

[54] **MEASURING AND SORTING APPARATUS**

[75] Inventors: **Louis J. Aull, Atlanta, Ga.; William E. Gritt, Indianapolis, Ind.**

[73] Assignee: **Amsted Industries Incorporated, Chicago, Ill.**

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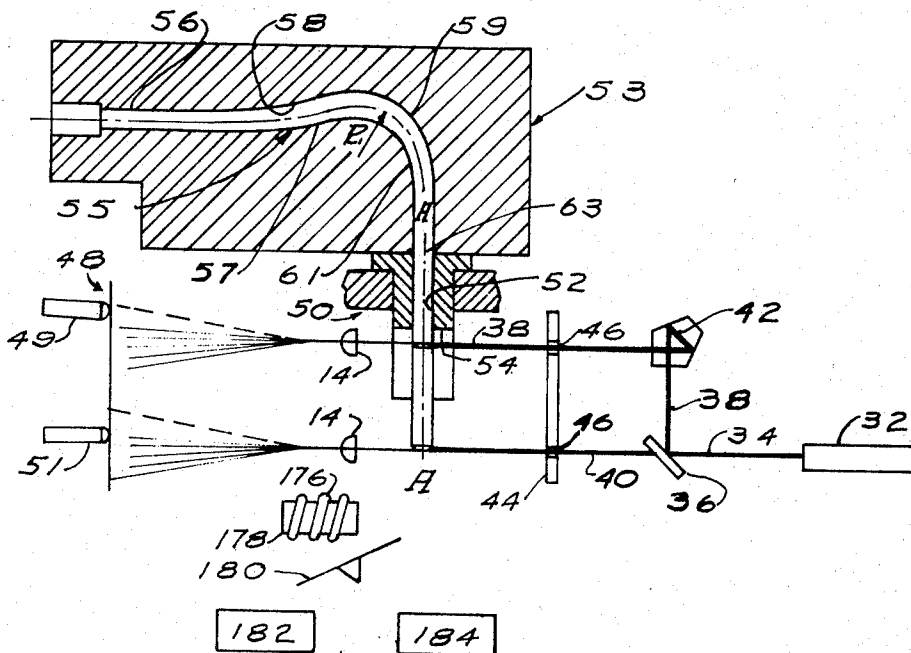
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Primary Examiner—Allen N. Knowles
Attorney—Walter L. Schlegel, Jr. and John W. Yakimow

[57] **ABSTRACT**

A method of and an apparatus for measuring and sorting articles is provided having a plurality of sensors that are responsive to the presence and absence of light. Non-diverging coherent light is projected against the sensors. The articles to be measured and/or sorted are guided through the light intermediate the source of the light and the sensors. In response to the sequence in which the sensors are shaded, a given dimension of the article may be readily determined. Based upon the determined dimension, each article may be deflected into one of a number of containers.

