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Gray

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[54] SORTING FIELD CORN FROM SWEET CORN

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[73] Assignee: **Sortex Company of North America, Inc.**, Lowell, Mich.

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[52] **U.S. Cl.** .... **209/111.7**; 356/158; 250/222 R
[51] **Int. Cl.** **B07c 5/342**
[58] **Field of Search** ...... 209/111.7, 111.6; 356/201, 356/204, 205, 206; 250/222 R, 562, 563; 356/156, 157, 158, 163, 168

[56] **References Cited**

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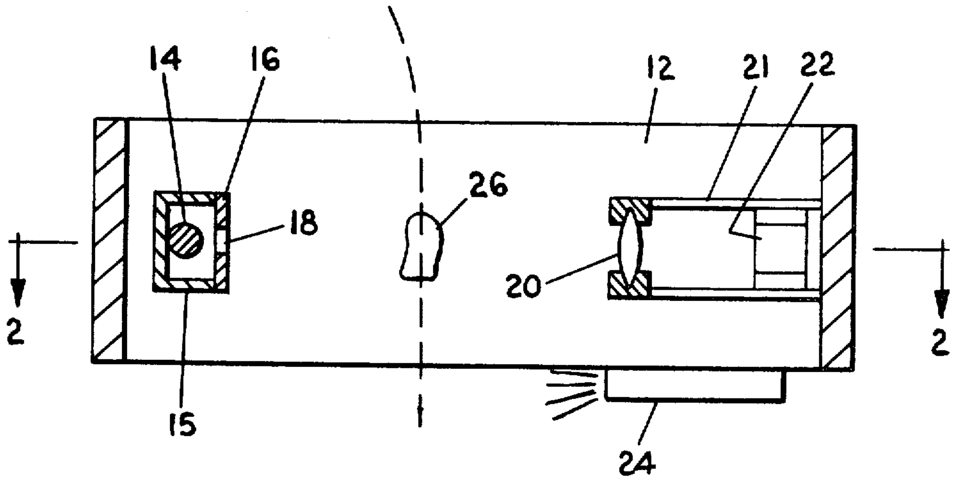
3,197,647	7/1965	Fraenkel	209/111.7 X
3,385,434	5/1968	Nelson	209/111.6
3,435,240	3/1969	Brunton	250/563 X
3,612,274	10/1971	Schmidt	209/111.6
3,729,619	4/1973	Laycak	250/562 X

Primary Examiner—Allen N. Knowles
Attorney, Agent, or Firm—McGarry & Waters

[57] ABSTRACT

A method for sorting field corn from sweet corn in a mixture of the two wherein a mixture of the two is passed seriatim through a viewing zone and illuminated from one side of the viewing zone to produce a shadow pattern on a opposite side of the viewing zone. The shadow pattern of each kernel is detected as it passes through the viewing zone and the kernels are sorted according to the shadow pattern thus produced. The shadow pattern for the kernels contains at least two areas of light attenuation and the ratio of one area to the other is calculated in order to sort the field corn from the sweet corn. The shadow pattern is measured by making multiple scans across the same as it passes through the viewing zone so that the entire shadow pattern is thus scanned. The signals obtained from the multiple scans are integrated to produce a composite of the entire shadow pattern.

