United States Patent [19]

Misra et al.

[11] **Patent Number: 4,991,721**

[45] **Date of Patent: Feb. 12, 1991**

[54] **AUTOMATION OF AN AIR-SCREEN SEED CLEANER**

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[73] Assignee: **Iowa State University Research Foundation, Inc.,** Ames, Iowa

[21] Appl. No.: **231,946**

[22] Filed: **Aug. 15, 1988**

[51] **Int. Cl.**[5] **B07B 9/00;** B07B 4/02; G05B 13/02

[52] **U.S. Cl.** **209/31;** 209/37; 209/139.001; 209/257; 209/546; 209/557; 364/502; 364/552

[58] **Field of Search** 209/21, 30–37, 209/44.1, 44.2, 134–139.1, 146, 147, 149, 153, 154, 237, 238, 255, 257, 546, 549, 552, 555, 557, 629, 639; 55/215, 218, 270, 279, 413, 423–426; 364/500, 502, 552, 555; 406/28, 168, 169, 173

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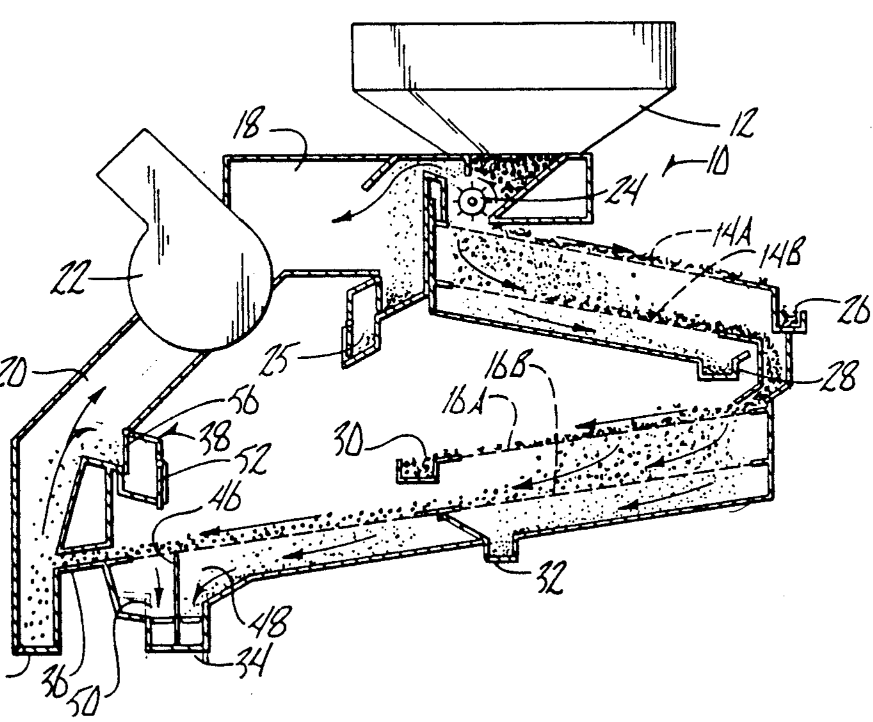
Primary Examiner—Margaret A. Focarino
Assistant Examiner—Edward M. Wacyra
Attorney, Agent, or Firm—Zarley, McKee, Thomte, Voorhees & Sease

[57] **ABSTRACT**

A cleaning system is provided for separating desired material from undesirable material in a mixture of particulate materials. The system includes an inlet for receiving the mixture of materials and an outlet for discharging the desired materials. At least one screen is provided for separating undersized material from oversized material within the mixture, and at least one vacuum air-lift is provided for separating the lighter material from the heavier material within the mixture. A first sensor is mounted below the discharge end of the screen for sensing the quantity of undersized material separated by the screen and a second sensor is mounted in the air-lift for sensing the quantity of lighter materials separated by the air-lift. The signals generated by the sensors can be received by a processing unit which adjusts the extent of separation by the screen and by the air-lift to achieve the desired efficiency of the cleaning system.

16 Claims, 23 Drawing Sheets



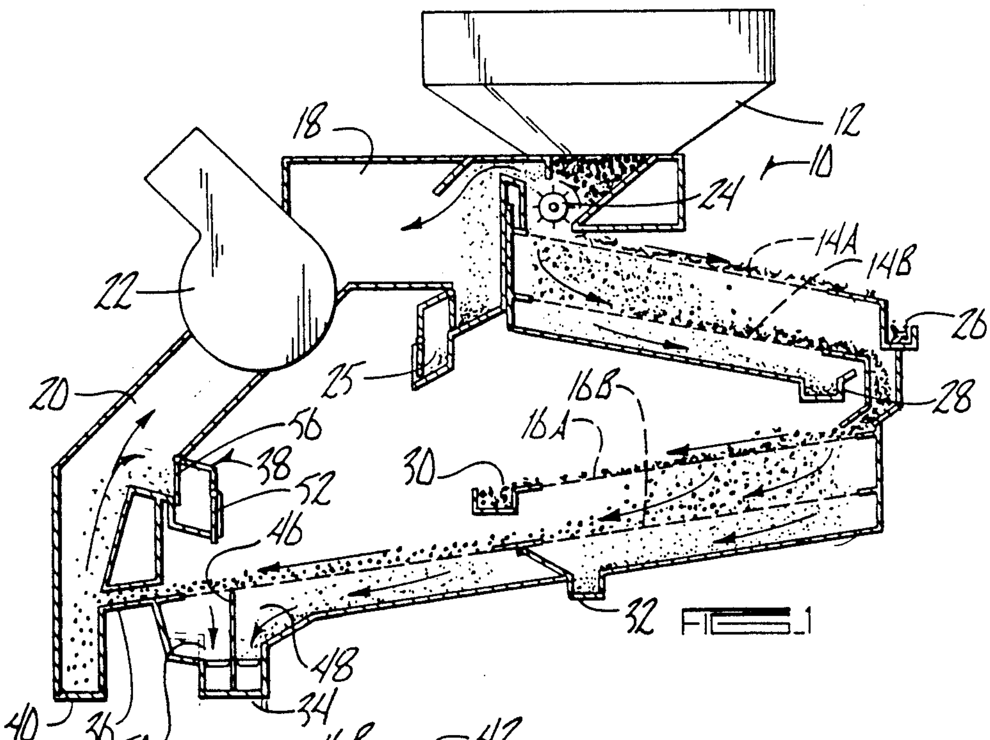


FIG_1

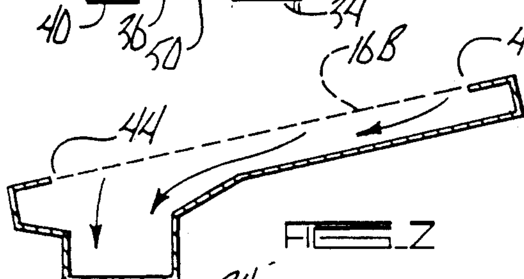


FIG_2

(PRIOR ART)

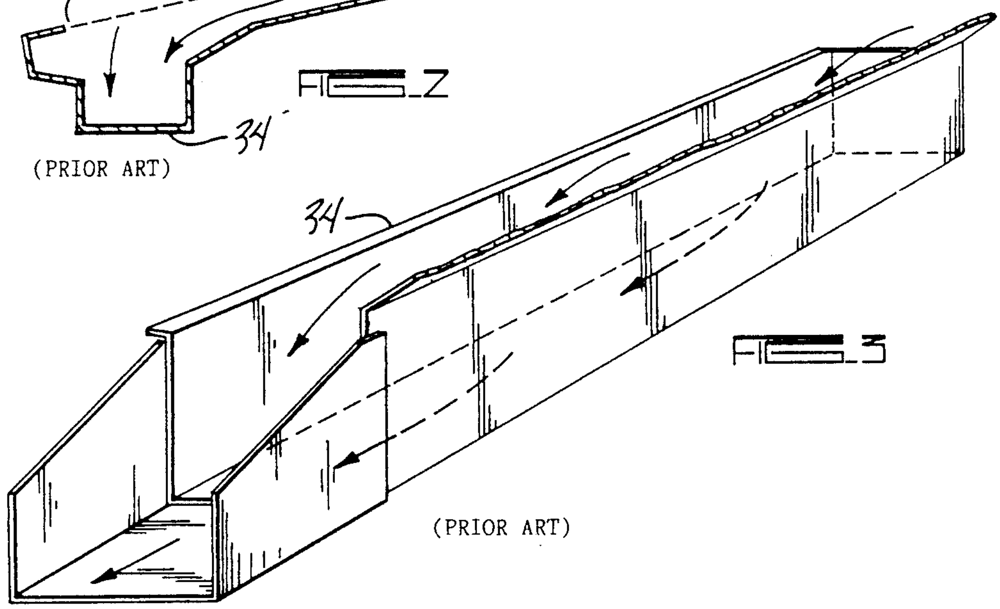


FIG_3

(PRIOR ART)

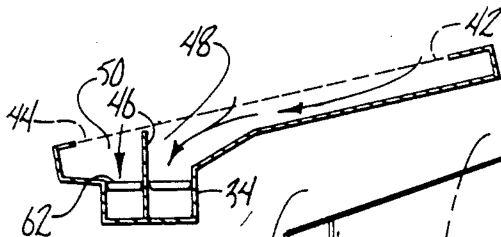


FIG. 4

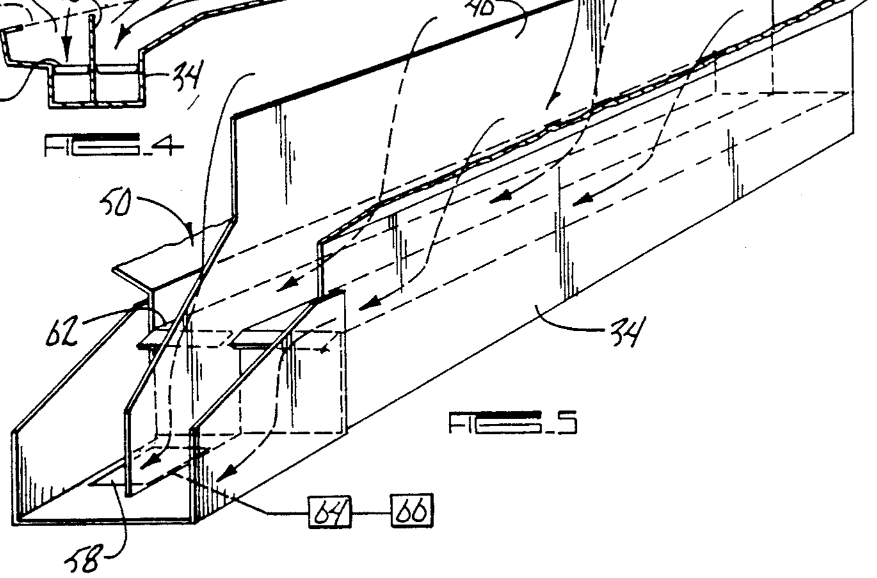
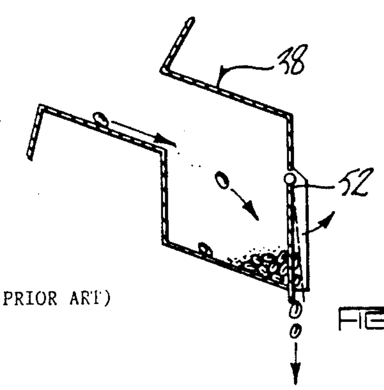
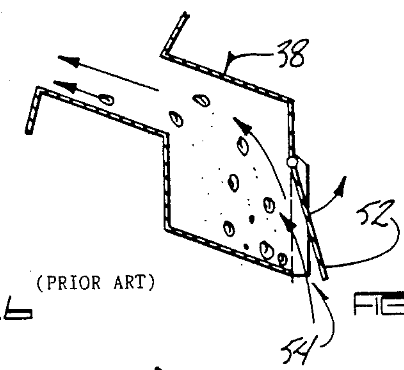


FIG. 5



(PRIOR ART) FIG. 6



(PRIOR ART) FIG. 7

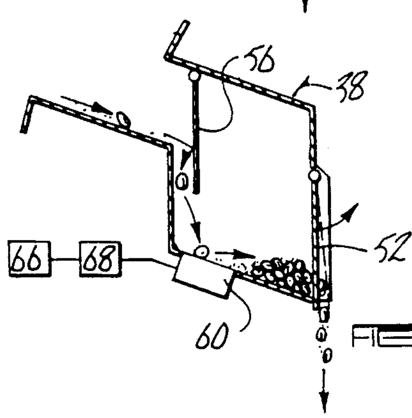


FIG. 8

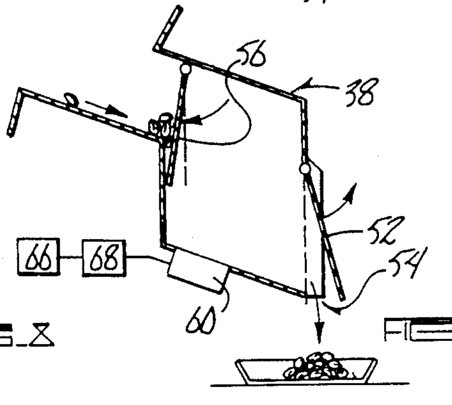


FIG. 9

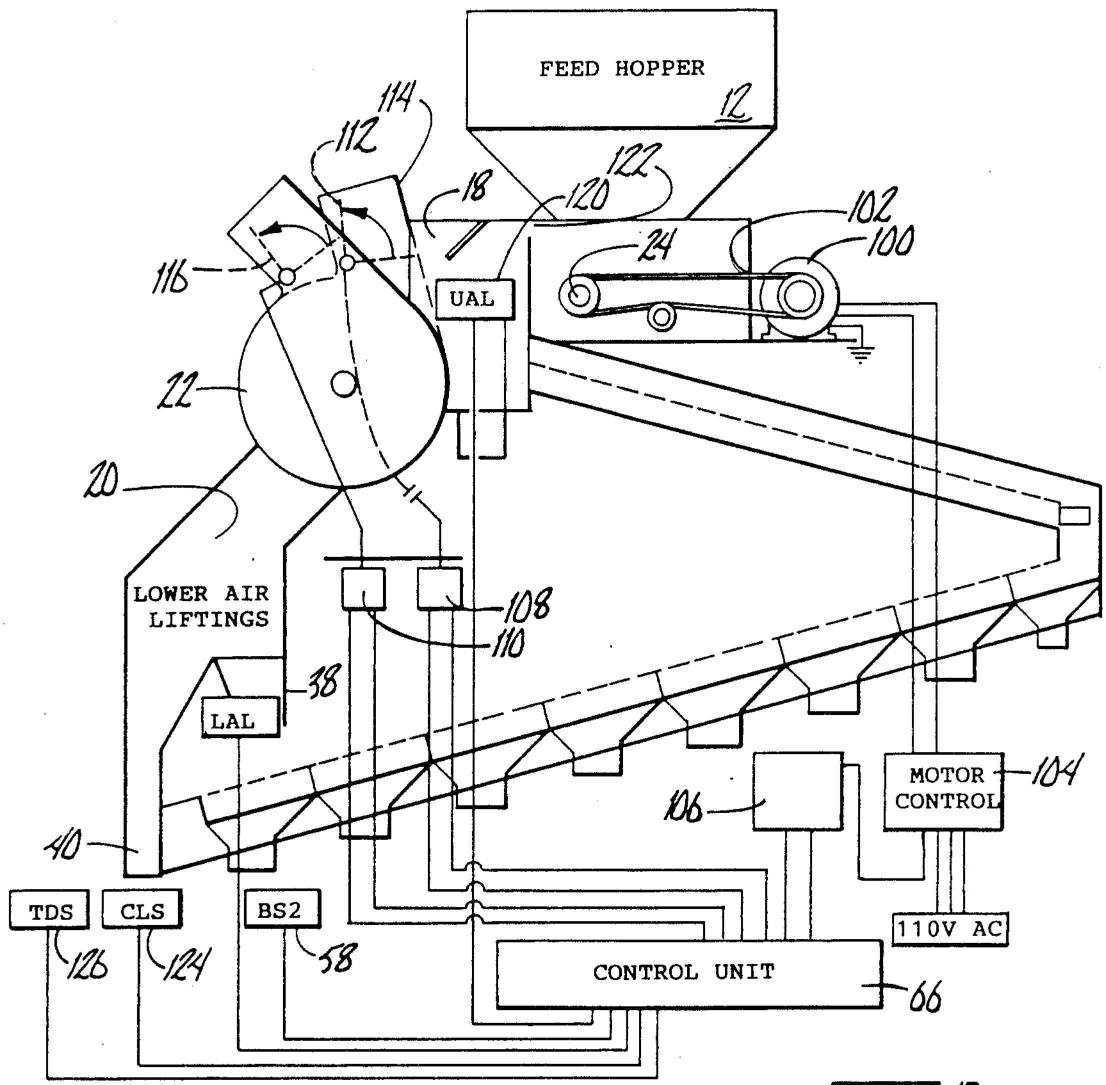

FEED HOPPER
12
114
112
122
18
120
102
100
24
116
UAL
22
20
LOWER AIR LIFTINGS
108
110
38
LAL
MOTOR CONTROL
104
106
40
TDS
CLS
BS2
110V AC
126
124
58
CONTROL UNIT
66

