July 15, 1969 P. M. L. SIMMONS 3,455,444

APPARATUS FOR SORTING PRODUCTS

Filed March 9, 1967 6 Sheets-Sheet 1

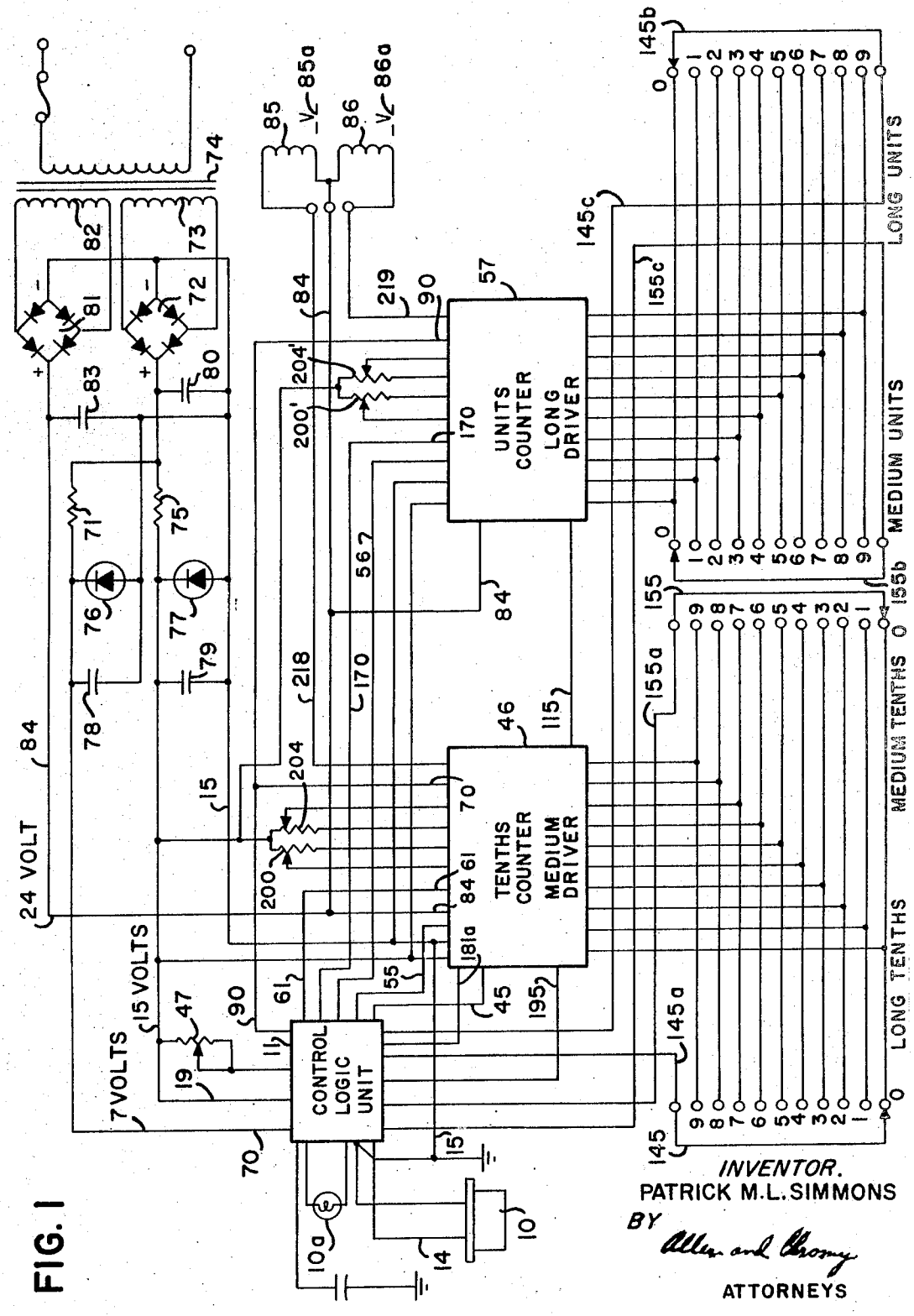


FIG. 1

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APPARATUS FOR SORTING PRODUCTS

Filed March 9, 1967 6 Sheets-Sheet 2

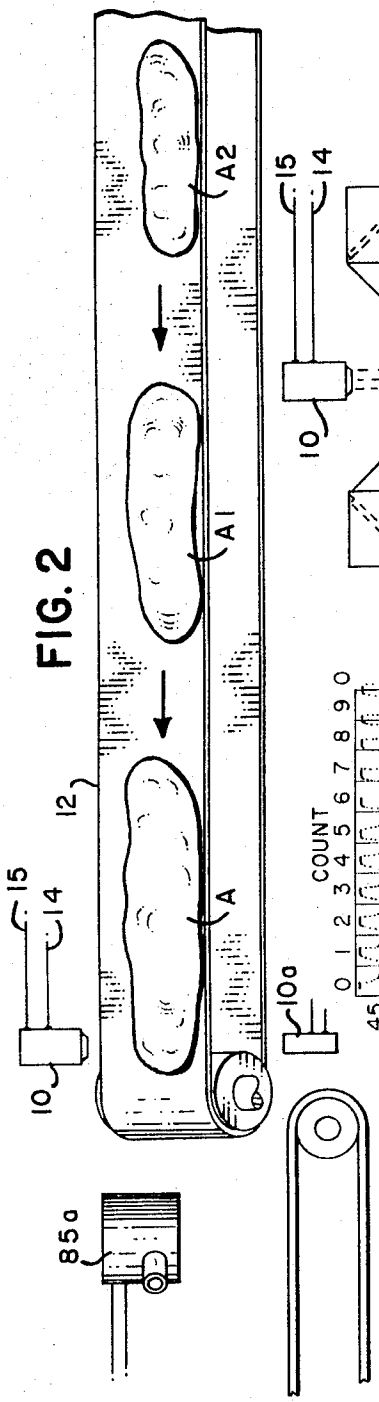


FIG. 2

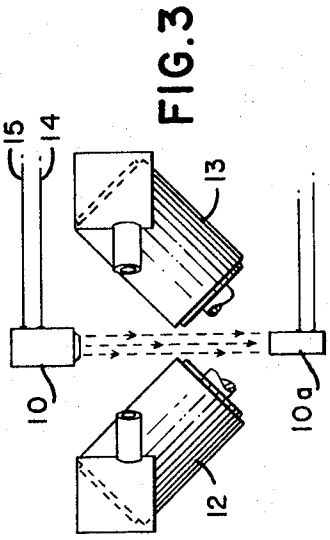


FIG. 3

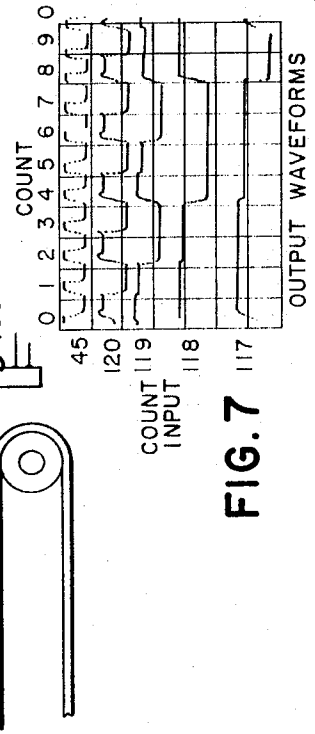


FIG. 7

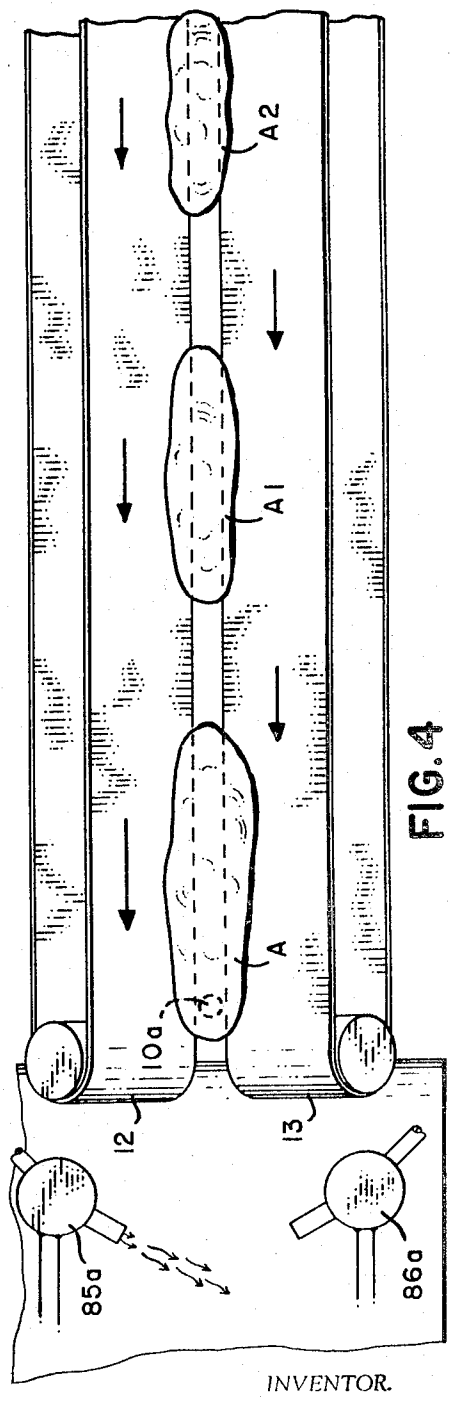


FIG. 4

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APPARATUS FOR SORTING PRODUCTS

