0	31.0	42.5	31.5	18.5	48.0	57.0	22.0	16.0	17.0	15.0
	15.5	36.0	17.5	19.0	12.5	42.5	44.0	39.0	25.5	52.0	58.5	22.5	35.0	27.0	39.0
	22.0	46.0	22.0	43.0	15.0	52.0	49.5	54.0	28.0	60.0	64.0	42.0	37.0	28.5	42.0
	29.0	49.5	31.0	46.5	30.0	79.5	58.5	60.0	55.5	64.5	66.5	58.5	53.5	36.0	50.5
	41.0	53.5	48.5	63.0	37.5	80.0	80.0	74.5	63.0	80.0	80.0	59.5	63.0	48.5	53.5
	43.5	65.5	50.5	70.5	54.5			80.0	80.0			73.5	64.0	80.0	80.0
	57.5	66.5	55.5	73.0	55.5							78.0	80.0		
	62.0	73.0	62.5	80.0	67.5							80.0			
	80.0	80.0	67.5		80.0										
			80.0												
			80.0												

APPENDIX C-2 (Continued)

AIR EJECTOR - HIGH AIR VELOCITY SETTING

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 1															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.5	9.5	3.0	4.0	0.0	6.5	4.5	0.5	0.0	0.0	1.5	0.0	0.5	1.5	4.0
	3.5	10.5	5.5	11.0	4.0	12.5	18.5	6.0	4.5	16.5	2.5	8.5	19.0	4.0	7.5
	11.0	11.0	6.5	11.5	5.0	19.5	20.5	8.5	10.5	19.0	4.5	9.5	28.0	4.5	14.5
	11.5	16.0	11.0	14.0	11.0	26.5	23.5	13.5	14.0	19.5	6.0	14.0	33.0	16.5	16.5
	19.0	22.5	18.5	18.0	14.5	31.0	26.0	22.0	25.5	26.0	6.5	15.0	34.5	21.5	17.5
	22.0	24.5	22.0	20.5	16.5	35.5	33.5	27.0	27.5	34.5	20.5	18.5	41.5	23.5	23.0
	26.5	29.5	26.0	24.0	25.5	37.5	40.0	34.0	32.5	48.0	26.0	19.5	53.0	24.5	31.5
	29.5	32.5	30.5	32.0	27.0	52.5	47.5	46.0	37.0	50.0	30.5	25.0	57.5	27.5	39.5
	33.0	35.0	32.0	34.5	29.5	57.5	51.0	47.0	46.0	57.5	31.0	31.0	58.0	32.0	41.0
	39.0	45.5	37.5	36.0	38.5	60.0	57.5	53.0	52.5	61.5	41.5	34.5	59.0	37.0	44.0
	44.0	46.5	43.0	41.5	43.0	72.5	64.0	55.5	56.0	63.0	45.5	38.0	67.0	39.0	45.0
	51.0	52.5	44.0	50.5	46.0	80.0	70.5	60.5	67.5	72.0	51.0	46.5	68.0	45.5	47.5
	55.0	54.5	50.5	54.5	47.5		74.0	67.5	68.0	80.0	53.0	50.5	72.5	46.0	50.0
	56.5	60.5	52.0	55.0	52.0		80.0	69.0	80.0		57.5	61.5	76.0	51.5	62.5
	59.0	67.0	59.0	62.0	57.5			77.0			60.5	65.0	80.0	55.5	71.5
	63.0	70.0	65.0	69.5	59.5			80.0			65.5	65.5		59.5	72.0
	68.5	73.5	65.5	70.5	62.5						74.0	66.0		61.5	72.5
	74.5	76.0	73.0	73.0	73.0						75.0	68.5		65.5	79.0
	78.0	79.5	73.5	74.5	75.0						79.0	73.5		67.0	80.0
	80.0	80.0	78.0	80.0	80.0						80.0	80.0		79.0	
	80.0		80.0											79.5	
														80.0	

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 2															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5.5	5.0	0.0	1.0	1.0	0.0	8.0	7.5	2.5	9.5	3.0	0.0	3.5	1.0	7.5
	7.0	9.5	4.5	1.5	1.5	6.5	14.5	9.0	9.0	10.5	13.0	2.5	9.5	5.0	9.5
	11.5	13.0	5.5	9.5	6.0	7.0	17.0	14.5	11.5	16.0	15.5	3.0	16.0	13.5	10.5
	15.5	17.5	11.0	12.0	10.0	10.5	19.0	16.0	16.5	20.0	21.0	16.5	17.5	20.5	13.5
	16.5	20.0	13.5	14.5	20.5	24.5	30.0	23.5	25.0	37.0	23.5	21.5	25.0	27.5	16.5
	20.5	28.0	15.5	15.0	23.5	29.0	35.5	27.5	27.5	40.5	32.0	25.5	33.5	32.0	33.0
	27.5	29.0	28.0	22.5	27.0	30.0	48.0	34.5	33.0	46.5	41.5	30.5	34.0	35.5	36.5
	29.5	36.0	31.0	25.0	32.5	32.5	49.0	43.0	36.5	47.5	43.0	36.5	39.0	41.5	42.0
	35.5	36.5	35.5	31.5	42.5	39.0	59.5	43.5	39.5	58.5	44.5	37.0	47.0	42.5	44.5
	38.5	41.0	37.0	32.5	43.5	42.5	62.0	52.5	48.0	65.5	59.0	41.5	52.5	45.0	47.0
	45.0	46.5	37.5	36.5	45.5	46.5	76.0	60.0	48.5	70.5	67.0	43.0	53.5	50.5	55.0
	47.5	50.5	45.0	44.5	50.5	50.0	76.5	69.0	57.5	73.0	68.0	55.0	59.5	54.5	60.5
	50.0	53.5	50.0	48.5	56.5	61.5	80.0	73.5	64.0	75.5	68.5	56.0	61.0	56.5	66.0
	53.0	57.5	52.0	54.0	60.0	65.5		76.0	71.5	76.0	72.0	64.0	71.0	62.5	74.5
	58.0	65.0	54.0	59.5	64.5	80.0		80.0	72.5	80.0	74.5	70.0	76.0	66.5	75.0
	61.5	66.0	56.0	62.0	65.5				79.5		80.0	74.5	77.5	69.0	75.5
	70.0	72.5	60.5	68.5	76.0				80.0			80.0	79.5	80.0	80.0
	74.5	78.0	65.0	70.5	77.5								80.0		
	78.5	80.0	72.0	79.5	80.0										
	80.0		79.5	80.0											
	80.0		80.0												

APPENDIX C-2 (Continued)

AIR EJECTOR - HIGH AIR VELOCITY SETTING

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 3															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.0	1.5	4.5	0.5	12.0	2.5	13.0	17.5	13.5	2.5	9.5	3.5	24.0	6.0	0.5
	17.5	15.5	9.0	10.5	20.5	8.0	14.5	34.5	28.0	4.0	14.0	6.5	27.5	10.0	4.0
	28.5	26.0	26.5	16.0	27.0	26.5	37.0	48.0	40.0	8.5	16.5	7.5	30.5	16.5	26.5
	30.0	36.0	28.0	27.5	40.0	49.0	50.5	60.5	45.5	41.5	47.5	12.0	59.5	20.5	29.5
	37.0	46.5	40.0	33.0	47.5	50.5	51.5	80.0	57.5	55.0	50.0	29.0	63.5	36.0	40.5
	40.0	51.0	44.5	41.0	56.5	61.0	80.0		60.5	60.0	55.5	44.5	64.5	46.0	43.5
	57.5	56.5	52.5	52.5	63.5	80.0			80.0	71.5	65.0	52.5	75.5	50.5	46.5
	60.5	59.5	61.5	60.5	64.5					80.0	79.5	61.5	80.0	66.5	62.5
	67.5	65.5	71.5	68.5	68.0						80.0	72.0		74.5	67.5
	68.5	71.0	79.0	80.0	78.5							80.0		80.0	80.0
	80.0	78.0	80.0		80.0										
		80.0													
REP 4															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	8.5	4.5	7.5	1.5	5.0	25.5	13.5	13.5	6.5	2.5	15.0	1.0	3.0	13.5	1.0
	13.5	19.5	18.5	7.5	18.0	33.0	21.5	22.5	13.0	8.0	23.5	31.0	5.0	21.5	7.5
	19.5	22.5	25.0	12.5	20.0	42.5	35.0	24.5	19.0	16.0	31.5	65.5	21.5	31.5	19.0
	22.0	33.5	29.0	28.5	34.0	62.0	65.0	45.5	33.0	53.0	32.5	70.5	40.0	45.5	33.0
	29.0	37.0	37.0	29.5	51.0	66.5	75.0	69.0	52.0	58.5	40.0	80.0	43.0	49.0	42.0
	33.0	47.5	42.5	37.0	56.0	80.0	80.0	80.0	62.5	80.0	42.5		70.5	56.5	59.5
	53.5	53.0	55.5	45.5	64.5				80.0		78.0		73.5	71.0	80.0
	55.0	56.5	62.0	62.0	71.0						79.5		76.0	75.0	
	58.5	76.0	75.0	71.5	79.5						80.0		80.0	80.0	
	71.0	80.0	79.0	80.0	80.0										
	80.0		80.0												
	80.0														