6 Claims, 7 Drawing Figures



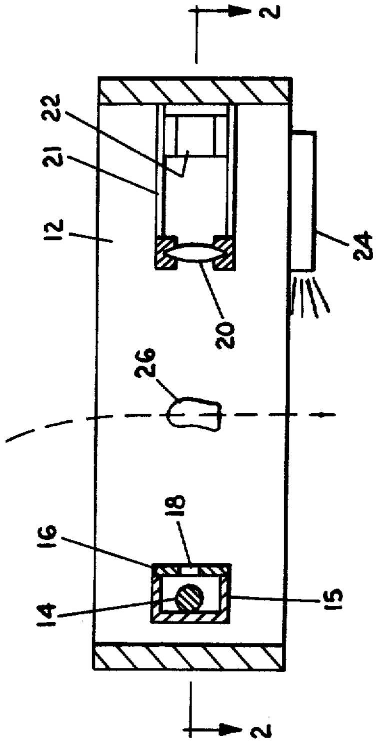


FIG. 1

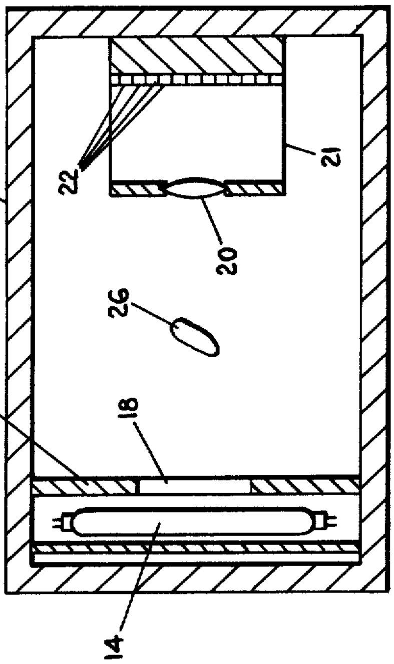


FIG. 2

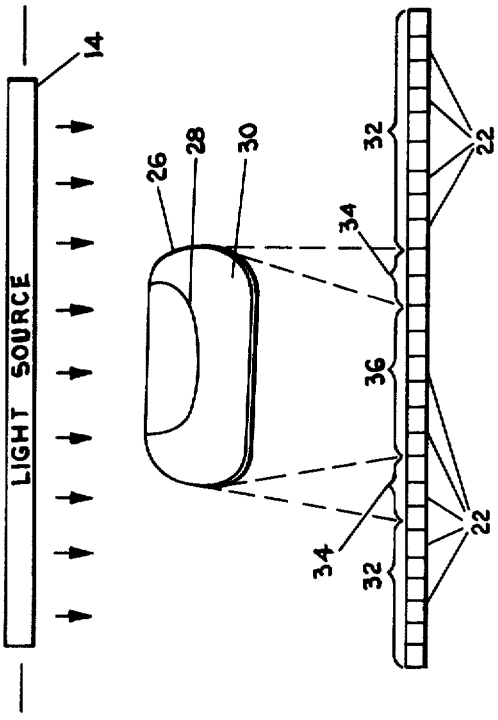


FIG. 3

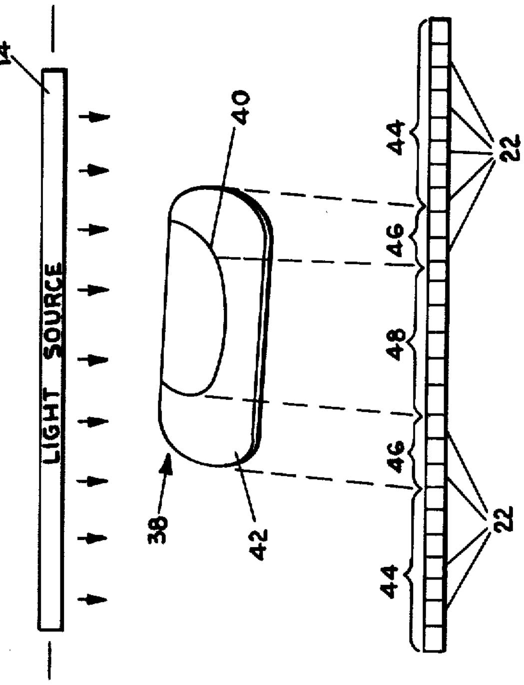


FIG. 4

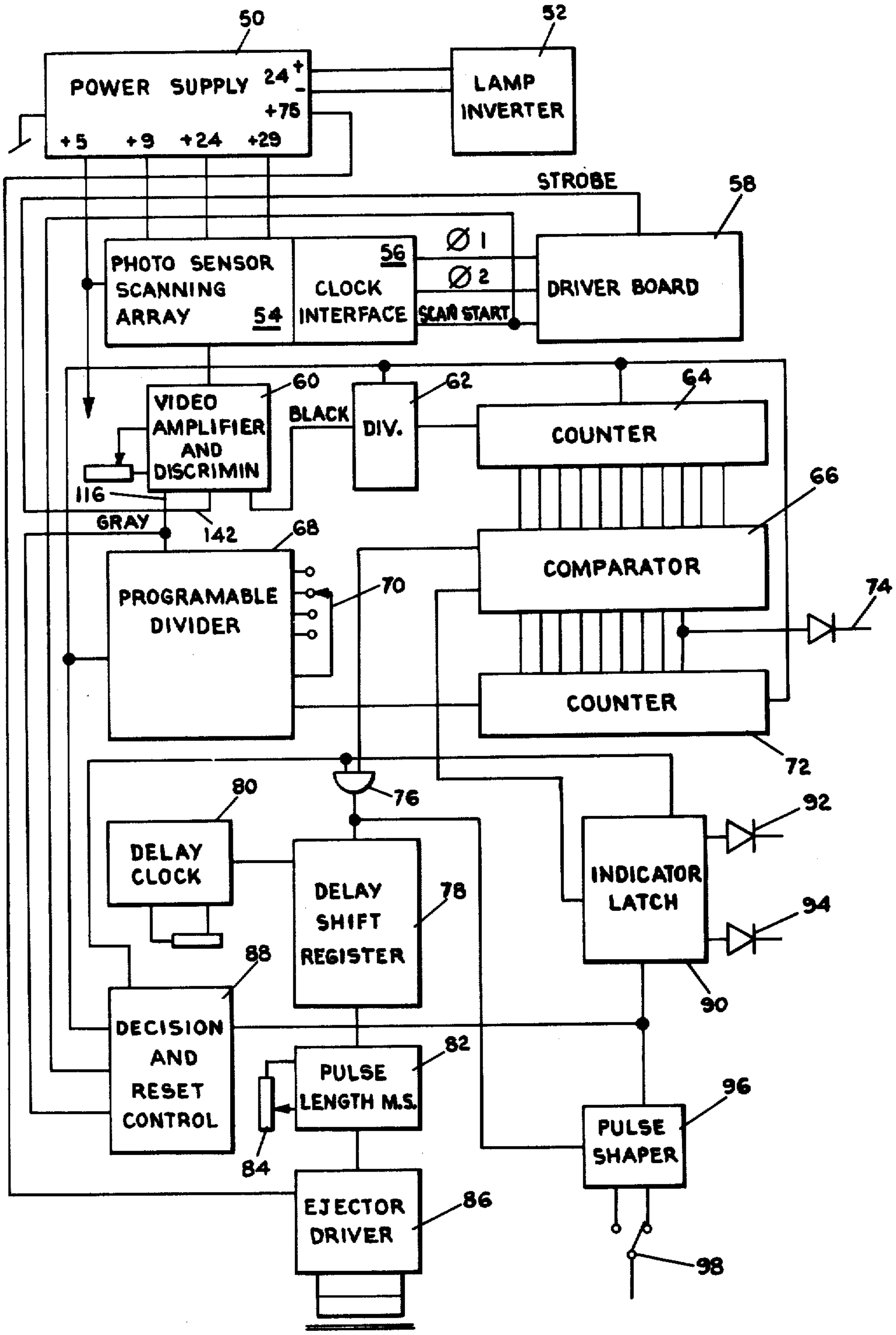

50
52
POWER SUPPLY
24
+
-
+75
+5
+9
+24
+29
LAMP INVERTER
STROBE
58
PHOTO SENSOR SCANNING ARRAY
54
56
CLOCK INTERFACE
Ø1
Ø2
SCAN START
DRIVER BOARD
VIDEO AMPLIFIER AND DISCRIMIN
60
BLACK
DIV.
62
64
COUNTER
116
GRAY
142
68
66
PROGRAMABLE DIVIDER
70
COMPARATOR
74
COUNTER
72
76
80
DELAY CLOCK
DELAY SHIFT REGISTER
78
INDICATOR LATCH
92
94
90
88
DECISION AND RESET CONTROL
PULSE LENGTH M.S.
82
84
96
PULSE SHAPER
EJECTOR DRIVER
86
98