7 Claims, 9 Drawing Figures



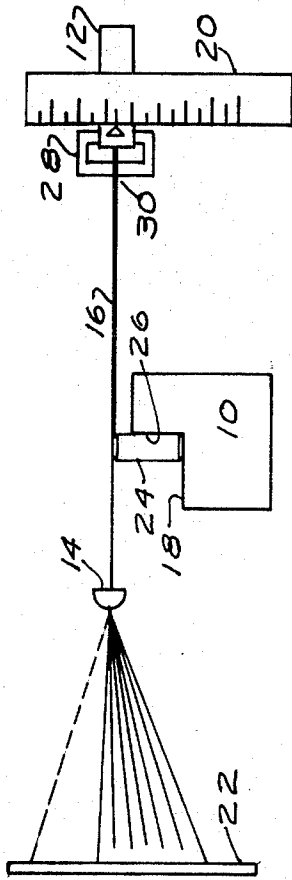


FIG. 1

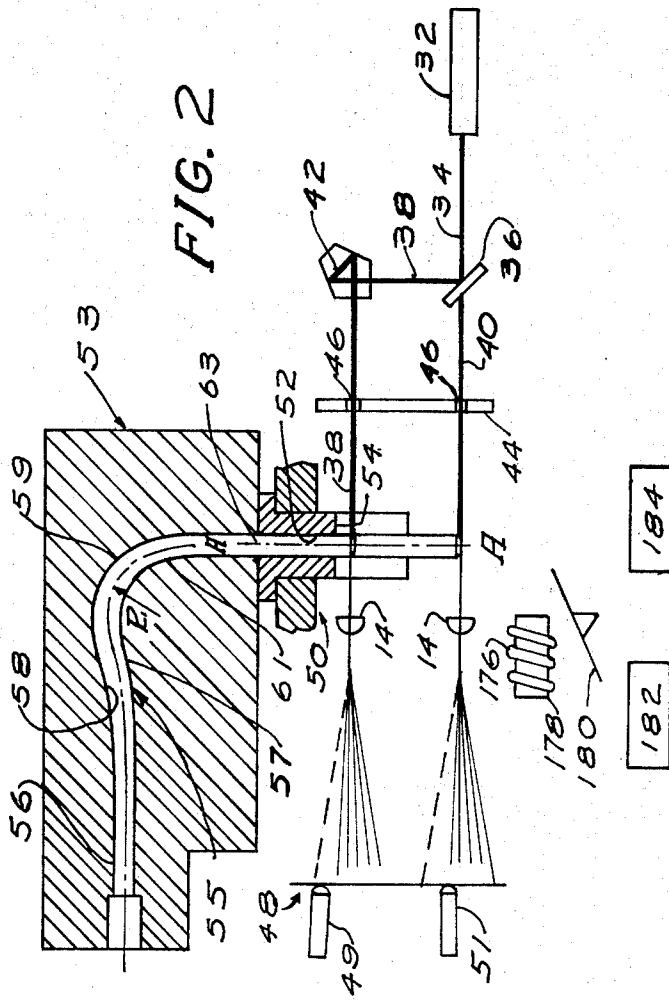
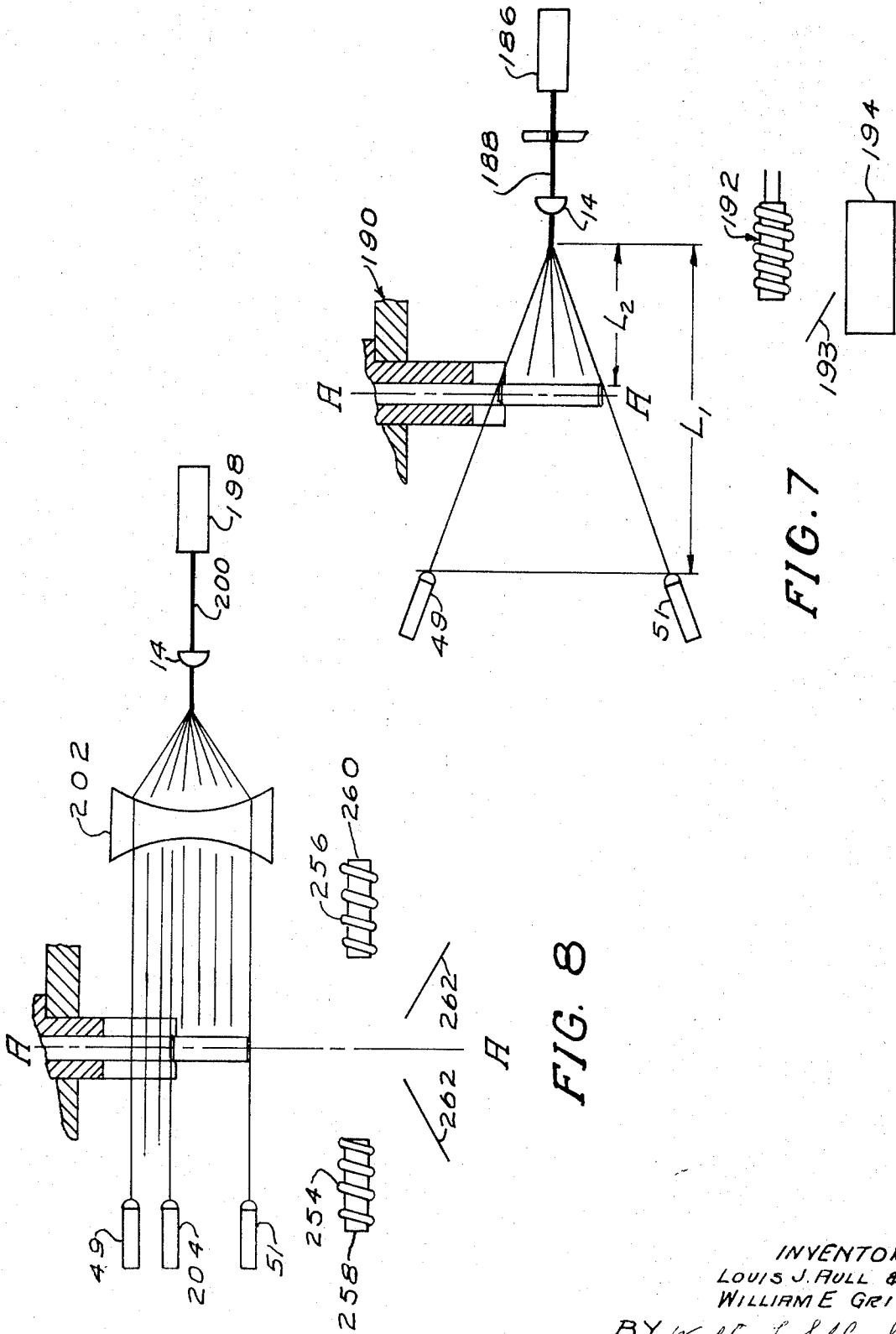