APPENDIX C-3

ROLLER EJECTOR - LOW AIR VELOCITY SETTING

RPM CODE			1					2					3		
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 1															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	1.0	2.0	1.5	1.0	5.0	5.0	4.0	2.0	4.0	3.0	4.0	0.5	4.5	2.0
	3.0	5.0	6.5	4.5	2.5	10.5	8.5	10.5	5.5	6.0	8.0	9.5	5.5	6.5	6.5
	8.0	8.0	10.5	7.5	8.5	14.5	16.0	13.5	6.0	8.5	12.0	15.5	10.0	12.0	10.0
	10.5	13.0	13.5	8.0	15.0	17.5	20.5	18.5	13.0	12.5	16.5	18.0	13.0	14.0	13.5
	14.5	17.5	16.5	14.0	18.0	22.5	26.5	28.5	20.0	19.0	23.0	23.0	21.0	16.5	15.5
	20.5	20.5	22.0	17.0	21.5	28.5	31.5	34.0	26.5	24.5	32.0	27.5	21.5	26.0	16.5
	23.5	26.5	27.0	21.0	26.0	37.5	37.0	38.0	28.5	34.5	33.5	31.0	25.5	29.0	22.5
	26.5	28.5	28.5	25.0	30.5	42.0	44.0	47.0	35.5	35.0	36.5	33.5	29.0	36.0	28.0
	33.5	33.5	34.5	29.5	34.5	46.5	49.5	47.5	40.0	42.0	39.5	40.0	34.0	41.0	30.5
	37.0	39.5	38.0	35.0	38.5	55.5	54.5	53.0	45.5	46.5	42.0	44.5	38.5	41.5	34.0
	40.5	43.5	39.0	40.0	42.5	59.0	62.5	63.0	50.0	54.0	46.5	49.5	46.5	46.5	40.0
	43.0	44.5	44.0	42.0	48.0	64.0	65.5	67.0	58.0	58.5	48.5	52.0	48.0	52.5	47.5
	49.0	50.5	47.0	47.0	51.5	69.0	73.0	71.0	64.0	61.5	56.5	58.5	54.0	61.5	50.5
	53.5	56.0	51.0	52.5	53.0	69.5	79.0	76.5	71.5	70.0	60.0	61.5	58.5	65.5	56.5
	56.0	59.5	55.5	57.0	54.0	75.0	80.0	80.0	77.5	78.5	62.0	67.0	59.5	70.0	57.0
	61.5	61.5	59.0	60.0	60.5	80.0			78.5	80.0	66.0	69.5	64.0	73.0	63.5
	65.0	67.0	63.0	62.0	63.0	80.0			80.0		69.5	75.0	70.0	76.0	66.0
	67.5	70.0	66.0	63.0	66.5						74.5	78.0	73.5	80.0	70.5
	73.0	70.5	68.5	69.0	69.0						80.0	80.0	78.0		75.0
	75.5	77.0	72.0	72.5	70.0								79.5		77.0
	80.0	80.0	75.0	75.5	73.0								80.0		80.0
		80.0	79.5	78.5	79.0										
			80.0	80.0	80.0										
REP 2															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.5	0.5	4.5	0.0	0.5	4.0	5.0	2.5	5.0	0.0	0.5	3.0	4.5	1.0	2.5
	2.5	3.0	6.0	4.5	6.5	9.5	12.0	6.5	11.5	4.0	2.0	11.5	6.0	4.5	10.5
	4.5	5.0	10.5	8.5	13.5	15.5	22.5	12.5	16.5	11.5	5.5	13.0	8.5	8.0	14.5
	6.5	8.0	16.5	11.0	15.5	19.5	23.0	17.0	23.5	13.0	11.0	17.5	15.5	13.0	17.0
	9.5	13.0	20.0	17.0	17.5	25.0	27.5	24.0	28.5	14.0	14.0	21.5	18.0	17.0	20.5
	15.0	16.5	23.5	22.0	21.0	31.5	35.0	25.0	37.0	22.0	20.0	25.5	20.5	22.0	27.5
	18.0	23.0	26.5	22.5	28.5	36.5	39.0	34.5	40.5	27.5	21.5	31.5	27.0	25.5	31.5
	20.0	24.0	27.5	29.0	32.0	42.0	44.5	38.5	42.5	31.5	26.0	34.5	28.5	27.0	32.0
	22.5	29.0	32.5	35.0	35.0	45.5	53.0	45.0	50.5	39.5	30.5	40.0	36.0	31.5	39.0
	28.0	34.5	35.0	39.0	38.0	53.0	55.5	49.5	55.5	47.5	35.0	42.5	40.5	34.5	44.0
	33.0	37.5	39.5	42.5	44.5	55.0	63.0	59.0	63.0	50.0	39.5	48.5	43.5	40.5	49.0
	37.5	41.5	44.5	46.5	48.5	57.0	67.0	63.5	66.5	57.0	45.5	52.5	47.5	45.0	51.5
	40.5	46.0	49.5	49.0	51.5	65.5	73.5	66.0	71.5	63.0	48.5	54.0	52.5	52.5	55.0
	45.5	50.5	52.5	57.0	55.5	67.0	80.0	74.0	78.5	64.5	52.0	62.5	55.0	55.0	61.5
	49.5	55.0	56.0	59.5	61.0	76.5		75.5	80.0	71.0	56.0	66.0	61.5	58.0	64.0
	53.5	60.0	61.0	62.0	64.0	80.0		80.0		75.5	60.0	67.5	64.5	60.5	70.0
	58.5	62.5	65.0	67.0	67.0					80.0	65.0	74.5	69.0	67.5	72.0
	61.0	66.5	68.5	71.0	73.0						70.0	77.0	69.5	71.0	78.0
	66.5	74.5	72.5	76.0	76.0						74.0	80.0	78.5	77.0	78.5
	71.0	76.0	80.0	78.5	79.0						78.0		80.0	80.0	80.0
	74.0	78.0	80.0	80.0	80.0						80.0				
	76.5	80.0													
	80.0														

APPENDIX C-3 (Continued)

ROLLER EJECTOR - LOW AIR VELOCITY SETTING

RPM CODE			1					2					3		
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 3															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2.0	7.0	2.0	5.5	6.0	6.5	7.0	1.5	3.0	2.5	11.5	5.0	8.0	5.5	17.5
	7.5	13.0	12.0	9.5	18.5	14.5	15.5	23.5	20.0	17.5	22.5	18.0	23.5	18.5	22.0
	15.5	25.0	19.5	20.0	31.5	30.5	35.5	32.5	35.5	31.5	36.0	32.5	32.5	23.0	42.0
	27.0	27.0	27.0	34.0	40.5	43.5	46.0	48.0	52.5	45.5	44.0	38.5	35.5	41.0	50.0
	32.5	30.5	35.0	38.0	48.5	54.5	66.5	57.0	66.5	56.0	59.5	46.5	43.0	51.5	58.5
	45.0	39.0	38.5	46.5	57.0	68.0	79.0	72.0	75.5	72.0	66.5	59.5	66.0	61.0	62.5
	49.0	49.5	52.5	51.0	63.5	80.0	80.0	80.0	80.0	80.0	72.5	74.0	75.0	67.0	71.5
	59.5	56.5	61.0	60.0	74.5						76.5	77.5	80.0	80.0	80.0
	68.5	63.5	62.5	71.0	80.0						80.0	80.0	80.0		
	75.5	69.0	74.0	79.5											
	80.0	80.0	80.0	80.0											
REP 4															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	7.5	0.5	4.5	3.5	1.5	2.0	3.5	12.0	10.0	9.0	8.5	1.5	11.5	9.5	9.0
	12.5	3.0	11.5	9.0	8.5	24.5	21.0	27.5	21.0	16.0	21.0	7.0	23.5	18.5	15.5
	25.0	15.0	19.0	19.0	19.5	34.0	31.5	39.5	35.0	30.0	30.0	18.5	34.0	30.0	32.5
	30.5	19.0	34.5	30.5	29.5	48.0	45.5	55.5	51.0	45.0	46.0	36.5	44.5	37.5	35.0
	35.5	30.5	38.5	39.0	33.5	65.5	61.0	72.0	61.5	60.0	62.0	37.5	53.0	48.0	45.5
	46.5	38.5	44.0	42.5	43.5	73.0	80.0	80.0	80.0	77.0	71.5	43.5	61.5	59.0	67.0
	55.0	47.0	54.5	50.0	55.0	80.0	80.0			80.0	80.0	49.5	62.5	71.5	70.5
	64.0	54.0	59.5	61.0	60.5							65.5	70.0	80.0	75.5
	70.0	63.0	75.0	71.0	69.5							75.5	80.0		80.0
	79.5	74.0	77.0	80.0	79.0							80.0			
	80.0	80.0	80.0		80.0										
		80.0													

APPENDIX C-3 (Continued)