FIG. 5

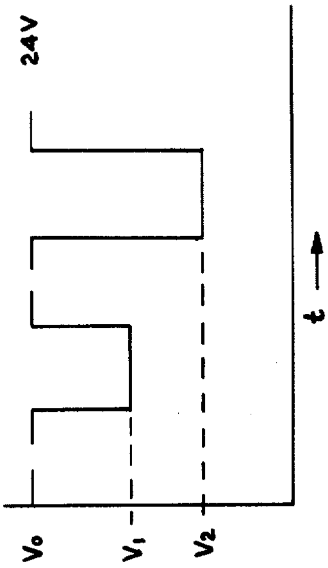

24V
V₀
V₁
V₂
t →

FIG. 7

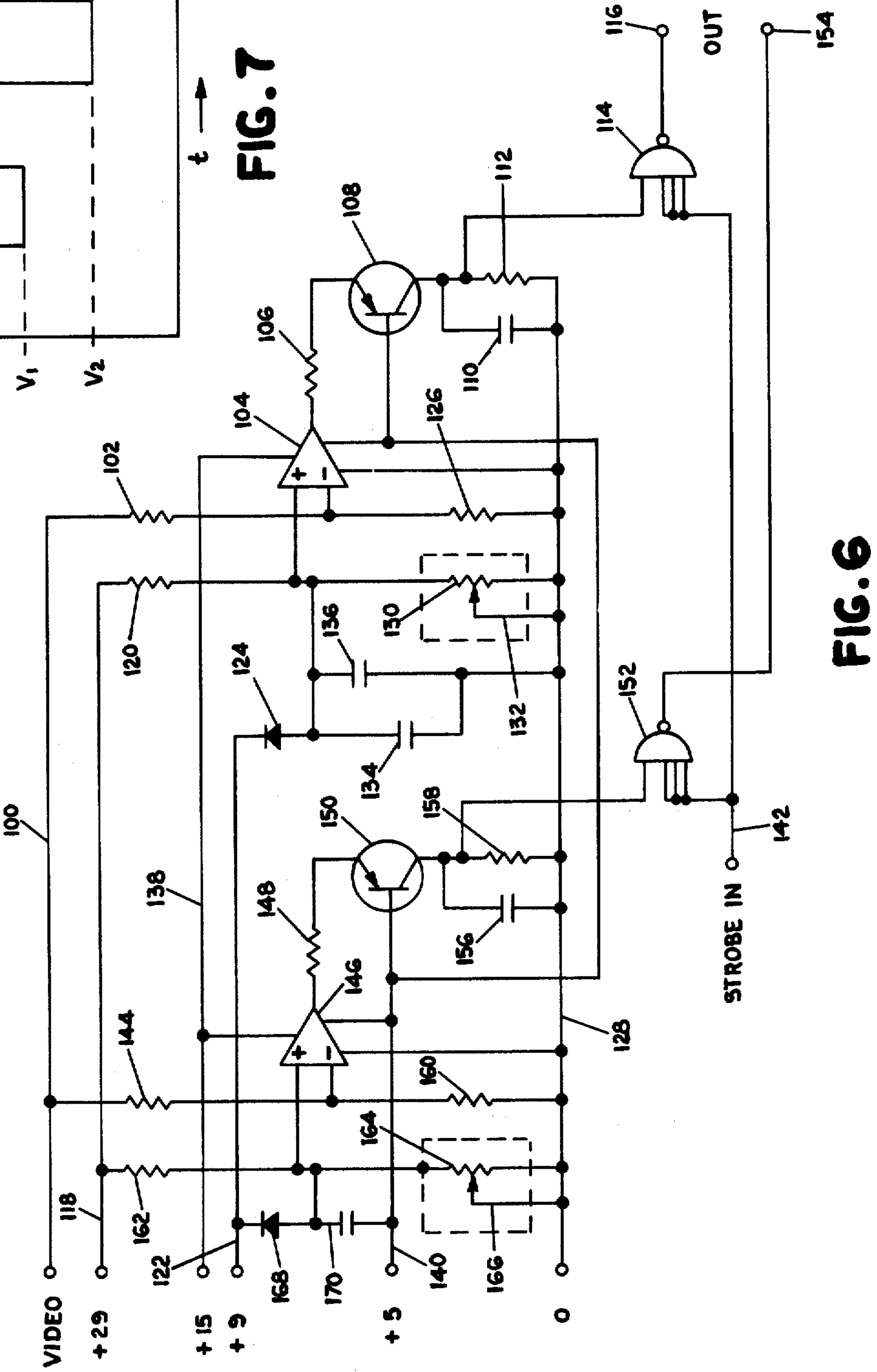

VIDEO
+29
+15
+9
+5
0
100
102
104
106
108
110
112
114
116
OUT
154
118
120
122
124
126
128
130
132
134
136
138
140
142
STROBE IN
144
146
148
150
152
156
158
160
162
164
166
168
170

FIG. 6

SORTING FIELD CORN FROM SWEET CORN

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to sorting of field corn from sweet corn. In one of its aspects, the invention relates to the sorting of field corn from sweet corn by detecting the shadow pattern produced by the field corn and the sweet corn.

2. State of the Prior Art

In the corn seed industry, kernels of sweet corn and field corn are unavoidably produced together. Both types of corn seed have substantially the same appearance in that each of the kernels has a yellow surface color of about the same hue. Further, both types of corn seed have a central white area surrounded by an endosperm or food sac which occupies the bulk of the seed. In the sweet corn, the food sac contains a sugary composition. In the field corn kernels, the food sac is more starchy. The field corn seed produces an inferior grade of corn and thus must be sorted from the sweet corn for an acceptable seed product.

The field corn has a somewhat smoother surface than the sweet corn and thus some sorting has been accomplished by the use of the different surface characteristics. However, the bulk of the sorting has taken place by hand in a tedious, time-consuming, and expensive process which nonetheless is not particularly reliable.

It has been found that the light absorption characteristics of the two types of seed corn are different. When light is projected against the two types of kernels, the light is diffused in the food sac and then re-emitted at the other side of the kernel. This diffused and re-emitted light is known as "transluminescent light."

It is known that the transluminescent light of sweet corn is substantially greater than that of field corn and this difference is also sensitive to the wave length of light directed against the seed corn kernels.

It has been proposed by Nelson in U.S. Pat. No. 3,385,434 to sort the seed corn from the field corn based on the transluminescent characteristics thereof. In the Nelson apparatus a strong light is beamed from multiple directions against the kernels of corn. Reflected and transluminescent radiations are detected and compared by a masked detecting means and the kernels are sorted according to the transluminescent characteristic while ignoring the surface reflected light. Whereas this type of apparatus appears to be sound in principle, the apparatus has been relatively unreliable in practice, probably because of the unpredictable effects of reflected radiation and because of the size differences of the seed corn kernels.

SUMMARY OF THE INVENTION

It has now been discovered, quite unexpectedly, that the seed corn kernels produce a shadow pattern which can be detected by a strip of photosensors in sufficient detail in order to classify the kernels in accordance with their interior structure. Thus, the shadow pattern of the seed corn differs significantly enough from the shadow pattern of field corn to permit the sorting of field corn from sweet corn in accordance with the shadow pattern thus produced.

According to the invention, the sweet corn and field corn in the mixture are passed seriatim through a viewing zone wherein they are illuminated from one side thereof to produce a shadow pattern on the opposite side of the viewing zone. The shadow pattern of each kernel is detected as it passes through the viewing zone and the kernels are sorted according to the shadow pattern thus produced.