FIG_10

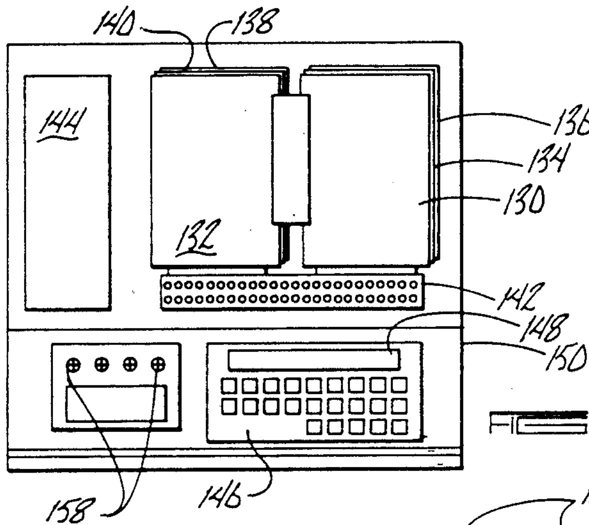


FIG. 11A

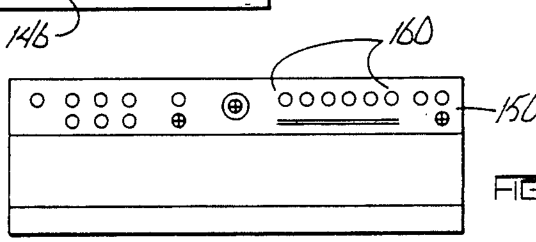


FIG. 11B

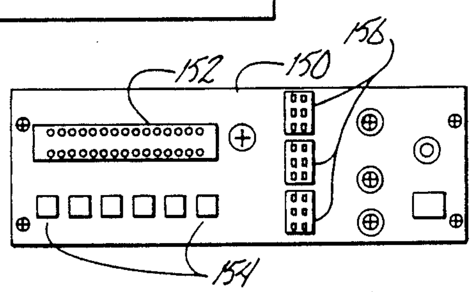


FIG. 11C

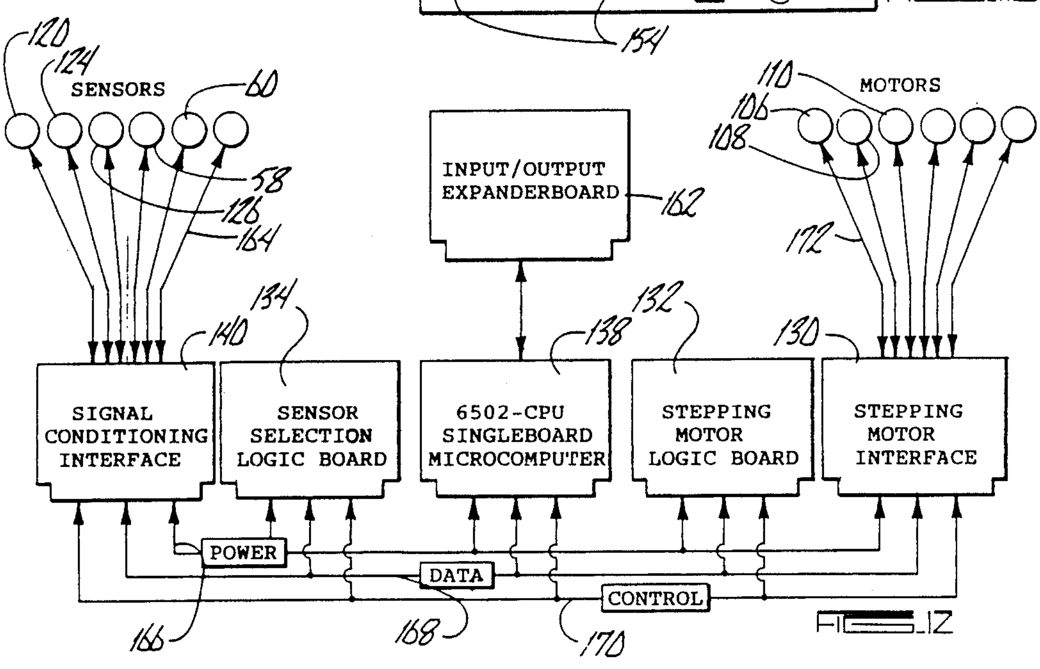


FIG. 12

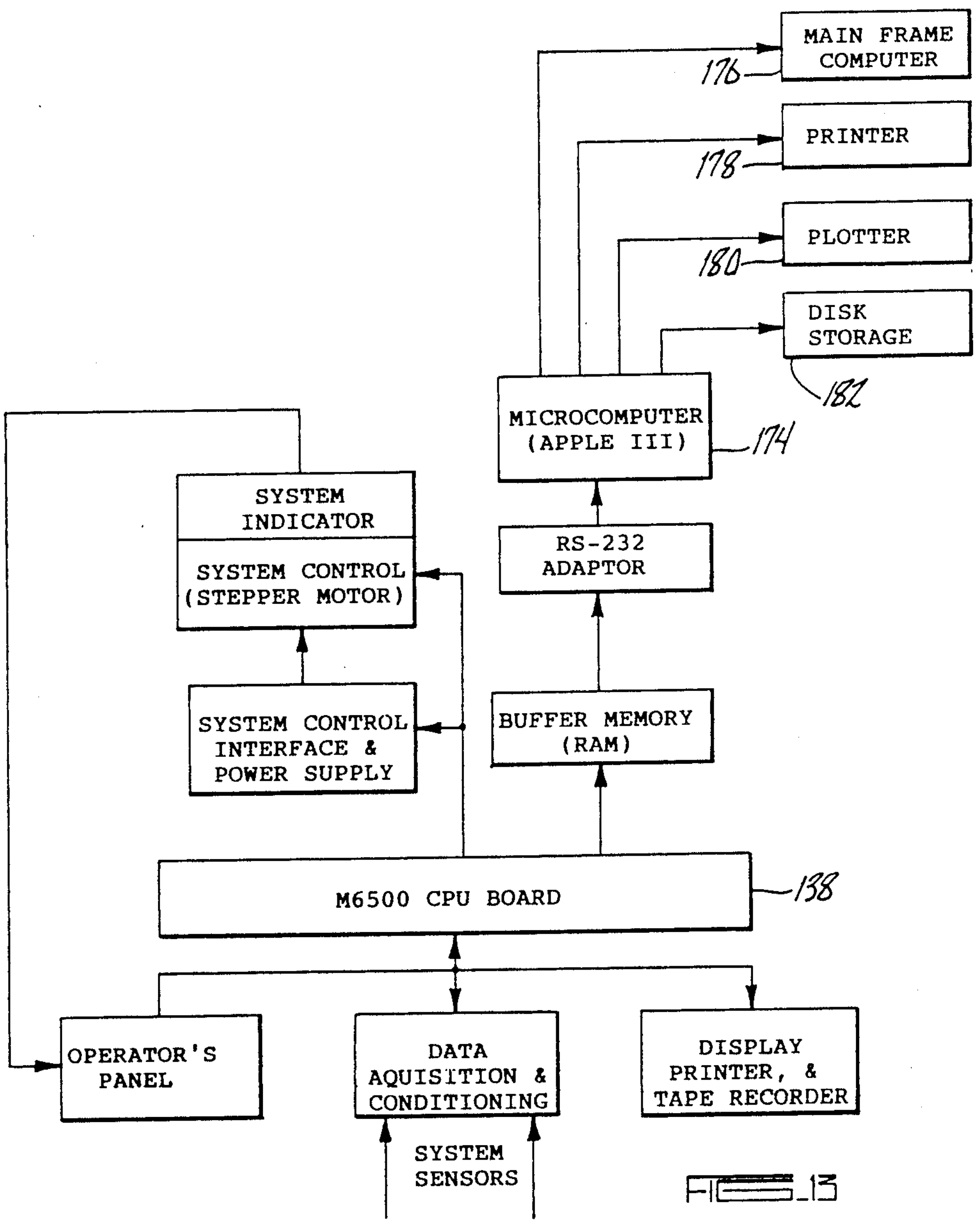

MAIN FRAME COMPUTER
176
PRINTER
178
PLOTTER
180
DISK STORAGE
182
MICROCOMPUTER (APPLE III)
174
RS-232 ADAPTOR
BUFFER MEMORY (RAM)
SYSTEM INDICATOR
SYSTEM CONTROL (STEPPER MOTOR)
SYSTEM CONTROL INTERFACE & POWER SUPPLY
M6500 CPU BOARD
138
OPERATOR'S PANEL
DATA AQUISITION & CONDITIONING
DISPLAY PRINTER, & TAPE RECORDER
SYSTEM SENSORS

FIG_13

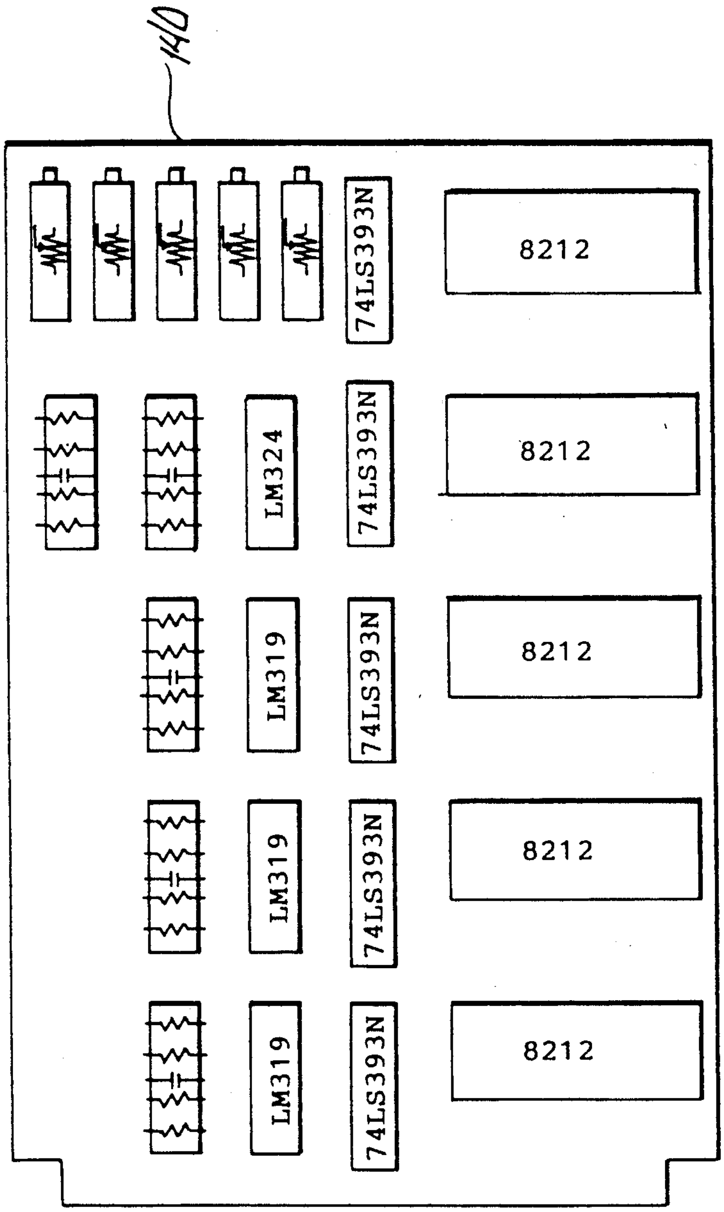


FIG. 14B

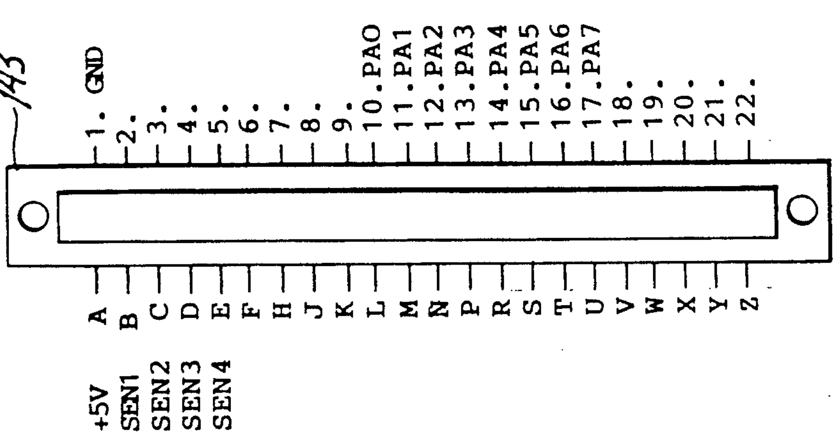


FIG. 14A

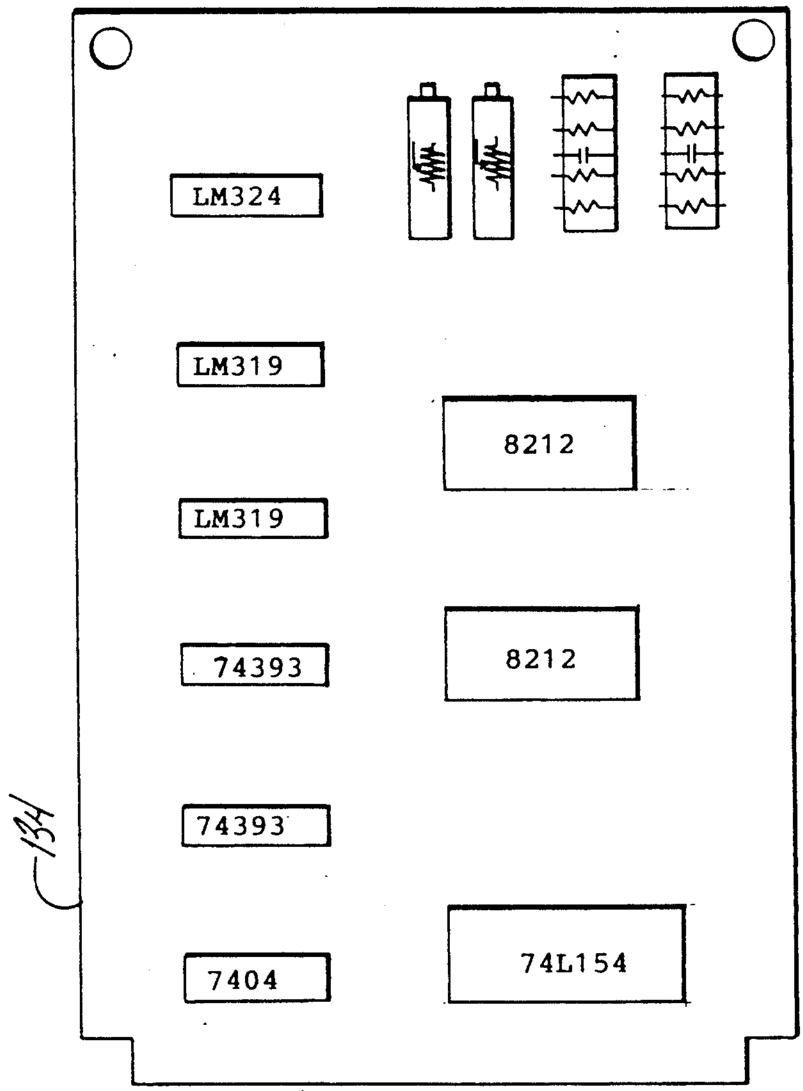


FIG. 15B

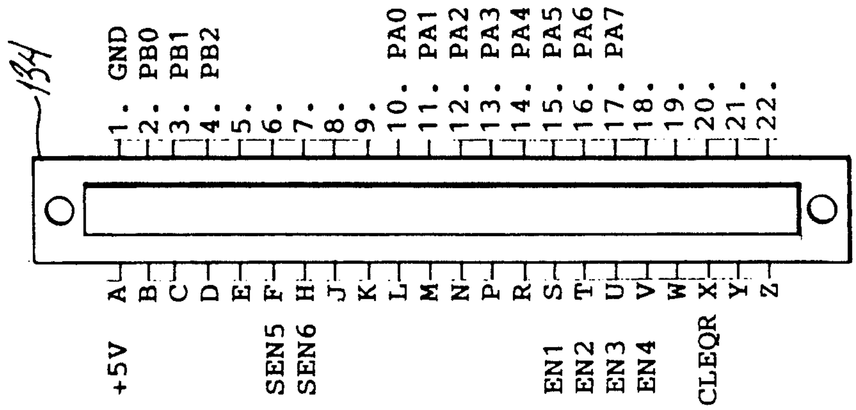


FIG. 15A

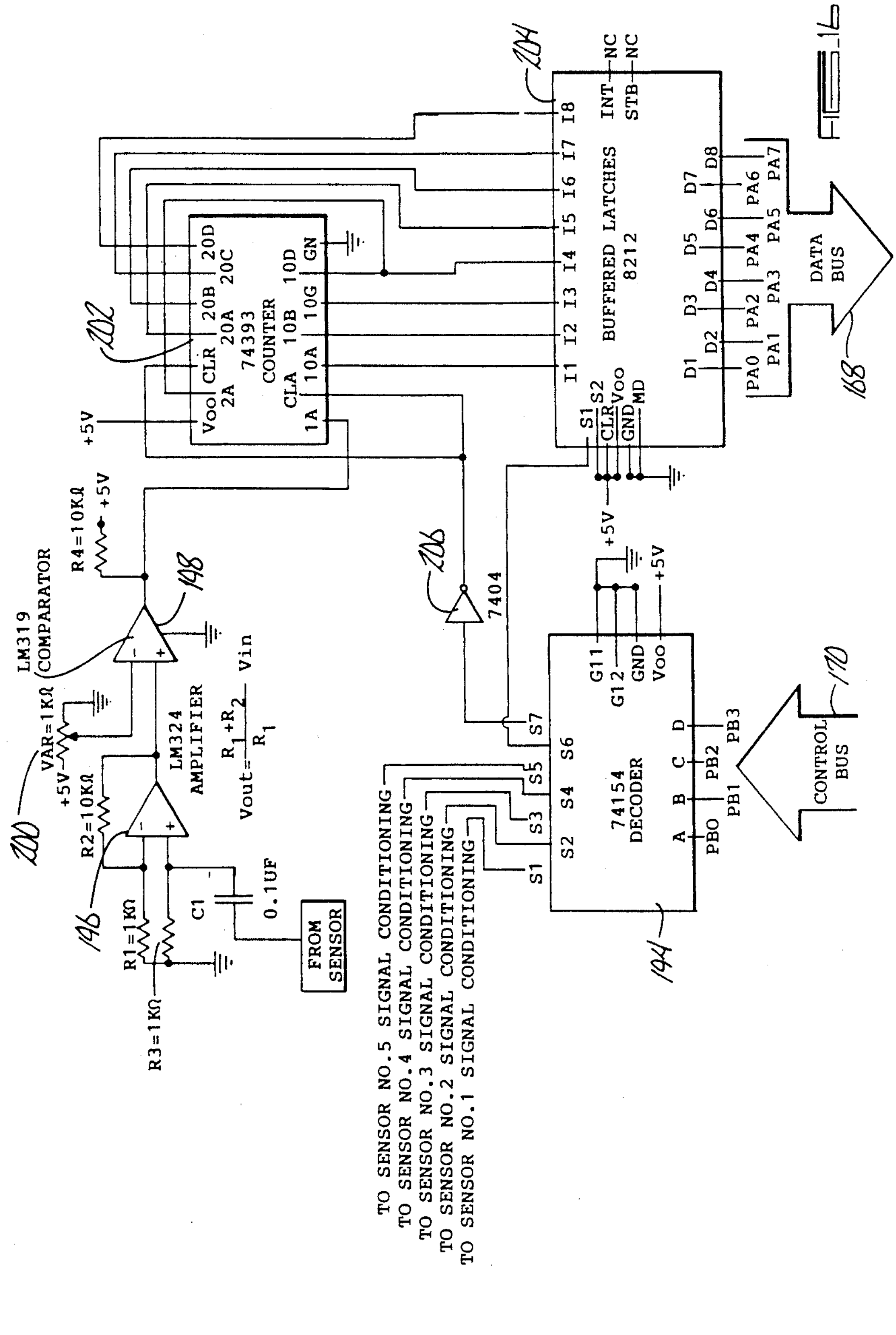

BUFFERED LATCHES
8212
I1 I2 I3 I4 I5 I6 I7 I8
INT—NC
STB—NC
D1 D2 D3 D4 D5 D6 D7 D8
PA0 PA1 PA2 PA3 PA4 PA5 PA6 PA7
S1 S2 CLR Voo GND MD
DATA BUS
168
204
74393
COUNTER
Voo CLR 20B 20D
2A 20A 20C
CLA 10B 10D
1A 10A 10G GN
202
+5V
R4=10KΩ
+5V
LM319
COMPARATOR
198
VAR=1KΩ
+5V
200
LM324
AMPLIFIER
R2=10KΩ
196
Vout=(R1+R2)/R1 Vin
R1=1KΩ
R3=1KΩ
C1
0.1UF
FROM SENSOR
206
7404
74154
DECODER
S1 S2 S3 S4 S5 S6 S7
G11 G12 GND Voo
A B C D
PB0 PB1 PB2 PB3
CONTROL BUS
170
194
TO SENSOR NO.5 SIGNAL CONDITIONING
TO SENSOR NO.4 SIGNAL CONDITIONING
TO SENSOR NO.3 SIGNAL CONDITIONING
TO SENSOR NO.2 SIGNAL CONDITIONING
TO SENSOR NO.1 SIGNAL CONDITIONING

FIG. 16

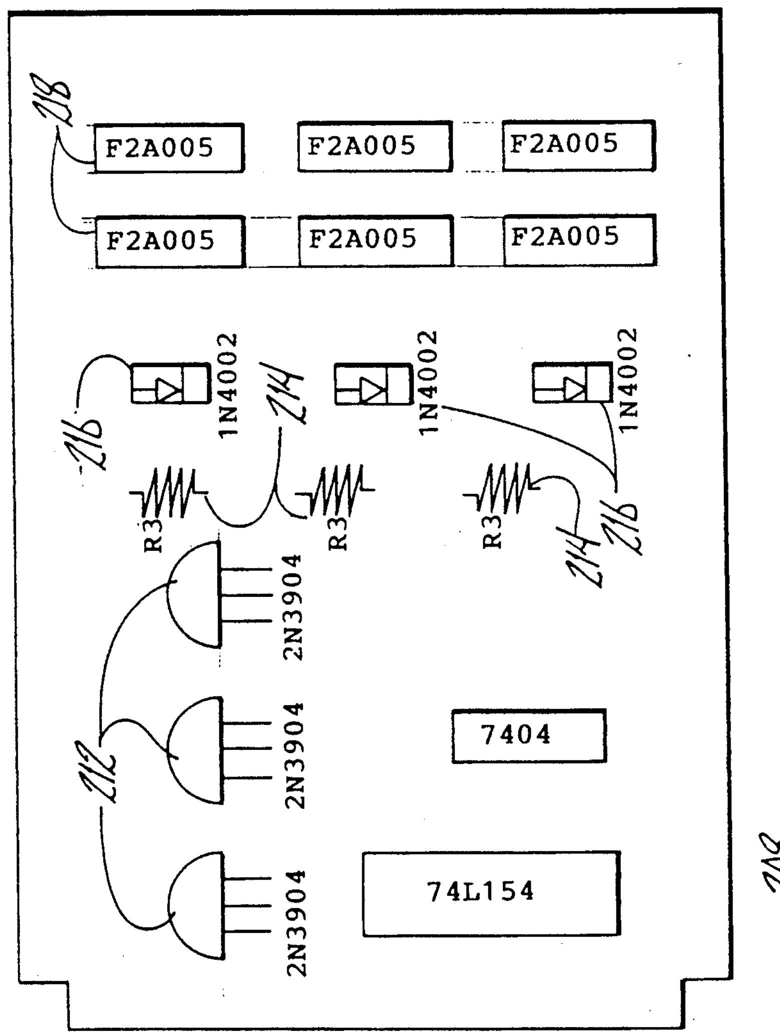


FIG_17B

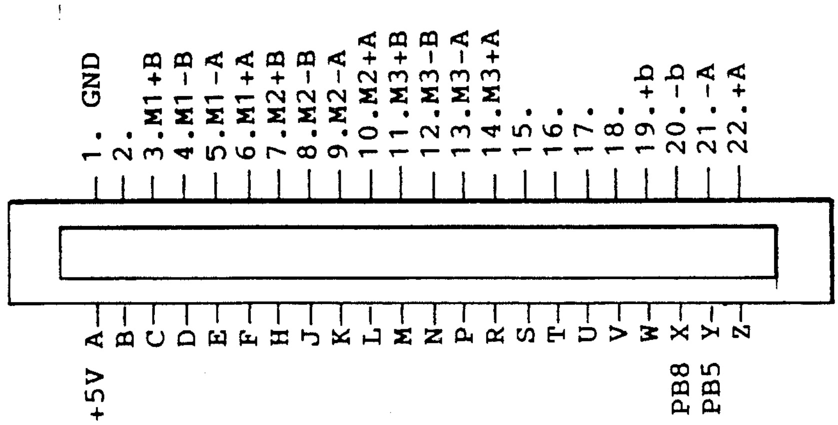


FIG_17A

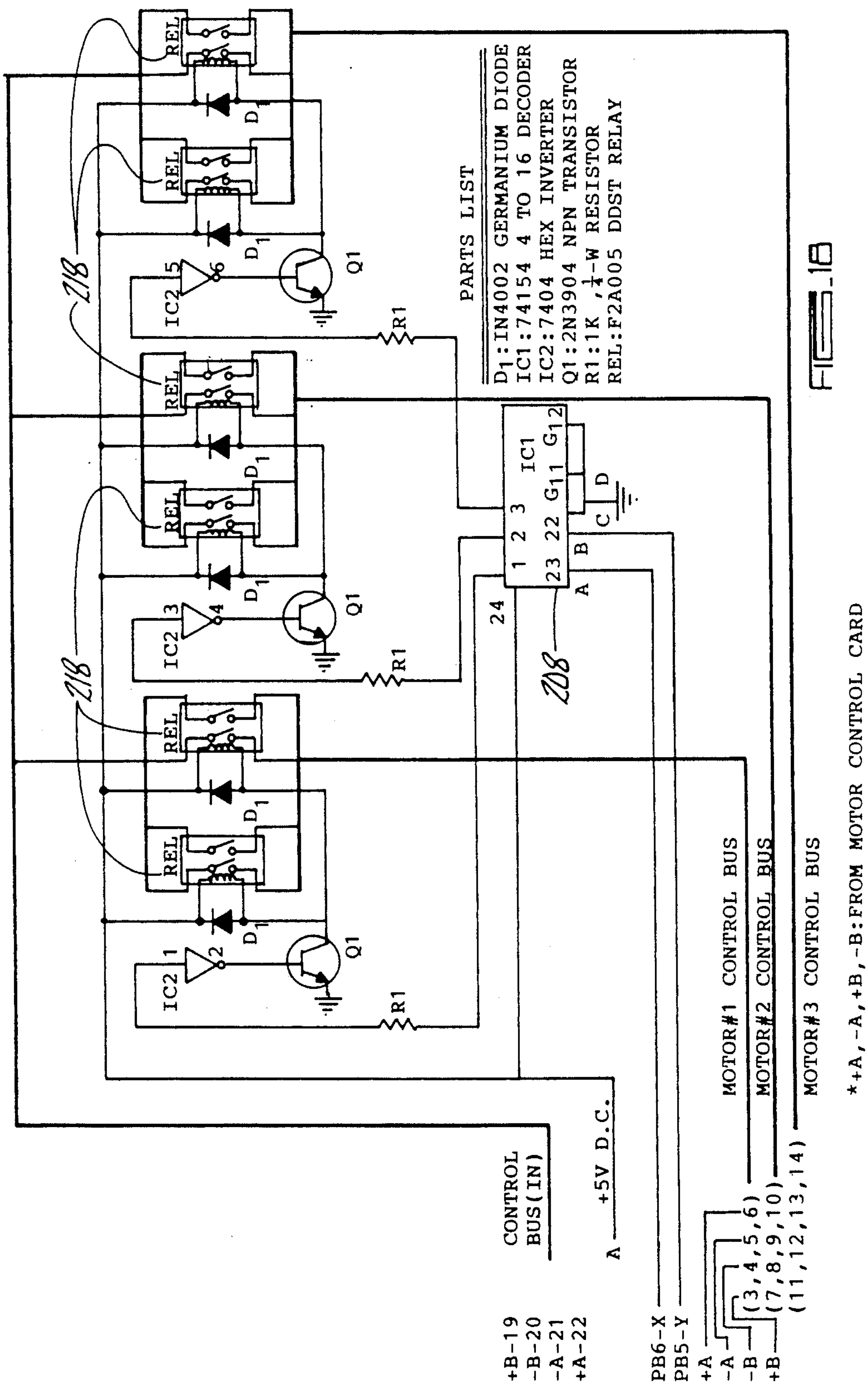

PARTS LIST
D1:IN4002 GERMANIUM DIODE
IC1:74154 4 TO 16 DECODER
IC2:7404 HEX INVERTER
Q1:2N3904 NPN TRANSISTOR
R1:1K ,¼-W RESISTOR
REL:F2A005 DDST RELAY
REL
D1
IC2
Q1
R1
218
IC1
G11
G12
A B C D
1 2 3
23 22
24
208
CONTROL BUS(IN)
+5V D.C.
A
+B-19
-B-20
-A-21
+A-22
PB6-X
PB5-Y
+A
-A
-B
+B
(3,4,5,6)
(7,8,9,10)
(11,12,13,14)
MOTOR#1 CONTROL BUS
MOTOR#2 CONTROL BUS
MOTOR#3 CONTROL BUS
*+A,-A,+B,-B:FROM MOTOR CONTROL CARD