ROLLER EJECTOR - HIGH AIR VELOCITY SETTING

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 1															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.5	0.5	2.0	1.5	2.5	3.5	8.0	2.5	1.5	8.5	2.5	2.5	4.5	1.5	2.5
	4.0	3.5	4.5	3.5	5.5	8.5	11.5	5.5	12.5	12.0	4.5	4.0	6.5	4.0	3.0
	8.5	8.0	10.0	7.0	12.0	15.5	18.0	12.0	16.0	17.5	10.5	10.5	7.5	8.5	9.0
	12.0	10.0	15.5	12.5	16.0	17.0	23.0	17.0	20.5	23.0	11.5	18.5	15.5	12.5	13.5
	17.0	16.5	19.0	18.0	19.0	24.5	30.0	21.5	30.0	26.5	16.0	22.0	18.0	17.5	15.0
	21.5	18.5	22.0	20.5	22.5	30.0	36.0	22.5	35.0	35.5	19.5	24.0	22.5	22.0	19.0
	25.0	24.5	26.0	25.0	28.0	34.0	40.0	26.5	40.5	38.0	24.5	25.5	29.0	27.5	24.5
	30.5	28.5	30.0	28.5	32.5	40.5	48.0	32.0	46.5	45.0	25.0	27.5	31.0	32.5	30.5
	32.5	31.5	34.5	34.0	34.5	49.0	51.5	37.5	47.5	50.5	29.0	34.5	34.5	39.5	33.0
	36.0	35.5	39.0	38.5	35.0	51.0	60.5	44.5	57.0	56.5	32.0	35.5	39.5	44.5	37.0
	40.0	42.5	42.5	40.5	38.5	51.5	66.0	54.0	60.0	62.0	34.0	42.5	43.5	49.0	44.5
	45.5	45.0	46.0	46.0	44.0	58.0	68.0	58.0	67.0	67.5	41.5	43.5	47.5	58.5	45.5
	50.5	49.5	53.0	48.0	47.5	62.0	74.0	62.0	75.5	76.5	47.0	52.5	53.0	60.0	49.5
	53.5	54.0	59.5	53.0	50.0	66.0	80.0	68.0	78.5	79.5	48.0	53.5	56.5	62.0	53.0
	58.0	59.0	64.5	56.5	55.5	73.5		72.5	80.0	80.0	53.0	58.0	58.5	66.0	55.0
	63.0	62.0	67.0	57.5	62.5	75.5		77.0			60.5	64.0	63.0	72.0	62.0
	68.0	66.5	72.5	61.0	65.0	79.5		80.0			61.5	67.0	66.5	76.5	63.5
	71.0	70.5	75.5	68.5	68.0	80.0					68.5	69.5	70.5	80.0	71.5
	73.5	74.5	79.5	72.0	70.0						70.5	73.5	71.5		72.0
	78.0	79.0	80.0	75.0	71.0						76.0	78.0	78.0		79.5
	80.0	80.0		79.0	80.0						77.0	80.0	79.5		80.0
		80.0		80.0							80.0		80.0		
REP 2															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.0	1.0	5.0	0.5	0.0	1.5	7.0	1.5	2.0	0.5	0.0	1.5	1.0	3.5	0.0
	5.5	5.0	7.0	4.0	6.5	4.0	9.0	8.0	9.0	7.0	5.5	9.0	4.5	6.0	4.0
	10.5	10.5	11.0	10.5	9.5	12.5	15.0	12.5	13.5	13.0	8.5	9.5	8.0	12.5	7.0
	14.0	13.0	16.0	14.0	13.5	20.5	23.0	20.5	17.0	20.5	13.5	15.0	15.0	14.5	13.0
	17.5	19.0	21.5	17.5	17.5	26.0	26.0	24.0	23.0	24.0	16.5	18.0	15.5	18.5	15.5
	22.0	21.5	26.5	21.5	21.5	30.5	32.0	30.5	30.0	29.0	22.5	22.0	18.0	22.5	21.5
	26.0	27.5	28.5	27.5	27.0	35.5	41.5	36.0	36.0	34.5	25.0	28.5	21.5	24.0	25.0
	26.5	31.0	32.5	30.0	29.5	41.5	42.0	40.5	41.5	43.0	30.0	29.5	26.5	26.5	29.5
	29.5	36.0	38.0	35.0	34.5	46.5	50.5	45.5	46.0	48.5	34.0	34.5	33.0	31.0	31.0
	34.0	39.0	42.5	38.0	38.0	52.5	56.5	54.0	53.5	53.5	35.5	39.5	34.0	32.5	32.0
	39.5	43.0	45.5	45.0	42.5	60.0	60.5	57.5	59.0	58.5	43.0	45.0	35.5	39.0	37.0
	44.0	47.0	49.5	47.5	46.0	62.5	66.5	64.0	62.0	63.0	47.0	50.0	40.0	46.5	41.0
	47.0	53.5	54.0	51.0	50.0	68.0	71.5	65.0	71.0	67.5	50.5	52.5	43.5	53.0	44.5
	53.0	54.5	59.5	54.0	57.0	69.5	77.5	73.5	75.5	76.0	57.0	55.5	48.5	56.0	50.5
	56.0	62.0	61.5	59.0	59.0	74.0	80.0	80.0	79.5	79.0	59.5	61.0	50.0	62.5	56.0
	59.0	63.5	66.5	64.0	62.5	79.5			80.0	80.0	61.5	63.5	55.5	66.5	56.5
	63.0	69.0	72.0	67.5	67.0	80.0					65.5	71.5	59.5	69.5	60.5
	67.5	73.0	76.0	72.0	70.0						69.5	74.5	65.0	73.5	64.5
	70.5	76.0	78.0	78.5	76.5						75.5	77.5	68.5	77.5	71.5
	76.0	80.0	80.0	80.0	78.0						77.5	80.0	75.5	80.0	73.0
	80.0				80.0						80.0		77.5		78.5
	80.0												80.0		80.0

APPENDIX C-3 (Continued)

ROLLER EJECTOR - HIGH AIR VELOCITY SETTING

RPM CODE			1					2					3		
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 3															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.0	5.5	6.5	1.0	7.5	14.0	10.5	1.5	1.0	5.5	5.0	4.5	0.0	0.5	2.5
	7.5	16.0	14.5	10.0	18.5	19.5	13.5	20.0	13.5	11.5	11.5	12.0	6.0	24.0	9.0
	20.0	24.5	21.0	15.5	22.0	39.0	31.0	41.5	22.5	22.0	24.5	30.0	15.5	27.0	14.5
	22.0	32.0	31.5	26.5	31.0	54.0	54.0	45.5	30.5	43.5	33.0	37.5	24.0	41.5	34.5
	26.0	38.5	33.5	34.0	38.5	63.0	64.5	59.5	41.5	51.5	45.0	48.0	35.0	53.0	39.5
	31.0	48.5	39.5	44.0	52.5	80.0	67.5	77.5	59.5	69.0	54.0	57.0	47.5	57.0	48.5
	43.0	61.0	48.5	48.0	57.0	80.0	72.0	80.0	69.5	80.0	68.5	74.0	56.5	68.0	55.5
	52.0	66.5	56.0	55.0	64.0		80.0		80.0		73.0	77.5	63.0	75.0	65.5
	60.0	72.5	63.0	66.5	74.0						80.0	80.0	80.0	80.0	80.0
	65.0	80.0	70.0	73.0	80.0										
	69.5	80.0	78.0	79.5											
	80.0		80.0	80.0											
REP 4															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.5	9.0	5.0	3.5	4.5	10.5	6.5	2.0	2.0	1.5	9.0	4.5	5.0	1.5	13.0
	7.5	13.5	16.0	13.5	11.0	26.5	20.0	24.5	17.0	17.5	18.0	12.0	15.0	8.0	25.0
	17.0	23.0	25.0	25.0	21.0	35.0	45.5	26.5	33.0	34.0	25.0	22.0	20.0	15.0	29.0
	23.5	35.5	33.0	31.5	30.5	58.5	60.5	37.0	50.0	46.5	38.0	36.0	35.0	28.0	39.5
	32.5	44.5	43.0	39.5	40.5	63.5	73.0	60.0	62.5	62.0	49.0	49.0	45.0	30.0	50.0
	44.0	53.5	53.0	45.0	45.0	75.5	80.0	75.0	77.0	67.5	65.0	59.5	58.5	46.5	65.0
	55.0	56.5	57.0	57.5	52.5	80.0		80.0	80.0	80.0	73.0	68.5	67.0	57.5	68.0
	60.5	65.0	66.0	64.5	62.5						80.0	78.5	79.5	72.0	80.0
	66.0	80.0	76.0	73.0	68.0							80.0	80.0	80.0	
	73.0		80.0	79.0	77.0										
	80.0			80.0	80.0										

APPENDIX C-3 (Continued)