In carrying out the invention, at least two areas of light attenuation are present in the shadow pattern and each of these two areas is measured. The ratio of one area to the other is calculated and used in sorting the field corn from the sweet corn. Generally, areas of substantially full attenuation are compared with areas of partial attenuation to sort the particles. Preferably, the ratio of full to partially attenuated areas is in the range of 33 – 40 percent, or greater for sorting.

In practice, as the kernels are passed through the viewing zone, the shadow pattern passes across a strip of photosensors. Repeated scans are made across the photosensors to detect the entire shadow pattern as it passes through the viewing zone. These repeated scans are integrated to produce signals representative of the total shadow pattern.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the accompanying drawings in which:

FIG. **1** is a side elevational view in section schematically illustrating the sorting method according to the invention;

FIG. **2** is a plan view in section taken along lines **2—2** of FIG. **1**;

FIG. **3** is an enlarged plan view schematically showing the shadow pattern produced by a field corn kernel passing through the viewing zone;

FIG. **4** is an enlarged plan view similar to FIG. **3** showing the shadow pattern produced by a sweet corn kernel passing through the viewing zone;

FIG. **5** is a schematic block diagram of an electrical system for an apparatus which can be used to carry out the sorting method according to the invention;

FIG. **6** is a schematic electrical diagram of an amplifier and discriminator used in the apparatus illustrated in FIG. **5**; and

FIG. **7** is a schematic representation of the wave form of the video signal from the scanning array.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, and to FIG. **1** and FIG. **2** in particular, there is shown a viewing zone for a sorting apparatus. The viewing zone comprises a housing **12**, open at both top and bottom to allow corn kernels **26** to pass freely therethrough. The kernels are fed seriatim from a suitable feeding device (not shown) to the top of the housing **12**. Suitable feeding devices include belt feeds and chutes and are well-known in the art of photoelectric sorting. Examples of suitable feeding devices are disclosed in a Fraenkel U.S. Pat. No. 3,197,647 and in Rayment U.S. Pat. No. 3,513,596.

A strip light source **14**, such as a fluoroescent tube, is mounted in a darkened box **15** within the housing **12** in back of a mask **16** having a slot opening **18**. A lens, mounted on a holder **21**, is supported across the housing from the light source **14** to focus the light passing through the slot onto a linear array of photosensors **22**. An air ejector **24** is mounted beneath the housing **12** to deflect the trajectory of the particles **26** under certain conditions to be described hereinafter. The photosensors **22** preferably comprise an array of photodiodes adapted to sense the intensity of the light from the light source. The photosensors **22** are separate sensing units which are programmed to scan across the slot **18** and to report the intensity received at each photosensor in a sequential manner. Such a programmed array of photodiodes are well-known, as, for example, the I.P.L. 7,000 series sold by I.P.L. (Integrated Photomatrix Limited) of Dorchester, Dorset, U.K. The array of photodiodes gives a high resolution of light intensity across the slot **18.** Thus, the photodiodes are suitably adapted to resolve the translucent characteristics of the kernels passing between the photodiodes and the slot **18.**

The number of photosensors in the array will depend on the resolution desired and the length of the slot. The size of the kernels **26** will determine the length of the slot **18.** If, for example, the kernels are in the range of ⅛ to ½ inch in diameter, the slot length will be about 1½ inches long. For such a slot length, a photosensor array of about **32** units is suitable. For purposes of simplicity, only a few of such sensors have been schematically represented in the drawings.

Reference is now made to FIG. **3** wherein there is shown schematically the effect of a field corn particle passing between the light source and the photosensor array **22.** The field corn kernel **26** has an opaque center **28** and a near opaque food sac (endosperm) surrounding the opaque center. The shadow cast by the field corn kernel **26** will be predominantly a full shadow area **36** but will contain partial shadow areas **34** at the sides thereof. Flanking the partial shadow areas **34** are full light areas **32.** The partial shadow areas **34** are a result of light rays from the light source directed angularly from the light source past the edge of the kernel **26.**

Although the food sac area **30** of the kernel **26** is not completely opaque, any light transmitted through the area **30** will be so attenuated as to produce a substantially full shadow area on the photodiodes **22.** Thus, the shadow pattern formed by a kernel of field corn will have certain areas of partially attenuated light or "gray" areas and certain areas of fully attenuated light or "black" areas.

The effect of a sweet corn kernel passing through the viewing zone is illustrated schematically in FIG. **4** to which reference is now made. The sweet corn kernel has an opaque center **40** like the field corn kernel but also has a translucent food sac area **42** surrounding the opaque center **40.** The food sac area **42** of the sweet corn kernel **38** is substantially more, for example, two to three times, as translucent as the corresponding area **30** of the field corn kernel **26.** Thus, the shadow pattern resulting from the sweet corn kernel is remarkably different from that of the field corn kernel. The sweet corn kernel shadow pattern will have a partial shadow areas or "gray" areas **46** and a full shadow area or a "black" area **488.** Flanking the partial shadow areas **46** will be light area **44** or areas of no light attenuation.