FIG. 18

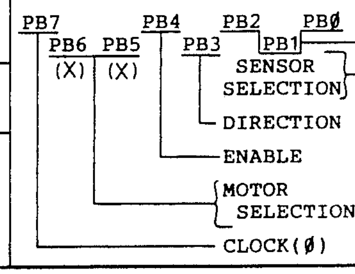
PORT B VALUE(#$)	FUNCTION	POWER LINE (OUTSIDE)	NOTE
6∅	DISABLE		
4∅ 48	M#1 CCW(DECREASE LOWER AIR) M#1 CW(INCREASE LOWER AIR)	>+12V DC	
2∅ 28	M#2CCW(DECREASE UPPER AIR) M#2 CW(INCREASE UPPER AIR)	>+12V DC	
∅∅ ∅8	M#3CCW(INCREASE FEED RATE) M#3 CW(DECREASE FEED RATE)	>+12V DC	

FIG. 19A

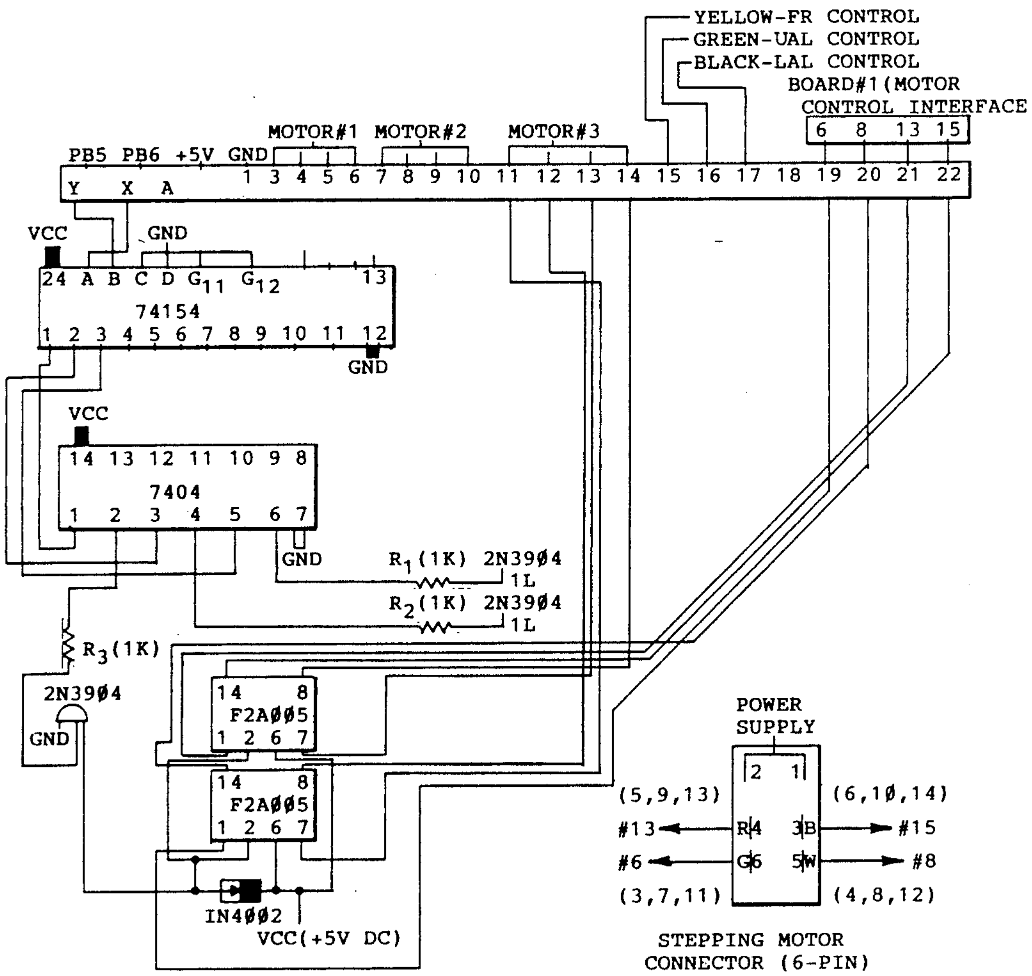


FIG. 19B

FIG. 19C

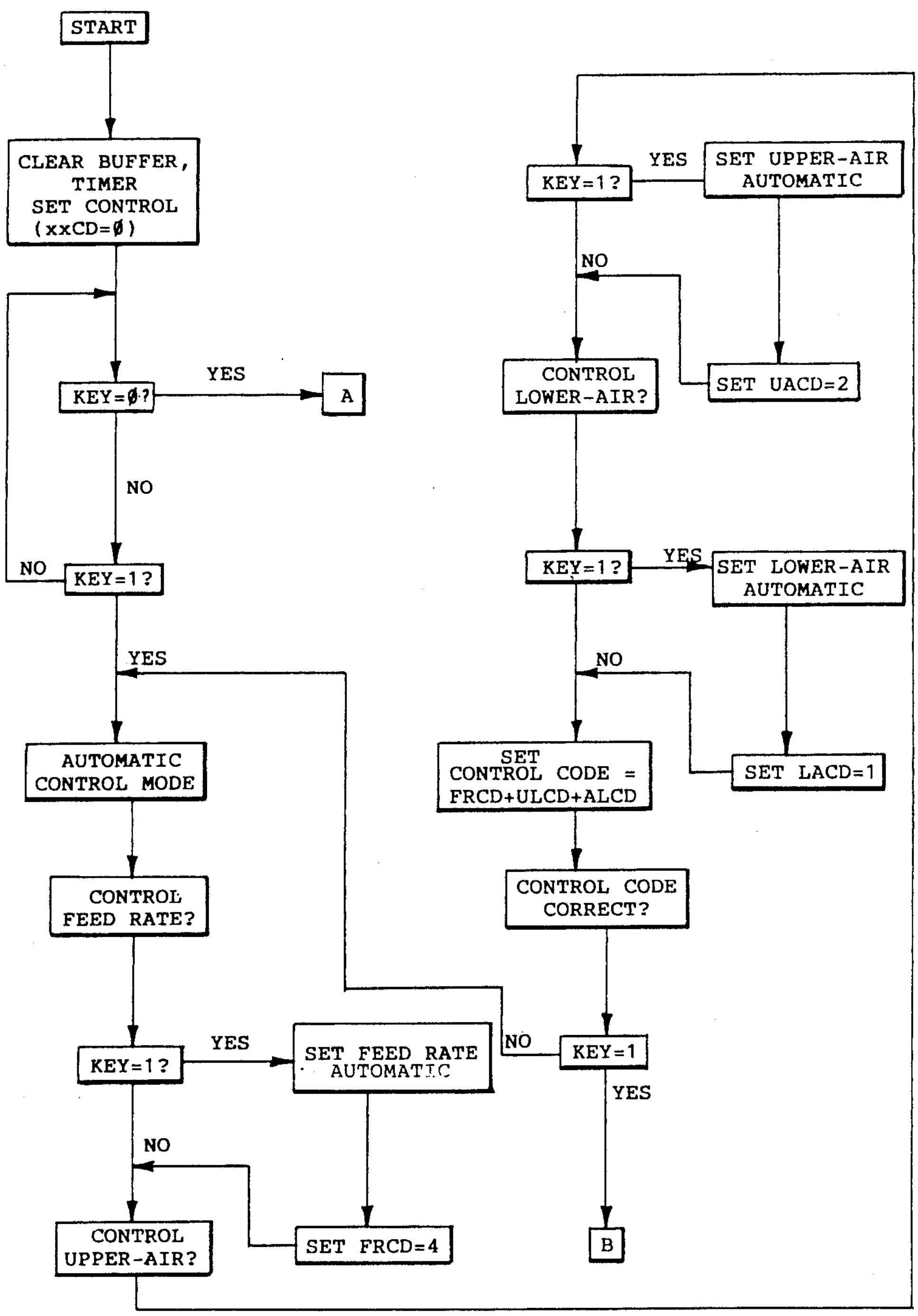
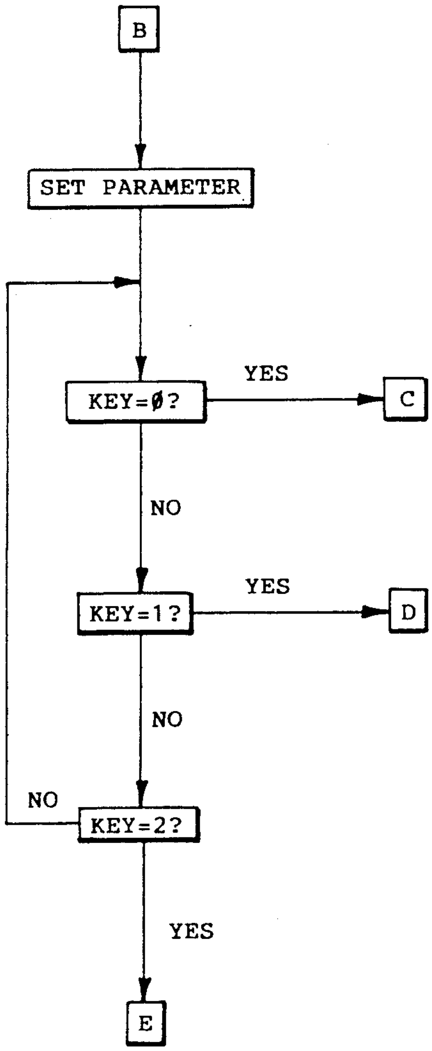

START
CLEAR BUFFER, TIMER SET CONTROL (xxCD=Ø)
KEY=Ø?
YES
A
NO
NO
KEY=1?
YES
AUTOMATIC CONTROL MODE
CONTROL FEED RATE?
KEY=1?
YES
SET FEED RATE AUTOMATIC
NO
SET FRCD=4
CONTROL UPPER-AIR?
KEY=1?
YES
SET UPPER-AIR AUTOMATIC
NO
SET UACD=2
CONTROL LOWER-AIR?
KEY=1?
YES
SET LOWER-AIR AUTOMATIC
NO
SET LACD=1
SET CONTROL CODE = FRCD+ULCD+ALCD
CONTROL CODE CORRECT?
NO
KEY=1
YES
B

FIG. 20



C: PROGRAM PRESET PARAMETERS ARE USED.
D: PARAMETERS GIVEN BY OPERATOR ARE USED.
E: PARAMETERS GIVEN BY AUTOMATIC READING PROGRAM ARE USED.

FIG_21

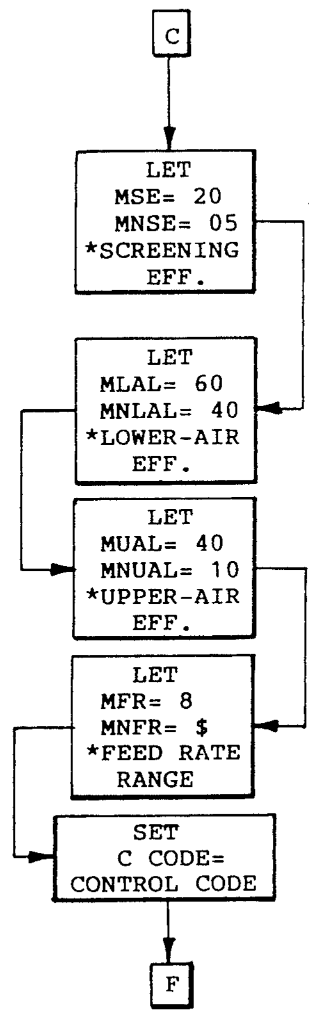


FIG_22

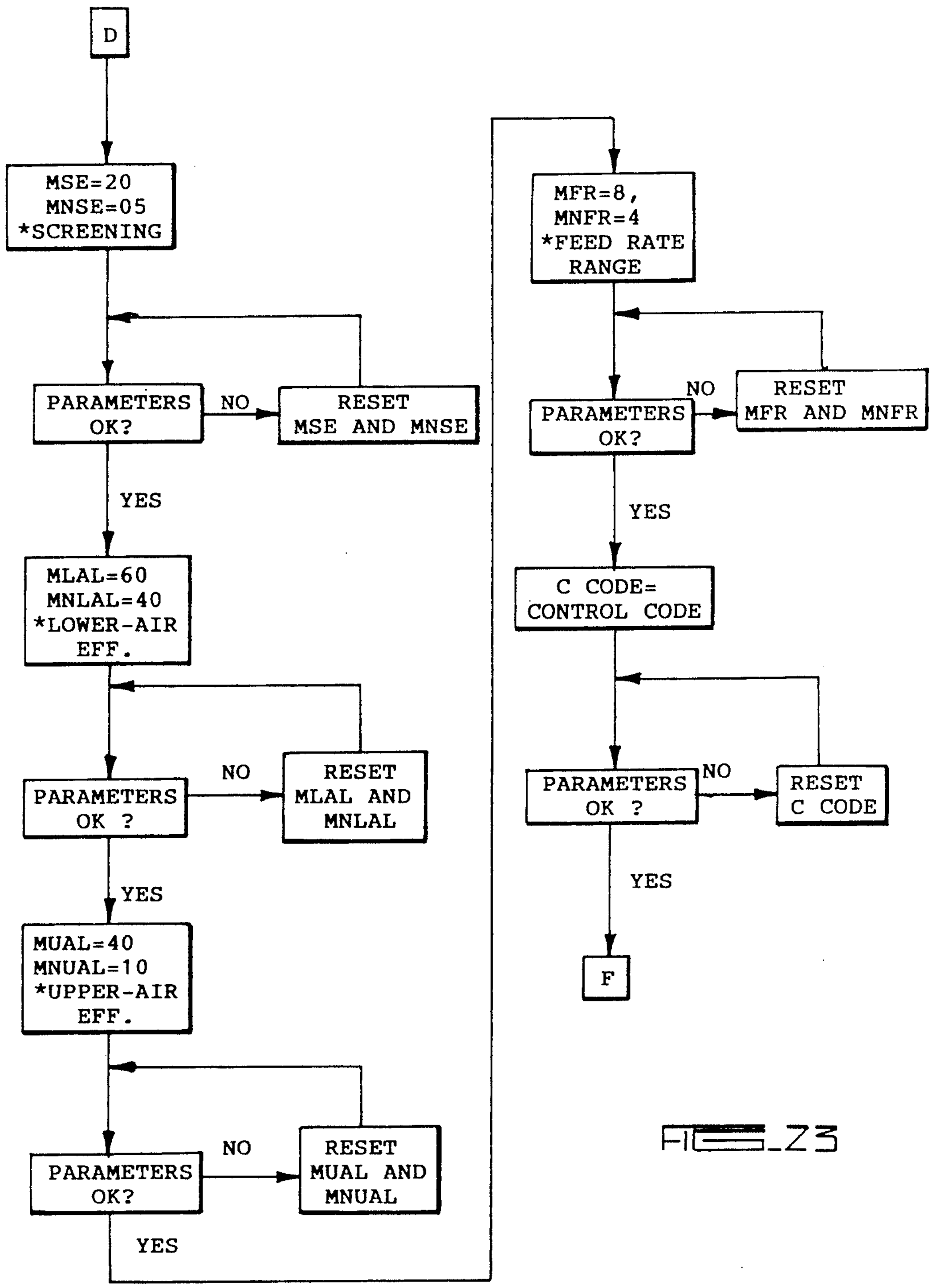

D
MSE=20
MNSE=05
*SCREENING
PARAMETERS OK?
NO
RESET MSE AND MNSE
YES
MLAL=60
MNLAL=40
*LOWER-AIR EFF.
PARAMETERS OK ?
NO
RESET MLAL AND MNLAL
YES
MUAL=40
MNUAL=10
*UPPER-AIR EFF.
PARAMETERS OK?
NO
RESET MUAL AND MNUAL
YES
MFR=8,
MNFR=4
*FEED RATE RANGE
PARAMETERS OK?
NO
RESET MFR AND MNFR
YES
C CODE= CONTROL CODE
PARAMETERS OK ?
NO
RESET C CODE
YES
F

FIG_23

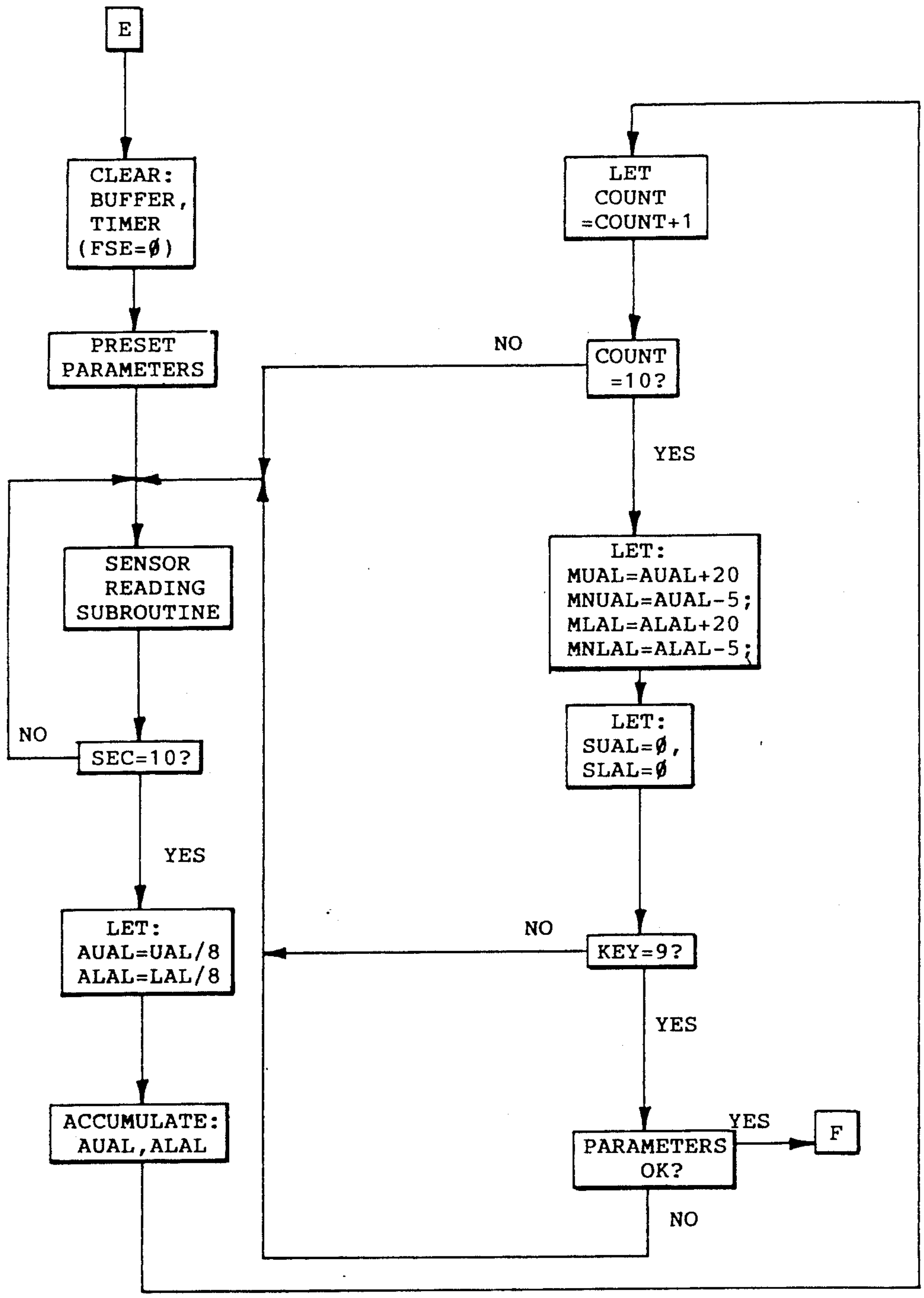

E
CLEAR: BUFFER, TIMER (FSE=Ø)
PRESET PARAMETERS
SENSOR READING SUBROUTINE
NO
SEC=10?
YES
LET: AUAL=UAL/8 ALAL=LAL/8
ACCUMULATE: AUAL,ALAL
LET COUNT =COUNT+1
NO
COUNT =10?
YES
LET: MUAL=AUAL+20 MNUAL=AUAL-5; MLAL=ALAL+20 MNLAL=ALAL-5;
LET: SUAL=Ø, SLAL=Ø
NO
KEY=9?
YES
YES
PARAMETERS OK?
F
NO