AIR EJECTOR - LOW AIR VELOCITY SETTING

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 1															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4.0	1.0	5.0	2.5	0.5	2.5	5.0	6.5	2.0	2.5	0.0	2.0	1.0	3.0	0.5
	7.0	5.5	7.5	7.0	3.5	7.5	8.5	7.5	5.5	8.0	5.5	6.0	2.0	5.0	10.0
	11.0	10.0	10.5	9.5	7.5	9.5	20.5	11.5	10.5	14.0	13.5	17.0	4.5	9.0	12.0
	16.5	14.5	13.0	15.5	13.5	21.0	23.0	18.0	17.5	18.0	17.5	20.0	9.5	12.0	12.5
	20.0	16.5	20.0	21.5	17.0	24.5	32.5	24.0	27.0	26.5	20.0	22.5	10.5	21.0	22.0
	25.0	17.5	26.5	24.0	22.0	28.0	34.0	27.0	30.0	30.5	26.0	24.5	16.5	22.5	26.5
	30.5	20.5	33.0	30.5	24.5	35.5	39.0	34.5	33.0	37.5	29.5	32.5	23.0	25.0	32.5
	31.5	27.5	34.5	32.5	25.5	38.0	45.5	45.0	41.0	41.5	32.0	38.0	30.5	36.0	36.5
	36.0	31.5	39.0	37.0	30.0	45.0	50.0	49.5	50.0	47.5	35.0	41.0	36.5	40.0	38.0
	44.5	35.0	41.5	41.5	35.5	55.0	54.0	54.5	57.5	52.5	41.0	49.0	43.5	42.0	40.0
	50.0	38.5	46.5	44.5	39.5	60.5	60.0	64.0	61.5	66.5	42.5	53.5	47.5	45.0	47.5
	54.0	44.0	52.5	48.5	42.0	63.0	65.0	66.0	63.5	68.0	55.5	55.0	53.5	51.5	55.5
	57.5	48.0	54.5	53.5	46.5	65.5	74.0	75.0	69.5	70.0	59.0	61.5	58.0	54.5	56.5
	61.5	51.0	60.0	58.0	50.5	71.0	76.5	78.0	80.0	74.5	63.5	63.5	61.0	64.5	58.0
	65.5	54.5	64.0	62.5	52.5	80.0	80.0	80.0		80.0	67.5	70.5	71.0	68.0	63.0
	69.0	60.0	67.5	67.0	57.5	80.0					72.5	72.0	72.5	72.0	67.5
	73.0	63.5	70.0	71.0	62.5						80.0	74.0	78.0	76.5	70.5
	77.5	67.0	77.0	74.0	67.0							79.5	79.0	80.0	75.0
	80.0	75.0	80.0	77.0	70.5							80.0	80.0		80.0
		79.0	80.0	80.0	74.0										
		80.0			79.5										
		80.0			80.0										
REP 2															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5.0	5.5	2.0	1.0	3.0	2.0	2.0	5.0	2.5	1.0	1.0	1.5	0.5	3.0	0.0
	7.5	7.0	4.5	7.0	6.0	4.5	7.5	8.0	6.5	9.5	4.0	10.5	7.5	9.0	8.5
	11.5	10.0	11.0	9.5	9.0	12.0	15.0	12.0	16.0	14.5	10.5	12.5	11.0	12.5	9.0
	14.5	14.0	16.0	14.5	14.0	19.5	20.0	14.0	21.5	20.5	17.0	22.5	13.5	19.0	10.0
	18.0	19.5	19.0	18.5	18.0	23.0	26.0	19.0	24.0	23.5	21.0	25.0	16.5	21.0	19.5
	22.0	23.0	22.0	22.0	22.0	28.5	32.0	27.0	30.0	29.0	24.0	26.5	22.0	29.0	22.5
	24.5	25.5	29.5	26.0	26.0	33.0	34.5	31.5	34.0	34.0	26.0	28.5	25.5	33.5	26.5
	29.0	28.0	30.5	30.5	29.5	35.0	43.5	40.0	43.0	42.5	30.5	37.5	30.0	37.0	31.0
	31.5	33.5	32.5	35.0	32.0	38.0	47.5	42.0	46.0	47.0	32.5	43.5	33.0	46.0	35.5
	36.5	38.5	35.5	40.0	36.0	46.0	55.0	44.5	52.5	53.5	37.5	45.0	37.5	52.0	37.0
	38.0	41.0	37.5	43.0	43.0	52.0	59.5	52.0	62.5	56.0	43.5	48.0	42.5	53.0	42.0
	40.0	45.0	44.0	49.0	44.0	56.5	61.5	56.5	64.0	64.0	49.0	52.5	51.0	55.5	44.5
	43.5	48.5	47.5	52.5	47.0	59.0	64.5	63.0	70.0	66.0	50.5	59.0	51.5	61.0	52.5
	49.0	56.5	50.0	56.5	52.0	67.5	72.0	65.5	73.5	77.0	59.5	60.5	53.0	64.0	60.0
	53.0	57.0	54.0	61.0	57.0	71.5	80.0	79.0	80.0	79.5	62.0	64.0	60.5	66.5	61.5
	57.0	61.0	59.0	66.0	61.0	76.5		80.0		80.0	68.0	72.0	62.5	72.5	62.5
	60.0	66.0	59.5	71.0	62.5	80.0					69.0	73.5	70.0	76.5	80.0
	64.5	71.0	66.5	73.0	68.0						75.5	75.0	71.0	80.0	
	70.0	74.5	72.0	76.0	70.0						80.0	78.0	80.0		
	73.0	76.5	75.0	80.0	75.0							80.0	80.0		
	79.0	80.0	80.0		78.5										
	80.0				80.0										

APPENDIX C-3 (Continued)

AIR EJECTOR - LOW AIR VELOCITY SETTING

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 3															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	8.5	6.0	7.5	5.5	1.5	14.0	2.0	5.0	9.0	10.0	3.5	15.0	10.0	5.5	1.0
	10.0	15.0	15.5	10.5	9.0	24.0	19.0	16.5	18.0	14.5	12.0	21.0	11.0	25.5	9.5
	20.0	22.0	27.0	20.0	19.5	42.5	35.0	37.0	33.0	45.0	43.0	22.5	15.5	39.0	17.5
	24.0	32.0	37.0	31.0	30.0	47.0	47.0	38.5	56.0	53.0	45.5	36.0	38.5	44.0	33.0
	37.0	45.0	44.0	33.0	35.5	61.5	57.0	64.5	62.0	60.0	50.0	43.5	39.0	65.0	51.0
	47.5	52.5	50.5	34.5	42.5	80.0	71.5	75.5	73.0	68.0	59.0	54.5	51.0	68.0	59.5
	53.0	58.0	60.5	39.5	51.0		80.0	80.0	80.0	80.0	69.5	74.0	61.0	70.5	70.5
	58.5	65.0	67.5	41.5	60.0						73.0	78.5	65.0	80.0	80.0
	68.0	73.5	76.0	52.5	67.5						80.0	80.0	78.5		
	79.0	80.0	80.0	60.0	78.0								80.0		
	80.0	80.0		69.0	80.0										
				74.0											
				76.5											
				78.0											
				80.0											
REP 4															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5.0	4.5	7.5	0.0	1.5	6.0	5.0	0.0	8.5	15.0	6.5	17.5	13.5	4.5	5.5
	5.5	12.0	16.0	4.0	10.0	18.0	22.5	14.0	18.0	25.0	12.0	22.5	32.0	10.5	42.0
	13.0	20.5	29.0	11.0	13.0	29.0	34.0	29.0	34.5	42.0	26.0	34.0	47.0	13.5	43.0
	22.0	29.0	35.0	19.5	28.0	39.5	44.5	44.5	42.5	60.0	34.0	43.0	61.5	19.0	56.5
	31.5	37.5	46.5	27.0	38.0	41.5	63.0	60.0	44.5	66.0	42.5	54.0	69.0	42.5	58.0
	38.0	44.5	54.0	32.5	44.5	55.0	75.0	68.5	66.5	80.0	52.5	65.0	75.0	43.5	60.0
	49.0	54.5	61.0	47.0	52.0	67.5	80.0	80.0	72.5		64.0	67.0	79.5	62.0	78.0
	55.5	66.5	68.0	52.0	62.0	80.0			80.0		72.0	80.0	80.0	75.5	80.0
	60.0	72.5	76.5	60.5	76.0						80.0			80.0	
	75.0	77.0	80.0	63.5	80.0										
	79.0	80.0		68.0											
	80.0			78.0											
				80.0											

APPENDIX C-3 (Continued)

AIR EJECTOR - HIGH AIR VELOCITY SETTING

RPM CODE			1					2					3		
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 1															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2.0	2.0	0.0	1.0	0.5	0.0	4.5	7.0	3.5	7.0	0.0	4.0	5.5	0.0	1.0
	5.0	6.5	5.0	7.0	3.0	7.5	11.0	9.0	8.0	11.0	5.5	8.0	7.0	4.5	3.5
	11.0	12.5	9.5	9.5	6.5	10.0	17.5	16.0	18.5	19.5	10.5	10.5	7.5	9.5	10.5
	13.0	16.5	12.5	13.0	10.0	18.0	23.0	21.5	23.5	23.0	16.5	20.5	13.0	19.5	13.5
	20.0	20.5	16.0	19.0	15.5	23.0	28.0	25.5	32.5	27.0	23.0	22.0	16.0	20.0	16.0
	21.0	24.0	21.0	23.5	20.0	28.5	34.0	30.0	35.5	35.0	26.5	24.0	18.0	22.0	21.0
	23.0	29.0	24.5	27.0	26.0	33.0	43.0	36.0	41.0	38.0	28.5	26.5	25.5	25.0	27.5
	28.5	33.5	28.5	32.5	28.5	35.5	44.5	43.0	50.5	45.5	34.0	32.0	30.0	28.0	30.5
	30.0	39.0	33.0	34.0	32.5	36.0	53.5	49.5	51.0	52.5	37.0	42.5	32.0	35.5	33.0
	35.0	41.0	35.5	41.0	37.0	46.5	56.5	55.0	55.0	55.5	45.0	43.5	36.5	44.0	40.0
	37.0	44.0	40.0	44.5	39.5	49.5	66.0	58.0	63.0	61.0	50.0	49.0	43.0	49.5	44.5
	43.0	45.0	45.5	46.5	44.0	52.5	67.5	62.0	67.0	66.0	52.5	54.5	50.0	54.0	50.0
	46.5	47.5	49.5	51.0	49.0	55.5	74.0	68.0	72.5	73.0	59.0	55.5	52.5	57.5	56.5
	50.5	54.5	53.0	54.5	52.5	58.5	78.5	72.0	77.0	77.0	60.5	61.0	54.0	58.5	59.5
	56.5	58.5	56.5	60.0	56.5	66.0	80.0	80.0	80.0	78.5	65.0	64.5	63.5	68.0	66.0
	58.5	59.5	65.5	64.5	60.0	72.5				80.0	70.0	70.0	64.0	70.0	69.5
	64.0	60.5	67.0	69.5	64.5	76.5					71.5	76.0	64.5	80.0	71.0
	68.5	65.5	72.5	71.5	68.0	80.0					75.5	80.0	71.0		80.0
	72.0	69.5	74.5	76.5	75.0						78.0		72.0		
	75.5	73.0	78.0	79.5	79.5						80.0		76.0		
	80.0	79.0	80.0	80.0	80.0								78.0		
		80.0											80.0		
REP 2															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5.0	0.5	2.5	1.5	3.0	6.0	1.5	2.0	3.5	2.0	3.5	4.5	4.5	4.5	0.5
	8.5	4.5	6.0	6.5	6.5	7.5	6.5	7.5	9.0	7.5	9.0	5.0	9.5	7.5	6.0
	13.5	8.5	9.5	10.5	13.0	11.5	15.0	15.0	10.5	15.0	13.5	9.5	13.0	9.0	7.0
	18.0	12.5	13.5	14.5	13.5	19.5	20.0	21.0	17.0	20.5	15.0	11.5	19.5	13.0	8.5
	21.5	17.0	17.5	19.0	19.0	22.0	25.0	25.5	23.0	26.0	24.0	24.5	25.0	20.0	15.5
	25.0	21.5	22.0	23.0	22.5	27.0	29.5	30.5	30.0	30.0	25.5	28.0	26.0	22.5	17.5
	29.0	24.0	24.0	28.0	26.0	34.0	31.5	37.5	33.5	35.5	28.0	33.0	29.5	24.5	20.5
	35.5	30.5	29.5	32.5	30.5	39.5	35.5	40.0	40.0	44.0	31.0	37.0	35.5	33.0	29.0
	37.5	36.5	33.5	35.5	35.5	45.0	44.5	47.5	45.0	48.0	37.5	40.5	37.0	37.5	33.5
	43.0	38.0	36.5	40.0	39.5	50.0	45.5	54.0	50.5	52.5	40.0	42.0	42.5	45.0	34.5
	47.0	43.0	40.5	43.0	45.0	56.5	52.5	58.0	57.5	59.0	50.0	43.5	46.0	46.0	43.0
	49.0	49.5	45.5	47.5	49.5	62.0	59.5	65.0	60.5	71.0	52.0	47.5	49.0	50.0	46.5
	53.0	50.5	49.5	53.0	55.5	66.0	63.5	72.5	68.0	75.0	53.0	50.0	52.5	52.0	51.0
	58.5	54.0	54.5	57.5	57.0	70.0	68.0	78.0	74.5	80.0	59.0	59.5	55.5	62.0	58.0
	62.5	58.5	57.5	60.5	59.5	77.0	72.5	80.0	80.0		68.0	66.5	59.5	65.0	59.5
	67.0	64.5	61.5	65.5	64.5	80.0	78.5				71.0	68.0	66.5	69.5	66.0
	70.0	67.5	66.0	69.5	70.5		80.0				73.0	71.5	72.5	71.0	70.0
	80.0	72.0	69.5	74.5	73.0						74.0	80.0	73.5	76.0	77.0
	80.0	76.5	73.5	78.5	76.0						80.0		74.5	80.0	79.0
		80.0	77.0	80.0	79.5						80.0		80.0		80.0
		80.0	78.0		80.0										
			80.0												