As illustrated in FIGS. **3** and **4,** both field corn and sweet corn give shadow patterns with both gray and black areas. However, the gray areas in the sweet corn shadow pattern are substantially larger than the gray areas of the field corn kernels. According to the invention, the black areas and the gray areas are integrated over the total pattern produced by each kernel as it passes through the viewing zone and the ratio of black areas to gray areas is computed. The kernels are thus sorted by activating the air ejector **24** responsive to the ratios thus computed. For example, those kernels whose black areas exceed 40 percent of the gray areas are ejected in the trajectory path and those particles whose black to gray areas is lower than 40 percent do not activate the ejector **24** and continue the normal trajectory path.

It has been found that a ratio of 33% to 40% of black to gray areas is suitable for sorting field corn from sweet corn.

Any suitable apparatus which measures and integrates the shadow pattern of kernels of corn passing through a viewing zone can be used in carrying out the method of the invention. A suitable apparatus is disclosed and claimed in the commonly assigned copending application of Urs Muehlethaler, Ser. No. 424,729, filed of even date herewith. The Muehlethaler apparatus will be described hereinafter:

An electrical system for obtaining the ratios and distinguishing between opaque and transparent particles is illustrated in FIG. **5** to which reference is now made. A power supply **50** is coupled to a lamp inverter **52** which drives the light source **14.** The power supply is also coupled to a photosensor scanning array **54** which contains the photosensors **22.** The scanning array **54** desirably is a linear array of silicon planar photodiodes integrated with a dynamic M.O.S. shift register on a monolithic chip. Multiplexing and amplifying M.O.S. devices are connected to each diode to interrogate each diode in sequence responsive to an input pulse propagated through the register to produce a single serial video output signal. Each diode produces an output pulse representative of the light intensity of the diode at the time the diode is interrogated. The output signal will thus be a series of pulses related to the light intensity at each of the diodes. Since the normal condition of the diodes is full light, the diodes do not report when there is full light. In other words, the pulses will represent the shadow and partial shadow areas seen by the photodiodes as a particle falls between the light source and the photodiodes. For purposes of simplicity, pulses generated by areas of partial shadow will be referred to as "gray pulses" and pulses produced from full shadow areas will be referred to as "black pulses." Further, the areas of partial shadow will be referred to as "gray" areas and the areas of full shadow will be referred to as "black" areas. The integrated scanning array can be purchased as a unit, for example, as an IPL 7,000 series from Integrated Photomatrix Ltd. of Dorchester, Dorset, U.K.

The scanning array **54** is driven by a scan clock driver **58** through a clock interface **56.** Scan clock driver circuits are well-known for driving scanning arrays and thus will not be described in detail for the sake of brevity. The scan clock driver **58** produces a scan start signal at a predetermined frequency and applies the scan start signal to the scanning array **54** through the clock interface **56.** The function of the clock interface is to raise the amplitude of the signal from the clock driver to a proper level for feeding to the scanning array. The scan clock driver **58** also applies signals to the scanning array **54** to regulate the rate at which the scanning array will scan across the photosensors. Normally, the scanning array **60** will be bistable so that two signals, 180° with respect to each other, are applied to scanning array.

A strobe signal is also produced by the scan clock driver **58** representative of the frequency of the clock pulses. The strobe signal has a frequency equal to that at which information is received from each photosensor.

The output from the scanning array 54 is illustrated schematically in FIG. 7. Any video signal will have an intensity of V_0 such as, for example, 24 volts and any areas of attenuated light will have a lesser voltage. For example, white glass would result in a voltage of about 20½ volts and green or brown glass would result in a voltage of 19½ volts. Each diode which sensed the white, green or brown glass would have a voltage V_1 as seen in FIG. 7. Similarly any areas of partial shadow as, for example, areas 32 of FIG. 3 would also be represented by V_1 in FIG. 7. Any black areas and shadows such as areas 30 in FIG. 3 or areas 44 in FIG. 4 would be represented by V_2 in FIG. 7 and would, for example, have a voltage of about 19 volts or less.

Referring now again to FIG. 5, the video signal from the photosensor scanning array 54 is fed to the video amplifier and discriminator 60. The video signal from the scanning array will consist of a number of pulses which may have different amplitudes. One value of amplitude will represent black pulses and another value or group of values of amplitude will represent gray pulses. The video amplifier and discriminator detects the number of black pulses and produces an output signal representative of the number of black pulses in any given scan. The output signal is merely a number of black pulses. This signal is applied to a counter 64 through a divider 62. The number of black pulses is divided by two in the divider 62 by a conventional flip-flop or other similar mechanism. The counter 64 counts the number of pulses applied thereto and produces a digital signal representative of the number of black pulses, which signal is applied to comparator 66.