FIG. 24

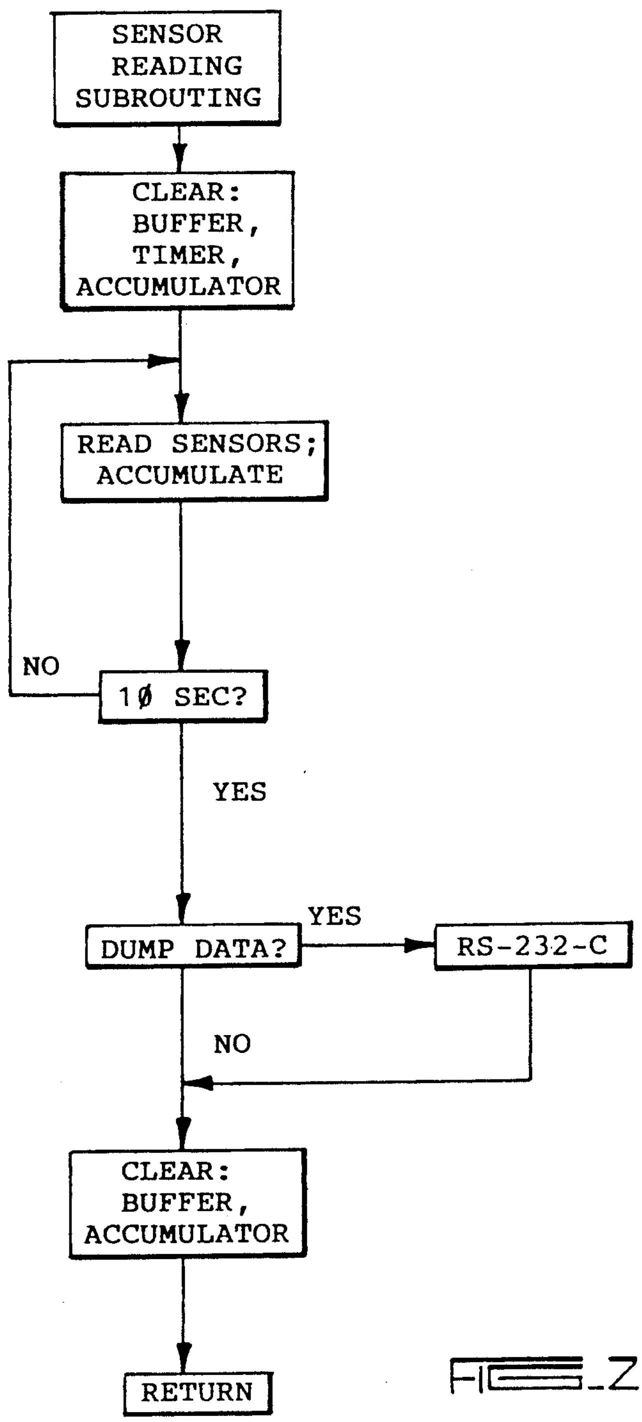

SENSOR READING SUBROUTING
CLEAR: BUFFER, TIMER, ACCUMULATOR
READ SENSORS; ACCUMULATE
NO
1Ø SEC?
YES
YES
DUMP DATA?
RS-232-C
NO
CLEAR: BUFFER, ACCUMULATOR
RETURN

FIG_25

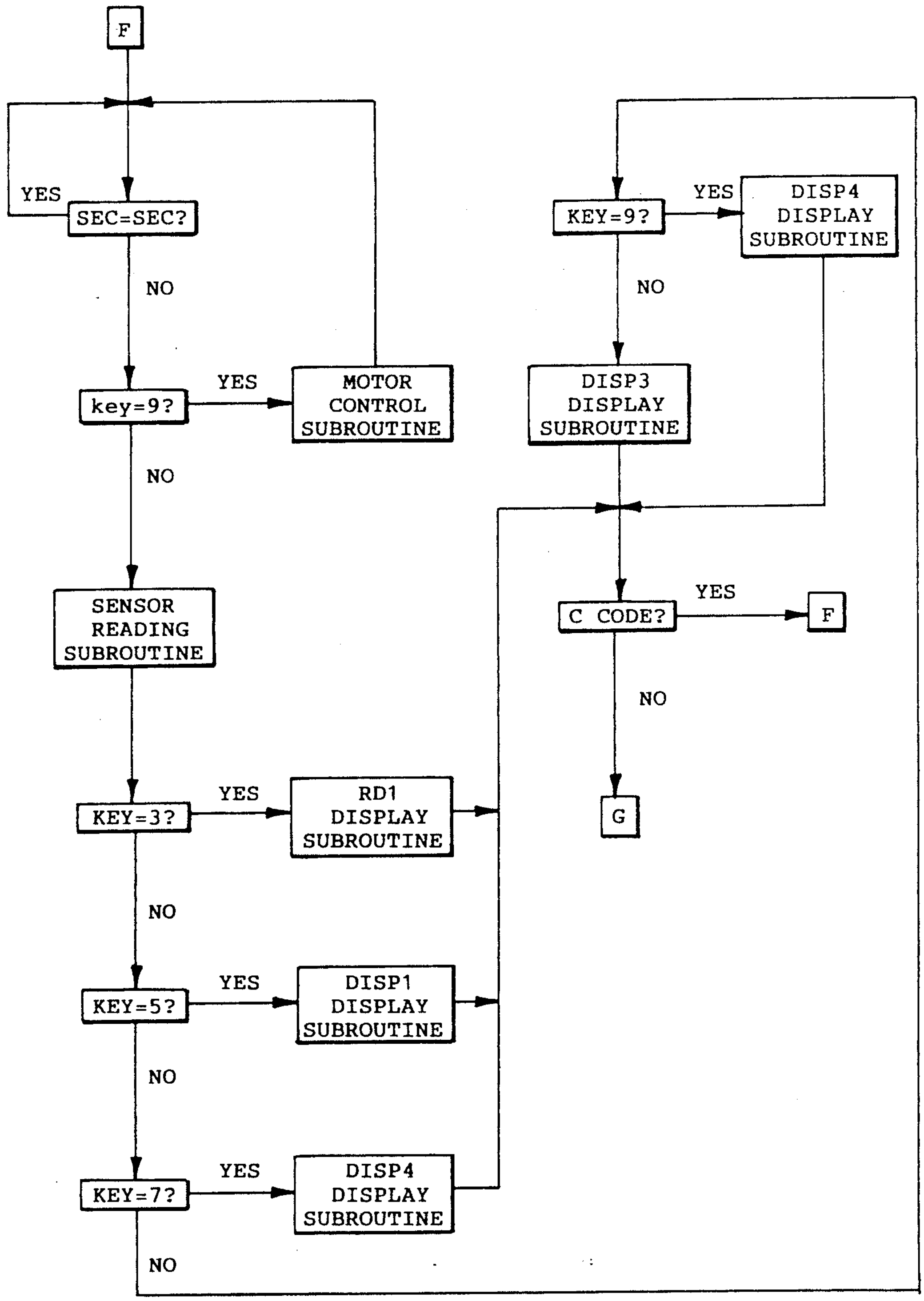

F
YES
SEC=SEC?
NO
key=9?
YES
MOTOR CONTROL SUBROUTINE
NO
SENSOR READING SUBROUTINE
KEY=3?
YES
RD1 DISPLAY SUBROUTINE
NO
KEY=5?
YES
DISP1 DISPLAY SUBROUTINE
NO
KEY=7?
YES
DISP4 DISPLAY SUBROUTINE
NO
KEY=9?
YES
DISP4 DISPLAY SUBROUTINE
NO
DISP3 DISPLAY SUBROUTINE
C CODE?
YES
F
NO
G

FIG_26

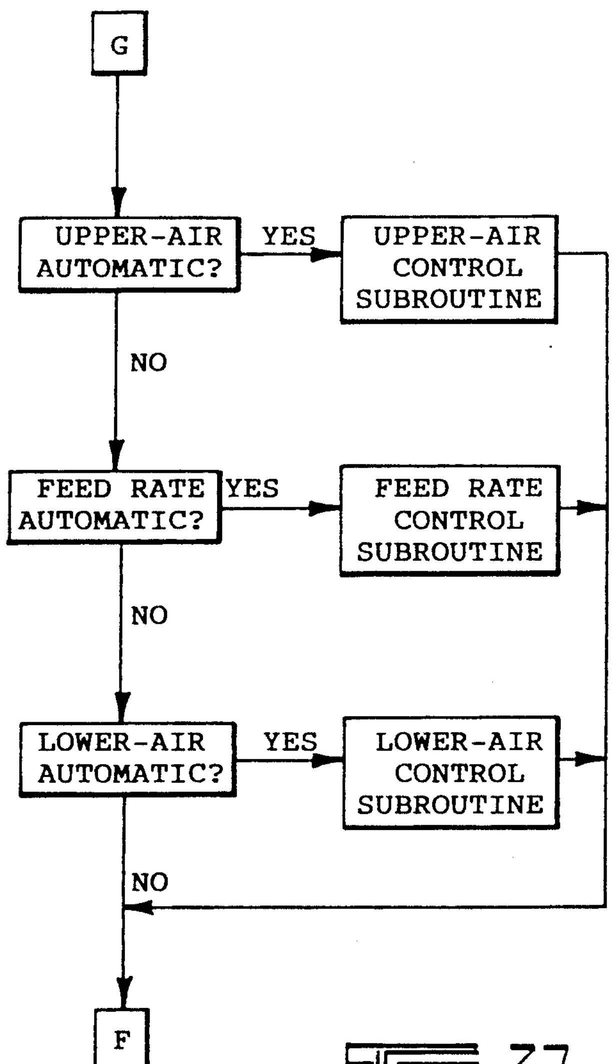

G
UPPER-AIR AUTOMATIC?
YES
UPPER-AIR CONTROL SUBROUTINE
NO
FEED RATE AUTOMATIC?
YES
FEED RATE CONTROL SUBROUTINE
NO
LOWER-AIR AUTOMATIC?
YES
LOWER-AIR CONTROL SUBROUTINE
NO
F

FIG_27

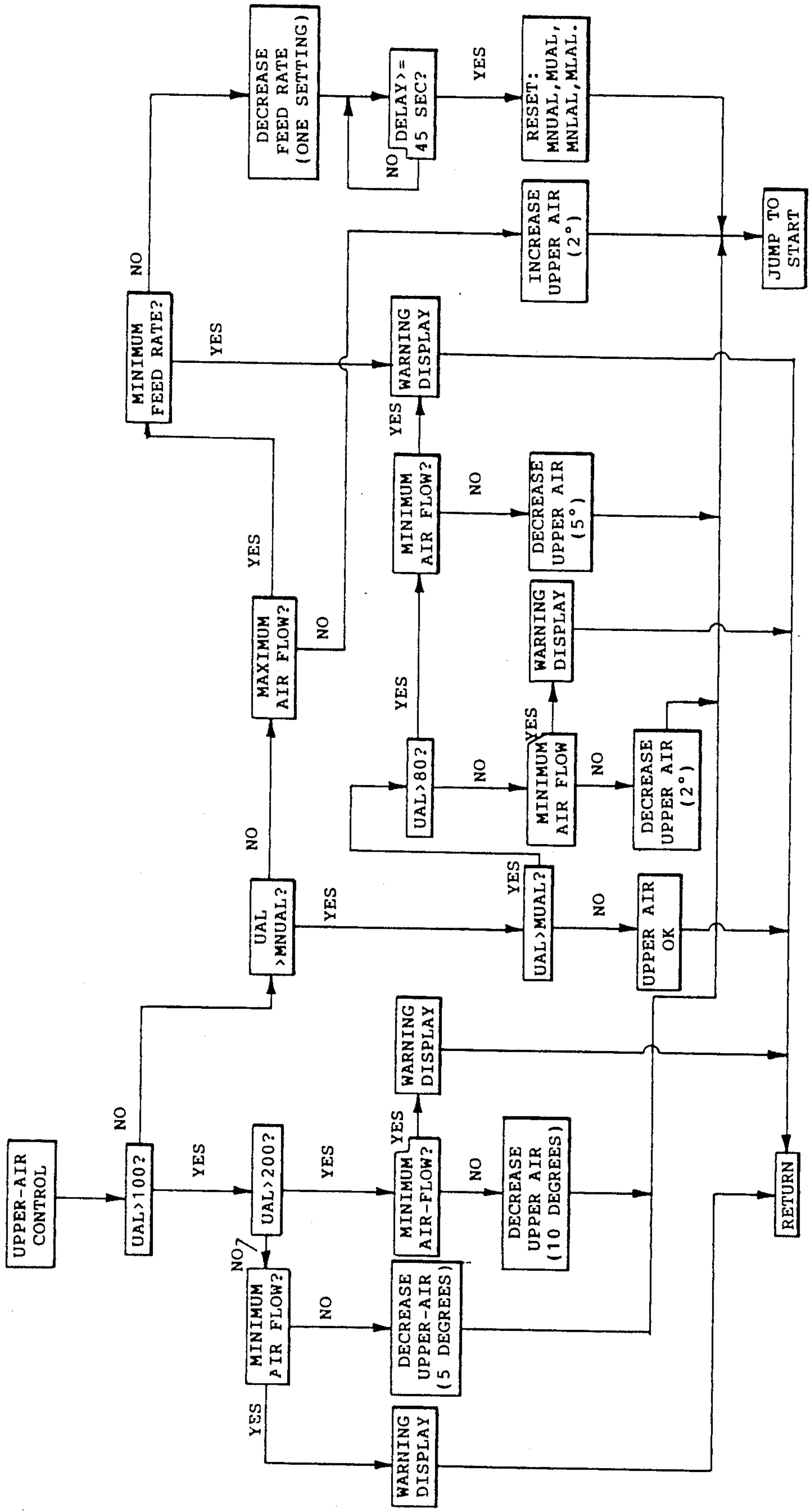

UPPER-AIR CONTROL
UAL>100?
YES
NO
UAL>200?
YES
NO
MINIMUM AIR-FLOW?
YES
NO
WARNING DISPLAY
DECREASE UPPER AIR (10 DEGREES)
MINIMUM AIR FLOW?
NO
YES
DECREASE UPPER-AIR (5 DEGREES)
WARNING DISPLAY
RETURN
UAL >MNUAL?
YES
NO
UAL>MUAL?
YES
NO
UPPER AIR OK
UAL>80?
YES
NO
MINIMUM AIR FLOW
YES
NO
WARNING DISPLAY
DECREASE UPPER AIR (2°)
MINIMUM AIR FLOW?
YES
NO
DECREASE UPPER AIR (5°)
WARNING DISPLAY
MAXIMUM AIR FLOW?
YES
NO
INCREASE UPPER AIR (2°)
JUMP TO START
MINIMUM FEED RATE?
YES
NO
WARNING DISPLAY
DECREASE FEED RATE (ONE SETTING)
DELAY>= 45 SEC?
YES
NO
RESET: MNUAL,MUAL, MNLAL,MLAL.

FIG_28

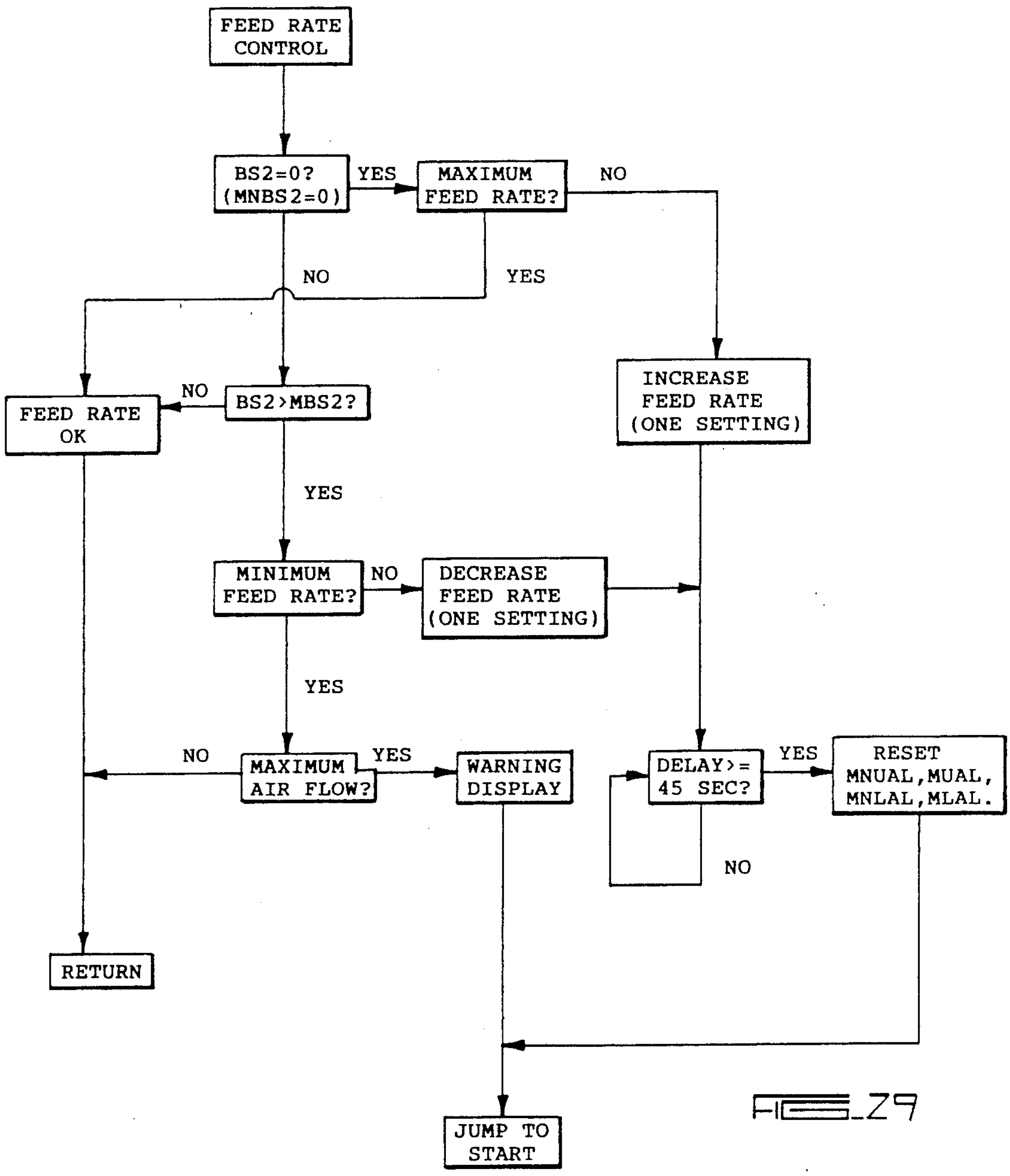

FEED RATE CONTROL
BS2=0? (MNBS2=0)
YES
MAXIMUM FEED RATE?
NO
NO
YES
INCREASE FEED RATE (ONE SETTING)
FEED RATE OK
NO
BS2>MBS2?
YES
MINIMUM FEED RATE?
NO
DECREASE FEED RATE (ONE SETTING)
YES
NO
MAXIMUM AIR FLOW?
YES
WARNING DISPLAY
DELAY>= 45 SEC?
YES
RESET MNUAL,MUAL, MNLAL,MLAL.
NO
RETURN
JUMP TO START

FIG_29

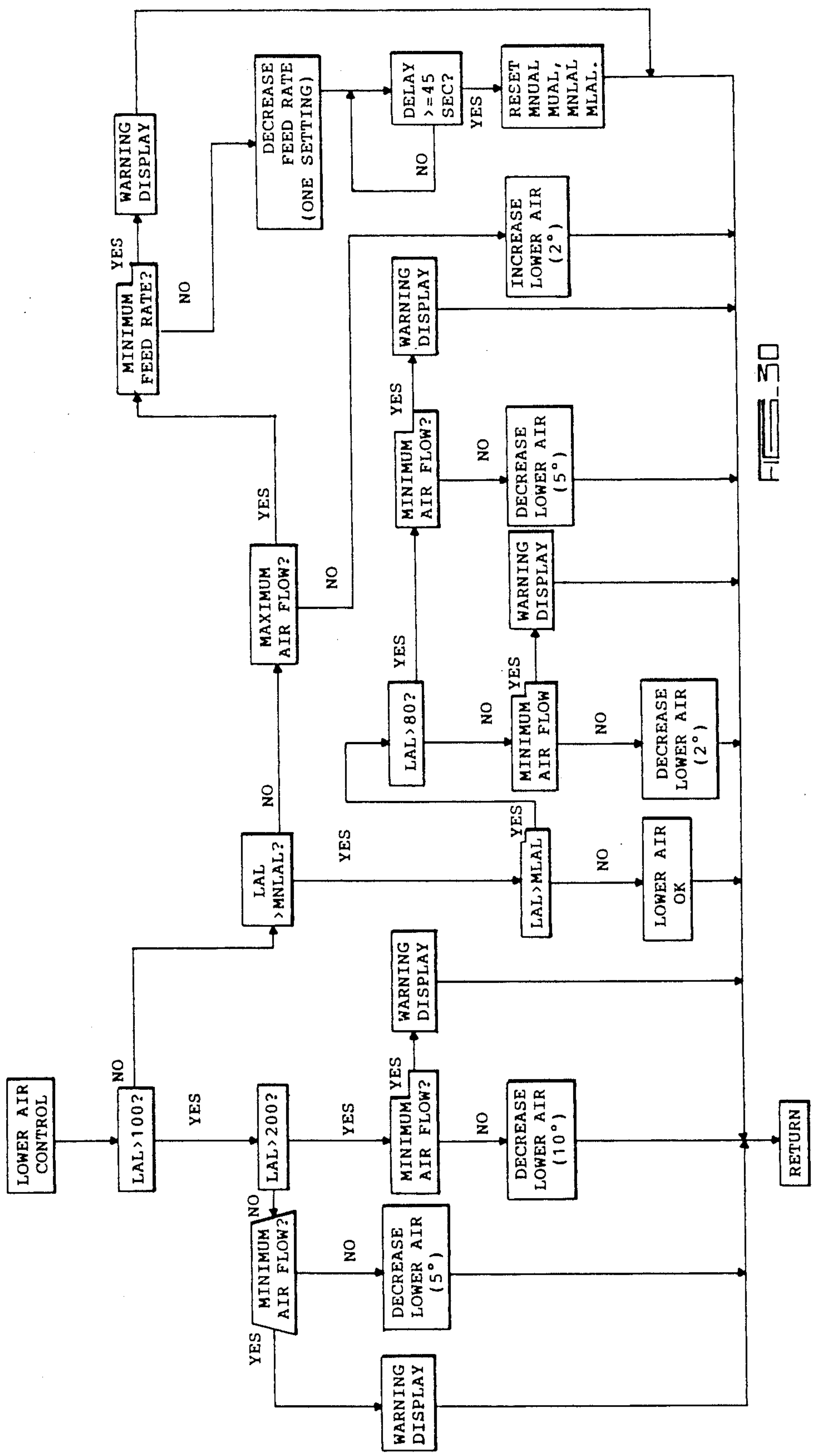

LOWER AIR CONTROL
LAL>100?
LAL>200?
MINIMUM AIR FLOW?
DECREASE LOWER AIR (10°)
DECREASE LOWER AIR (5°)
WARNING DISPLAY
LAL >MNLAL?
LAL>MLAL
LOWER AIR OK
LAL>80?
MINIMUM AIR FLOW
DECREASE LOWER AIR (2°)
MAXIMUM AIR FLOW?
INCREASE LOWER AIR (2°)
MINIMUM FEED RATE?
DECREASE FEED RATE (ONE SETTING)
DELAY >=45 SEC?
RESET MNUAL MUAL, MNLAL MLAL.
RETURN
YES
NO