Filed March 9, 1967 6 Sheets-Sheet 3

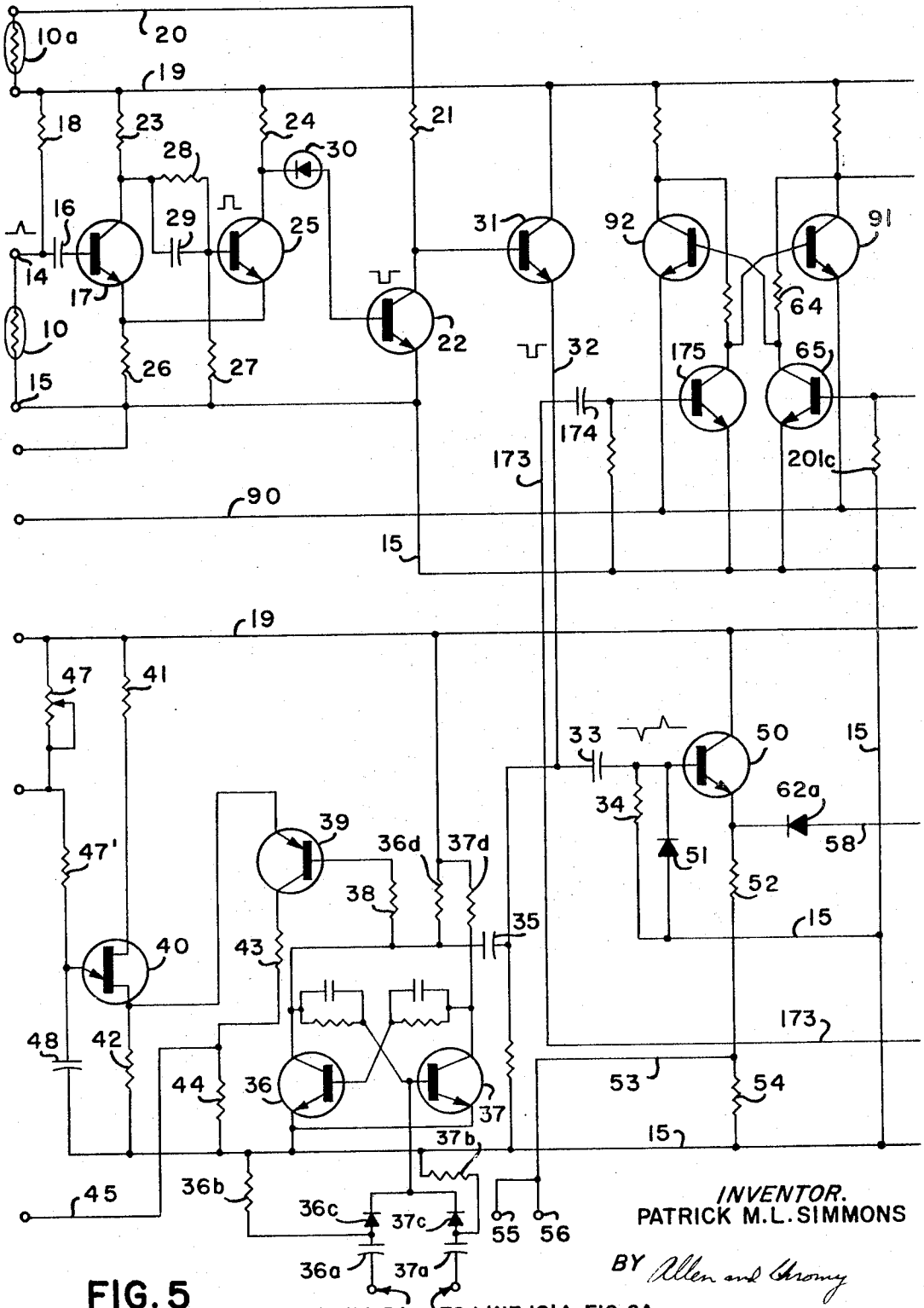


FIG. 5

TO LINE 61, FIG. 5A TO LINE 181A, FIG. 6A

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July 15, 1969 P. M. L. SIMMONS 3,455,444

APPARATUS FOR SORTING PRODUCTS

Filed March 9, 1967 6 Sheets-Sheet 4

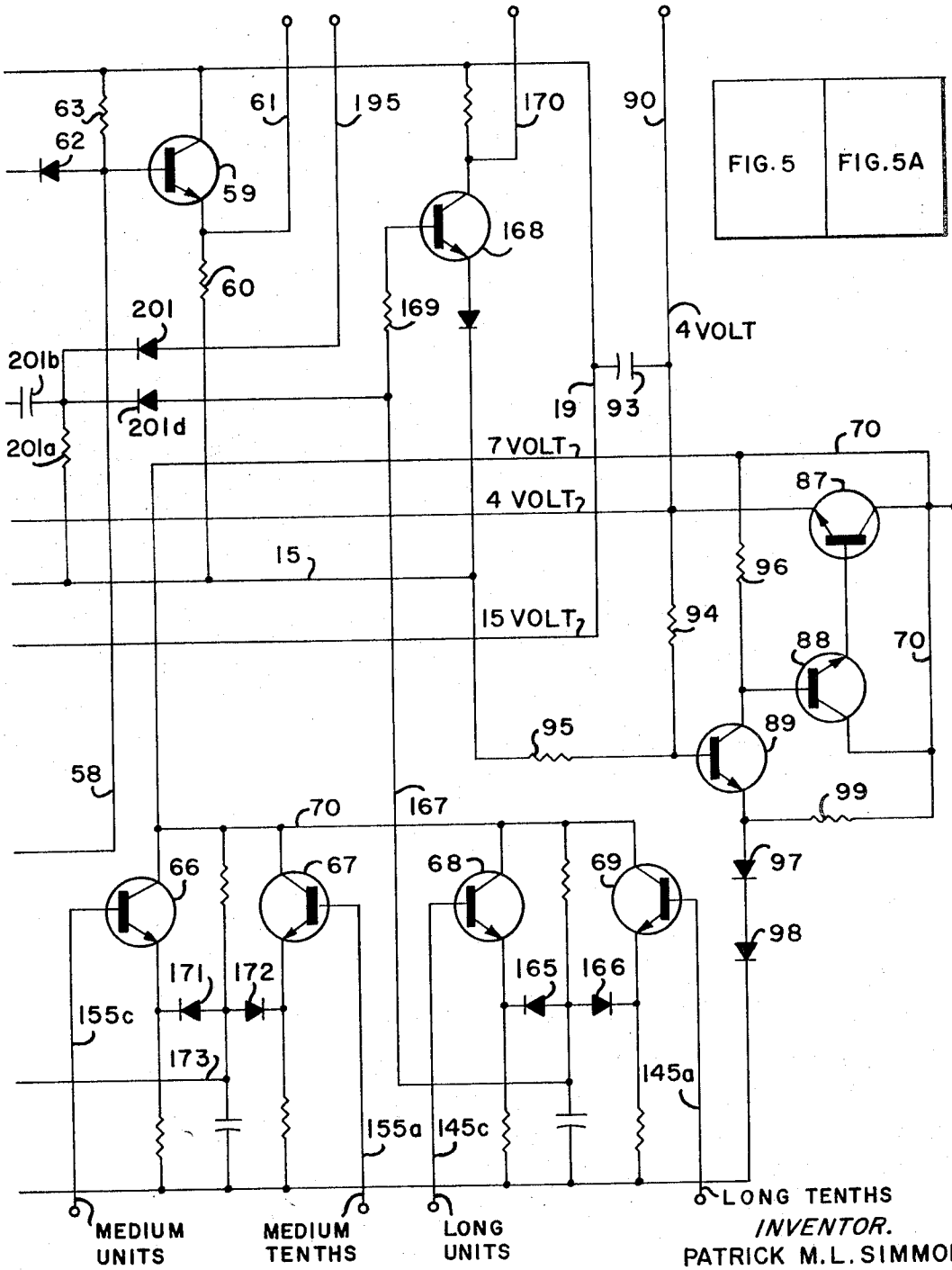


FIG. 5 | FIG. 5A

FIG. 5A

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July 15, 1969 P. M. L. SIMMONS 3,455,444