APPENDIX C-3 (Continued)

AIR EJECTOR – HIGH AIR VELOCITY SETTING

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 3															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	14.5	0.0	0.0	7.0	3.5	3.0	1.0	5.0	9.0	11.5	14.5	1.5	0.0	7.0	22.0
	15.5	7.0	6.0	16.5	14.0	14.0	17.5	19.0	20.0	16.5	26.0	12.0	2.0	10.5	25.5
	22.5	16.5	15.0	22.5	22.0	32.5	30.0	37.5	52.5	23.0	38.0	22.0	17.5	19.5	35.0
	34.0	25.0	25.0	30.0	33.5	50.5	43.5	53.5	59.0	38.0	44.0	31.0	20.0	23.5	38.5
	36.0	33.5	32.0	40.0	39.5	63.5	54.5	69.5	70.0	41.0	64.0	39.0	28.0	48.0	61.0
	42.5	41.5	39.5	51.0	46.5	73.5	58.5	74.5	80.0	48.0	69.0	47.5	49.5	50.0	66.0
	50.0	53.0	48.0	56.0	57.0	80.0	72.5	80.0	80.0	69.5	69.5	54.0	52.5	63.5	70.5
	58.0	59.5	57.5	63.5	63.0		80.0			74.0	80.0	66.0	67.0	78.0	80.0
	66.5	69.5	64.5	72.5	69.0					80.0		70.5	68.5	80.0	
	78.0	78.5	71.5	80.0	80.0							80.0	78.5		
	80.0	80.0	80.0										80.0		
REP 4															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4.5	8.0	1.5	7.5	7.0	10.0	24.0	28.5	7.0	15.5	6.0	0.5	6.0	0.5	4.0
	15.0	14.0	10.0	11.5	9.5	14.0	30.0	31.5	26.5	19.5	10.5	11.0	10.5	9.0	28.5
	19.5	26.0	19.0	18.5	14.0	32.0	47.0	54.0	42.5	34.5	20.0	21.0	31.5	10.5	37.5
	30.0	35.5	29.0	26.5	28.0	51.0	57.5	69.0	57.0	50.0	29.0	36.5	36.0	20.5	39.0
	38.5	42.0	36.0	38.5	32.0	59.0	63.5	70.5	74.0	58.0	43.5	51.5	55.0	32.5	47.0
	47.5	48.0	41.5	45.0	39.5	71.0	76.5	80.0	80.0	75.0	47.5	60.0	62.0	49.5	52.0
	55.0	57.5	50.5	54.0	49.0	80.0	80.0			80.0	57.0	72.0	75.5	65.0	63.0
	60.0	64.0	60.0	62.0	50.0						65.0	77.0	80.0	67.5	80.0
	69.0	72.0	69.0	75.0	59.0						72.0	80.0		79.0	80.0
	76.0	80.0	74.0	79.0	69.0						80.0			80.0	
	80.0		80.0	80.0	73.5										
					80.0										
					80.0										

APPENDIX D

D-1 ORIGINAL DATA FOR SEED SPACINGS AT EXIT OF SEED MERGING MANIFOLD

D-2 ORIGINAL DATA FOR SEED SPACINGS ON CONVEYOR BELT

APPENDIX D-1

LOW AIR VELOCITY SETTING

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 1															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.5	0.5	0.5	0.0	0.5	6.0	12.5	9.0	4.5	3.0	9.0	5.0	0.5	4.0	1.0
	2.5	3.0	2.5	4.5	2.5	10.0	16.5	13.5	5.5	13.0	16.0	7.5	6.0	14.0	9.0
	9.5	11.5	4.0	5.0	13.5	15.5	35.0	22.5	8.5	29.0	30.5	22.5	22.5	26.5	11.0
	10.5	27.0	8.0	12.0	14.5	17.5	36.5	24.0	17.0	36.0	47.5	32.0	29.0	30.0	16.5
	12.5	28.0	11.5	14.5	20.0	23.5	66.0	36.0	24.5	37.5	52.5	40.5	34.5	32.5	17.5
	20.5	42.5	17.5	19.0	20.5	28.5	79.5	40.0	27.0	52.0	54.5	45.5	44.0	38.0	21.5
	27.0	43.5	24.5	20.0	29.0	32.0	80.0	49.5	28.0	57.5	58.5	50.0	49.5	40.5	31.5
	33.5	47.0	27.5	28.5	37.5	46.5		52.0	38.0	62.5	61.0	52.0	57.0	49.5	33.5
	36.0	52.5	33.0	40.0	39.5	60.0		67.5	42.5	70.0	65.5	53.5	59.5	58.0	37.0
	40.5	61.5	33.5	45.5	43.5	76.5		72.5	55.0	80.0	69.5	79.0	62.5	60.0	38.0
	42.5	62.5	38.5	47.0	45.5	80.0		80.0	62.0		72.0	80.0	64.0	64.0	45.0
	46.5	64.0	39.5	47.5	50.0				66.0		80.0		66.0	66.0	63.0
	48.5	68.0	42.0	50.5	55.5				70.5				73.5	80.0	64.0
	49.0	69.5	47.0	55.0	57.5				73.0				80.0	80.0	69.0
	56.0	71.5	54.0	61.5	62.0				80.0						77.0
	62.0	77.5	58.5	62.5	63.0										80.0
	63.0	78.5	59.5	72.0	64.0										
	73.5	79.5	62.5	75.0	65.0										
	77.5	80.0	67.5	77.0	70.5										
	80.0		69.5	79.5	73.0										
			80.0	80.0	79.5										
					80.0										
REP 2															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	4.5	4.5	0.0	4.0	4.5	2.5	8.0	1.0	16.5	6.5	3.5	2.0	8.0	2.0	9.5
	10.0	5.0	6.0	6.0	6.5	13.5	10.5	10.0	19.5	28.5	19.0	5.0	9.5	10.0	14.0
	11.5	10.5	14.0	7.5	18.0	18.0	16.5	13.0	22.5	34.5	21.0	18.5	20.0	17.5	19.0
	13.0	17.0	15.0	10.5	18.5	27.5	23.5	14.5	27.0	46.0	30.5	31.5	32.0	18.0	23.0
	16.0	19.0	17.0	11.0	30.5	30.0	29.0	15.5	39.0	55.5	56.5	36.5	34.0	20.5	28.5
	19.0	22.5	19.0	31.0	35.0	55.0	31.0	17.5	41.0	59.5	63.5	38.0	38.0	30.5	30.0
	22.0	31.0	23.0	32.5	40.0	61.0	36.5	24.5	62.0	65.0	69.5	42.0	41.0	38.0	37.5
	22.5	34.5	28.5	38.5	45.0	69.5	54.0	50.0	67.0	69.5	71.0	45.0	50.0	42.5	43.5
	24.5	38.0	34.5	40.5	47.0	80.0	59.0	55.0	73.0	74.5	78.5	53.0	51.0	56.0	49.5
	27.0	45.0	42.0	44.5	47.5		70.0	62.0	80.0	80.0	80.0	66.5	53.0	66.0	52.5
	32.0	47.5	42.5	50.0	52.5		80.0	73.0				71.0	61.5	70.0	55.5
	40.5	51.5	49.5	50.5	56.5			80.0				73.0	67.5	74.0	71.5
	46.0	56.5	59.5	52.0	60.5							75.0	71.0	79.5	74.5
	51.5	63.5	62.0	58.5	61.5							77.0	77.0	80.0	80.0
	52.5	67.0	72.0	60.0	64.0							80.0	79.0		
	57.0	75.0	73.5	66.0	64.5							80.0	80.0		
	59.0	78.0	78.0	72.0	70.0								80.0		
	61.0	80.0	80.0	72.5	77.5										
	65.0	80.0		77.5	80.0										
	68.5			78.5											
	74.5			80.0											
	76.0														
	80.0														
	80.0														