FIG_30

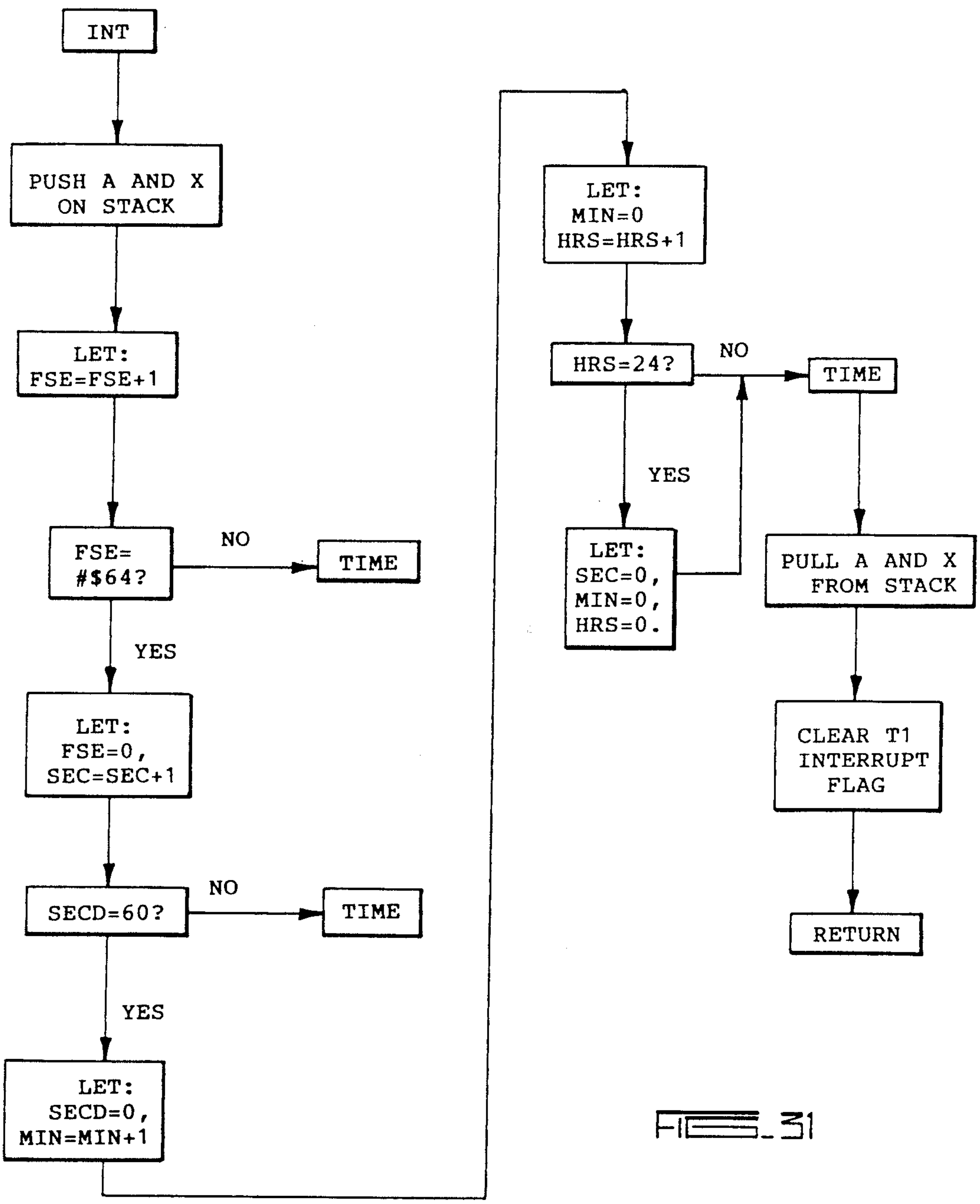

INT
PUSH A AND X ON STACK
LET: FSE=FSE+1
FSE= #$64?
NO
TIME
YES
LET: FSE=0, SEC=SEC+1
SECD=60?
NO
TIME
YES
LET: SECD=0, MIN=MIN+1
LET: MIN=0 HRS=HRS+1
HRS=24?
NO
TIME
YES
LET: SEC=0, MIN=0, HRS=0.
PULL A AND X FROM STACK
CLEAR T1 INTERRUPT FLAG
RETURN

FIG. 31

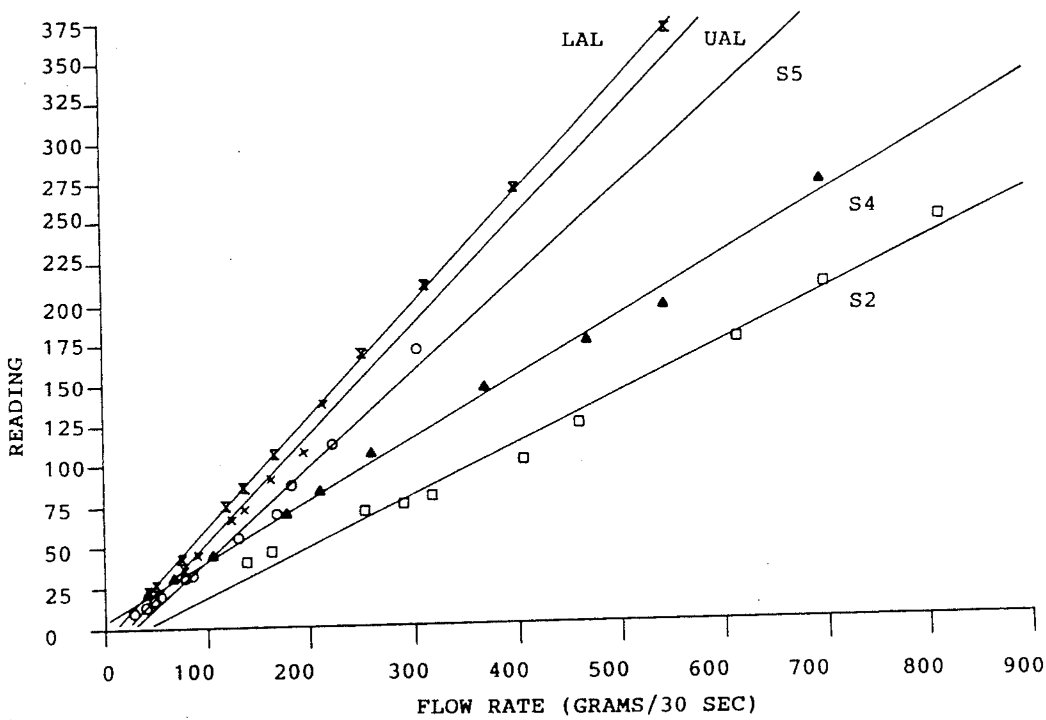

375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
READING
0
100
200
300
400
500
600
700
800
900
FLOW RATE (GRAMS/30 SEC)
LAL
UAL
S5
S4
S2

FIG_3Z

AUTOMATION OF AN AIR-SCREEN SEED CLEANER

BACKGROUND OF THE INVENTION

In seed cleaning operations, the quality of the final seed mixture is an important factor. Conventional seed cleaning systems utilize screens and air to remove foreign matter and other undesirable materials from the desired seeds. Typically, two air separation stages are provided for lifting and removing lightweight materials. The first air-lift is located at the seed hopper and draws a strong stream of air through the entire bulk of seed as it feeds into the cleaning machine. This initial air-lift removes most of the light trashy material from the seed bulk. A second air-lift is normally located adjacent the outlet of the cleaning machine where the cleaned seeds are discharged. This second air-lift removes any remaining light off-grade seeds, hollow kernels, or broken seeds which are not sifted by the screens. The terminal velocity of the seed is an important operating criterion, and proper adjustment of the air-lift is crucial for efficient separation and cleaning

Typically, at least two screens are also utilized for cleaning the seed. The first or top screen removes coarse foreign material which is larger than the seed, while allowing the seed, dirt, and other small particles to pass through onto the finer second or bottom screen. This second screen retains the clean seed on top, while allowing the foreign material which is smaller than the seed to pass through. The feed rate along the screens must be properly adjusted to obtain maximum and efficient performance.

In these conventional seed cleaning machines, the adjustments of the air-lift vacuum and the screen feed rate are accomplished manually by visual inspection and trial and error. Frequent supervision and adjustment by the operator is necessary to maintain the seed quality with minimum seed loss. Also, such manual adjustments are made at spaced timed intervals, and therefore necessarily attempt to correct problems which have already allowed foreign matter to remain in the finished seed product and/or allowed good seed to be removed with the waste by the screens and air-lift.

Therefore, a primary objective of the present invention is the provision of an improved seed cleaning system which allows for maximization of cleaning efficiency.

Another objective of the present invention is the provision of an improved seed cleaning system which is continuously monitored and adjusted for controlling the efficiency of the operation.

A further objective of the present invention is the provision of a seed cleaning system having an improved airlift spout.

Yet another objective of the present invention is the provision of a seed cleaning system having an improved screening spout.

Still another objective of the present invention is the provision of a seed cleaning system having a computer processing unit for monitoring and adjusting the seed cleaning operation, if desired.

These and other objectives will become apparent from the following description of the present invention.

SUMMARY OF THE INVENTION

The present invention improves upon conventional seed cleaning machines having dual screens and dual air-lifts for cleaning the seed. The improved system includes a computerized processing unit for continuously monitoring the material removed from the seed mixture by the screens and air-lifts and for continuously adjusting the air-lift vacuum and the screen feed rate so as to achieve the desired cleaning efficiency.

The present invention further improves the conventional cleaning system by providing an improved air-lift spout having an inner gate and a standard outer gate for the upper and lower air-lifts. The inner gate is normally open during operation of the system, but will automatically close to maintain the air-lift vacuum when the outer gate is opened to retrieve a sample from the air-lift spout.

The present invention also improves upon the conventional cleaning system by providing an improved screening spout having a divider plate therein adjacent the downstream end of the final screen. The divider plate divides the screening spout into an upstream side and a downstream side, such that the upstream side collects the undersized materials sifted along the substantial length of the final screen, while the downstream side collects the undersized materials sifted immediately adjacent the discharge end of the screen. The presence of any material in the downstream side of the spout indicates that separation along the screen has been incomplete. Accordingly, a single sensor positioned in the downstream side of the screening spout is sufficient for monitoring the screen's operation. Additional sensors along the length of the screen can therefore be eliminated.

The screening sensor produces a signal corresponding to the quantity of undersized material passing through the screen at the discharge end thereof. Similarly, a sensor in the air-lift spout produces a signal corresponding to the quantity of lighter material separated by the air-lift. The sensors are operatively connected to the computerized processing unit which continuously receives and processes the respective signals for monitoring the cleaning operation and for adjusting the extent of separation by the screen and air-lift to achieve a desired efficiency for this system.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view of a conventional seed cleaning machine.

FIG. **2** is a schematic side elevational view of a conventional screening spout.

FIG. **3** is a perspective view of a conventional screening spout.

FIG. **4** is a schematic side elevational view of the improved screening spout of the present invention.

FIG. **5** is a perspective view of the improved screening spout of the present invention.

FIG. **6** is a schematic of a conventional air-lift spout in a closed position.

FIG. **7** is a schematic view of a conventional air-lift spout in an opened position.

FIG. **8** is a schematic view of the improved air-lift spout of the present invention in a closed position.

FIG. **9** is a schematic view of the improved air-lift spout of the present invention in an open position.

FIG. **10** is a schematic representation of the seed cleaning machine of FIG. **1** with sensors, motors, and control units for automating the seed cleaning machine.

FIGS. 11A, 11B, and 11C are top, front, and back schematic views, respectively, of one embodiment of a control unit for the embodiment of FIG. 10.

FIG. 12 is a schematic representation of the electrical connection of the sensors and motors to the circuitry of the control unit of the embodiment of FIG. 10.

FIG. 13 is a block diagram of the inner connection of various elements of one embodiment of a control unit for the system depicted in FIG. 10.

FIGS. 14A and 14B depict schematic representations of the signal conditioning interface or board of FIG. 12.

FIGS. 15A and 15B are schematic representations of one embodiment of sensor selection logic board or sensor logic board of FIG. 12.

FIG. 16 is an electrical schematic of an embodiment for the sensor logic board of FIGS. 15A and 15B.

FIGS. 17A and 17B are schematic representations of one embodiment of the motor logic board or stepping motor logic board of FIG. 12.

FIG. 18 is an electronic schematic of an embodiment of the motor logic board of FIGS. 17A and 17B.

FIGS. 19A, 19B and 19C are schematic tables and representations of an embodiment and function of the stepping motor interface of FIG. 12.

FIGS. 20–31 are schematic flow chart representations of an automatic control program which can be utilized with the invention.

FIG. 32 is a graphic representation of operation of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

An air-screening seed cleaner **10** is schematically shown in FIG. **1**. Cleaner **10** includes an inlet feed hopper **12**, a first set of screens **14A** and **14B**, a second set of screens **16A** and **16B**, an upper air-lift **18** and a lower air-lift **20**. Air-lifts **18** and **20** are of the vacuum type wherein the vacuum is created by a fan **22** for each air-lift. (Only one fan is shown.) Fans **22** include an adjustable damper **23** for controlling the vacuum created by the fan. The hopper, screens, air-lifts and fans are conventional, and do not form a part of the present invention.

In the operation of a conventional seed cleaner, a mixture of the seed to be cleaned and foreign material is fed into hopper **12** which introduces the mixture onto screen **14A** at a fixed rate as determined by a motorized feed wheel **24**. As the mixture is fed onto screen **14A**, the vacuum in air-lift **18** removes most of the light trashy materials from the mixture, which are collected in a trough or spout **25** for disposal. The oversized rough scalp remains on top of screen **14A** while the undersized material, including the desired seeds, passes through screen **14A**. A trough or spout **26** at the end of screen **14A** collects the rough scalp for disposal. Similarly, screen **14B** retains the oversized particles, which includes the desired seed, while the undersized material passes therethrough and is collected in trough or spout **28** for disposal.

As the cleaning operation continues, the desired seed from screen **14B**, which still includes a quantity of undesirable foreign matter, passes onto screen **16A**. Again, the oversized close scalp is retained on top of screen **16A** and collected in a trough or spout **30** for disposal, while the undersized particles, including the desired seed, passes through screen **16A** and onto screen **16B**. Screen **16B** allows fines and splits to pass therethrough which are collected in troughs or spouts **32**, **34** for disposal, while the desired clean seeds are retained on top of screen **16B**.

At the discharge end **36** of screen **16B**, the cleaned seeds are introduced into the lower air-lift **18** wherein lighter materials, such as off-grade seeds, hollow kernals, or broken seeds, which have not been sifted out by the screens are removed and collected in a spout **38** for disposal. Finally, the clean seeds are discharged through an outlet **40** for collection.

During the cleaning operation, it is desirable to monitor the screening efficiency from the screening spout **34**. A conventional screening spout is shown in FIGS. **2** and **3**. With the conventional spout, monitoring is difficult since spout **34** collects the undersized screenings from the feed end **42** to the discharge end **44** of screen **16B**, as indicated by the arrows in FIG. **3**. To overcome this problem, the present invention provides a new design for the screening spout **34**, as shown in FIGS. **4** and **5**. More particularly, a divider plate **46** is vertically disposed within spout **34** so as to divide the spout into an upstream side **48** and a downstream side **50**. Thus, the upstream side **48** collects the undersized material sifted along the substantial length of screen **16B** while the downstream side collects the undersized material sifted immediately adjacent the discharge end **44** of screen **16B**. Accordingly, the presence of any sifted material in the downstream side **50** of spout **34** indicates that the separation by the screen of the undersized material from the oversized material is incomplete.

It is also desirable to monitor the air-lift efficiency to be sure that desired seeds are not being lifted for disposal rather than remaining on the screens and ultimately dropping for discharge through outlet **40**. Lower air-lift spout **38** is structurally and functionally identical to upper air-lift spout **25**, therefore only spout **38** will be described.

FIGS. **6** and **7** show a conventional lower air-lift spout **38**. Spout **38** typically includes a pivotally mounted gate **52** which normally is pulled shut due to the vacuum within air-lift **20** and spout **38**. As the weight of the liftings deposited in spout **38** increases, the weight will push gate **52** open slightly, thereby allowing the liftings to fall out, as indicated in FIG. **6**. This slight opening of gate **52** does not significantly effect the operation of air-lift **20**. In order to check the quality of the lower air-liftings within spout **38**, in conventional operation, the operator manually opens gate **52** and reaches into spout **38** to grab a handful of liftings However, such opening of gate **52** causes exterior air to be drawn into spout **38** through outlet opening **54** which causes the liftings to be sucked rearwardly away from opening **54**, as shown by the arrows in FIG. **7**. Furthermore, such opening of gate **52** reduces the vacuum within lower air-lift **20**, therefore causing some lightweight materials to fall for discharge through outlet **40**.

The present invention provides improved air-lift spouts **25** and **38** having pivotally mounted second interior gates **56**, as shown in FIGS. **8** and **9**.

In normal operation, as shown in FIG. **8**, second gate **56** is normally opened so as to allow the liftings to pass thereby for collection adjacent first gate **52**. However, when first gate **52** is opened to retrieve a sample of liftings, the vacuum within air-lift **20** pulls second gate **56** closed, as shown in FIG. **9**, so as to prevent exterior air from being drawn into air-lift **20** and so as to maintain the vacuum level within air-lift **20**. Thus, the efficiency of the air-lift is not decreased when first gate **52** is opened, as with the conventional spout shown in FIGS. 6 and 7.

As the operation of the screen separation and air-lift separation is monitored, it may be necessary to adjust one or both of these operations so as to achieve the desired cleaning efficiency. Therefore, the present invention provides a first sensor **58** adjacent to downstream side **50** of screen **16B**, seen in FIGS. **4** and **5**, and a second sensor **60** below second gate **56** of air-lift spout **38**, as seen in FIGS. **8** and **9**.

Sensor **58** senses the quantity of undersized material received in downstream side **50** of spout **34**. Spout **34** includes a plate **62** which allows for gravity flow of the lightweight material onto sensor **58**. Sensor **58** produces a signal corresponding to the quantity of lightweight material impacting thereon. An interface **64** receives the signal from sensor **58** and forwards it to a processing unit **66** which then adjusts the screening operation to achieve the desired efficiency of the system, as described hereinafter. More particularly, the processing unit **66** can automatically adjust the rotation speed of feed wheel **24** so that the feed rate of the mixture onto screen **14A** is controlled to allow more or less screening separation to be accomplished along screens **14A**, **14B**, **16A** and **16B**.

Similarly, sensor **60** in air-lift spout **38** produces a signal corresponding to the quantity of lighter material sensed thereby. An interface **68** receives the signal from sensor **60** and forwards it to the processing unit **66**, which then automatically pivots damper **23** within the respective fan **22** so as to adjust the air-lift vacuum to produce more or less separation as necessary to achieve the desired cleaning efficiency.

While sensors **58** and **60** are shown to be an impact sensor, it is understood that other types of sensors can be utilized, such as photo-electric sensors.

FIGS. **10-32** are specifically directed to a preferred embodiment of the invention which utilizes sensors to monitor the seed cleaning process, and computer(s) to gather, compile, and interpret what is detected at the sensors. By merging the sensors and computer control with the previously described advances in the structure of the seed cleaning mechanism, improvement over the art is achieved. Materials of a variety of size, shape, and weight can be sorted efficiently, economically, and accurately.

In the preferred embodiment, sensor monitoring and computer processing allows at least three modes of operation for the invention. As will be discussed in more detail, the invention can merely monitor the operation of the separation of the material, and display the results for the operator, or record and store results over a selected period of time. Secondly, in a semi-automatic mode, the embodiment of the invention can monitor and display separation operation, and inform the operator what changes are desirable to reach the preferred level of separation efficiency. Third, the present invention can be configured to operate autonomously. In this mode, the controlling computer would alter the operation of the separator automatically, to maintain a predesired separation efficiency or operation.

It is to be understood that the following is a description of a preferred embodiment only, and that many different configurations of the invention are possible.

FIG. **10** shows a specific preferred embodiment of the invention with monitors or sensors and computer control. Separation hardware is generally the same as is shown in FIG. **1**, and like reference numerals refer to like parts.

FIG. **10** shows motor **100** attached to belt **12** which rotates feed wheel **24**. Motor **100** controls the speed of feed wheel **24**, which in turn determines the rate at which the material is introduced to the separator. The speed of motor **100** is controlled by motor control **104** such as is known in the art, and which is connected to a 110 volt alternating current source.