APPARATUS FOR SORTING PRODUCTS

Filed March 9, 1967 6 Sheets-Sheet 5

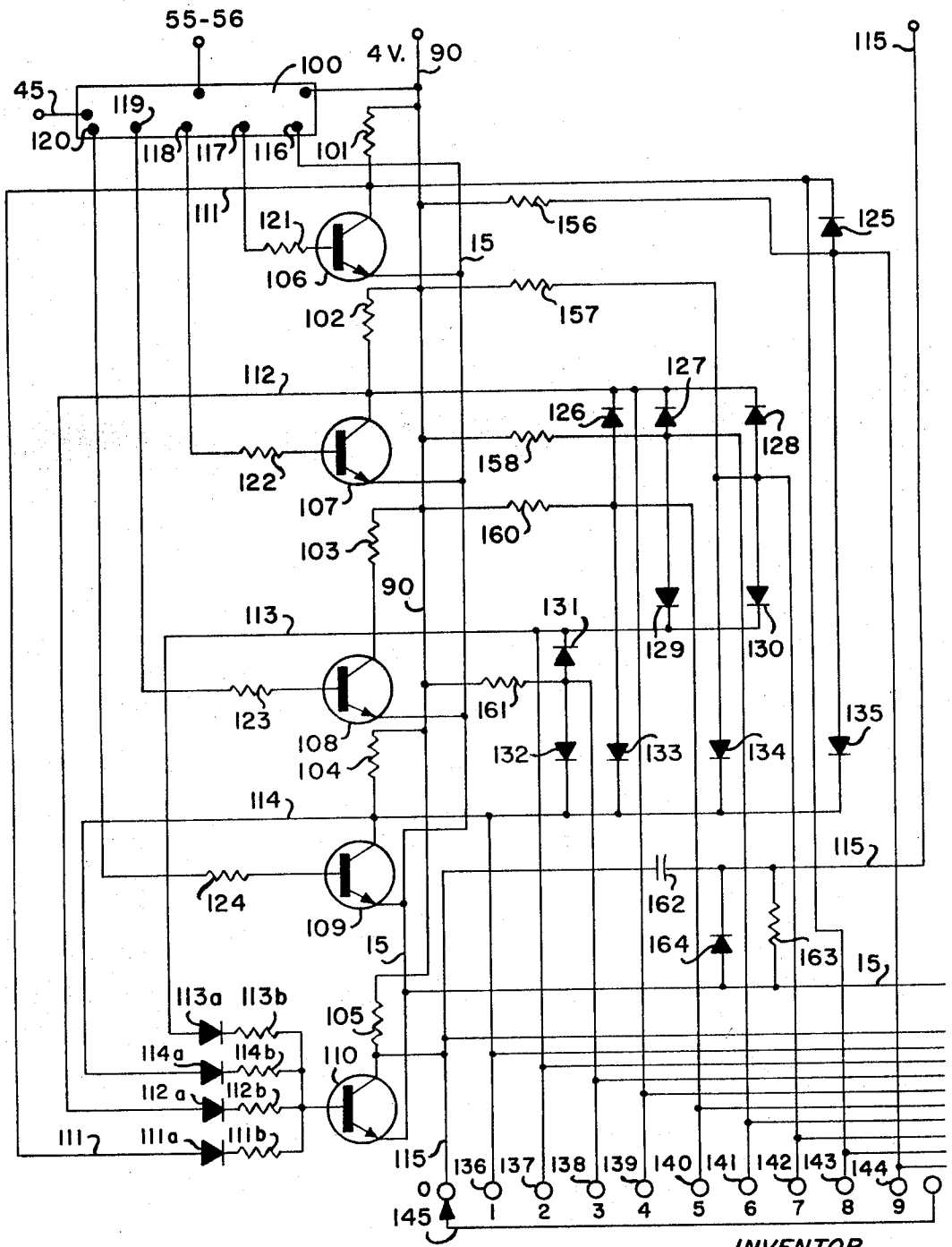


FIG.6

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July 15, 1969 P. M. L. SIMMONS 3,455,444

APPARATUS FOR SORTING PRODUCTS

Filed March 9, 1967

6 Sheets-Sheet 6

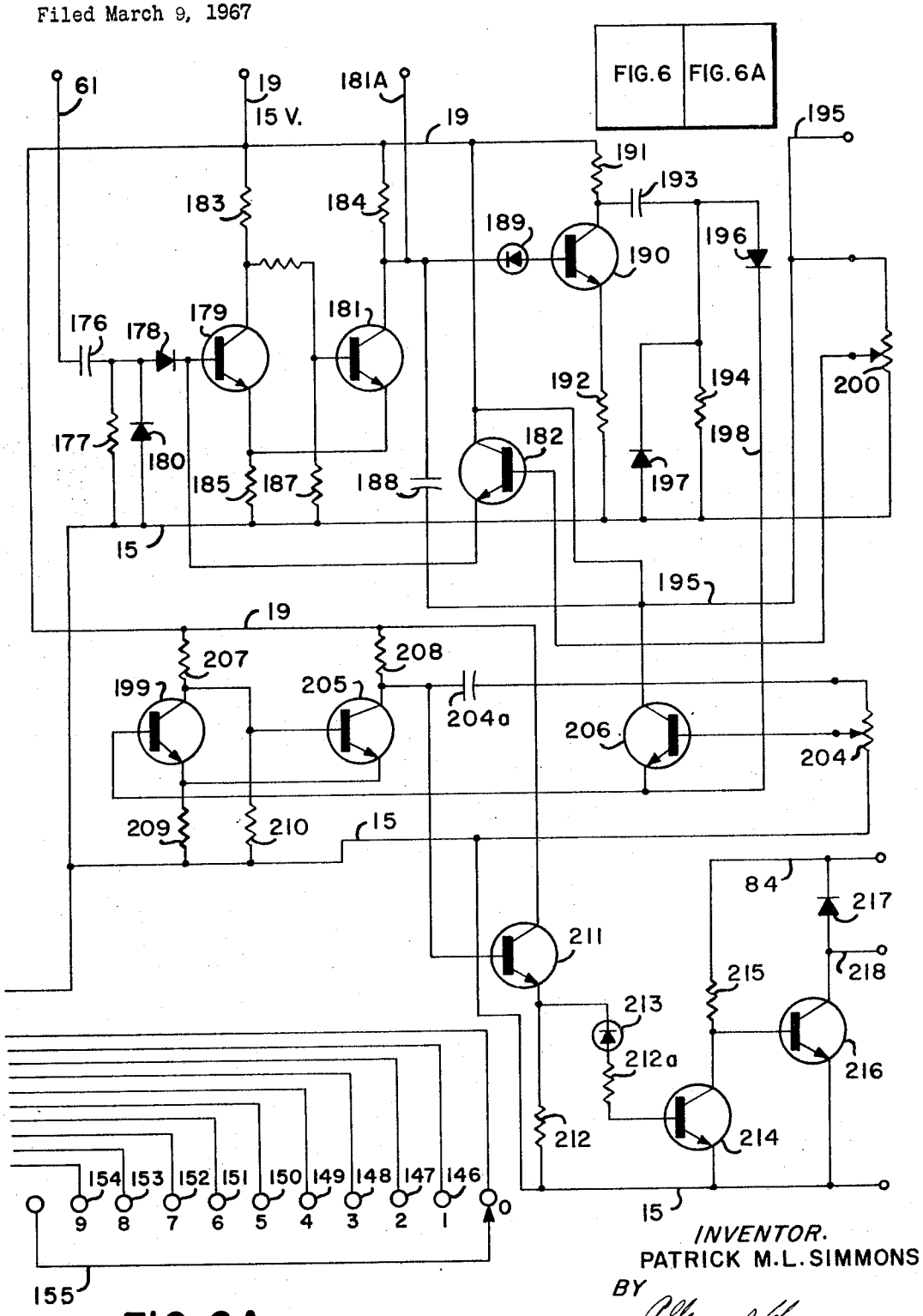


FIG. 6A

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United States Patent Office 3,455,444 Patented July 15, 1969