FIG. 2

INVENTOR
 LOUIS J. FULL &
 WILLIAM E. GRITT
 BY *Walter F. Schlegel, Jr.*
John W. Zakmon



INVENTOR
 LOUIS J. RULL &
 WILLIAM E. GRITT
 BY *Walter J. Hillegel, Jr.*
John W. Yankin

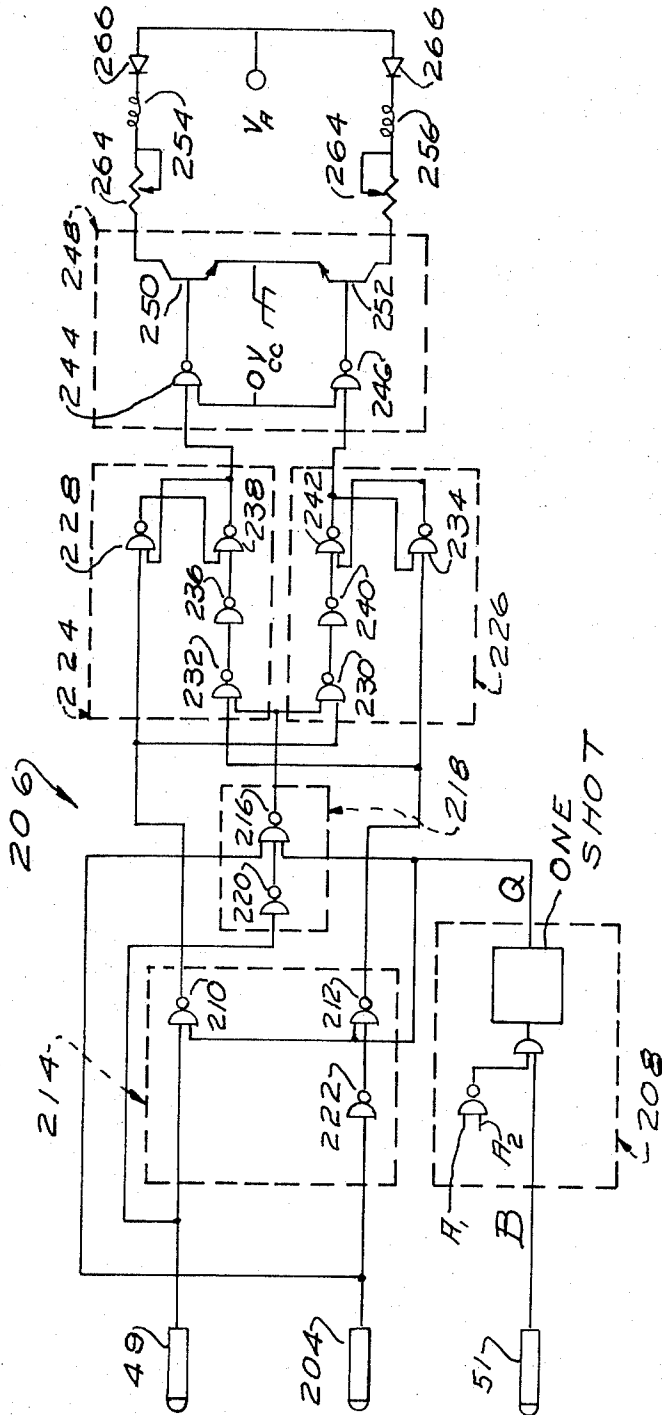


FIG. 9

INVENTOR
LOUIS J. FULL &
WILLIAM E. GRITT
BY *Walter C. Schlegel, Jr.*
John W. Yakimow