APPENDIX D-1 (Continued)

LOW AIR VELOCITY SETTING

RPM CODE	1					2					3				
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 3															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.0	1.0	18.0	0.0	1.5	4.5	1.5	0.0	6.0	7.5	8.5	11.0	1.5	5.5	0.0
	1.5	3.0	20.0	10.5	3.0	6.0	15.5	2.0	22.0	8.5	26.0	20.0	5.0	9.0	5.0
	5.5	15.5	25.0	12.5	10.5	10.0	24.5	9.5	29.0	15.5	32.0	27.5	6.5	26.0	12.5
	6.5	20.0	35.0	19.5	12.0	23.5	29.0	15.5	32.5	27.0	46.5	29.5	13.0	42.0	17.0
	8.0	21.0	37.5	24.0	21.5	27.0	31.0	21.0	42.0	35.5	53.0	31.0	15.0	53.0	20.0
	13.5	23.0	38.5	30.0	24.0	30.0	33.0	36.0	57.5	37.5	56.0	34.0	22.5	67.0	35.0
	18.5	38.0	41.5	32.5	27.0	69.5	38.5	39.0	64.0	40.0	62.0	38.5	39.5	72.0	45.5
	22.5	45.5	48.5	39.0	28.0	76.5	45.5	41.0	71.0	43.0	65.5	43.5	59.0	74.0	50.5
	28.5	48.0	49.5	46.0	33.0	80.0	57.5	44.0	74.5	45.0	71.5	56.0	61.0	80.0	67.0
	36.5	54.0	50.0	51.5	35.0		58.5	52.5	77.5	56.5	77.5	59.0	69.5	80.0	69.0
	39.5	61.0	52.0	53.0	49.0		62.0	74.5	80.0	64.5	80.0	60.5	73.5		77.0
	43.5	62.5	57.0	61.0	51.0		68.0	76.5		70.0		67.0	78.0		80.0
	48.0	63.5	68.5	64.5	57.5		73.0	80.0		80.0		74.0	79.5		
	50.0	70.5	69.5	66.5	58.0		80.0					79.0	80.0		
	53.0	71.0	71.0	67.0	60.0							80.0			
	55.0	78.0	80.0	76.0	67.5										
	69.5	80.0	80.0	77.5	70.5										
	74.0			79.5	74.5										
	77.0			80.0	75.5										
	80.0				80.0										
	80.0														
REP 4															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5.5	0.0	4.5	5.5	4.0	4.5	1.0	16.5	7.5	1.0	6.5	4.0	15.5	10.5	8.5
	6.0	6.0	19.5	9.5	12.0	17.5	3.5	19.5	9.0	11.0	15.0	18.0	16.5	16.0	15.5
	6.5	10.0	21.0	15.5	20.5	20.0	6.5	29.0	17.0	31.0	19.5	20.5	20.5	19.0	21.0
	8.0	19.0	28.0	17.0	24.5	28.5	19.5	34.5	18.5	47.5	25.5	23.0	25.5	35.0	26.5
	13.0	22.0	29.0	17.5	30.5	37.5	25.5	44.5	30.5	51.0	29.0	35.0	30.5	37.0	32.5
	21.5	29.0	31.0	21.0	33.0	39.0	29.5	50.5	36.5	51.5	32.0	37.5	35.0	39.0	42.5
	27.0	38.0	34.0	27.0	43.0	56.5	40.5	64.5	40.0	59.0	40.5	44.0	39.5	41.5	48.0
	29.0	43.0	47.5	31.0	45.0	60.0	58.0	74.0	46.0	60.0	46.0	55.0	43.0	43.5	49.0
	38.0	44.5	52.0	44.0	49.0	64.0	64.5	80.0	49.0	64.5	56.0	62.5	47.0	45.0	52.0
	43.5	51.0	64.0	47.5	56.0	69.0	75.0	80.0	57.0	66.0	57.5	66.0	59.0	47.5	53.0
	44.0	53.0	69.5	48.5	57.5	77.0	80.0		61.5	76.5	59.5	70.5	63.0	51.5	69.0
	48.0	62.5	71.5	52.5	61.5	80.0			67.5	80.0	79.0	80.0	73.5	73.5	80.0
	49.5	69.0	75.5	62.5	68.5				78.5		80.0		80.0	80.0	
	52.5	70.5	76.0	69.0	69.5				80.0						
	56.5	80.0	78.0	74.0	73.0										
	57.5		79.0	80.0	76.0										
	64.0		80.0		80.0										
	74.0		80.0												
	80.0														

APPENDIX D-1 (Continued)

HIGH AIR VELOCITY SETTING

RPM CODE			1					2					3		
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 1															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	1.0	5.0	2.5	3.5	0.0	32.5	7.0	13.5	0.0	2.0	12.0	6.0	21.5	1.5
	4.5	4.5	6.5	5.5	4.5	6.5	37.5	12.0	18.0	7.0	5.5	15.0	12.0	30.0	4.0
	9.5	19.0	20.5	16.0	7.5	10.5	41.5	20.0	24.5	10.5	14.5	18.5	15.5	32.0	6.5
	15.5	24.0	24.5	17.0	10.5	24.5	45.0	31.5	29.5	23.5	17.0	24.5	17.0	34.0	9.5
	20.0	25.0	29.0	20.0	18.0	30.5	51.5	33.5	33.0	28.0	40.5	30.5	19.0	37.5	12.5
	27.0	27.5	33.5	24.5	27.5	39.5	57.0	43.0	45.0	39.5	42.5	44.0	25.5	44.0	13.5
	28.5	33.0	37.0	32.5	31.5	44.5	59.0	48.5	48.5	42.0	44.5	49.5	31.5	46.5	20.0
	32.5	34.5	41.0	38.0	32.0	55.5	75.5	53.5	52.0	43.5	56.5	56.5	40.0	53.5	28.0
	40.5	37.5	43.0	42.5	33.0	58.0	76.5	80.0	65.0	45.5	61.5	63.5	42.5	80.0	34.0
	42.5	41.0	48.5	46.5	36.0	65.5	78.5	80.0	71.0	57.0	71.5	69.5	63.0		36.0
	45.5	47.0	56.5	49.5	44.0	67.0	79.0		78.0	67.0	80.0	73.0	66.5		38.5
	48.0	53.5	58.0	57.0	46.0	80.0	80.0		80.0	75.0	80.0	74.0	76.0		50.5
	50.0	60.5	62.0	62.5	53.0		80.0			80.0		78.0	80.0		52.0
	61.0	63.0	65.0	64.0	59.0							79.5			63.0
	62.0	65.5	67.5	65.5	60.5							80.0			73.0
	67.0	66.0	76.0	66.5	61.5										80.0
	70.0	79.0	80.0	68.0	66.0										
	75.0	80.0	80.0	70.0	69.5										
	80.0			80.0	79.0										
				80.0	80.0										
					80.0										
REP 2															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.5	4.5	0.5	2.0	11.0	11.5	1.5	4.0	15.0	12.5	7.5	0.5	1.0	0.0	0.0
	8.5	5.5	3.5	3.0	15.5	17.5	5.5	14.0	22.0	21.5	14.5	6.5	5.0	6.0	20.5
	14.0	6.5	4.0	5.5	16.5	21.5	24.0	19.5	32.0	28.5	17.0	10.0	11.5	8.0	25.0
	23.5	11.5	25.0	9.5	18.5	32.0	39.5	21.0	38.5	34.5	20.5	15.0	19.5	15.0	26.5
	25.0	14.0	30.5	16.0	20.5	41.0	42.0	27.5	48.0	35.5	25.0	23.0	26.5	20.0	28.0
	28.5	17.5	31.5	22.5	24.5	46.0	43.0	31.5	53.0	38.0	26.0	30.5	32.5	23.0	31.0
	31.0	27.5	36.0	34.0	27.0	55.0	52.0	36.5	56.0	46.5	39.0	41.0	38.0	24.0	46.0
	34.5	31.5	39.0	40.5	30.5	65.0	64.0	43.5	69.0	49.5	64.5	42.0	40.0	29.5	48.0
	43.5	46.5	40.0	43.0	34.0	70.5	66.0	54.0	70.5	53.5	66.5	64.0	43.5	33.5	50.5
	46.5	53.5	46.5	47.0	38.0	80.0	80.0	57.5	80.0	65.5	67.5	66.5	58.0	42.0	52.5
	51.5	54.0	51.5	49.0	40.0			66.0		78.0	74.0	69.5	67.0	59.0	54.0
	56.0	56.0	53.5	52.5	47.5			67.5		80.0	80.0	74.5	68.0	64.5	61.5
	60.5	57.5	55.0	69.5	49.0			77.5				79.0	69.0	71.0	64.5
	61.5	73.0	56.5	70.0	53.5			80.0				80.0	74.5	75.5	80.0
	63.0	80.0	60.5	71.0	65.0								80.0	79.5	
	78.5		69.0	72.0	77.0									80.0	
	80.0		72.5	74.0	78.5										
			78.0	75.5	80.0										
			78.5	80.0											
			80.0												

APPENDIX D-1 (Continued)