A stepper motor **106** is connected to motor control **104** and serves to adjust motor control **104** to in turn adjust speed of motor **100**. Stepper motor **106** is in turn controlled by processor or control unit **66**.

In the preferred embodiment, motor **100** can be any electrical rotary motor. Stepper motor **106** can be obtained from Japanese Products Corporation, 7 West Chester Plaza, Elmsford, N.Y. 10523 under product designation KP8M2-003 stepping motor, and should have 1.5° per step with 0.41 Nm (58 oz in) dynamic torque.

FIG. **10** also shows two additional stepper motors **108** and **110** which are directly connected and controlled by processor or control unit **66**. Stepper motor **108** is operatively connected to damper **112** of upper air fan **114**. Stepper motor **110** is operatively connected to damper **112** of lower air fan **22**. By connective means such as are known in the art (and not shown) stepper motors **108** and **110** can adjust dampers **112** and **116** in the exhaust of upper and lower fans **114** and **22**, to in turn adjust the vacuum created by those fans. Thus, by controlling dampers **112** and **116**, the amount of suction or vacuum in upper and lower air lifts **18** and **20** can be controlled.

Stepper motors **108** and **110** can also be obtained from Japanese Products Corporation, under product designation number KP6M2-003 stepping motors. In the preferred embodiment, they would be bigger than stepping motor **106** and would have 0.99 Nm (140 oz in) dynamic torque for controlling the opening of dampers **112** and **116**.

It can therefore be seen that each of stepper motors **106**, **108** and **110** can control parameters in the separation process which will affect the efficiency of separation.

FIG. **10** also shows that a plurality of sensors can be positioned at certain locations in the separator and transmit signals to control unit **66** so that the efficiency of separation can be monitored. FIG. **10** shows that upper air lift sensor **120** can be positioned in the path of air liftings which are pulled through opening **122** into upper air lift chamber **18** by the vacuum from upper air fan **114**. The impacting of air liftings upon upper air lift sensor **120** causes a signal proportionate to the amount of impacting to be generated and sent to control unit **66**. By monitoring upper air lift sensor **120** over a period of time, the quantity of upper air liftings being pulled from the material can be derived.

Sensor **58** is positioned so as to monitor the amount of bottom screen materials which are separated from the desired portion of the material. It functions as previously described with respect to FIGS. **4** and **5**. By producing a signal proportionate to the amount of screened material impacting upon it, bottom screen sensor **58** sends a signal to control unit **66** which can be used to derive information about the efficiency of separation.

Sensor **60**, which will be referred to as lower air lift sensor **60**, is positioned within spout **38** for lower air liftings. It operates as described with respect to FIGS. **8** and 9 above, and just as with upper air lift sensor **120**, produces a signal proportionate to the amount of air liftings which impact upon it and sends those signals to control unit **66**.

In the preferred embodiment of FIG. **10**, a clean seed sensor **124** can be positioned directly under outlet **40**. It produces a signal proportionate to the amount of clean seed which impacts upon it, and sends that signal to control unit **66**. It is also to be understood that a total discard seed sensor **126** can also be utilized to produce a signal proportionate to the total discarded seeds which impact upon it.

Each of the sensors can be what are called impact sensors. Alternatively they can be photo-electric detectors. In the preferred embodiment, the bottom screen sensor **58**, lower air lifting sensor **60**, and upper air lifting lift sensor **120** are grain loss sensors available from Dickey-john Corporation under the product designation Shoe Sensor, Part No. 10822-0013. The clean seed sensor in the preferred embodiment is also a grain loss sensor from Dickey-john Corporation under the product designation Walker Sensor, Part No. 15491-0001. All sensors can be ordered from Dickey-john Service Center, 6212 East 14th Street, Des Moines, Iowa, or P. 0. Box 10, Auburn, Ill. 62615.

It therefore can be seen from FIG. **10**, that control unit **66** obtains monitoring information from sensors **58**, **60**, **120**, **124** (and possibly **126**). By comparing those signals to predetermined ranges, control unit **66** can issue instructions to stepper motors **106**, **108**, or **110** to selectively alter feed rate, upper air lift, or lower air lift, according to desire and according to keeping the separation process within the pre-set ranges. Thus, the system can automatically adjust to achieve maximum efficiency of separation.

A preferred embodiment of control unit **66** will now be described. By referring to FIGS. **11A**, B and C, control unit **66** includes circuit boards (reference numerals **130**, **132**, **134**, **136**, **138** and **140**) all of which plug into a common bus **142**, and are in electrical connection with a power supply **144**, a keyboard **146**, and a display **148**. All of these elements are contained within a cabinet **150** which includes appropriate power supply plug-ins and communication line plug-ins for attachment of control unit **66** to the sensors, the motors, and other processing equipment, if desired. For example, a 30-pin jack **152** can serve to be connected to a digital communications bus so that data can be sent to other processing equipment (see FIG. **11C**). Appropriate sensor jacks **154** receive cables from the sensors utilized in the system. Motor jacks **156** receive plugs from communication cable to stepper motors **106**, **108**, and **110**. Additionally, plugs exist for 5 VDC, 12 VDC, ground (DC) and 110 VAC (see FIG. **11C**).

Control unit **66** can also contain miscellaneous control switches or buttons. For example, auto control buttons **158** can be used to select pre-set auto control ranges (see FIG. **11A**). Additionally, sensor buttons **160** (see FIG. **11B**) can be utilized to bring up on display **148** the instantaneous value for any of the sensors of the system. Other control buttons and features can be incorporated into control unit **66** as are desired.

FIG. **12** schematically depicts the relationship of circuit boards **130**, **132**, **134**, **136**, **138** and **140**. Board **138** comprises a single board micro-computer, which in the preferred embodiment is a 6502-CPU or 6502A-CPU. The 6502A-Micro-Processor (board **138**) contains 72 lines of input/output (I/O), 4K bytes of RAM, 20K bytes of ROM/EPROM, five timers and two levels of interrupt compressed onto one 11.5 centimeter by 16.5 centimeter standard plug board. The 72 lines of user I/O are configured in logical groups to three edge connectors. Two of the connectors are used for the keyboard/display (reference numerals **146** and **148**) and for printer modules. The third connector can be used for other purposes.

Keyboard **146** includes 23 keys, some of alphanumeric nature, and some of multiple function nature. Display **148** consists of a 14-segment fluorescent character display. An on-board 8035 micro-processor (not shown) is also utilized to control display **148**, and to interface with CPU **138**.

In the preferred embodiment, a Model-6571 input-/output expander board **162** is connectable via RS-232C ports to CPU **138**, and in turn can be connected to a 20-character, 120 LPM thermal printer (Olivetti PU-1800 Printer) which is not shown.

FIG. **12** shows that signal conditioning interface board **140** receives electrical signals generated by sensors **120**, **124**, **126**, **58** and **60** over separate communication channels **164**. Signal conditioning interface **140** is also contained on a standard plug board and is connected to power bus **166**, data bus **168**, and control bus **170**; all of which are interconnected for communication between boards **130**, **132**, **134**, **138** and **140**.

Sensor selection logic board **134** contains the necessary circuitry to choose the particular sensor or sensors, for a certain time period, and relay that data to CPU **138**.

Stepping motor driver interface board **130** is connected over six channels **172** to various stepper motors. In the preferred embodiment, only three channels **172** are used, namely, for stepper motors **106**, **108** and **110**. Stepping motor selection logic board **132** then functions with CPU **138** to select which stepping motor will be driven according to the instructions of CPU **138**.

Therefore, FIG. **12** shows that processor **66** contains the necessary components to receive the monitoring signals from the sensors, and control operation of the stepping motors according to preset ranges or parameters which are introduced to CPU **138**. Processor **66** can also send monitoring information to a printer, or to other processing components, such as a micro-computer, or main frame computer.

FIG. **13** depicts in schematic form, one embodiment of the control and processing components for a separator control system according to the present invention. Again, it can be seen that CPU **138** is the center of the system. FIG. **13** additionally utilizes micro-computer **174** (an Apple III computer) which in turn interfaces with main frame computer **176**, printer **178**, plotter **180**, and disc storage **182**. It can therefore be seen that the processing capability of the present invention can expand beyond processor **66**. Such additional processing can be utilized to preserve a large quantity of data from the separation process, and allow close and complete analysis of operation of the system.

Specifics regarding boards **130**, **132**, **134**, **138** and **140** of processor **66** will now be described. FIG. **14** schematically depicts the components which would be associated with the signal conditioning interface board **140**. As can be seen, ports B,C,D and E receive signals from four sensors (sensors **58**, **60**, **120**, and **124**). A +5 volts and ground are supplied through ports "A" and "1", respectively. Board **140** essentially contains components for four or five incoming channels from the sensors, the channels are processed through variable resistors **184**, capacitor resistor sub-circuits **186**, LM319 components, LM324 operational amplifier, 74LS393N counters, and finally 8212 IC buffered latches. These components receive the sensor signals and condition them to prepare them for reliable and accurate presentation to CPU **138**.

FIGS. **15**A and B show schematically the components associated with sensor selection logic board **134**. Board **134** includes a 74L154 decoder and 7404 converter. Again, the board is powered by +5 volts DC.

FIG. **16** consists of an electrical schematic which sets forth the combined operation of boards **134** and **140**. It is to be understood that FIG. **16** is representative of how processor **66** can select a signal from one of the sensors and forward that data to CPU **138**. Similar circuitry is utilized for all sensors. FIG. **16** shows three outputs from port B (PB0, PB1, and PB2) are connected to decoder **194** (identified by number 74L154). to allow processor **66** to address eight outputs from the computer program driving processor **66**.

FIG. **16** illustrates how the input from a sensor passes through a 0.1 microfarad capacitor to filter out undesirable +5 VDC, which is present in the output of the sensor when there is no load. The sensor signal is then fed to a LM324 operational amplifier (reference numeral **196**) which presents a gain equal to the sum: 1+(R2/R1). After amplification, the signal is then directed to LM319 comparator **198**, which is connected to a 1 kilo ohm potentiometer **200** to allow adjustment and sensitivity of comparator **198**.

The output of comparator **198** is sent to 74393 counter **202** which operates to convert the signal to a digital number. The eight output lines from counter **202** are each directed to eight input lines of 8212 buffered latches **204**. The data held in buffered latches **204** is transferred to data bus **168** when decoder **!94** generates a low voltage signal according to instructions from control bus **170**; as the **7404** converter (reference numeral **206**) converts the low voltage signal to a high voltage signal which enables the eight output lines of buffered latches **204** to transfer data to the system data bus **168**. The software programming takes the data and stores it in memory.

Furthermore, after a selected reading time period for the sensors, the low voltage signals sent through control bus **170** to inputs PB0, PB1 and PB2 of port B of decoder **194**. This low voltage signal clears counter **202** and prepares it for the next loop in the program, which will function to direct another reading of the sensors. In the preferred embodiment, board **140** contains signal conditioning for **5** channels (or sensors), whereas board **134** contains signal conditioning for two additional channels (or sensors), plus contains the decoder **194** and converter **206**.

FIGS. 17A and B, 18 and 19A, B and C, are electrical schematics for one embodiment of motor logic selection board 132. FIGS. 17A and B shows generally the combination of electronic parts which are operatively connected upon the standard plug board. A 74L154 decoder (reference numeral **208**) and a 7404 hex inverter (reference numeral **210**) are used on board **132**. Three 2N3904 transistors (reference numeral **212**), three resistors **214**, and three diodes **216** are also utilized. Finally, six relays **218** are included. Resistors **214** comprise one kilo ohm resistors.

Because processor **66** needs to control each of stepper motors **106**, **108** and **110**, stepper motor selection logic circuit **132** is utilized to receive the motor control signals from CPU **138**, and then select the appropriate stepper motor to be controlled. The signals from board **132** are then sent through stepping motor driving interface board **130** to the appropriate stepping motor.

FIG. **18** shows the exact electronic connection of the various components. It is to be understood that pins **PB5** and **PB6** receive signals from the system control bus **170** (from CPU **138**) and input those signals to decoder **208**. Decoder **208** selects which motor is to be controlled by those signals and then transfers the signals from control bus **170** (shown as +B, −B, −A, and +A) through two sets of F2A005 double pole - single throw relays (reference numerals **218**) to the desired stepping motor.

FIGS. **20**–**31** depict in flow chart form, the programming and operational steps which processor **66** can follow during operation of the invention. FIG. **20** depicts the initializing of the program whereby the operator can choose the mode of operation of processor **66**. As previously described, the mode can either be set to (a) simply monitor the separator as it functions, (b) semi-automatically monitor and inform the operator of which settings should be maintained to keep operation within certain predesired ranges, or (c) total autonomous control of the operation. In the monitoring mode, data is collected, displayed, and any undesirable situation is conveyed but no actual adjustment is made by processor **66**. In any of those three modes, data can also optionally be transferred to another device, and/or stored for record keeping for future analysis

FIG. **21** depicts the part of the software program whereby the ranges or parameters for the separation process to be automatically controlled are input.

FIG. **25** depicts the operation of the software for obtaining readings from the sensors. Instructions are issued to read all the sensors simultaneously. The readings for each sensor are then accumulated for a preselected specified time period (in FIG. **25** the period is set at **10** seconds, but this can be selected according to desire). The software then instructs processor **66** to compare the accumulated value of the upper-air spout sensor **120**, and compares it with the pre-entered, preselected range. If the value is below the prescribed minimum, or above the prescribed maximum, in the automatic mode, processor **66** adjusts either the damper **112** to upper air fan **114** through stepper motor **108**, adjusts the speed of feed wheel **24** through stepper motor **106**, or adjusts both. Once the value from the upper-air spout sensor **120** is within the prescribed range, processor **66** checks the accumulated value of the reading from the screening spout sensor or bottom screen sensor **58**, and compares that value with the range prescribed for it. If the reading is too high or too low (that is, outside the range), processor **66** adjusts the speed of feed wheel **24** through stepper motor **106** accordingly. Processor **66** then checks the reading from lower air spout sensor **60**, and similarly brings the readings within its prescribed range by adjusting damper **116** of fan **22** (to adjust the amount of lower air liftings), or the speed of feed wheel **24**, or both.

After this adjustment process, processor **66** loops to repeat the reading of the sensor and the corrections. This process continues in the automatic mode until processor **66** is directed otherwise.

In the preferred embodiment, any time an adjustment of air, in either upper air fan **114** or lower air fan **22** is made, processor **66** initiates another reading of the sensors and loops back to start the correction process over again. On the other hand, if feed rate through feed wheel **24** is changed at any time, processor **66** waits for a specified time period (in the preferred embodiment **45** seconds, or otherwise if desired), and then loops to repeat the process of reading the sensors and correcting. This software routine is depicted in FIGS. 27–30.

Specific parameters used in the preferred embodiment of the invention are described as follows. If the readings at either upper or lower air lifting sensors **120** or **60** are below the minimum pre-set value, and the respective damper of the respective fan is not fully open, the software instructs processor **138** to in turn instruct the appropriate stepper motors to increase air by opening the corresponding damper electro-mechanically. The damper is then opened approximately 2° by the stepper motor, and the result is then checked.

Conversely, if the reading from the appropriate sensor is above the maximum value, air is decreased by closing the respective damper electro-mechanically. The amount of closing of the dampers is related to the difference between the signal read and the maximum value allowable according to the following prescription: 80>reading>max—decrease damper by 2°; 200>reading>max—decrease damper by 5°; and reading>200—decrease damper by 10°. It is to be understood that both the values of "80" and "200" can be changed, as can the degree of damper closing (2°, 5°, or 10°) according to desire. It has been determined that these specifications insure uniformity of seed quality, when the invention is used for seed separation, without loss of good seeds.

Processor **66** also can decrease the feed rate of feed wheel **24** if the reading from either the upper air or lower air sensors **120** and **60** is less than the minimum value assigned, and the damper for the respective fan **114** or **22** is fully opened. If it should occur that the feed rate is already at a minimum, a warning can be issued by processor **66**, either through display **148**, or by some other alarm means. It is to be understood that the software modifies the values of the optimum sensor reading range if the feed rate is changed during operation.

The feed rate is also decreased if the reading from bottom screen sensor **58** exceeds the maximum allowable value, and the feed rate is above the specified minimum feed rate. Conversely, the feed rate is increased if the reading from bottom screen sensor **58** is below the minimum value (usually 0) and the feed rate is below the specified maximum feed rate.

FIG. **21** again depicts the software programming which allows the invention to have three modes of operation to provide flexibility for the operator. For example, the operator can change the adjustments of upper air, lower air and feed rate by using keyboard **146** of processor **66**. This operation is depicted in FIG. **26**. Additionally, the software functions depicted in FIG. **26** allows the operator to display the various sensors' readings at any time by pressing a specific key (for example, pressing key **5** displays the reading of lower air at any time).

By selecting key "0" in FIG. **21**, the "completely automatic" mode is selected as depicted in FIG. **22**. In the completely automatic mode, processor **66** uses preset values as the optimum ranges for operation of the separator.

By selecting key "1" in FIG. **21**, the "semiautomatic" mode is selected as depicted in FIG. **23**. In this mode, the operator assigns values that are used as optimum values

Finally, by selecting key "2" in FIG. **21**, an "automatic pilot" mode is selected which is depicted in FIG. **24**. In this mode, the operator adjusts the machine and the computer maintains the status by measuring the values for a few minutes in the beginning, and computes the range using the average.

FIG. **31** depicts the software flow chart for a 24-hour clock interrupt service routine which is used by the other parts of the software.

Appendix A, attached to this specification, sets forth a specific object code for software according to the invention, and according to FIGS. **20–31**. It is to be understood, however, that variations in the programming can be utilized while staying within the boundaries of the present invention. Options and alternatives to the programming can be used, such as are well within the skill of those of ordinary skill in the art.

FIG. **32** graphically depicts the linear relationship between reading of the various sensors of the preferred embodiment of the invention, and increase in flow rate of the material being separated. It can therefore be seen that by adjusting parameters of the separator through the use of processor **66**, selected separation output of materials can be achieved.

It will be appreciated that the included preferred embodiment is given by way of example only, and not by way of limitation to the invention, which is solely described by the claims herein. Variations obvious to one skilled in the art will be included within the invention defined by the claims.

It is understood that the cleaning system of the present invention is not limited to seed cleaning, but rather can be utilized for the cleaning of any type of mixture of particulate materials wherein oversized and undersized materials are separated and/or wherein lighter and heavier materials are separated.

Thus, it is seen that the present invention encompasses at least all of the stated objectives.