MEASURING AND SORTING APPARATUS

BACKGROUND OF THE INVENTION

It is often desirable to be able to quickly and accurately measure a large number of articles of varying lengths. Rulers, micrometers, vernier calipers, gauge blocks, dial indicating devices and the like have been used for this purpose in the past. In each instance, however, the given article must be either picked up or the measuring instrument located next to the article to be measured in order that a visual reading may be made by an operator. In grouping a multitude of small articles into given size lengths this becomes a slow and expensive process. Furthermore, the accuracy of many of the known measuring devices and their inability to indicate small, e.g., less than 0.001 of an inch, differences in length limit their use under given conditions.

BRIEF DESCRIPTION OF THE INVENTION

The invention may best be described in conjunction with the separation of a number of long and short cylindrical pins into two groups. In one embodiment the pins are directed lengthwise through two beams of light of an electro-optic inspection device. The beams are parallel non-diverging coherent light beams such as produced by a laser. The spacing between the two beams is determined by the length of the pins and should be somewhat greater than the length of the short pin but less than the length of the long pin. Distal from the point through which the pins are directed, the two beams are diverged through separate cylinder lenses which magnify the width of each beam.

Each diverging beam projects against a sensing device which detects the presence or absence of the projected light. The sensing devices are connected to a logic circuit. When a pin breaks the first beam, by cutting off the light to the sensing device, the logic circuit is set to an operative position to sense the length of the pin. If the first beam projects light against its sensing device before the second beam is broken, the part is considered short and the circuit latches at a first position until it is reset by the next pin. If the second beam is interrupted before the first beam projects light against its sensing device, the part is considered long and the circuit latches to a second position until it is reset by the next pin.

The latched decision of the logic circuit automatically activates or de-activates an electrically energized magnetic deflector in order that short pins will move in one direction and long pins in another direction. A switch is used to select the deflection of either the long pins or the short pins.

A machine has been constructed according to the preceding description. In checking parts at a rate of seven parts per second an accuracy of ± 0.0002 inches has been achieved. To date the limiting factor of the speed of the machine is the feeder used to direct the parts through the beam of light. The theoretical operating speed of the machine, which uses "low-speed" electronics, is fifty parts per second.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically illustrates a side elevational view of a basic light-optic measuring system;

FIG. 2 schematically illustrates a side elevational view, partly in section, of an automatic light-optic measuring system;

FIG. 3 is a simplified electrical schematic diagram of a circuit which may be used in combination with the automatic system illustrated in FIG. 2;

FIG. 4 is a timing diagram illustrating the relationship with respect to time of an electrical signal at various points in the circuit depicted by FIG. 3;

FIG. 5 is a simplified electrical schematic diagram of a logic circuit which may be used in combination with the circuit illustrated in FIG. 3;

FIG. 6 is a simplified electrical, schematic diagram of a circuit which may be used in combination with the circuits of FIGS. 3 and 5;

FIG. 7 schematically illustrates a side elevational view of another embodiment of an automatic light-optic measuring system;

FIG. 8 schematically illustrates side elevational view of still another embodiment of an automatic light-optic measuring system; and

FIG. 9 is a simplified electrical schematic diagram of a circuit which may be used in combination with the system illustrated in FIG. 8.

DETAILED DESCRIPTION OF DRAWINGS

FIG. 1 schematically illustrates a basic light-optic measuring system having a jig 10 located intermediate a laser 12 and a diverging lens 14. The laser 12 is used to produce a non-diverging, coherent beam of light 16 having a given circular cross-section. The beam of light 16 may be moved vertically relative to a reference surface 18 on jig 10 by moving laser 12 with a known adjustable scale type device 20. The distance between beam 16 and surface 18 can be readily determined by device 20.