3,455,444

APPARATUS FOR SORTING PRODUCTS

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Filed Mar 9, 1967, Ser. No. 621,981
Int. Cl. B07c 5/08, 1/10; B07b 13/04
U.S. Cl. 209—82 9 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for sorting products according to their lengths. The product to be sorted is moved at a predetermined speed by a conveyor through a scanning zone which employs a light source and a light sensitive cell for generating an electric pulse while the product is being moved through this scanning zone. The electric pulse is used to control the supplying of pulses from a pulse generator to a counting apparatus which counts the pulses while the product is in the scanning zone, so that the number of pulses counted is a measure of the product length. A control signal is supplied to a solenoid controlling an air jet valve whereby this solenoid is energized long enough so that the air jet controlled thereby can deflect the product in the sorting operation.

This invention relates to apparatus for sorting products such as cucumbers according to their lengths.

An object of this invention is to provide an improved apparatus for sorting products according to lengths thereof, said apparatus employing a photodetector device for scanning the product during movement of the product thereover, whereby a signal is produced to gate the output of a pulse generator to supply pulses from the generator to pulse responsive means such as a counting means which provides output signals characterized by the length of the products which are to be sorted.

Another object of this invention is to provide an improved product sorting apparatus for sorting products according to the lengths thereof, said apparatus employing a pulse generator which supplies pulses to a counting means during intervals when the products are moved through a scanning zone, said counting means providing outputs which are characterized by the different product lengths so that product deflecting means for deflecting products of different lengths may be selectively energized and said products sorted according to the lengths thereof.

Still another object of this invention is to provide an improved sorting apparatus for sorting products according to the length thereof, said apparatus being provided with an electronic counting means which is actuated while a product is in a scanning zone so that products of different lengths are characterized by different signals received from the counting means.

Other and further objects of this invention will be apparent to those skilled in the art to which it relates from the following specification, claims and drawing.

In accordance with this invention there is provided an improved apparatus for sorting products according to their lengths. In this apparatus the product to be sorted is moved by suitable conveyor means through a scanning zone which employs a photodetector device. This apparatus also employs a pulse generator which is in continuous operation and generates pulses at a predetermined rate. The output of the photodetector is employed to trigger a Schmitt trigger circuit which supplies a pulse through suitable amplifying means to a gate that is connected to control the supplying of pulses from the pulse generator to an electronic pulse counting means. The pulse counting means is provided in two sections, one of which is responsive to the individual pulses and is designated the tenths counter, and the other one of which is responsive to the output of the first section which furnishes an output pulse for each ten input pulses. The second section is designated the units section for reasons which will be apparent further in the description of this invention. These sections are provided with length selection switches which may be manually adjusted whereby they will provide output signals at predetermined product lengths, for example, medium lengths and long lengths. At the same time, signals from the photodetector circuit output are transmitted to another gate. This gate which is referred to as the medium length gate is also connected to receive the medium length signals from the counting means. The output from the medium length gate is supplied to suitable delay circuits employing monostable multivibrators for controlling the air delay and air time of the air supplied to the air jet solenoid valve which controls the air to the medium length deflector apparatus for deflecting the medium length products from their line of travel to suitable receptacle or conveying means provided therefor. The signals for the long length products are transmitted to the long length output circuit which is supplied to signal delay means employing monostable multivibrator circuits for providing suitable delay to the solenoid valve which controls the air jet for deflecting the long products. This signal delay is similar to the signal delay employed for the medium length signals.

Further details of this invention will be set forth in the following specification, claims and drawing in which, briefly:

FIG. 1 is a schematic wiring diagram of an embodiment of this apparatus showing the control logic unit and the counting and driving means in block form;

FIG. 2 is a sectional view taken through the length of the conveyor showing only one of the conveyor belts;

FIG. 3 is an end view showing the conveyor, product scanning apparatus and product deflecting jets;

FIG. 4 is a plan view of a portion of the V-shaped trough conveyor employed in this apparatus for conveying the products through a scanning zone in which the photodetector is positioned;

FIGS. 5 and 5A show a wiring diagram of the logic unit shown in FIG. 1. FIGS. 5 and 5A should be viewed together with the right hand side of FIG. 5 joined to the left hand side of FIG. 5A, as shown in the block diagram in the upper right hand corner of FIG. 5A;

FIGS. 6 and 6A show the wiring diagram of the counter and driver employed in each of the counter-driver blocks shown in FIG. 1. FIGS. 6 and 6A should be viewed together with the right hand side of FIG. 6 joined to the left hand side of FIG. 6A, as shown in the block diagram in the upper right hand corner of FIG. 6A; and

FIG. 7 is a diagram showing the waveform of input to decade counter **100** over line **45**, and also showing the waveforms supplied at output terminals **117**, **118**, **119** and **120** of the decade counter.

Referring to the drawing in detail, reference numeral **10** designates a photodetector or light-sensitive cell which may be of the infrared sensitive silicone photodiode type. This photodetector is positioned opposite the light source **10***a* to receive radiant energy therefrom when no opaque object is interposed therebetween, as shown in FIG. 3. The light source **10***a* produces an output that is rich in the near infrared portion of the spectrum. The photodetector **10** and the light source **10***a* may be located above and below the conveyors **12** and **13**, respectively, as shown in FIGS. 2 and 3. These conveyors are supported on suitable pulleys to form a trough therebetween and they are of the type disclosed in Patent No. 3,212,621.

The articles A, A1 and A2, which are to be sorted ac-

cording to their lengths, are supplied to the conveyor **12–13** as a single file from apparatus such as is disclosed in Patents No. 2,728,443 and No. 2,792,929. The articles are spaced on the conveyors **12–13** and moved in single file to the scanning zone in which the photodetector **10** and light source **10***a* are positioned. When an article A is passing between the photodetector **10** and the light source **10***a*, the light rays emitted by the source **10***a* are interrupted by the article for a time interval, depending on the length of the article and the velocity thereof.

The photodetector **10** is connected by lines **14** and **15** to the input of a Schmitt trigger circuit including transistors **17** and **25** shown in FIG. 5. Line **14** is coupled by capacitor **16** to the base of transistor **17**. Line **14** is also connected by resistor **18** to the positive 15 volt line **19** to supply electric current to the photodetector. The light source **10***a* is connected between the lines **19** and **20**. Line **20** is connected to the collector of transistor **22** through resistor **21**. Thus, the light source **10***a*, resistor **21** and transistor **22** are connected in series between the positive 15 volt line **19** and the ground line **15**. Resistors **23** and **24** are connected between the positive line **19** and the collectors of transistors **17** and **25**, respectively. The emitters of these transistors are connected together and to the upper terminal of resistor **26**, the lower terminal of which is connected to the line **15** which is grounded to the chassis of the apparatus. The base of transistor **25** is connected to the collector of transistor **17** through resistor **28** which is shunted by capacitor **29**. Resistors **23**, **27** and **28** are connected in series between the positive line **19** and the ground line **15**, and the common connection between resistors **27** and **28** is connected to the base of transistor **25** to provide bias voltage thereto.

Each time a positive pulse is supplied to the base of transistor **17**, that is, each time an article A passes between photodetector **10** and light source **10***a*, a substantially square pulse is supplied to the base of transistor **25**. The cathode of diode **30** is connected to the collector of transistor **25** and the anode of this diode is connected to the base of transistor **22** so that a negative going square pulse is supplied to the base of the latter transistor from the Schmitt trigger through diode **30** when a positive pulse is developed in the circuit of photodetector **10**.