HIGH AIR VELOCITY SETTING

RPM CODE			1					2					3		
SAMPLE	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
REP 3															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3.5	1.0	0.5	1.5	1.0	1.0	2.0	5.0	1.0	0.0	6.5	7.0	3.0	3.5	5.5
	6.0	3.5	1.5	4.5	4.0	11.0	4.0	12.5	2.5	4.5	20.5	9.5	10.0	6.5	6.0
	12.5	5.5	3.0	16.5	6.5	25.5	12.5	29.5	8.0	20.5	23.0	13.5	20.0	15.0	17.0
	13.0	10.5	9.0	18.0	9.5	30.0	23.0	37.0	9.5	27.0	37.5	22.5	21.0	17.5	19.5
	14.0	11.5	12.5	20.0	20.0	31.5	24.5	50.0	12.5	30.5	46.0	29.0	30.0	26.5	25.0
	24.0	17.0	22.0	22.5	25.0	46.5	28.0	52.5	18.0	36.5	49.0	33.0	34.0	33.0	27.0
	26.0	22.5	31.5	24.0	25.5	48.0	37.5	56.0	21.0	55.0	72.0	37.5	47.5	45.5	28.5
	28.0	28.5	33.5	34.5	27.0	59.5	40.5	59.5	24.5	69.0	74.0	38.5	50.0	58.0	53.5
	30.0	32.0	34.5	35.5	36.0	75.5	43.0	65.5	29.0	71.0	75.5	48.0	58.5	64.0	61.5
	31.0	36.5	37.5	38.5	37.5	77.5	49.0	72.0	57.5	76.0	79.5	52.5	62.0	65.5	63.5
	40.5	40.5	38.0	39.5	40.5	79.0	59.5	75.0	60.5	80.0	80.0	58.0	64.5	74.0	74.5
	42.5	43.0	46.0	42.5	46.0	80.0	67.5	80.0	65.5			60.5	73.0	80.0	76.5
	47.0	52.0	53.0	48.0	49.0		72.0		67.5			62.0	77.0	80.0	80.0
	51.5	58.0	55.5	52.5	51.5		79.5		75.5			66.0	80.0		
	56.5	60.5	65.5	59.0	55.5		80.0		80.0			74.0			
	60.5	63.5	66.5	59.5	64.0							80.0			
	65.5	69.5	67.5	67.0	67.0										
	68.0	70.5	69.5	69.0	71.0										
	73.5	72.5	80.0	71.5	72.0										
	80.0	76.0		79.5	78.5										
		78.0		80.0	79.0										
		80.0			80.0										
REP 4															
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	2.5	9.5	1.0	2.0	0.0	7.0	0.5	0.0	0.5	1.5	0.0	1.5	5.5	11.0	0.5
	4.0	15.0	5.0	6.0	4.5	10.5	1.0	19.0	2.5	5.5	5.0	4.0	9.5	16.5	7.0
	9.0	18.0	10.0	8.5	10.5	15.0	1.5	21.0	27.0	23.5	8.0	5.5	14.5	30.5	16.5
	14.5	20.5	11.5	15.0	11.5	23.0	18.0	22.5	29.5	25.5	10.5	17.5	17.0	32.5	21.0
	21.5	24.5	14.5	15.5	18.0	31.0	21.0	36.0	33.0	38.5	14.0	19.5	19.0	35.0	23.0
	24.0	27.0	19.0	18.5	26.0	50.0	24.0	39.0	61.0	44.5	17.0	22.0	21.0	44.0	41.5
	24.5	29.0	21.5	19.5	27.5	51.5	30.5	46.5	78.5	50.0	27.5	31.5	24.5	49.5	46.0
	32.0	30.5	22.5	25.0	30.0	55.0	40.0	50.5	80.0	53.5	30.0	45.0	34.5	50.5	49.5
	34.0	34.0	25.5	34.5	30.5	58.5	46.0	58.0		57.5	32.5	48.0	47.5	64.0	68.5
	37.0	37.0	29.0	38.0	40.0	59.5	54.0	60.0		58.5	33.5	49.5	49.0	68.0	74.0
	39.5	49.5	40.5	47.5	42.5	67.0	61.5	67.0		75.0	38.0	53.5	61.0	76.5	75.5
	43.0	50.0	43.5	51.0	47.5	71.0	67.0	75.5		80.0	39.0	58.5	70.5	80.0	78.5
	45.0	51.0	58.0	54.0	52.0	76.0	68.5	80.0			47.0	60.0	77.5		80.0
	56.0	53.0	60.5	57.0	53.0	80.0	78.0				66.0	80.0	79.0		
	57.5	58.0	66.5	75.0	54.5		80.0				80.0	80.0	80.0		
	58.5	70.0	68.0	76.0	55.0										
	61.5	74.0	69.0	77.0	60.5										
	68.5	78.5	75.5	80.0	64.0										
	69.5	80.0	77.5		72.5										
	72.0		80.0		75.5										
	73.0				80.0										
	80.0														

APPENDIX D-2

REP 1
RPM CODE 1

SAMPLE	1	2	3	4	5
	10.0	10.0	10.0	10.0	10.0
	10.5	12.5	10.0	11.0	11.5
	14.0	14.5	11.5	12.0	19.5
	16.5	18.5	14.5	14.0	20.5
	16.5	21.0	24.0	25.5	22.0
	18.0	22.5	27.0	27.5	25.0
	20.5	24.0	29.5	29.5	25.0
	21.5	25.5	31.0	30.0	27.0
	23.0	26.5	32.5	33.0	29.5
	25.5	28.0	35.0	34.0	31.5
	27.5	28.5	42.5	37.0	32.0
	29.5	30.0	43.5	38.5	34.5
	31.0	34.0	43.5	40.5	36.0
	37.0	34.5	44.0	50.0	39.0
	40.0	36.5	46.5	52.5	40.5
	42.0	36.5	57.0	57.0	43.0
	47.5	45.5	57.0	58.5	44.0
	49.5	50.0	59.0	60.0	46.0
	52.0	54.0	60.0		50.5
	54.5	59.0	60.0		52.5
	55.5	60.0			55.5
	60.0				57.5
					59.0
					60.0

APPENDIX D-2 (Continued)

REP 1
RPM CODE 2

SAMPLE	1	2	3	4	5	6
	10.0	10.0	10.0	10.0	10.0	10.0
	10.0	11.0	12.0	10.5	11.0	13.0
	11.0	13.0	17.5	14.0	12.0	13.5
	14.5	17.0	18.0	15.0	14.0	14.5
	18.5	25.0	23.0	26.0	14.5	17.0
	21.0	26.5	24.5	27.5	15.5	18.5
	23.0	28.5	25.5	28.0	16.5	26.0
	23.5	30.0	27.5	29.0	17.5	28.5
	24.0	31.0	29.0	30.5	18.0	30.5
	26.5	32.5	30.0	32.5	19.5	31.0
	26.5	38.0	30.5	33.0	23.0	31.5
	28.0	38.5	31.5	34.0	31.0	34.5
	30.5	38.5	33.0	43.5	32.5	37.0
	32.5	40.0	34.5	45.0	35.5	38.0
	33.0	40.5	35.0	47.0	40.0	38.5
	35.5	41.0	35.5	48.5	43.5	39.5
	40.0	44.0	47.0	50.5	46.0	45.5
	43.0	48.0	49.0	52.5	46.5	46.5
	46.0	49.5	50.5	56.0	49.0	48.0
	51.0	52.5	51.5	58.5	52.0	49.5
	54.5	56.5	53.5	60.0	53.5	51.5
	55.5	57.5	60.0		54.0	53.0
	59.5	60.0			60.0	54.0
	60.0	60.0				54.5
						56.0
						59.5
						60.0

APPENDIX D-2 (Continued)

SAMPLE

REP 1
RPM CODE 3

1	2	3	4	5
10.0	10.0	10.0	10.0	10.0
11.0	10.5	11.5	10.5	11.5
11.5	15.0	15.0	12.0	15.0
14.5	16.0	21.0	12.5	15.5
23.0	19.5	25.0	14.0	17.0
24.5	21.0	27.5	15.5	18.5
24.5	22.0	29.5	17.0	21.0
25.0	23.0	31.0	17.0	27.0
26.0	29.5	32.5	17.5	31.0
27.5	31.5	33.5	18.0	32.0
29.0	38.0	36.0	19.5	33.5
34.0	38.5	37.5	20.5	35.0
34.5	42.5	38.5	21.5	36.0
35.5	43.0	39.5	23.5	37.0
40.5	47.0	40.0	24.5	39.5
43.0	49.0	47.0	28.0	46.0
44.0	53.0	50.0	35.0	48.5
48.0	53.5	55.5	41.0	50.0
49.0	59.5	57.5	42.5	53.0
52.0	60.0	58.5	46.0	56.0
60.0		58.5	47.5	60.0
		60.0	50.0	
		60.0	51.5	
			59.0	
			60.0	
			60.0	