Lens 14 is preferably one-half of a cylinder, such as a glass rod cut in half. A vertical cross section taken on the diameter of the beam of light 16 is diverged, and thereby magnified, by lens 14 and appears as a vertical line of light on a flat screen 22 that is spaced from lens 14.

In measuring an article, such as pins 24 (only one shown), which vary in length plus or minus 0.020 of an inch, the beam of light 16 may be 0.050 of an inch in diameter. The lens 14 may magnify the vertical diameter of the beam fifty times to an equivalent length of 2.500 inches onto screen 22. The distance between the center of the 0.050 of an inch beam and the reference surface 18 may be adjusted by the scale device 20 to the desired length of the pins to be measured.

In operation, pin 24 is located on surface 18 and held against vertical surface 26 of jig 10. If the pin is the desired length, one-half of beam 16 will be blocked by the pin. The remainder of beam 16 will pass through lens 14 and project light onto the lower one-half of screen 22. Larger pins will allow a lesser amount of light to be projected onto screen 22 while smaller pins will allow a greater amount of light to be projected onto screen 22. Due to the magnification factor of 50, a 0.001 of an inch variation in the length of a pin will register as a 0.050 of an inch variation on screen 22. By providing a scale on screen 22, small variations in the size of an article can be quickly and easily detected for the purpose of visually sorting the pins into various size groups.

The size of beam 16 may be increased or decreased as desired as may the magnifying power of lens 14. For large magnifications, even of 50, it is advisable to provide a mask 28 in front of laser 12 having a circular or square hole 30 of a given cross section. The hole will permit coherent light waves to pass while blocking the non-coherent halo that often exists around a beam of light projected from a laser. The hole may be further used to control the cross-sectional dimension of the beam 16.

It is appreciated that the light-optic system amplifies the shadow image of a part placed in the path of the light. The light being coherent and monochromatic allows the magnification to take place without complex optics. All that is needed is a diverging lens. The shadow produced by the coherent, monochromatic light may be amplified without the great degree of refraction and interference normally encountered by normal light thereby requiring a less critical mechanical handling system.

Measurements are normally needed in only one plane. Since the light-optic system can be used with only two dimension divergence to make such measurements, two big advantages are realized: (1) energy is not wasted in a large diverging area; and (2) less bulk and size is required to house and align the system.

FIG. 2 schematically illustrates an automatic light-optic measuring system that may be readily adapted for sorting articles into given groups of varying lengths. For simplicity, the system will be described in conjunction with the sorting of parts of two different lengths.

A laser 32 is used to project a non-diverging, coherent beam of light 34 against a beam splitter 36. The beam splitter divides the beam of light 34 into two beams 38 and 40 of equal power which are at an angle of 90° relative to each other. A pentaprism 42 is used to reflect beam 38 90° into a position where it is parallel to beam 40 and spaced therefrom the approximate distance to be measured. If desired, two lasers may be used instead of the beam splitter-pentaprism arrangement.

A mask 44 having two holes 46 may be used to restrict the non-coherent halo around the beams 38 and 40. The mask is optional but advisable where high magnification ratios are used.

A diverging lens 14, similar to the one previously described, is located in the path of each beam 38, 40. The lenses 14, are used to magnify the vertical cross section of each beam of light a given number of times to project a corresponding line of light against a sensing apparatus 48.

Upper and lower sensors 49 and 51 are part of apparatus 48. The sensors may be photo-electric cells or photo-transistors which are preferably small in size, have the ability to repeat their decision as to the presence or absence of light and must be fast in responding, e.g., 200 microseconds or less. The IN 2175, Duo-diode sold by Texas Instruments Company is one of many sensors that are suitable for this purpose. The sensors 49 and 51 should also be adjustable in both the vertical and horizontal planes relative to the beams of light. It is understood that the sensors 49 and 51 need not be located in one vertical plane. If desired, the path of the diverged beams may be redirected by known optic devices.

In measuring cylindrical objects, a bushing 50 having a passage 52 may be located between the lenses 14 and the source 32 of the two beams 38 and 40. The center axis A—A of passage 52 should be vertical and perpendicular to the beams 38 and 40 and should also lie in the same plane as the two beams. A slot 54 may be provided in bushing 50 to permit the passage of one or both of the beams of light 38 and 40 through passage 52 and against their respective lenses 14.