The collector of transistor **31** is connected to the positive supply line **19** and the base of this transistor is connected to the collector of transistor **22**. Thus, a negative going pulse is also supplied to line **32** which is connected to the emitter of transistor **31**. Line **32** transmits this negative going pulse to the differentiating circuit including capacitor **33** and resistor **34**, and through capacitor **35** to the flip-flop gate employing transistors **36** and **37**. Line **32** also supplies this pulse to the base of gating transistor **39** through capacitor **35** and resistor **38**. The flip-flop gate performs reset functions if abnormally long pulses are transmitted from the Schmitt trigger employing transistors **17** and **25**, as will be described hereinafter.

A unijunction transistor **40** is employed as a relaxation oscillator which operates continuously at a fixed frequency of about 1000 pulses per second. The two connections of the unijunction transistor **40**, which are made to one portion of the semiconductor thereof, are connected through resistors **41** and **42** to the positive supply line **19** and the ground line **15**, respectively. Also, the lower semiconductor connection is connected to the emitter of the gate transistor **39**.

It will be noted that the collector of transistor **39** is connected to the ground line **15** through resistors **43** and **44** and the common connection between these resistors is connected to line **45** which is the counter input line leading to the counter and driver unit **46** shown in FIG. 1. Thus, the collector of the gating transistor **39** is supplied with negative potential.

The junction electrode of the unijunction transistor **40** is connected to the upper terminal of capacitor **48** and through resistor **47′** to the variable resistor **47** which is used to control the frequency of the pulses generated by the unijunction relaxation oscillator. The variable resistor **47** is preferably positioned outside of the logic unit, as shown in FIG. 1, so that it is readily accessible for adjusting the frequency of the oscillator.

Transistor **39** functions as a gate for supplying pulses generated by the relaxation oscillator **40** to the line **45** and counter unit **46** while an article A is passing between photodetector **10** and light source **10***a*. Transistor **39** supplies these pulses to line **45** when a negative going pulse is applied to the base thereof from transistor **31** by way of line **32**, coupling capacitor **35** and resistor **38**. This negative going pulse is of course above the ground potential of line **15**. Thus, pulses are supplied from the relaxation oscillator **40** to the counter input line **45** as long as the photodetector **10** is coveed by an article being scanned.

The negative going pulse on line **32** is also transmitted to the differentiating circuit, including the capacitor **33** and resistor **34**, which is connected to the base of transistor **50**. Diode **51** is connected with its cathode to the base of transistor **50** and its anode to the ground line **15** to bypass the negative spike of the pulse resulting from differentiation of the pulse supplied over line **32**. The collector of transistor **50** is connected to the positive line **19** and the emitter is connected through resistor **52** to the reset signal line **53**. Two branches **55** and **56**, shown in FIGS. 1 and 5, are provided to the reset signal line. Branch **55** is connected to counter unit **46** to reset the binary counting unit **100** thereof and branch **56** is connected to counter unit **57** to reset a similar binary counting unit therein. Another resistor **54** is connected between line **53** and ground line **15**.

The output of transistor **50** is connected as an emitter follower to the cathode of diode **62***a*. The anode of diode **62***a* is connected to line **58** which is connected to the base of transistor **59**. It will be noted that resistors **52**, **54** and **63** are connected in series between the positive **15** volt line **19** and ground line **15**. Line **58** is also connected to the anode of diode **62**, the cathode of which is connected to the collector of transistor **91** and through resistor **64** to the collector of transistor **65** of the flip-flop circuit, which will be described hereinafter.

Line **58** is also connected to the bottom terminal of resistor **63**, the top terminal of which is connected to the positive line **19**. Thus, transistor **50** is actually connected across resistor **63** which is connected between the positive 15 volt line and the base of transistor **59**. The collector of transistor **59** is also connected to the positive 15 volt line **19** and the emitter of this transistor is connected to line **61** which forms the output circuit carrying the signal corresponding to the medium length products. Line **61** is connected to the counter and driver unit **46**, as shown in FIG. 1, and supplies a signal to drive a Schmitt trigger circuit employed in this unit, as will be described hereinafter.

Two coincidence circuits employing transistors **66–67** and **68–69** are employed in the logic unit of this apparatus shown in FIG. 5A. The collectors of these transistors are connected together to the positive 7 volt supply line **70**. Line **70** is connected through resistor **71**, shown in FIG. 1, to the positive terminal of the bridge rectifier **72** which is connected to the secondary **73** of transformer **74**. Bridge rectifier **72** also supplies current to the 15 volt line **19** through resistor **75**. Resistors **71** and **75** function as voltage dropping resistors to reduce the voltages on lines **19** and **70** to 15 volts and 7 volts, respectively. Suitable voltage regulating diodes **76** and **77** of the Zener type are connected between lines **70** and **19**, respectively, and ground line **15**, and these voltage regulating diodes are shunted by capacitors **78** and **79**, respectively. Filter capacitor **80** is connected across the rectifier bridge circuit **72**. Another bridge rectifier circuit **81** is connected across the secondary **82** and filter capacitor **83** is connected across this latter bridge circuit. Bridge circuit **81** provides positive 24 volt supply to line **84** leading to the

counter and driver units **46** and **57** and solenoid valves **85** and **86**, as shown in FIG. 1.

Transistors **87**, **88** and **89**, shown in FIG. 5A, are employed to provide a regulated 4 volt current supply to line **90** which is connected to the emitters of transistors **91** and **92** employed in the reset circuit. The voltage drop across transistor **87** is maintained at about 3 volts to maintain the voltage of line **90** substantially constant at 4 volts. This line is provided with a filter capacitor **93** of large capacity.

Resistors **94** and **95** are connected in series between the 4 volt line **90** and the ground line **15**, and the common connection between these resistors is connected to the base of the regulating transistor **89**. Resistor **96** is connected between the 7 volt supply line **70** and the base of transistor **88** and also the collector of transistor **89**. The emitter of transistor **89** is connected to the anode of diode **97**. The cathode of diode **97** is connected to the anode of diode **98**, the cathode of which is connected to the ground line **15**. Thus, transistor **89** is connected in series with resistor **96** and diodes **97** and **98** between the 7 volt supply line **70** and the ground line **15** so that it controls the bias supplied to the base of transistor **88**. The collector of transistor **88** is connected to the 7 volt line **70** and the emitter of this transistor is connected to the base of transistor **87**. Thus, transistor **88** controls the bias supplied to the base of transistor **87**. The bias of the base of transistor **89** is responsive to voltage fluctuations of the 4 volt line **90** so that these fluctuations are used to control the bias of base of transistor **87** through transistor **88** whereby the voltage drop across transistor **87** is maintained at about 3 volts.

The counter driver units **46** and **57** are connected in accordance with the diagrams shown in FIGS. 6 and 6A which will now be described in detail. The block **100** is a decade counter and employs four flip-flops. This decade counter is of conventional construction and may be of the type CμL 958 manufactured by the Fairchild Semiconductor Division of Fairchild Camera and Instrument Corporation. The decade counter **100** is provided with an input terminal connected to the input line **45** leading to the control logic unit **11**. It is also provided with a reset terminal connected to the reset line **55** which leads to the control logic unit **11**. The decade counter **100** is also provided with a terminal that is connected to the 4 volt line **90** which is also connected to the upper terminal of each of the resistors **101** to **105**, inclusive. The lower terminals of resistors **101** to **105**, inclusive, are connected to the collectors of transistors **106** to **110**, inclusive, respectively, and to lines **111** to **115**, inclusive, respectively.

Decade counter unit **100** is provided with a terminal **116** which is connected to the ground line **15** and, in addition, this unit is provided with four output terminals **117**, **118**, **119** and **129** which are connected to the bases of transistors **106**, **107**, **108** and **109**, respectively, through resistors **121**, **122**, **123** and **124**, respectively. Terminals **117**, **118**, **119** and **120** of the decade counter provide binary signal output.