APPENDIX A

Auto. Control Main Program.
Program: C000/C9FF
Text : 1000/70FF
Ver: April 28, 1987. [signature]

```
OUT=
```

```
*=$00
RUN *=*+1
HOUR *=*+1
MIN *=*+1
SECD *=*+1
DECM *=*+12
UAL *=*+1
LAL *=*+1
```

```
*=$C040
NEWSET
 JSR CLR
 LDX #0
FIRST LDA TT,X
 JSR OUTPUT
 JSR DELAY
 INX
 CPX #20
```

```
DR1=$9200
CTR1=$9201
BR1=$9400
*=$A000
 DRB *=*+1
 DRA *=*+1
DDRB *=*+1
DDRA *=*+1
T1CL *=*+1
T1CH *=*+1
READ=$E93C
ACR =$A00B
CLR=$EB44
DEBK1=$ED2C
OUTPUT=$E97A
PCR=$A00C
IER =$A00E
PDRA=$A480
PDRB=$A482
RDRUB=$E95F
RCHECK=$E907
CRCK=$EA24
IRQV=$A404
NUMA=$EA46
OUTD=$EF05
PHXY=$EA9E
PLXY=$EBAC
 *=$40
 MLAL *=*+1
 MNLAL *=*+1
 MUAL *=*+1
 MNUAL *=*+1
 MSE *=*+1
 MNSE *=*+1
 FR *=*+1
 MFR *=*+1
 MNFR *=*+1
 ANG *=*+1
TURNN *=*+1
ANGN *=*+1
 CCODE *=*+1
UANG *=*+1
UTURN *=*+1
UANGN *=*+1
 *=$50
DMCHK *=*+1
 COUNT *=*+1
 *=$60
 TEMUA *=*+1
 TEMLA *=*+1
 TEMFR *=*+1
 CLI
 LDA #00
 STA TEMUA
 STA TEMLA
 STA TEMFR
BSL *=*+1
CLS *=*+1
TOTAL *=*+1
FSEC *=*+1
TSEC *=*+1
HEXT *=*+2
HEXA *=*+1
DSTA *=*+1
KEYM *=*+1
DIR *=*+1
MTCON *=*+1
TH *=*+1
TM *=*+1
CDRB *=*+1
*=$010C
 JMP PRESET
*=$010F
 JMP NEWSET
 *=$0112
 JMP $D000
 *=$C000
PRESET
 LDA #$FF
 STA COUNT
 LDA #$60
 STA MLAL
 LDA #$40
 STA MNLAL
 LDA #$40
 STA MUAL
 LDA #$10
 STA MNUAL
 LDA #$20
 STA MSE
 LDA #$05
 STA MNSE
 LDA #4
 STA FR
 LDA #8
 STA MFR
 LDA #1
 STA MNFR
 LDA #$30
 STA ANG
 LDA #00
 STA CCODE
 LDA #$40
 STA UANG
 LDA #$01
 STA DMCHK
 JMP PREGO
CONT LDA DSTR
 CMP #$40
 BNE DP1
 JSR RD1
 JMP CLEN
 BNE FIRST
 JSR DELAY
 JSR DISP0
 JSR DFESL
 JSR DISPL
 JSR DFUAL
 JSR DISPU
 JSR DPLAL
 JSR DISPL
PREGO
 JSR RD1
 LDA #$00
 STA DSTA
 LDA COUNT
 CMP #$FF
 BNE NOSET
 LDA #$0C
 STA BR1
 LDA #$4E
 STA CTR1
 LDA #$2E
 STA CTR1
NOSET
 LDA #0
 STA DDRA
 LDA #$FF
 STA DDRB
 LDA #$C0
 STA ACR
 LDA #$C0
 STA IER
 LDA #$77
 STA DRB
 LDA #$70
 STA DRB
 LDX #0
 LDA #0
RECL STA HOUR,X
 INX
 CPX #21
 BNE RECL
 LDA #$80
 STA DSTA
 LDA #$F0
 STA T1CL
 LDA #$30
 STA T1CH
 LDA #<IIRQ
 STA IRQV
 LDA #>IIRQ
 STA IRQV+1
 LDA #$77
 STA DRB
 LDA #$70
 STA DRB
 PLA
```

```
START
 LDA SECD
 CMP SECD
 BEQ START
ACCU
 LDA #$EF
 STA PDRA
 LDA PDRB
 EOR #$FF
 BNE DP
 LDA DSTR
DP STA DSTR
 CMP #$03
 BNE DPA
 JSR MOTOR
 JMP NOC
DPA
 LDA #$71
 STA DRB
 LDX #0
 JSR SENS
 LDA #$72
 STA DRB
 LDX #2
 JSR SENS
 LDA #$73
 STA DRB
 LDX #4
 JSR SENS
 LDA #$74
 STA DRB
 LDX #6
 JSR SENS
 LDA #$75
 STA DRB
 LDX #8
 JSR SENS
 LDA #$76
 STA DRB
 LDX #10
 JSR SENS
 LDA #$77
 STA DRB
 LDA #$70
 STA DRB
 LDA SECD
 AND #$0F
 CMP #0
 BEQ CONT
 JMP ACCU

 CMP #2
 BEQ MOT2
DP1 CMP #$20
 BNE DP2
 JSR DISP1
 JMP CLEN
DP2 CMP #$10
 BNE DP3
 JSR DISP4
 JMP CLEN
DP3 CMP #$08
 BNE DP5
 JSR RD1
 JMP CLEN
DP5 JSR DISP2
CLEN
 LDA DMCHK
 CMP #$01
 BNE NODM
 JSR DUMP
NODM
 LDA CCODE
 AND #$04
 CMP #4
 BEQ AUUA
 JMP FRCH
AUUA
 SED
 LDA DECM+10
 CMP #$00
 BEQ CHUA1
 INC TEMUA
 LDA TEMUA
 CMP #2
 BEQ DEUA
 JMP FRCH
CHUA1
 LDA UAL
 CMP MNUAL
 BCS CHUA
MTUA
 NOP
 PHA
 JSR URI
 LDX #0
 LDA #$18
 STA DRB
MTUA1 LDA #$FF
 STA TSEC
MTUA2
 LDA #$08
 STA DRB
 LDA TSEC
 BNE MTUA2
 INX
 CPX #6
 BNE MTUA1
MOT2A
 LDA #$48
 CLI
 LDA #1
 ADC UANG
 STA UANG
 JMP NOC
URI LDX #0
 JSR CLR
RB1 LDA RE,X
 JSR OUTPUT
 INX
 CPX #20
 BNE RB1
 RTS
CHUA LDA UAL
 CMP MUAL
 BCS DEUA
 JMP FRCH
DEUA PHA
 JSR UR0
 LDX #0
 LDA #$10
 STA DRB
MTUB1 LDA #$FF
 STA TSEC
MTUB2 LDA #$00
 STA DRB
 LDA TSEC
 BNE MTUB2
 INX
 CPX #6
 BNE MTUB1
 LDA #$77
 STA DRB
 LDA #$70
 STA DRB
 PLA
 SEC
 LDA UANG
 SBC #1
 STA UANG
 LDA #0
 STA TEMUA
 JMP NOC
FRCH LDA CCODE
 AND #$02
 CMP #2
 BEQ AUFR
 JMP LACH
AUFR
 LDA DECM-4
 CMP #0
 BEQ CHFR1
 INC TEMFR
 LDA TEMFR
 CMP #3
 BEQ RDE
```

```
 JMP AIR
 HFR1
 LDA BS2
 CMP #00
 BNE U1
 LDA FR
 CMP MFR
 BEQ AIR1
 JSR S0
 INC FR
 CLC
 PHA
 LDA #$05
 ADC MNLAL
 STA MNLAL
 LDA #$50
 STA DRB
 LDA #$FF
 STA TSEC
MOT1A
 LDA #$40
 STA DRB
 LDA TSEC
 BNE MOT1A
 PLA
 JMP NFR
AIR1 LDX #0
AIR1A LDA AIR1B,X
 JSR OUTPUT
 INX
 CPX #20
 BNE AIR1A
 JMP LACH
U1
 LDA BS2
 CMP MSE
 BCC AIR2
MOT2
 LDA FR
 CMP MNFR
 BNE MOT2B
 JMP STOP
MOT2B
 LDA ANG
 CMP #$90
 BCS DEMF1
 JSR F0
DEMF2
 DEC FR
 SEC
 PHA
 LDA MNLAL
 SBC #$05
 STA MNLAL
 LDA #$58
 STA DRB
 LDA #$FF
 STA TSEC
 STA DRB
 LDA TSEC
 BNE MOT2A
 PLA
 JMP NFR
DEMF1 LDX #0
DEMFA LDA DEMFB,X
 JSR OUTPUT
 INX
 CPX #20
 BNE DEMFA
 LDA FR
 SBC #1
 STA MFR
 JMP DEMF2
AIR2 JMP LACH
NFR
 NOP
 LDA #$77
 STA DRB
 LDA #$70
 STA DRB
 JSR NFR1
 PHA
 LDX #0
NFRAA
 LDA #$FF
 STA TSEC
NFRA
 LDA TSEC
 BNE NFRA
 INX
 CPX #40
 BNE NFRAA
 PLA
 JMP NOC
NFR1 PHA
 LDX #0
 JSR CLR
NFR2 LDA NF,X
 JSR OUTPUT
 INX
 CPX #20
 BNE NFR2
 PLA
 RTS
RD1 LDX #0
 JSR CLR
 LDA CCODE
 CMP #7
 BEQ RDA
 CMP #6
 BEQ RDB
 CMP #5
 BEQ RDC
 CMP #4
 BEQ RDD
 CMP #2
 BEQ RDF
 CMP #1
 BEQ RDG
 JMP RDH
RDA LDA RDA1,X
 JSR OUTPUT
 INX
 CPX #20
 BNE RDA
 RTS
RDB LDA RDB1,X
 JSR OUTPUT
 INX
 CPX #16
 BNE RDB
 RTS
RDC LDA RDC1,X
 JSR OUTPUT
 INX
 CPX #16
 BNE RDC
 RTS
RDD LDA RDD1,X
 JSR OUTPUT
 INX
 CPX #12
 BNE RDD
 RTS
RDE LDA RDE1,X
 JSR OUTPUT
 INX
 CPX #16
 BNE RDE
 RTS
RDF LDA RDF1,X
 JSR OUTPUT
 INX
 CPX #12
 BNE RDF
 RTS
RDG LDA RDG1,X
 JSR OUTPUT
 INX
 CPX #12
 BNE RDG
 RTS
RDH LDA RDH1,X
 JSR OUTPUT
 INX
 CPX #14
 BNE RDH
 RTS
STOP NOP
 PHA
 LDX #0
 JSR CLR
```

```
STOP1 LDA STOPA,X
 JSR OUTPUT
 INX
 CPX #20
 BNE STOP1
 PLA
 LDA ANG
 CMP #$90
 BEQ WORST
 JMP LACH
WORST LDX #0
WORST1 LDA WORSTA,X
 JSR OUTPUT
 INX
 CPX #20
 BNE WORST1
 LDA FR
 STA MFR
 JMP NOC
LACH LDA CCODE
 AND #$01
 CMP #1
 BEQ AIR
 JMP NOC
AIR
 LDA DECM+2
 CMP #$00
 BEQ CHLA1
 INC TEMLA
 LDA TEMLA
 CMP #2
 BEQ TUR1A
 JMP NOC
CHLA1
 LDA LAL
 CMP MNLAL
 BCS X1
 JSR MTLA
 JMP NOC
TUR1A CMP #1
 BNE TUR1B
 JMP TUR2
TUR1B JMP TUR1
MTLA
 NOP
 SED
 CLC
 LDA ANG
 CMP #$90
 BCS DEMF
 LDA #2
 ADC ANG
 STA ANG
 CLD
 PHA
 JSR R0
 LDA #$38
 STA DRB
 LDX #0
MTLA1 LDA #$FF
 STA TSEC
MTLA2
 LDA #$23
 STA DRB
 LDA TSEC
 BNE MTLA2
 INX
 CPX #6
 BNE MTLA1
 LDA #$77
 STA DRB
 LDA #$70
 STA DRB
 PLA
 RTS
DEMF
 JMP MOT1
UR0 PHA
 JSR CLR
 LDX #0
UR0A LDA UR,X
 JSR OUTPUT
 INX
 CPX #20
 BNE UR0A
 PLA
 RTS
R0 PHA
 JSR CLR
 LDX #0
R0A LDA R,X
 JSR OUTPUT
 INX
 CPX #20
 BNE R0A
 PLA
 RTS
X1 LDA LAL
 CMP MLAL
 BCC NOCA
 CMP #$80
 BCS TUR1
 LDA #5
 STA TURNN
 LDA #2
 STA ANGN
 JMP TUR3
NOCA
 JMP NOC
TUR1
 LDA #25
 STA TURNN
 LDA #10
 STA ANGN
 JMP TUR3
TUR2
 LDA #12
 STA TURNN
 LDA #5
 STA ANGN
TUR3
 JSR MTLB
 JMP NOC
MTLB NOP
 SED
 SEC
 LDA ANG
 SBC ANGN
 STA ANG
 CLD
 PHA
 JSR OVER
 LDA #$30
 STA DRB
 LDX #0
MTLB1 LDA #$FF
 STA TSEC
MTLB2
 LDA #$28
 STA DRB
 LDA TSEC
 BNE MTLB2
 INX
 CPX TURNN
 BNE MTLB1
 LDA #$77
 STA DRB
 LDA #$70
 STA DRB
 PLA
 RTS
OVER PHA
 JSR CLR
 LDX #0
OVERB LDA OVER1,X
 JSR OUTPUT
 INX
 CPX #20
 BNE OVERB
 PLA
 RTS
NOC
 LDA TEMLA
 CMP #2
 BNE NCHKLA
 LDA #0
 STA TEMLA
NCHKLA
 LDA MIN
 CMP #5
 BNE NONEW
 LDA #0
 STA TEMUA
 STA TEMLA
NONEW
 LDA #0
 LDX #0
```

```
REP2 STA DECM,X
 INX
 CPX #17
 BNE REP2
RECHK
 LDA SECD
 AND #$0F
 CMP #0
 BNE RECHK
 JMP START
SDATA JMP START
DELAY LDY #0
DEL INY
 JSR DESK1
 CPY #$1F
 BNE DEL
 RTS
IIRQ PHA
 LDA #$FF
 STA TSEC
 SED
 CLI
 LDA #1
 ADC FSEC
 STA FSEC
 CMP #$64
 BNE TIME
 LDA #0
 STA FSEC
 STA TSEC
 CLC
 LDA #1
 ADC SECD
 STA SECD
 CMP #$60
 BNE TIME
 LDA #0
 STA SECD
 CLC
 LDA #1
 ADC MIN
 STA MIN
 CMP #$60
 BNE TIME
 LDA #0
 STA MIN
 CLC
 LDA #1
 ADC HOUR
 STA HOUR
 CMP #24
 BNE TIME
TIME LDA T1CL
 PLA
 RTI
DISP0 JSR CLR
 LDX #0
DIS0A LDA DIS0,X
 JSR OUTPUT
 INX
 CPX #13
 BNE DIS0A
 LDA CCODE
 JSR NUMA
 JSR READ
 CMP #$0D
 BNE NCODE
 RTS
NCODE
 JSR RCHECK
 JSR RDRUB
 ASL A
 ASL A
 ASL A
 ASL A
 AND #$F0
 STA CCODE
 JSR RCHECK
 JSR RDRUB
 AND #$0F
 CLC
 ADC CCODE
 STA CCODE
 JMP DISP0
DISP1 JSR CLR
 PHA
 LDA #$0D
 JSR OUTD
 LDA CCODE
 JSR NUMA
 LDA #$20
 JSR OUTD
 LDX #0
DISP LDA MESG,X
 JSR OUTPUT
 INX
 CPX #7
 BNE DISP
 LDA HOUR
 JSR NUMA
 LDA #':
 JSR OUTD
 LDA MIN
 JSR NUMA
 LDA #':
 JSR OUTD
 LDA SECD
 JSR NUMA
 LDA #$20
 JSR OUTD
 PLA
 RTS
DISP2
 JSR CLR
 LDX #0
DSP21 LDA DSP2A,X
 JSR OUTPUT
 INX
 CPX #10
 BNE DSP21
 LDA FR
 JSR NUMA
 LDA DSTF
 CMP #$40
 BNE DSP2A
 RTS
DSP2A
 JSR READ
 CMP #$0D
 BNE NFEED
 RTS
NFEED JSR RCHECK
 JSR RDRUB
 ASL A
 ASL A
 ASL A
 ASL A
 AND #$F0
 STA FR
 JSR RCHECK
 JSR RDRUB
 AND #$0F
 CLC
 ADC FR
 STA FR
 JMP DISP2
DISPU JSR CLR
 LDX #0
DSPU1 LDA DSPUA,X
 JSR OUTPUT
 INX
 CPX #15
 BNE DSPU1
 LDA UANG
 JSR NUMA
 JSR READ
 CMP #$0D
 BNE NUP
 RTS
NUP JSR RCHECK
 JSR RDRUB
 ASL A
 ASL A
 ASL A
 ASL A
 AND #$F0
 STA UANG
 JSR RCHECK
 JSR RDRUB
 AND #$0F
 CLC
 ADC UANG
 STA UANG
 JMP DISPU
DISPL JSR CLR
 LDX #0
```

```
DSPL1 LDA DSPLA,X
 JSR OUTPUT
 INX
 CPX #15
 BNE DSPL1
 LDA ANG
 JSR NUMA
 JSR READ
 CMP #$0D
 BNE NLOW
 RTS
NLOW JSR RCHECK
 JSR RDRUB
 ASL A
 ASL A
 ASL A
 ASL A
 AND #$F0
 STA ANG
 JSR RCHECK
 JSR RDRUB
 AND #$0F
 CLC
 ADC ANG
 STA ANG
 JMP DISPL
DISP3
 JSR CLR
 LDX #0
DSP31 LDA DSP3A,X
 JSR OUTPUT
 INX
 CPX #4
 BNE DSP31
 LDA DECM+10
 JSR NUMA
 LDA DECM+11
 JSR NUMA
 LDA #$20
 JSR OUTD
 LDA #$20
 JSR OUTD
 LDX #0
DSP32 LDA DSP3B,X
 JSR OUTPUT
 INX
 CPX #4
 BNE DSP32
 LDA DECM+2
 JSR NUMA
 LDA DECM+3
 JSR NUMA
 LDA #$20
 JSR OUTD
 RTS
DISP4
 JSR CLR
 LDX #0
DSP41 LDA DSP4A,X
 JSR OUTPUT
 INX
 CPX #4
 BNE DSP41
 LDA DECM+6
 JSR NUMA
 LDA DECM+7
 JSR NUMA
 LDA #$20
 JSR OUTD
 LDA #$20
 JSR OUTD
 LDX #0
DSP42 LDA DSP4B,X
 JSR OUTPUT
 INX
 CPX #4
 BNE DSP41
 LDA DECM+4
 JSR NUMA
 LDA DECM+5
 JSR NUMA
 LDA #$20
 JSR OUTD
 JSR OUTD
 RTS
DPBS2 JSR CLR
 LDX #0
DPBMA LDA DIBM,X
 JSR OUTPUT
 INX
 CPX #9
 BNE DPBMA
 LDA MSE
 JSR NUMA
 LDX #0
DPBNA LDA DIBN,X
 JSR OUTPUT
 INX
 CPX #7
 BNE DPBNA
 LDA MNSE
 JSR NUMA
 JSR READ
 CMP #$0D
 BNE DPBS2
 RTS
DPUAL JSR CLR
 LDX #0
DPUMA LDA DIUM,X
 JSR OUTPUT
 INX
 CPX #9
 BNE DPUMA
 LDA MUAL
 JSR NUMA
 LDX #0
DPUNA LDA DIUN,X
 JSR OUTPUT
 INX
 CPX #7
 BNE DPUNA
 LDA MNUAL
 JSR NUMA
 JSR READ
 CMP #$0D
 BNE DPUAL
 RTS
DPLAL JSR CLR
 LDX #0
DPLMA LDA DILM,X
 JSR OUTPUT
 INX
 CPX #9
 BNE DPLMA
 LDA MLAL
 JSR NUMA
 LDX #0
DPLNA LDA DILN,X
 JSR OUTPUT
 INX
 CPX #7
 BNE DPLNA
 LDA MNLAL
 JSR NUMA
 JSR READ
 CMP #$0D
 BNE DPLAL
 RTS
DISP5 JSR CLR
 LDX #0
DSP51 LDA DSP5A,X
 JSR OUTPUT
 INX
 CPX #18
 BNE DSP51
 LDA DMCHK
 JSR NUMA
 JSR READ
 CMP #$0D
 BNE NDM
RTS
NDM JSR RCHECK
 JSR RDRUB
 AND #$0F
 STA DMCHK
 JMP DISP5
F0 PHA
 LDX #0
F0A LDA F01,X
 JSR OUTPUT
 INX
 CPX #20
 BNE F0A
 PLA
 RTS
```

```
S0 PHA
 LDX #0
S0A LDA FED,X
 JSR OUTPUT
 INX
 CPX #20
 BNE S0A
 PLA
 RTS
SENS PHA
 CPX #8
 BNE GO1
 LDA DRA
 AND #$F0
 STA HEXA
 JMP GO
GO1 LDA DRA
 STA HEXA
 JMP GO
GO
 JSR HEXD
 CLC
 LDA HEST+1
 ADC DECM+1,X
 STA DECM+1,X
 BCC LOOP
 INC DECM,X
LOOP CLC
 LDA HEST
 ADC DECM,X
 STA DECM,X
 CPX #0
 BEQ SCLS
 CPX #2
 BEQ SLAL
 CPX #4
 BEQ SBS2
 CPX #6
 BEQ STOTAL
 CPX #10
 BEQ SUAL
 PLA
 RTS
SUAL LDA DECM+1,X
 STA UAL
 PLA
 RTS
SBS2 LDA DECM+1,X
 STA BS2
 PLA
 RTS
SLAL LDA DECM+1,X
 STA LAL
 PLA
 RTS
SCLS LDA DECM+1,X
 STA CLS
 PLA
STOTAL LDA DECM+1,X
 STA TOTAL
 PLA
 RTS
HEXD SED
 LDA #0
 STA HEST
 STA HEST+1
 LDA HEXA
 AND #$0F
 CMP #$0A
 BCC NEXT
 CLC
 ADC #6
NEXT STA HEST+1
 LDA HEXA
 AND #$10
 BEQ NEX1
 CLC
 LDA #$16
 ADC HEST+1
 STA HEST+1
NEX1 LDA HEXA
 AND #$20
 BEQ NEX2
 CLC
 LDA #$32
 ADC HEST+1
 STA HEST+1
NEX2 LDA HEXA
 AND #$40
 BEQ NEX3
 CLC
 LDA #$64
 ADC HEST+1
 STA HEST+1
 BCC NEX3
 INC HEST
NEX3 LDA HEXA
 AND #$80
 BEQ NEXL
 CLC
 LDA #$28
 ADC HEST+1
 STA HEST+1
 BCC NEX4
 INC HEST
NEX4 INC HEST
 NEXL NOP
 RTS
DUMP NOP
 PHA
 SED
 LDX #0
 LDY #0
 LDA DECM-3
 AND #$0F
 ASL A
 STA TH
 LDA DECM-2
 AND #$F0
 LSR A
 LSR A
 LSR A
 LSR A
 ORA TH
 STA TH
 JSR ASCI
 LDA DECM-1
 AND #$0F
 ASL A
 ASL A
 ASL A
 ASL A
 STA TM
 LDA DECM-1
 AND #$F0
 LSR A
 LSR A
 LSR A
 LSR A
 ORA TM
 STA TM
 JSR ASCI
 LDA #$20
 JSR WAIT
 LDA #$44
 JSR WAIT
 LDA #$41
 JSR WAIT
 LDA #$54
 JSR WAIT
 LDA #$41
 JSR WAIT
 LDA #$20
 JSR WAIT
 LDA FR
 JSR ASCI
 LDA #$20
 JSR WAIT
 LDA VANG
 JSR ASCI
 LDA ANG
 JSR ASCI
 LDA #$20
 JSR WAIT
 LDX #0
MP1 LDA DECM,X
 JSR ASCI
 INY
 CPY #2
 BNE TO
 LDA #$20
 JSR WAIT
 LDY #0
```

```
RTS
BNE MP1
LDA #$0D
JSR WAIT
LDA #$0A
JSR WAIT
PLA
RTS
ASCI PHA
LSR A
LSR A
LSR A
LSR A
JSR MP2
PLA
AND #$0F
MP2 CLC
ADC #$30
CMP #$3A
BCC WAIT
CLC
ADC #1
JSR WAIT
RTS
WAIT PHA
MPI LDA CTR1
AND #$01
BEQ MP3
PLA
STA DR1
RTS
MOTOR NOP
PHA
ENTER
LDA #$70
STA DRB
LDX #0
LDA #4
STA KEYM
JSR CLR
ENT1 LDA ENT1A,X
JSR OUTPUT
INX
CPX #20
BNE ENT1
JSR READ
CMP #$31
BEQ ADJUA
CMP #$32
BEQ ADJLA
CMP #$0D
BNE ENTER
JMP NEXM
ADJUA LDA #0
STA MTCON
JSR CLR
LDX #0
ADUA1 LDA ADUAA,X
JSR OUTPUT
INX
ASL A
ASL A
ASL 1
CPX #20
BNE ADUA1
JMP DIRCH
ADJLA LDA #$20
STA MTCON
JSR CLR
LDX #0
ADLA1 LDA ADLAA,X
JSR OUTPUT
INX
CPX #20
BNE ADLA1
JMP DIRCH
DIRCH LDA #$DF
STA PDRA
JSR CLR
LDA PDRB
EOR #$FF
BNE MT1
LDA KEYM
MT1 STA KEYM
CMP #$40
BNE MT2
LDA MTCON
ADC #$08
STA DRB
JMP DIRCH
MT2 CMP #$08
BNE MT3
LDA MTCON
STA DRB
JMP DIRCH
MT3 CMP #$20
BNE MT4
JMP ENTBR
MT4 LDA #$70
STA DRB
LDA #$77
STA DRB
LDA KEYM
CMP #$80
BEQ NEXM
JMP DIRCH
NEXM LDA #$80
STA DSTR
JSR RD1
PLA
RTS
ENT1A .BYT 'ADJ UA=1
....ADJ LA=2'
ADUAA .BYT 'UPPER AI
R: 8(-UA-)2 '
ADLAA .BYT 'LOWER AI
R: 8(-LA-)2
DIS0 .BYT 'CONTROL I
ODE:'
MES3 .BYT '   TIME=
R .BYT '* INCREASE L
OWER AIR
TO INX
CPX #12
OVER1 .BYT 'WARNING:
OVER MAX LAL'
FED .BYT '* INCREASE
FEED RATE'
F01 .BYT 'WARNING:FO
OR SIFTING'
RB .BYT '* INCREASE
UPPER AIR'
NF .BYT '*CHANGING F
EED WAIT'
OVERB1 .BYT 'WARNING
:OVER MAX UAL
CLEAN .BYT 'CLEAN SC
(BL HR)='
STOPA .BYT '** MINIM
UM FEED RATE
DSP1A .BYT 'FEED RAT
E
AIR1S .BYT '** MAXIM
UM FEED RATE
DEMPE .BYT '*AN2=30
MAX FR=FR-1
DSP4A .BYT 'SS1=
DSP4B .BYT 'SS2=
WOR3TA .BYT '** CHEC
K CLEANER! **
RDA1 .BYT 'AUTOMATE:
UA, FR, LA'
RDB1 .BYT 'AUTOMATE:
UA, FR'
RDC1 .BYT 'AUTOMATE:
UA, LA'
RDD1 .BYT 'AUTOMATE:
UA'
RDE1 .BYT 'AUTOMATE:
FR, LA'
RDF1 .BYT 'AUTOMATE:
FR'
RDG1 .BYT 'AUTOMATE:
LA'
RDH1 .BYT 'AUTOMATE:
NONE'
DSP1A .BYT 'UAL=
UR .BYT 'WARNING:OVE
R MAX UAL
DSP5A .BYT 'DUMP DAT
A (YES=1)'
DISM .BYT 'SS1 MAX=
```

```
DIBN  BYT '     MIN='
DIUM  BYT 'UAL: MAX=
'

DIUN .BYT '     MIN='
DILM .BYT 'LAL: MAX=
'

DSPIS .BYT 'LAL='
DILN .BYT '     MIN='
DSFUA .BYT 'UPPER-FA
N OPEN:'
DSFLA .BYT 'LOWER-FA
N OPEN:'
TT  BYT 'CONTROL PRO
GRAM APST
 .END
OUT=
 DEBK1=$ED2C
 RCHECK=$E907
 OUTPUT=$E97A
 RDRUB=$E95F
 CLR=$EB44
 READ=$E93C
 NUMA=$EA45
*=$40
MLAL *=*+1
MNLAL *=*+1
MUAL *=*+1
MNUAL *=*+1
MSE *=*+1
MNSE *=*+1
FR *=*+1
MFR *=*+1
MNFR *=*+1
ANG *=*+1
TURNN *=*+1
ANGN *=*+1
CCODE *=*+1
UANG *=*+1
UTURN *=*+1
UANGN *=*+1
*=$50
DMCHK *=*+1
 *=$3000
 LDX #0
 LDA #0
AGAIN STA MLAL,X
 INX
 CPX #20
 BNE AGAIN
 LDA #$60
 STA MLAL
 LDA #$40
 STA MNLAL
 LDA #$05
 STA MUAL
 LDA #$02
 STA MNUAL
 LDA #$10
 STA MSE
 LDA #$00
 STA MNSE
 LDA #4
 STA FR
 LDA #8
 STA MFR
 LDA #2
 STA MNFR
 LDA #$30
 STA ANG
 LDA #$30
 STA UANG
 LDA #7
 STA CCODE
 LDA #1
 STA DMCHK
ASK JSR CLR
 LDX #0
QUEE LDA QUES0,X
 JSR OUTPUT
 INX
 CPX #20
 BNE QUEE
 JSR DELAY
 JSR DELAY
 LDA #$40
 STA $010C
 STA $010F
 STA $0112
 LDA #00
 STA $010D
 LDA #$00
 STA $010E
 LDA #$40
 STA $110
 LDA #$00
 STA $0111
 LDA #00
 STA $0113
 LDA #$00
 STA $0114
 JSR CLR
 LDX #0
NAME LDA NAM,X
 JSR OUTPUT
 INX
 CPX #20
 BNE NAME
 JSR DELAY
 JSR DELAY
ASKA JSR CLR
 LDX #0
QUEA LDA QUN,X
 JSR OUTPUT
 INX
 CPX #20
 BNE QUEA
 JSR READ
 CMP #$30
 BEQ ASK0
 CMP #$31
 BNE ASKA
 JMP $C000
ASK0 JSR CLR
 LDX #00
QES0 LDA QUEEN0,X
 JSR OUTPUT
 INX
 CPX #13
 BNE QES0
 LDA CCODE
 JSR NUMA
 JSR READ
 CMP #$0D
 BNE NCCODE
 JMP ASK0A
NCCODE
 JSR RCHECK
 JSR RDRUB
 ASL A
 ASL A
 ASL A
 ASL A
 AND #$F0
 STA CCODE
 JSR RCHECK
 JSR RDRUB
 AND #$0F
 CLC
 ADC CCODE
 STA CCODE
 JMP ASK0
ASK0A
 JSR CLR
 LDX #0
QUEE0A LDA QUN0A,X
 JSR OUTPUT
 INX
 CPX #A
 BNE QUE00A
 LDA MUAL
 JSR NUMA
 JSR READ
 CMP #$0D
 BNE NMUAL
 JMP ASK1
NMUAL
 JSR RCHECK
 JSR RDRUB
 ASL A
 ASL A
 ASL A
```