A separator 53 may be used to feed pins into passage 52 in bushing 50. The pins may be fed from a conventional vibratory type feeder (not shown) in a continuous end to end orientation into separator 53. The separator 53 has a special contoured inner passage 55 which causes the pins to separate and fall one at a time through beams 38 and 40. The illustrated separator 53 is designed for pins having a 0.141 inch diameter. Passage 55 has a square entrance passage 56, 0.146 of an inch on each side, which is approximately straight and horizontal. The entrance passage 56 becomes slightly curved or angled upwardly at point 57 then is radially curved downwardly. Although one dimension of passage 55 begins to vary at point 57, the other dimension is 0.146 of an inch throughout separator 53. The radius R_1 to the center of the downwardly curved portion of the passage should be smaller than the length of the largest pin to be measured. It is understood that the upper contour 58 of passage 55 must provide clearance for a pin to move through the straight and curved portions of the passage. Parabolic contours 59 and 61 gradually reduce the width of the passage 55 beyond the downwardly curved portion until the sides of the passage are substantially parallel and perpendicular to beams 38 and 40. At exit point 63, the passage 55 is again square in cross section and is 0.146 of an inch on each side.

Pins traveling through separator 53 will enter passage 55 horizontally oriented in end to end contact. Each pin will be elevated slightly at one end as it approaches point 57 and will cam the preceding pin around the downwardly curved portion until the slope angle of the passage will no longer hold the pin. The pin will thereafter drop leaving the following pin in a climbing position around the curve formed by radius R_1 . The parabolic curves 59 and 61 are used to restrict, dampen and prevent bouncing oscillations of each pin as it falls through the vertical section of passage 55. Excessive bouncing oscillations or sharp curvature changes in the passage will delay the fall of a pin allowing a following pin to catch up.

It is understood that the pins must be spaced as they leave the vertical section of passage 55 and enter bushing 50. Separator 53 will function with contours that approximate the ones disclosed. However, the dimensions of the passage 55 should never exceed twice the diameter of the pins that are to be measured.

In use, a pin is fed through passages 55 and 52 and allowed to fall by the force of gravity. As the front end of the pin passes through beam 38, a shadow is cast on upper sensor 49 causing a logic circuit to activate.

Briefly, the logic circuit operates in the following manner. If a shadow is cast on lower sensor 51 before the upper sensor 49 is activated by the beam of light 38, the pin is considered long. If the upper sensor 49 is activated by the beam of light 38 before a shadow is cast

on the lower sensor 51, the pin is considered short. Either decision — long or short — is latched instantly and held until the next pin resets the circuit by interrupting beam of light 38 to sensor 49.

FIG. 3 illustrates a diagram of an electrical circuit which may be used in conjunction with the automatic electro-optic measuring apparatus illustrated in FIG. 2. The circuit is powered by a d.c. power supply 60 which is a regulated a.c. to d.c. converter that derives its power from readily available a.c. line voltage. An input transformer 62 has its primary winding 64 connected across the a.c. line and its secondary winding 66 connected across the input of a full wave rectifier, such as a diode bridge 68. Pulsating d.c. voltage appearing across the output of diode bridge 68 is smoothed by a shunt connected filtering capacitor 70 and then applied to the collector of a transistor 72. Transistor 72 is, in turn, connected as a series voltage regulator with a Zener diode 74 and parallel connected filtering capacitor 76 in its base circuit. A load resistor 78 and a filtering capacitor 80 are each connected in shunt with the emitter circuit of transistor 72.

Driving current for transistor 72 is drawn through a current limiting resistor 82 which is connected between the positive terminal of smoothing capacitor 70 and the base of transistor 72. The value of resistor 82 is selected to assure that the reverse breakdown potential for Zener diode 74 is exceeded under all operating conditions, thereby insuring that there is substantially constant driving current for transistor 72 which, in turn, insures that d.c. voltage appearing across the final filtering capacitor 80 remains at a substantially constant amplitude despite the changes that inherently occur from time to time in the load into which such voltage is fed.

Upper sensor 49 is connected to the positive terminal of the d.c. power supply 60 and the base of transistor 84 which is connected in common emitter configuration and used as a signal amplifier-inverter generally designated 86. When the leading edge of a pin interrupts beam of light 38 to sensor 49 the current flow from sensor 49 goes from a high (or "1") level to a low (or "0") level as illustrated by signal A in FIG. 4. Transistor 84 which is on when light is projecting against sensor 49 stops conducting. Signal B from amplifier-inverter 86 thereby goes from a low ("0") level to a high ("1") level. The presence of light on sensor 49 again turns transistor 84 on thereby dropping signal B to a low ("0") level.