The collectors of transistors **106**, **107**, **108** and **109** are connected to a network of diodes **125** to **135**, inclusive, for the purpose of providing a decade digital output on contacts **136** to **144** of switch **145**, and contacts **146** to **154** of switch **155** from the binary output of decade counter **100**. For this purpose the cathode of diode **125** is connected to the collector of transistor **106**; the cathodes of diodes **126**, **127** and **128** are connected to the collector of transistor **107**; the cathodes of diodes **129**, **130** and **131** are connected to the collector of transistor **108**, and the cathodes of diodes **132**, **133**, **134**, and **135** are connected to the collector of transistor **109**. In addition, the anodes of diodes **125** and **135** are connected together and to the number **9** contacts **144** and **154**; the anodes of diodes **128**, **130** and **134** are connected together and to the number **7** contacts **142** and **152**. The anodes of diodes **127** and **129** are connected together and to the number **6** contacts **141** and **151**; the anodes of diodes **126** and **133** are connected together and to the number **5** contacts **140** and **150**, and the anodes of diodes **131** and **132** are connected together and to the number **3** contacts **138** and **148**. The number **1** contacts **136–146**, the number **2** contacts **137–147**, the number **4** contacts **139–149** and the number **8** contacts **143–153** of the count selector switches are connected directly to the collectors of transistors **109**, **108**, **107** and **106**, respectively. The anodes of the various diodes in the diode network are also connected to the positive 4 volt line **90** through resistors **156** to **161**, as shown.

The collectors of diodes **106**, **107**, **108** and **109** are connected by lines **111**, **112**, **113** and **114**, respectively, to the anodes of diodes **111***a*, **112***a*, **113***a* and **114***a*, respectively, and the cathodes of these diodes are connected to one side of resistors **111***b*, **112***b*, **113***b* and **114***b*, respectively. The other sides of these resistors are connected together to the base of transistor **110**. Diodes **111***a*, **112***a*, **113***a* and **114***a* and resistors **111***b*, **112***b*, **113***b* and **114***b* form an OR gate so that transistor **110** is on as long as any one of transistors **106**, **107**, **108** and **109** is on. The emitter of transistor **110** is connected to the ground line **15** and the collector thereof is connected to line **115** which leads to the zero contacts of switches **145** and **155**. Line **115** also leads to the differentiating circuit including the capacitor and resistor **163**. Resistor **163** is connected between line **115** and the ground line **15** and the diode **164** is connected with its cathode to line **115** and its anode to line **15** so that the negative pulse of the differentiated signal is bypassed through this diode to ground. The positive pulse is supplied over output line **115** to the input of the decade counter in unit **57** shown in FIG. 1. Transistor **110** is off when the tenth pulse is supplied to decade counter **100** inasmuch as at that time all the transistors **106**, **107**, **108** and **109** are off. When transistor **110** is turned off a pulse is transmitted over line **115**.

The counter and driver unit **57** is the same as the unit **46** illustrated in FIGS. 6 and 6A. The input line **115** leading to unit **57** from unit **46** furnishes the input to the decade counter in unit **57**.

Switch **145**, which is designated the long tenths switch, is connected to line **145**, as shown in FIG. 1, and this line leads to the base of transistor **69**, as shown in FIG. 5A of the logic unit **11**. Switch **155** which is designated the medium tenths switch is connected to line **155***a* which leads to the base of transistor **67** shown in FIG. 5A of the logic circuit **11**. The counter-driver unit **57** is also provided with count selector switches **145***b* and **155***b* corresponding to switches **145** and **155** of counter-driver unit **46**. Count selector switch **145***b*, which is connected to the unit **57**, is designated as the long units switch, and this switch is connected to line **145***c* leading to the base of transistor **68** of the logic circuit shown in FIG. 5A. Count selector switch **155***b* is designated as the medium units switch and this switch is connected to line **155***c* leading to the base of transistor **66** in the logic circuit shown in FIG. 5A.

Switches **145***b* and **145** are adjusted to select the length of the long article in the sorting process. Thus, if switch **145***b* is set on contact **4** and switch **145** is set on contact **5**, then the apparatus is set to select long products having lengths of 4.5 units. These contacts must be supplied with pulses simultaneously from the counter-driver circuits **46** and **57**, respectively, so that both the transistors **68** and **69** are turned on simultaneously. The emitters of these transistors are connected through diodes **165** and **166** to the line **167** which is connected to the base of transistor **168** through resistor **169**. The collector of transistor **168** is connected to line **170** which is referred to as the output line carrying the signal for the long product. Line **170** leads from the control logic unit **11** to the drive input of the unit **57**, as shown in FIG. 1. This corresponds to the drive input line **61** on unit **46** shown in FIG. 6A.

Likewise, if the medium units switch **155***b* is positioned on contact **2** thereof and the medium tenths switch **155**

is positioned on contact 3, the apparatus is set for medium length products of 2.3 units. These contacts must be activated simultaneously from the units 57 and 46, respectively, so that transistors 66 and 67 are turned on simultaneously. The emitters of these transistors are connected to cathodes of diodes 171 and 172, respectively, and the anodes of these diodes are connected together to line 173. Line 173 is coupled by capacitor 174 to the base of transistor 175 which is connected as a flip-flop oscillator with transistor 65, as shown in FIG. 5. Thus, for medium length products, a positive pulse is supplied on line 173 to the base of transistor 175 which is turned on thereby and transistor 65 of the flip-flop is turned off. Transistor 175 also turns transistor 91 off and, as a result, the cathode of diode 62 becomes more positive. Diodes 62 and 62*a* form an AND gate for controlling transistor 59 which is turned on when both of these diodes are high. The base of transistor 59 is supplied with pulses over line 58 from diode 62*a* which are derived from the output of the Schmitt trigger that is connected to the photodetector 10. Line 58 carries signals corresponding to long, medium and short products A, A1 and A2 shown in FIG. 2. However, transistor 59 is turned on only when a positive signal is also transmitted over line 173 to the reset flip-flop. The emitter follower of transistor 59 is connected to output line 61 which carries the signal for the medium length products to the multivibrator employing transistors 179, 181 and 182 shown in FIG. 6A.

The signal supplied on line 61 which corresponds to the medium length products is fed to the differentiating circuit including the capacitor 176 and resistor 177 shown in FIG. 6A. The positive pulse of the differentiated signal is passed through diode 178 to the base of transistor 179. The negative pulse of this signal is bypassed through diode 180 to ground line 15. Transistors 179 and 181 are connected as a Schmitt trigger circuit which is provided with regenerative feedback by transistor 182 so that the circuit becomes a monostable multivibrator adapted to generate pulses of predetermined length depending on the setting of the variable contact on potentiometer 200. This potentiometer is referred to as the "air delay" and provides for the desired delay before the medium air valve 85 is turned on to deflect the product, as will be described hereinafter.

Transistors 179 and 181 have the collectors thereof connected to the 15 volt supply line 19 through resistors 183 and 184, respectively. The emitters of these transistors are connected together and to the top terminal of resistor 185. The bottom terminal of this resistor is connected to the ground line 15. Additional resistors 186 and 187 are connected in series between the collector of transistor 179 and the ground line 15 and the common connection of these resistors is connected to the base of transistor 181. The collector of transistor 181 is also connected to the upper terminal of the capacitor 188 and to the cathode of diode 189. The anode of this diode is connected to the base of transistor 190.

Capacitor 188 and resistor 200 form a time delay circuit to control the feedback to the base of transistor 179 through transistor 182. Output line 195 leading to the anode of diode 201 (FIG. 5A) from the delay circuit supplies a reset pulse to the base of transistor 65 of the flip-flop (FIG. 5) to turn this transistor on and turn transistor 175 off.

The anode of diode 201 is connected to line 195 and the cathode of this diode is connected to the upper terminal of resistor 201*a* and the right hand side of capacitor 201*b*. The left hand side of this capacitor is connected to the upper terminal of resistor 201*c* and to the base of transistor 65. The bottom terminals of resistors 201*a* and 201*c* are connected to the ground line 15. Thus, a positive reset pulse is supplied over line 195 to the base of transistor 65 through diode 201 and capacitor 201*b*. An additional diode 201*d* is connected with its cathode to the upper terminal of its resistor 201*a* and with its anode to line 167. Thus, a reset pulse may also be supplied to the base of transistor 65 from the long signal pulse line 167.

The collector of transistor 190 is connected to the positive 15 volt line 19 through resistor 191 and it is also connected to one side of the capacitor 193. Capacitor 193 and resistor 194 form a differentiating circuit which receives a relatively long pulse from the monostable multivibrator employing transistors 179, 181 and 182 and differentiates this pulse so that a positive and a negative pulse are produced therefrom. The negative pulse is bypassed to the ground line by diode 197 which is connected across resistor 194, and the positive pulse is fed through diode 196 to line 198 which leads to the base of transistor 199. Transistors 199, 205 and 206 comprise another monostable multivibrator for controlling the time interval air is supplied to the medium product air valve 85*a*.