The video amplifier and discriminator 60 detects the number of gray pulses in the video input signal and produces an output signal representative of the number of pulses in the discriminator. This output signal representative of the gray pulses is also in the form of a number of pulses and is applied to a programmable divider 68 having a selector switch 70. The divider 68 divides the number of pulses applied thereto by one of a plurality of selected numbers and produces an output signal representative of the quotient. The divider, for example, can be programmed to divide the pulses by four, five, six or eight so that the output therefrom is a signal representative of one-fourth, one-fifth, one-sixth or one-eighth of the input signal. The selection is made by the selector switch 70. The output from the programmable divider 68 is applied to counter 72 which counts the input gray pulses and produces a digital signal representative of the number of pulses applied thereto. This digital signal is applied to comparator 66. The digital number applied to the comparator by the counter 64 is compared with the digital number applied by the counter 72 and an output signal results if the number applied by the counter 64 is greater than the number applied by th counter 72. A gray counter 74 which comprises a light emitting diode, is coupled to an output of counter 72 to give a visual indication of any signals representative of gray signals for any given scan.

Referring again now to FIG. 5, the output from the comparator 66 is fed to AND gate 76 which is open when a signal is applied from a decision and reset control circuit 88. Thus, when AND gate 76 is open, the signal from comparator 66 is applied to delay shift register 78 which delays the signal and applies the delayed signal to an adjustable pulse length monostable circuit 82 having an adjustable potentiometer 84. The output signal from the pulse length monostable circuit 82 is applied to an ejector drive 86 which operates the air ejector 24. An adjustable delay clock 80 is coupled to the delay shift register 78 to time the delay applied to the signal in the delay shift register 78.

The decision and reset control 88 receives a scan start signal from the scan clock driver as a measure of the start of each scan across the photosensors. A signal representative of gray pulses from the video amplifier and discriminator 60 is also applied to the decision and reset control 88. The decision and reset control senses the first and only the first scan without a gray pulse, i.e., signal from the video amplifier and discriminator 60 representative of the gray reporting photosensors, and generates an output decision signal responsive to such a scan. The output decision signal from the decision and reset control 88 is applied to the programmable divider 68, to the divider 62 and to the counters 64 and 72 to reset each of these circuits. At the time the reset signal is applied to the counter circuits, a gating signal is also applied to AND gate 76 and to an indicator latch 90. The signal to AND gate 76 allows the output signal from the comparators 66 to pass to the delay shift register 78 as described above.

The indicator latch 90 is also coupled to the output from the comparator 66 to receive a signal in the event that the gray pulses exceed the black pulses. A visual indicator 92 such as a light emitting diode, is coupled to the indicator latch 90 to light up when there is no signal from the comparator 66. Similarly, a visual indicator 94, such as a light emitting diode, is coupled to the indicator latch 90 to light up when a signal is received from the comparator 66. The indicator latch serves as a latching device and gate to illuminate the indicators 92 and 94 responsive to a signal (or absence of a signal) from the comparator and responsive to a signal from the decision and reset control 88. In other words, the output from the comparator 66 is applied continuously to the indicator latch 90 but is inoperative to illuminate the indicators 92 or 94 until a signal is received from the decision and reset control 88. Upon receipt of such a signal, the illuminator 92 will be illuminated if there is no signal from the comparator 66 and the indicator 94 will be illuminated if a signal is received from the comparator 66. The latch 90 maintains the indicator 90 or 94 in an on position until a new signal is applied from the decision and reset control 88. The indicator 74 can be used to determine whether there is dirt or other foreign matter in front of the photosensors.

The pulse shaper 96 having a manual switch 98 is coupled to the indicator latch 90 and to the delay shift register 78 to manually test the ejector system. The pulse shaper 96 is also coupled to the decision and reset control 88 to reset the counters after each actuation of the pulse shaper 96.

Reference is now made to FIG. 6 for a description of the video amplifier and discriminator circuit 60. A video input line 100 from the photosensor scanning array 54 (FIG. 5) is applied to the inverting input of a comparator 104 through a resistor 102. The comparator 104 compares the voltage of each pulse in the signal with a preset voltage applied to the non-inverting input of the comparator 104 and produces an output signal if the voltage of any given pulse is within a specified range as, for example, 19½ to 21 volts. The output of comparator **104** is attenuated in resistor **106** and amplified in transistor **108**, and applied to NAND gate **114**. A filter circuit of a capacitor **110** and a resistor **112** controls the amplitude of the signal applied to NAND gate **114** by the amplifier **108**. The strobe signal is applied to NAND gate **114** through line **142**. The strobe signal is generated by the scan clock driver **58** and represents the frequency of the clock pulse. When the strobe signal **142** is applied to NAND gate **114**, the gate will open when a pulse representing a gray signal from a photodiode is applied to the gate. An output signal from NAND gate **114** is applied to terminal **116** which in turn is applied to the programmable divider **68** (FIG. 5). A voltage line **118** having, for example, a voltage of **29** volts is applied to the non-inverting input to the comparator through resistor **120**. A lesser voltage line **122**, containing, for example, **9** volts, is also applied to the non-inverting input of the comparator **104** through a clamping diode **124**. Capacitors **143** and **136** are connected between a ground line **128** and a positive input to the comparator **104**. Voltage lines **138** and **140**, containing, for example, **15** volts and **5** volts respectively, are applied to the comparitor to provide power for the comparitor **104**. Resistor **126** is provided between ground line **128** and the inverting input to the comparitor **104**. In a similar manner, potentiometer **130** having an adjustable slide **132** is provided between the non-inverting input to comparitor **104** and the ground line **128**. Normally, the potentiometer **130** is set at a predetermined value so that gray pulses representing either flint glass or green or brown glass are detected by the comparitor. However, as indicated above, the voltage representative of green and brown glass will be somewhat less than the voltage representative of the flint glass. Thus, the potentiometer **130** can be set so as to sort the flint glass from the green and brown glass. This color sorting can take place by simply raising the level at which the comparitor will produce an output signal to thereby eliminate the green and brown glass from the gray pulses.