SAMPLE	1	2	3	4	5	6	7	8	9
REP 2 RPM CODE 1									
	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	10.0	10.0	13.0	15.5	10.5	13.5	10.0	17.0	12.0
	13.5	10.0	15.5	17.5	12.5	14.5	11.0	25.0	15.0
	14.5	13.5	23.0	17.5	13.5	15.5	12.0	28.0	23.0
	16.0	15.0	23.0	18.0	16.5	22.5	13.5	31.0	24.0
	22.0	16.0	23.0	18.5	18.5	24.0	14.5	32.5	25.0
	26.5	18.0	23.5	23.0	21.0	29.0	16.5	33.5	26.0
	28.0	18.5	25.0	26.0	21.5	31.0	19.0	35.0	27.0
	29.5	19.0	25.5	27.0	22.0	31.5	19.5	36.0	30.0
	31.5	21.5	27.0	29.5	23.5	33.5	20.5	37.0	37.0
	33.5	24.0	29.0	36.0	24.0	34.5	34.0	38.5	38.0
	36.0	25.0	30.5	38.5	24.5	36.0	36.0	40.5	40.0
	40.0	25.5	38.0	47.0	27.0	37.0	40.0	41.5	41.0
	42.5	30.0	38.5	48.0	30.0	37.0	42.0	43.0	44.0
	45.0	32.5	42.5	50.0	34.5	37.5	42.0	48.0	45.5
	50.0	35.0	43.5	51.0	35.5	40.0	45.5	49.0	46.0
	51.5	36.5	45.5	52.0	37.0	49.5	46.5	56.0	46.5
	56.0	38.5	46.5	56.0	43.5	53.0	48.0	57.0	47.0
	60.0	48.5	47.5	57.0	46.5	55.0	51.0	57.0	49.5
		52.5	48.0	60.0	47.0	56.0	52.0	58.5	50.5
		56.5	50.0	60.0	47.5	58.0	54.5	60.0	60.0
		60.0	53.0		49.0	59.5	57.0		
		60.0	57.5		51.5	60.0	60.0		
			59.5		53.0		60.0		
			60.0		53.5				
					58.0				
					60.0				

APPENDIX D-2 (Continued)

SAMPLE	1	2	3	4	5	6	7	8
REP 2								
RPM CODE 2								
	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	14.0	10.0	10.0	11.0	14.0	18.5	10.0	12.0
	18.0	16.5	11.0	13.0	15.5	19.0	10.5	12.5
	23.5	18.0	14.0	17.5	20.5	20.0	11.0	18.5
	26.5	21.0	15.0	19.5	24.0	21.5	12.0	20.0
	27.0	22.5	18.0	21.0	25.0	26.0	13.5	20.5
	28.5	23.5	24.0	23.0	25.5	27.0	15.5	21.5
	30.0	25.5	31.0	27.0	27.5	32.0	20.5	25.0
	30.5	28.0	33.5	29.5	29.0	35.0	21.0	30.0
	32.0	31.0	36.5	31.5	37.5	36.0	22.5	31.0
	33.0	33.5	40.0	32.0	39.5	39.5	29.5	37.5
	35.0	36.0	40.0	34.0	41.0	41.0	34.5	39.5
	39.0	38.5	42.0	37.0	45.5	42.5	36.0	41.5
	40.5	39.0	42.0	41.0	47.5	45.5	37.0	43.5
	42.5	42.0	44.5	41.5	49.0	47.0	38.0	45.0
	46.5	43.5	46.5	46.0	49.0	52.5	43.0	57.0
	52.0	45.0	51.0	49.5	52.5	53.5	47.0	58.0
	56.5	46.5	51.0	50.5	54.0	55.5	48.5	59.5
	58.0	47.5	52.0	51.0	56.5	60.0	49.5	60.0
	60.0	53.0	57.5	52.5	60.0	60.0	50.0	
		56.0	58.5	54.0			53.0	
		57.5	60.0	56.0			59.0	
		58.0		58.0			60.0	
		58.0		60.0				
		60.0						
		60.0						

APPENDIX D-2 (Continued)

SAMPLE	1	2	3	4	5	6	7	8
REP 2 RPM CODE 3								
	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	12.5	11.5	12.0	11.0	19.5	12.0	12.0	11.0
	14.0	13.0	14.5	13.5	21.0	13.0	14.5	11.5
	15.5	16.0	15.5	14.5	23.0	14.5	19.0	17.5
	19.0	32.0	16.5	16.0	30.0	17.0	21.0	23.5
	23.0	32.5	16.5	17.0	38.0	32.5	22.5	24.0
	25.5	33.5	28.5	19.0	42.5	33.0	25.0	24.0
	26.0	35.5	29.0	21.5	44.0	35.5	27.5	25.5
	27.5	36.0	36.0	22.5	45.0	35.5	30.0	33.5
	31.0	42.5	43.5	25.0	47.0	37.0	32.5	35.0
	32.5	43.0	46.5	27.5	47.0	37.0	37.0	36.5
	34.0	47.5	47.5	32.0	49.0	39.0	40.5	37.0
	38.0	51.0	48.5	34.5	49.5	43.5	42.0	39.5
	39.0	53.5	51.5	35.5	49.5	43.5	43.0	40.0
	40.0	55.0	52.0	42.5	50.0	47.5	45.5	44.0
	44.5	56.5	52.5	44.5	51.5	50.0	49.5	53.5
	48.0	57.0	55.5	47.0	59.0	58.5	54.0	54.5
	51.5	60.0	59.5	48.0	60.0	59.5	58.0	56.5
	56.5		60.0	55.5		60.0	60.0	59.0
	59.0			56.5				59.0
	60.0			58.5				60.0
				59.0				
				60.0				

APPENDIX D-2 (Continued)

SAMPLE	1	2	3	4	5
REP 3					
RPM CODE 1					
	10.0	10.0	10.0	10.0	15.0
	17.0	10.0	13.5	10.5	15.0
	19.0	11.0	15.0	10.5	15.5
	19.0	11.5	19.5	12.5	18.5
	19.5	15.5	22.0	13.0	20.0
	20.0	19.0	24.0	13.5	22.5
	20.0	21.5	25.0	15.5	25.0
	21.0	26.5	25.5	17.5	26.5
	25.5	27.5	27.0	18.5	29.0
	26.5	30.5	29.0	22.0	32.0
	28.0	37.5	31.0	23.5	37.0
	34.5	38.0	31.5	24.0	38.0
	37.0	40.0	32.0	26.5	40.0
	37.5	41.0	34.0	29.0	43.0
	38.5	43.5	35.5	30.5	47.5
	40.5	47.5	40.0	31.5	48.5
	41.0	51.0	42.5	33.5	58.0
	42.0	52.5	45.5	36.5	58.5
	46.0	55.0	47.0	37.5	59.5
	49.5	57.5	47.5	39.0	61.0
	51.0	60.0	56.0	46.5	63.0
	54.0	60.0	57.0	48.0	64.5
	58.5		60.0	49.5	65.0
	60.0			54.5	
				55.5	
				60.0	

APPENDIX D-2 (Continued)

SAMPLE	1	2	3	4	5	6	7
REP 3 RPM CODE 2							
	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	10.5	11.5	11.0	10.0	10.0	10.0	12.0
	14.5	13.5	25.0	15.0	14.0	17.5	14.5
	18.5	13.5	26.5	16.5	15.0	19.5	15.5
	19.0	15.0	29.0	18.5	19.5	21.0	18.5
	29.5	16.0	30.5	19.0	21.0	22.0	19.0
	31.5	17.0	31.0	26.0	21.5	22.5	19.0
	33.5	19.5	31.0	28.0	23.0	24.5	22.0
	39.5	27.5	31.0	30.0	25.5	27.5	23.5
	43.5	30.0	41.5	32.5	26.5	31.5	26.5
	46.0	37.0	43.5	33.5	28.0	32.5	36.0
	48.0	39.5	45.0	35.5	31.0	34.5	37.5
	50.0	41.0	46.5	36.0	34.5	35.5	39.0
	54.5	43.5	47.5	37.0	37.5	41.0	40.5
	56.5	44.5	49.5	39.5	38.5	43.0	42.0
	58.0	45.5	54.5	42.0	41.5	45.0	44.5
	59.5	46.0	54.5	44.0	41.5	46.5	46.0
	60.0	47.0	56.0	47.0	41.5	48.5	46.5
		51.0	57.0	48.5	45.0	51.5	47.0
		57.0	57.0	52.5	47.0	52.5	50.5
		60.0	58.0	60.0	48.5	58.0	55.5
			59.5	60.0	57.0	59.0	57.0
			60.0		59.5	60.0	60.0
					60.0		60.0

APPENDIX D-2 (Continued)

REP 3
RPM CODE 3

SAMPLE	1	2	3	4	5	6	7	8
	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	13.0	16.5	13.5	11.5	14.0	12.5	10.5	13.0
	13.5	18.5	21.5	12.0	15.5	13.5	14.5	19.5
	15.0	20.0	23.0	14.0	17.5	14.0	21.5	21.0
	17.0	21.5	25.0	15.5	18.5	17.5	25.0	23.0
	18.5	22.5	33.0	20.5	19.5	19.0	25.5	25.0
	19.0	23.0	34.0	27.5	20.5	25.5	26.5	27.0
	20.0	24.0	35.0	28.0	22.0	32.0	29.0	28.0
	21.5	26.5	39.5	28.5	28.5	32.5	32.0	34.5
	23.5	28.5	40.0	34.0	36.0	33.0	37.5	35.0
	23.5	33.0	41.0	36.5	38.0	39.5	37.5	36.5
	24.0	40.0	57.0	37.0	42.5	44.0	38.0	36.5
	24.0	40.5	57.5	37.5	44.0	45.5	39.0	39.0
	25.0	42.0	60.0	38.5	46.0	46.5	46.0	41.5
	25.0	42.5		43.0	48.0	48.0	47.5	41.5
	26.5	43.5		50.5	48.5	48.5	49.5	42.5
	28.5	43.5		53.0	49.5	49.5	50.5	43.0
	29.0	44.0		55.5	50.5	50.0	51.5	50.5
	30.5	49.0		58.0	58.0	51.5	53.5	52.5
	32.5	50.0		59.5	59.0	52.0	60.0	54.5
	46.0	51.5		60.0	59.5	56.0	60.0	55.0
	48.0	52.5		60.0	60.0	59.0		57.0
	52.0	54.5		60.0		60.0		57.5
	52.5	56.5						59.0
	58.5	57.5						60.0
	60.0	60.0						60.0

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