The collectors of transistors 199 and 205 are connected to the positive 15 volt line 19 through resistors 207 and 208, respectively, and the emitters of these two transistors are connected together and to the top terminal of resistor 209, the bottom terminal of which is connected to the ground line 15. The base of transistor 205 is connected to the collector of transistor 199 and to the top terminal of resistor 210, the bottom terminal of which is connected to the ground line 15. Feedback to the base of transistor 199 is supplied from the emitter of transistor 206. The base of this transistor is connected to the variable contact of potentiometer 204.

Potentiometer 204 and capacitor 204*a*, which are connected in series between the collector of transistor 205 and ground line 15, form a delay circuit. Thus, by adjusting the variable contact of the potentiometer 204, the feedback in the monostable multivibrator is controlled and the length of the pulse produced by this multivibrator may be adjusted. Potentiometers 200 and 204 and 200'–204' (FIG. 1) which are connected to the monostable multivibrators in units 46 and 47 are provided for the purpose of obtaining predetermined delay and timing of the energization of the solenoids 85 and 86. The connections to potentiometers 200 and 204 are shown in FIG. 6A and potentiometers 200' and 204' are connected in similar fashion to monostable multivibrators provided in unit 57. Potentiometers 200 and 200' are adjusted to provide for air delay, that is, to compensate for the time it takes for the product to travel from the scanning zone to the appropriate air jet nozzle. In other words, if the compressed air were turned on by valves controlled by the solenoids 85 or 86 at the time that the product is being scanned for length determination, then, obviously, the air jet would be premature. Accordingly, the potentiometers 200 and 200' are adjusted to delay the application of the signal to the solenoids an appropriate length of time required for the product to travel from the scanning zone to the air jet zone. Potentiometers 204 and 204' are provided for controlling the air time, that is, the time the air is turned on at the jets so that the air jet is turned on long enough to develop the proper product deflecting action.

The output of the second monostable multivibrator comprising transistors 199, 205 and 206 is supplied to the base of transistor 211 from the collector of transistor 205 and is amplified by transistors 211, 214 and 216. The collector of transistor 211 is connected to the 15 volt line 19 and the emitter of this transistor is connected to the cathode of diode 213, the anode of which is connected through resistor 212*a* to the base of transistor 214. Also, the emitter of transistor 211 is connected to the top terminal of resistor 212, the bottom terminal of which is connected to the ground line 15. The collector of transistor 214 is connected to the base of transistor 216 and also to the positive 24 volt line 84 through resistor 215. The emitter of transistor 214 and the emitter of transistor 216 are both connected to the ground line 15. The collector of transistor

216 is connected to line 218 which leads to the solenoid 85' controlling the valve 85*a* through which air is supplied for the air jets employed for deflecting the medium length products. The 24 volt line 84 also is connected to the solenoid 85 and diode 217 is connected between line 84 and line 218 to bypass the counter-electromotive force generated in this solenoid when energization thereof is interrupted, that is, when transistor 216 is turned off.

The monostable multivibrators employing the transistors 179, 181, 182 and the transistors 199, 205, 206 are included in the unit 46 shown in FIG. 1 which is designated the tenths counter-medium driver, and they comprise the medium length product driver. A similar arrangement of multivibrators is employed in the unit 57 which is designated the units counter-long driver and the output line 219, which is connected between the unit 57 and the solenoid 86, corresponds to the output line 218 connected between unit 46 and solenoid 85. Thus, when a signal corresponding to a long product is supplied over long line 170 from the logic unit 11 to the unit 57, an output signal is transmitted over line 219 to the solenoid 86. This solenoid controls an air valve 86*a* which supplies compressed air to the air jet positioned at the outlet o the conveyor 12, 13 to deflect the long product. Likewise, a signal from the tenths counter-medium driver unit 46 energizes solenoid 85 which controls an air valve 85*a* which supplies compressed air to the air jet positioned at the outlet of the conveyor 12, 13 to deflect the medium product.

The flip-flop including transistors 36 and 37 is provided for controlling the transistor 39 in cases where an unusually long gating action prevails at this transistor. Under such conditions it is desired to turn off this transistor even though a negative going signal is being supplied thereto over line 32, and this flip-flop is provided for that purpose. The emitters of the transistors 36 and 37 are connected together to the ground line 15 and the collectors are connected to the positive 15 volt line 19 through resistors 36*d* and 37*d*, respectively. Resistors and capacitors are provided between the bases of these transistors and the collectors thereof, as employed in conventional flip-flop circuits. In addition, the base of transistor 37 is connected to the cathodes of diodes 36*c* and 37*c*. The anodes of diodes 36*c* and 37*c* are connected to one side of the resistors 36*b* and 37*b*, respectively. The other sides of these resistors are connected to the ground line 15. Capacitor 36*a* is provided between the anode of diode 36*c* and line 61, as shown in FIG. 5A, and capacitor 37*a* is provided between the anode of diode 37*c* and line 181A in FIG. 6A. Capacitors 36*a* and 37*a* and resistors 36*b* and 37*b* form circuits of suitable time constants so that the suitable energizations thereof from either line 61 or line 181A will turn transistor 37 on and turn transistor 36 off. When transistor 36 is on, it does not interfere with the negative going signal being supplied to the base of transistor 39. However, when transistor 37 is turned on and transistor 36 is turned off, then the base of transistor 39 becomes excessively positive and this transistor is thus turned off even though the negative going signal is being supplied thereto over line 32.

The operation of this apparatus is summarized as follows. A product A to be graded according to length is passed by the conveyor 12, 13 into the scanning zone at a predetermined speed. When the product A is in the scanning zone it interrupts the light passing from the light source 10*a* to the photodetector 10, thereby causing a positive pulse to be generated by the Schmitt trigger employing transistors 17 and 25. The length of the positive pulse depends on the length of the product and the speed at which it is moved by the conveyor. A corresponding negative going pulse is supplied on the output line 32 of transistor 31 and this negative going pulse is transmitted to the differentiating circuit employing capacitor 33 and resistor 34, from which the positive spike is transmitted to the base of transistor 50 which transmits a positive pulse to the base of transistor 59 over line 58. Line 32 also supplies a negative going pulse to the base of transistor 39 through capacitor 35 and resistor 38. Transistor 39 functions as a gate passing pulses generated by the unijunction multivibrator employing transistor 40, as long as the base thereof is receiving the negative going pulse and transmitting these pulses to the output line 45, which is connected to the decade counter 100 in the unit 46. If the flip-flop employing transistors 36 and 37 should be operated, as will be described later hereinafter, to raise the potential of the base of transistor 39 to a predetermined positive potential, then transistor 39 will shut off passage of the pulses from the unijunction multivibrator to line 45 even though a product is between the light source 10*a* and the photodetector 10, since the negative going pulse supplied over line 32 is insufficient to overcome the positive bias supplied from the flip-flop employing transistors 36 and 37.

Line 45 supplies pulses to the decade counter 100 as long as the product A is passing between the light source 10*a* and the photodetector 10 so as to interrupt passage of light therebetween. Decade counter 100 provides binary signal output to the bases of transistors 106, 107, 108 and 109 over lines connected to output terminals 117, 118, 119 and 120, respectively. This signal output is illustrated in FIG. 7 in which the waveforms on the input line 45 and the binary output terminals 117, 118, 119 and 120 are illustrated opposite these reference numerals. The diode network connected to these transistors decodes the binary output into a decade output which is supplied to the contacts of switches 145 and 155, which are designated as the long tenths and medium tenths switches, respectively.

As long as the binary output signals from the counter 100 function to turn the transistors 106, 107, 108 and 109 on, transistor 110 remains off. This condition prevails during the first nine pulses supplied to counter 100 over line 45. On the tenth pulse all transistors 106, 107 108 and 109 are turned off and transistor 110 is turned on through the operation of the OR circuit connected to the base thereof. A pulse is then supplied to line 115 and to the differentiating circuit including capacitor 162 and resistor 163. Line 115 is connected to the input of the decade counter in unit 57 which corresponds to the decade counter 100 in unit 46, shown in FIG. 6. Thus, the counter in unit 57 receives one pulse over line 115 for each ten pulses supplied to counter 100 in unit 46 over line 45. The circuit of unit 57 is similar to that in unit 46. Unit 57 also includes a binary to decade decoder which is connected to the contacts of the long units and medium units switches 145*b* and 155*b* shown in FIG. 1.