04/20/87

DATA RESET (START)

```
 ASL A
 AND #$F0
 STA MUAL
 JSR RCHECK
 JSR RDRUB
 AND #$0F
 CLC
 ADC MUAL
 STA MUAL
 JMP ASK0A
ASK1
 LDX #00
QUES0 LDA QUESN2,
 JSR OUTPUT
 INX
 CPX #7
 BNE QUES0
 LDA MNUAL
 JSR NUMA
 JSR READ
 CMP #$0D
 BNE NMNUA
 JMP ASK2A
NMNUA
 JSR RCHECK
 JSR RDRUB
 ASL A
 ASL A
 ASL A
 ASL A
 AND #$F0
 STA MNUAL
 JSR RCHECK
 JSR RDRUB
 AND #$0F
 CLC
 ADC MNUAL
 STA MNUAL
 JMP ASK0A
ASK2A
 JSR CLR
 LDX #0
QUES1 LDA QUESN1,
 JSR OUTPUT
 INX
 CPX #9
 BNE QUES1
 LDA MLAL
 JSR NUMA
 JSR READ
 CMP #$0D
 BNE NMLAL
 JMP ASK2
NMLAL
 JSR RCHECK
 JSR RDRUB
```

```
 ASL A
 ASL A
 ASL A
 ASL A
 AND #$F0
 STA MLAL
 JSR RCHECK
 JSR RDRUB
 AND #$0F
 CLC
 ADC MLAL
 STA MLAL
 JMP ASK2A
ASK2 LDX #0
QUES2 LDA QUESN2,X
 JSR OUTPUT
 INX
 CPX #7
 BNE QUES2
 LDA MNLAL
 JSR NUMA
 JSR READ
 CMP #$0D
 BNE NMNLA
 JMP ASK3
NMNLA
 JSR RDRUB
 ASL A
 ASL A
 ASL A
 ASL A
 AND #$F0
 STA MNLAL
 JSR RCHECK
 JSR RDRUB
 AND #$0F
 CLC
 ADC MNLAL
 STA MNLAL
 JMP ASK2A
ASK3
 JSR CLR
 LDX #0
QUES3 LDA QUESN3,X
 JSR OUTPUT
 INX
 CPX #9
 BNE QUES3
 LDA MSE
 JSR NUMA
 JSR READ
 CMP #$0D
 BNE NMSE
 JMP ASK4
NMSE
 JSR RDRUB
```

```
 ASL A
 ASL A
 ASL A
 ASL A
 AND #$F0
 STA MSE
 JSR RCHECK
 JSR RDRUB
 AND #$0F
 CLC
 ADC MSE
 STA MSE
 JMP ASK3
ASK4 LDX #0
QUES4 LDA QUESN4,X
 JSR OUTPUT
 INX
 CPX #9
 BNE QUES4
RPT4 JSR READ
 CMP #$0D
 BNE RPT4
ASK5 JSR CLR
 LDX #0
QUES5 LDA QUESN5,X
 JSR OUTPUT
 INX
 CPX #9
 BNE QUES5
 LDA MFR
 JSR NUMA
 JSR READ
 CMP #$0D
 BNE NMFR
 JMP ASK6
NMFR JSR RCHECK
 JSR RDRUB
 AND #$0F
 STA MFR
 JMP ASK5
ASK6 LDX #0
QUES6
 LDA QUESN6,X
 JSR OUTPUT
 INX
 CPX #8
 BNE QUES6
 LDA MNFR
 JSR NUMA
 JSR READ
 CMP #$0D
 BNE NMNFR
 JMP $C040
NMNFR JSR RCHECK
 JSR RDRUB
 AND #$0F
```

```
 STA MNFR
 JMP ASK5
DELAY LDY #0
DEL JSR DEBK1
 INY
 CPY #$FF
 BNE DEL
 RTS
QUESN5 .BYT 'FR:  MA
X='
QUESN6 .BYT '   MIN=
'
QUES0 .BYT 'AUTO-CON
TROL VER 1.0'
QUESN0 .BYT 'CONTROL
 CODE='
QUN .BYT 'RESET DATA
=0: RUN=1 '
QUN0A .BYT 'VAL: MAX
='
QU05 .BYT '   MIN=00
'
QUESN1 .BYT 'LAL: MA
X='
QUESN2 .BYT '   MIN=
'
QUESN3 .BYT 'BS2: MA
X='
NAM .BYT 'BY MISRA &
 SHYY  ISU'
QUESN4 .BYT '   MIN=
00'
 .END
 *=$50
DMCHK *=*+1
COUNT *=*+1
 MSLAL *=*+1
 LSLAL *=*+1
 MSVAL *=*+1
 LSVAL *=*+1
 AMLAL *=*+1
 ALLAL *=*+1
 AMVAL *=*+1
 ALVAL *=*+1
 *=$00
RUN *=*+1
HOUR *=*+1
MIN *=*+1
SECD *=*+1
DECM *=*+12
VAL *=*+1
LAL *=*+1
BS2 *=*+1
CLS *=*+1
TOTAL *=*+1
FSEC *=*+1
TSEC *=*+1
HEST *=*+2
HEXA *=*+1
DSTR *=*+1
KEYM *=*+1
DIR  *=*+1
MTCON *=*+1
TH *=*+1
TM *=*+1
CDRB *=*+1
 *=$0112
 JMP $D000
 *=$D000
 LDA #$60
 STA MLAL
 LDA #$40
 STA MNLAL
 LDA #$40
 STA MVAL
 LDA #$10
 STA MNVAL
 LDA #$20
 STA MSE
 LDA #$05
 STA MNSE
 LDA #4
 STA FR
 LDA #8
 STA MFR
 LDA #2
 STA MNFR
 LDA #$30
 STA ANG
 LDA #00
 STA CCODE
 LDA #$40
 STA VANG
 LDA #$01
 STA DMCHK
 LDX #0
 JSR CLR
TIT LDA TITL,X
 JSR OUTPUT
 INX
 CPX #20
 BNE TIT
 JSR DELAY
 JSR CLR
 LDX #0
NAME LDA NAM,X
 JSR OUTPUT
 INX
 CPX #20
 BNE NAME
 JSR DELAY
 JSR CLR
 LDX #0
REME LDA REME1,X
 JSR OUTPUT
 INX
 CPX #20
 BNE REME
 LDA #$00
 STA DSTR
 LDA #$03
 STA SR1
 LDA #$4E
 STA CTR1
 LDA #$22
 STA CTR1
 LDA #0
 STA DDRA
 LDA #$FF
 STA DDRB
 LDA #$C0
 STA ACR
 LDA #$C0
 STA IER
 LDA #$77
 STA IRB
 LDA #$70
 STA DRB
 LDX #5
 LDA #0
RECL STA HOUR,X
 INX
 CPX #21
 BNE RECL
 LDA #$80
 STA DSTR
 LDA #$F0
 STA T1CL
 LDA #$3C
 STA T1CH
 LDA #<IIRQ
 STA IRQV
 LDA #>IIRQ
 STA IRQV+1
 CLI
 LDA #0
 STA COUNT
 STA MSLAL
 STA LSLAL
 STA MSVAL
 STA LSVAL
 STA AMLAL
 STA ALLAL
 STA AMVAL
 STA ALVAL
START
 LDA SECD
 CMP SECD
 BEQ START
```

```
ACCU
 LDA #$EF
 STA PDRA
 LDA PDRB
 EOR #$FF
 BNE DP
 LDA DSTP
DP STA DSTP
 CMP #$01 —
 BNE DPA
 JMP SETRA
 JMP NOC
DPA
 LDA #$71
 STA DRB
 LDX #0
 JSR SENS
 LDA #$72
 STA DRB
 LDX #2
 JSR SENS
 LDA #$73
 STA DRB
 LDX #4
 JSR SENS
 LDA #$74
 STA DRB
 LDX #6
 JSR SENS
 LDA #$75
 STA DRB
 LDX #8
 JSR SENS
 LDA #$76
 STA DRB
 LDX #10
 JSR SENS
 LDA #$77
 STA DRB
 LDA #$70
 STA DRB
 LDA SECD
 AND #$0F
 CMP #0
 BEQ CONT
 JMP ACCU
CONT
DPS JSR DISPD
CLEN
 JSR DUMP
NOC
 LDA COUNT
 CMP #10
 BEQ AVE
 INC COUNT
 LDA #0
 LDX #0
REP2 STA SEDM,X
 INX
 CPX #17
 BNE REP2
RECH
 LDA SECD
 AND #$0F
 CMP #0
 BNE RECHK
 JMP START
CALC
 CLC
 LDA SEDM-1
 ADC LSLAL
 STA LSLAL
 BCC LOPL
 INC MSLAL
LOPL CLC
 LDA SEDM-2
 ADC MSLAL
 STA MSLAL
 CLC
 LDA SEDM-11
 ADC LSUAL
 STA LSUAL
 BCC LOPU
 INC MSUAL
LOPU CLC
 LDA SEDM-10
 ADC MSUAL
 STA MSUAL
 RTS
AVE JSR CLR
 LDX #0
AVEA LDA AVE1,X
 JSR OUTPUT
 INX
 CPX #7
 BNE AVEA
 LDA LSLAL
 AND #$F0
 LSR A
 LSR A
 LSR A
 LSR A
 AND #$0F
 STA LSLAL
 LDA MSLAL
 AND #$0F
 ASL A
 ASL A
 ASL A
 ASL A
 ORA LSLAL
 STA LSLAL
 LDA MSLAL
 AND #$F0
 LSR A
 LSR A
 LSR A
 LSR A
 STA MSLAL
 LDA LSUAL
 AND #$F0
 LSR A
 LSR A
 LSR A
 LSR A
 STA LSUAL
 LDA MSUAL
 AND #$0F
 ASL A
 ASL A
 ASL A
 ASL A
 ORA LSUAL
 STA LSUAL
 LDA MSUAL
 AND #$F0
 LSR A
 LSR A
 LSR A
 LSR A
 STA MSUAL
 STA AMUAL
 JSR NUMA
 LDA LSUAL
 STA ALUAL
 JSR NUMA
 LDX #0
AVEB LDA AVE2,X
 JSR OUTPUT
 INX
 CPX #5
 BNE AVEB
 LDA MSLAL
 STA AMLAL
 JSR NUMA
 LDA LSLAL
 STA ALLAL
 JSR NUMA
 LDA #0
 STA COUNT
 STA MSLAL
 STA LSLAL
 STA MSUAL
 STA LSUAL
```

```
 JMP NOC
DELAY LDY #0
DEL JSR DEBK1
 INY
 CPY #$FF
 BNE DEL
 RTS

CHKUA
 LDA AMUAL
 SEQ SETUA
 LDA #$99
 STA MUAL
 LDA #$60
 STA MNUAL
 JMF CHKLA
SETUA
 CLC
 LDA ALUAL
 ADC #$20
 STA MUAL
 BCC SETMU
 LDA #$99
 STA MUAL
SETMU
 LDA ALUAL
 CMF #7
 BCC EQ0
 SEC #5
 STA MNUAL
 JMP CHKLA
EQ0 LDA #2
 STP MNUAL
CHKLA
 LDA AMLAL
 BEQ SETLA
 LDA #$99
 STA MLAL
 LDA #$60
 STA MNLAL
 JMP FINISH
SETLA
 CLC
 LDA ALLAL
 ADC #$20
 STA MLAL
 BCC SETML
 LDA #$99
 STA MLAL
SETML
 LDA ALLAL
 CMF #7
 BCC EQ1
 SBC #5
 STA MNLAL
 JMP FINISH
EQ1 LDA #2
 STA MNLAL
FINISH
 JMP $C040
DSP4A .BYT 'BS1='
DSP4B .BYT 'BS2='
DSP3A .BYT 'UAL='
DSF3B .BYT 'LAL='
AVE1 .BYT 'AV UAL='
AVE2 .BYT ',LAL='
TITL .BYT 'DATA READ
 & AVER PGM'
REME1 .BYT '*** DATA
 READING ***'
NAM .BYT 'BY SHYY &
[illegible]
```

We claim:

1. An improved cleaning system for separating lighter material from heavier material in a mixture of particulate materials, the system including an inlet for receiving the mixture, an outlet for discharging heavier material, and a vacuum air-lift means between the inlet and the outlet for separating the lighter material from the heavier material, the air-lift means having a spout for collecting the lighter material and having a first gate movable between a normal closed position for maintaining the vacuum of the air-lift means and a second open position for discharging the lighter material, the improvement comprising:

a second gate in said air-lift spout mounted upstream from the first gate and being movable between a normal open position when the first gate is closed and a closed position when the first gate is open; and

a sensor for sensing the quantity of lighter material separated by the air-lift means, the sensor being mounted in the spout downstream from the second gate so that when the second gate is in the open position, the lighter material separated by the air-lift means enters the spout and passes the second gate for sensing by the sensor.

2. The cleaning system of claim 1 wherein the second gate is pivotally mounted in the spout so as to automatically move to the closed position by the vacuum of the air-lift means when the first gate is open.

3. The cleaning system of claim 1 wherein the sensor produces signals corresponding to the quantity of lighter material sensed by the sensor, and the sensor is interfaced with a processing means for receiving and processing the signals for monitoring the cleaning system and for adjusting the extent of separation by the air-lift means to achieve a desired efficiency of the system.

4. The cleaning system of claim 1 further comprising at least one elongated screen for separating undersized material from oversized material, the screen having a feed end and a discharge end, and a screening spout adjacent the discharge end for collecting the undersized material sifted through the screen,

a divider plate mounted in the screening spout so as to divide the screening spout into an upstream side and a downstream side, the upstream side collecting the undersized material sifted along the substantial length of the screen and the downstream side collecting the undersized material sifted immediately adjacent the discharge end of the screen, whereby the presence of undersized material in the downstream side of the screening spout indicates that the separation by the screen of the undersized material from the oversized material is incomplete; and

another sensor mounted in the downstream side of the screening spout for sensing the quantity of undersized material collected therein.

5. The cleaning system of claim 4 wherein the another sensor produces signals corresponding to the quantity of undersized material sensed by the another sensor and the another sensor is interfaced with a processing means for receiving and processing the signals for monitoring the cleaning system and for adjusting the extent of separation by the screen to achieve a desired efficiency of the system.

6. A method for separating desire material from undesirable material in a mixture of particulate materials, comprising:

introducing the mixture onto a first screen means for separating undersized material from oversized material within the mixture, the screen means having a feed end and a discharge end;

sensing the quantity of undersized material separated by the screen means adjacent the discharge end thereof and generating a signal corresponding to such quantity;

depositing the oversized material into an air-lift means for separating lighter material from heavier materials within the oversized materials;

sensing the quantity of lighter materials separated by the air-lift means and generating a signal corresponding to such quantity;

adjusting the extent of separation by the screen means and the extent of separation by the air-lift means in response to the respective generated signals so as to achieve a desired cleaning efficiency; and

sampling the separated lighter materials to determine the quality thereof.

7. The method of claim 6 wherein the adjustments are made by a processing unit which receives and processes the respective signals.

8. The method of claim 6 further comprises dividing the discharge end of the screen means into an upstream side and a downstream side, the sensing of the quantity of undersized materials occurring only on the downstream side of the discharge end of the screen means.

9. The method of claim 6 wherein the sampling further includes opening a first gate and closing a second gate within said air-lift means so as to maintain the vacuum therein, the sample being located between the first and second gates.

10. The method of claim 9 wherein the closing of the second gate is automatic and simultaneous with the opening of the first gate.

11. The method of claim 6 further comprising receiving any of said generated signals with a processing means.

12. The method of claim 11 further comprising presenting a user of the method with official information from said processing means regarding and corresponding to the generated signals.

13. The method of claim 11 further comprising interpreting the generated signals with the processing means and instructing a user how to adjust any of the introduction and separation of material to cause the method to achieve desired separation of undesirable material from desirable material.

14. The method of claim 11 further comprising automatically adjusting with the processing means any of the introduction and separation of material on a continuous, automatic basis to achieve pre-set separation of undesirable material from desirable material.

15. The method of claim 11 further comprising controlling operation of one or more motors in response to the generated signals.

16. A method of separating an undesired portion from a desired portion of a mixture of various size, shape and weight materials, comprising the steps of:

feeding material into a separator means at a first rate of feed; separating at least some of the undesirable portion of the material from the desirable portion of material in the separator means;

sensing the quantity of undesirable material which is separated from the desirable material in the separator means;

adjusting at least one of the set of feed rate of the material and separation of the material to change the separation process; and

sampling the separated undesirable portion of materials to determine the quality thereof.

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