A similar circuit is provided for developing pulses relating to the black pulses. The video signal in line **100** is applied to the inverting input of comparitor **146** through resistor **144**. A resistor **160** is provided between the gound line **128** and the inverting input of comparitor **146**. Voltages from voltage lines **188** and **140** are also applied to the comparitor **146** to provide power therefor. The non-inverting input to the comparitor **146** is provided by voltage line **122** through clamping diode **168**. A capacitor **170** is provided between voltage line **140** and the non-inverting input to comparitor **146**. Further, potentiometer **164** having slider **166** is provided between the ground line **128** and the input to comparitor **146**. The slider **166** on potentiometer **164** adjusts the level at which black pulses are sensed by the comparitor **146**.

The output from comparitor **146** is amplified by transistor **150** after being attenuated by resistor **148** and the signal is thereafter applied to NAND gate **152** which is strobed with a signal from strobe line **142**. Filter circuits including capacitor **156** and resistor **158** control the amplitude of the signal to NAND gate **152**. The output from NAND gate **152** is applied to the black output terminal **154** which is coupled to divider **62** (FIG. 5).

The amplifier and discriminator circuit operates as follows: The video signal containing pulses representative of gray and black areas as seen by the photosensors is applied to the video input line **100**. Gray pulses representing individual photosensors within any gray area and having a voltage in the range of about **19½** to **21** volts, triggers the comparitor **104** to produce pulse signals at gate **114**. Those pulses having a voltage of **19** volts or below trigger the comparitor **146** to produce pulse signals at gate **152**. Thus, each pulse in the video signal having a voltage in the range of **19½** to **21** will give rise to a signal at gate **114**. Similarly, each pulse in the video signal having a voltage of **19** volts or below will give rise to a signal at gate **152**. The NAND gates **152** and **114** will respond to the gray and black pulses as strobe signals are applied thereto so that the gray and black pulses are applied to the respective terminals **154** and **116**.

In operation, the kernels of corn are passed seriatim through the viewing zone wherein they are illuminated from one side thereof. The shadow pattern cast by the light source is scanned repeatedly as the particle falls through the viewing zone to obtain an integrated signal representative of the gray and black areas in each particle. Each photosensor produces a pulse representative of the light intensity at the photosensor during each scan. The total number of gray pulses and black pulses are counted and the ratio of black to gray pulses is computed. If the black to gray pulse ratio exceeds 33 – 40 percent, the particle is determined to be a kernel of field corn and the kernel is ejected. If the ratio of black to gray is less than 33 – 40 percent, the kernel is determined to be sweet corn and it passes unobstructed into an accept bin. The ratio can be set at either 33 or 40 percent or at any ratio there between.

Reasonable variation and modification are possible within the scope of the foregoing disclosure, the drawings, and the appended claims without departing from the spirit of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method for sorting field corn from sweet corn in a mixture of the sweet corn and field corn, the method comprising the steps of:

passing the kernels in the mixture seriatim through a viewing zone;

illuminating the kernels from one side of the viewing zone to produce a shadow pattern of at least two areas of light attenuation on an opposite side of the viewing zone;

detecting each of the areas of each kernel shadow pattern separately as it passes through the viewing zone; and

sorting the kernels according to the relative size of the areas of the shadow pattern thus produced.

2. A method for sorting field corn from sweet corn according to claim **1** wherein the sorting step comprises calculating the ratio of one such area of light attenuation to another.

3. A method for sorting field corn from sweet corn according to claim **2** wherein the sorting step further comprises rejecting those kernels which produce a shadow pattern wherein the ratio of one area of light attenuation to the other exceeds a predetermined value.

4. A method for sorting field corn from sweet corn according to claim **3** wherein the one area is substantially full attenuation and the other area is partial attenuation and the ratio of one area to the other is at least 0.33.

5. A method for sorting field corn from sweet corn according to claim **3** wherein the one area is substantially full attenuation and the other area is partial attenuation, and the ratio of one area to the other is in the range of 0.33-0.40.

6. A method for sorting field corn from sweet corn according to claim **2** wherein the detecting step comprises making multiple scans across the shadow pattern as it passes through the viewing zone and integrating the multiple scans to produce a composite of the entire shadow pattern.

* * * * *