At the outset when this apparatus is adjusted for operation, the long units switch 145*b* and the long tenths switch 145 are set on predetermined contacts thereof which correspond to the selected lengths of the long product. Thus, switch 145*b* may be set on contact 4 and switch 145 may be set on contact 5. This adjustment may be made to correspond substantially to 4.5 inches by adjusting the oscillator frequency by varying the potentiometer 47 or by adjusting the speed of the conveyors 12–13, or both. The medium units switch 155*b* and medium tenths switch 155 are also set so that the apparatus will select the medium length products. For example, switch 155*b* may be set on contact 3 and switch 155 may be set on contact 2, giving a medium product length of 3.2, which, of course, must be less than the long product length selected above.

In order for the apparatus to select a long product, both lines 145*a* and 145*c* must be energized simultaneously from the counters in apparatus 46 and 57 so that signals are supplied simultaneously thereby to the bases of transistors 68 and 69, shown in FIG. 5A. These transistors form part of a coincidence circuit and the emitters thereof supply signals to the diodes 165 and 166 which supply a positive signal over line 167 to the base of transistor 168. This transistor is connected to line 170 which transmits a signal to the long driver apparatus 57. At the

same time, a positive signal is supplied over line **167** to diode **201***d* which transmits this signal to the base of transistor **65** to reset the flip-flop employing transistors **65** and **175** so that transistor **65** is turned on in case it was turned off, and this blocks the AND gate employing transistor **59**.

Line **170** leads from the control logic unit **11** to the long driver monostable multivibrators in the unit **57** which function as previously described to supply a signal on line **219** to the solenoid **86** which controls the air jet valve **86***a*. Energizing the solenoid **86** opens the valve **86***a* and provides a blast of air to deflect the long product A and cause it to travel to the long product conveyor or receptacle.

The signal corresponding to a medium length product is transmitted over lines **155** and **155***c* to transistors **66** and **67** of the coincidence circuit, shown in FIG. 5A, and through these transistors to the diodes **171** and **172**. These diodes transmit the signal to line **173** which is connected through capacitor **174** to the base of transistor **175** of the reset flip-flop which is turned on by this signal and transistor **65** is turned off. At the same time the cathode of diode **62** becomes more positive since transistor **91** is turned off. It will be noted that diodes **62** and **62***a* comprise an AND gate, and when positive potential is applied to the cathodes of both of these diodes, then transistor **59** is turned on and the signal corresponding to the medium length product is supplied to line **61** which is connected to the medium driver circuit in unit **46**. The monostable multivibrators of this unit function to cause energization of line **218** which leads to the solenoid **85**. This solenoid opens the air valve **85***a* and an air jet is supplied at a predetermined time to deflect the medium length product A1. It will be noted that this apparatus provides no means for deflecting the short length products, and these are allowed to proceed without deflection to a suitable conveyor or receptacle provided therefor while the long and medium products are deflected to separate conveyors or receptacles.

While I have shown a preferred embodiment of the invention, it will be apparent to those skilled in the art that the invention is capable of variation and modification from the form shown.

What I claim is:

1. In apparatus for sorting products according to their lengths, the combination comprising means moving the product to be sorted through a zone having scanning means, said scanning means having means generating an electric pulse when a product is in the process of being scanned, means responsive to said electric pulse transmitting an electric signal while the product is in said scanning zone, said signal comprising a number of pulses determined by the length of the time interval that the product was in said scanning zone, means responsive to said number of pulses producing control signals characterized by two different product lengths, said last mentioned means including means selecting different values for each of said different product lengths, means including a gate responsive to said electric pulse and to the control signal characterized by one of said product lengths, said last mentioned means including a flip-flop circuit which is responsive to the control signal corresponding to said one product length and is set thereby, and means activated by the control signal corresponding to the other of said product lengths resetting said flip-flop circuit if said circuit was previously in set condition, means associated with said product moving means for separating said products according to said different lengths and means responsive to said control signals activating said separating means, said last mentioned means including said gate and said flip-flop circuit.

2. In apparatus for sorting products according to their lengths, the combination comprising means moving the product to be sorted through a zone having scanning means, means transmitting an electric signal while the product is in said scanning zone, said signal comprising a number of pulses determined by the length of time interval that the product is in said scanning zone, means responsive to said pulses for producing control signals characterized by different product lengths, means responsive to said control signals connected to said last mentioned means for controlling separating means which separates the products according to their lengths, said separating means including solenoid valves controlling air jets, and said means producing control signals including monostable multivibrator means for producing pulses of long enough duration to open the selected solenoid valves and provide an air jet to deflect the predetermined products.

3. In apparatus for sorting products according to their lengths, the combination as set forth in claim **2** further characterized in that said multivibrator means includes a cascade of two monostable multivibrators controlled by each of said control signals, the first thereof generating a pulse which delays the opening of the predetermined solenoid valve for a time interval required for the product to travel from the scanning zone to a zone opposite the air jet nozzle and the second multivibrator controlling the duration of energization of the predetermined solenoid valve.

4. In apparatus for sorting products according to their lengths, the combination comprising means moving the product to be sorted through a scanning zone, means producing an electric pulse while the product is in said scanning zone, a pulse generator, pulse counting means, means responsive to said electric pulse for transmitting pulses from said generator to said counting means during the time interval the product is in said scanning zone, means responsive to said counting means for producing control signals characterized by medium and long product lengths, means associated with said counting means for selecting a range of different values for the medium and long product lengths, separating means connected to said selecting means for separating the products in the range of the desired lengths, a flip-flop circuit adapted to be set by the control signal corresponding to the medium product length, a gate responsive to said electric pulse and to said flip-flop circuit in the set condition for activating said separating means, and means activated by the control signal corresponding to the long product length for resetting said flip-flop circuit if said flip-flop circuit was previously set by a control signal corresponding to said medium product length.

5. In apparatus for sorting products according to their lengths, the combination comprising means moving the product to be sorted through a scanning zone, means generating an electric signal while the product is in said scanning zone, a pulse generator, pulse counting means, means responsive to said electric signal for transmitting pulses to said counting means from said pulse generator during the time interval the product is in said scanning zone, means responsive to said counting means for producing control signals characterized by different product lengths, means selecting the control signals corresponding to the desired product lengths, and means connected to said selecting means for separating the products in the range of the desired lengths, including solenoid valves controlling air jets, and said means producing control signals including monostable multivibrator means for producing pulses of long enough duration to open the selected solenoid valves and provide an air jet to deflect the predetermined products.

6. In apparatus for sorting products according to their lengths, the combination as set forth in claim **5** further characterized in that said multivibrator means includes a cascade of two monostable multivibrators controlled by each of said control signals, the first thereof generating a pulse which delays the opening of the predetermined solenoid valve for a time interval required for the product to travel from the scanning zone to a zone opposite the air jet nozzle and the second multivibrator controlling

the duration of energization of the predetermined solenoid valve.

7. In apparatus for sorting products according to their lengths, the combination comprising means moving the product to be sorted through a zone having scanning means, said scanning means comprising a light sensitive device that is sensitive to infrared light connected to a Schmitt trigger circuit, means transmitting an electric signal while the product is in said scanning zone, said signal comprising a number of pulses determined by the length of time interval that the product is in said scanning zone, means selecting predetermined numbers of said pulses corresponding to different product lengths, said last mentioned means producing control signals characterized by different product lengths, means connected to said last mentioned means for controlling separating means which separates the products scanned according to their lengths.

8. In apparatus for sorting products according to their lengths, the combination as set forth in claim 7 further characterized in that said signal transmitting means comprises a transistor and the output of said Schmidt trigger is supplied in the form of a negative going pulse to the base of said transistor.

9. The method of sorting products according to their lengths comprising the steps of moving a single file of the products oriented lengthwise through a scanning zone, generating an electric pulse while one of the products is being moved through the scanning zone, generating electric pulses continuously at a selected frequency, using said electric pulse for controlling the transmission of said electric pulses to a pulse counting apparatus, adjusting said counting apparatus to produce control signals characterized by at least two different product lengths, selectively transmitting said control signals to product separating apparatus that is encountered by the products after the products pass through said scanning zone, delaying the energization of the separating apparatus by the control signal by the time interval required for the product to pass from the scanning zone to the separating apparatus, thereafter deflecting the product according to its length by directing an air jet thereagainst, and extending the time interval of the control signal sufficiently to enable the air jet to deflect the product and effect the separation thereof.

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