The collector of transistor 84 is connected to a bistable circuit generally designated 88 and illustrated as a Schmitt trigger. Circuit 88 is used to square the non-rectangular wave B. During conductance of transistor 84, voltage is being drained away from transistor 90 which is therefore in an off or non-conductive state. The base of the second transistor 92 in Schmitt trigger 88 is forward biased by voltage dividers consisting of resistors 94, 96 and 98 thereby maintaining transistor 92 in a conductive state. As input voltage to the base of transistor 90 increases, a critical voltage is reached where transistor 90 begins to conduct causing transistor 92 to instantaneously go to a non-conducting state providing a high ("1") level signal C at terminal 100. When the input voltage to transistor 90 is again lowered below another critical value, because of the presence of beam 38 against sensor 49, transistor 90 in-

stantaneously goes to a non-conducting state permitting transistor 92 to again go to a conductive state thereby providing a low ("0") level signal C at terminal 100.

Leading and lagging edge detectors generally designated 102 and 104 are connected to terminal 100. A capacitor 106 is connected across the d.c. power lines between the Schmitt trigger 88 and the detectors 102 and 104 to filter out any pulsating d.c. voltages that may exist. Detectors 102 and 104 are respectively connected to terminal 100 in series with capacitors 108 and 110 which permit the passage of pulsating voltage.

Transistor 112 in detector 102 is in a non-conductive state when signal C is at a low ("0") level thereby maintaining transistor 114 in an on or conductive state. As signal C goes to a high ("1") level capacitor 108 charges making transistor 112 momentarily conductive and thereby draining current from the base of transistor 114 making it non-conductive resulting in a pulse-type signal D at terminal 113.

Signal D is fed through a diode 115 which blocks reverse current flow and then into a known monostable multivibrator generally designated 116 which is timed by capacitor 118. The pulse of signal D is used to trigger monostable 116 switching it to an unstable state where it remains for a predetermined time before returning to its original stable state. The inverted output signal E from monostable 116 is fed to connector R.

It is understood that the pulse of signal E occurs at the instant that signal C goes from a low ("0") level to a high ("1") level. When signal C goes from a high ("1") level to a low ("0") level, capacitor 108 again charges. The charge in this instance though is opposed to that needed to permit transistor 112 to go to a conductive state therefore the signal D from the leading edge detector 102 remains at a low ("0") level.

The base of transistor 120 in lagging edge detector 104 is connected in series with capacitor 110. When signal C is at a low ("0") level transistor 120 is in a conductive state. When signal C goes to a high ("1") level capacitor 110 charges. The charge does not effect the conductive state of transistor 120. When signal C goes from a high ("1") level to a low ("0") level capacitor 110 again charges but this time in a negative direction counteracting the voltage to the base of transistor 120. Transistor 120 is momentarily driven to a non-conductive state thereby creating a pulse-type signal F at terminal 119 which occurs at the instant that signal C goes from a high ("1") level to a low ("0") level.

Signal F is fed into a diode 121 which blocks reverse current flow, and then into a monostable multivibrator 122 identical to monostable 116 thereby becoming inverted pulse signal G at connector S. Capacitor 118 of monostable 116 and capacitor 124 of monostable 122 are chosen so that the widths of the pulse in signals E and G are equal.

The circuit 126 for lower sensor 51 operates in a manner similar to the circuit indicated by amplifier-inverter 86, Schmitt trigger 88, filter 106, leading edge detector 102 and monostable multivibrator 116 creating an inverted pulse signal H at connector T. It should be noted that for the apparatus illustrated in FIG. 2, a lagging edge detector-monostable multivibrator for lower sensor 51 is not required.

The location of the pulse created by circuit 126 relative in time to the pulses in signals E and G will vary depending upon the length of the pin. A short pin will be located for a given period of time between beams of light 38 and 40. In such a case the signal created by circuit 126 will appear as signal H in FIG. 4. For a long pin, both beams 38 and 40 will be interrupted for a given period of time. In such a case the pulse created by circuit 126 will be located relative in time between the pulses of signals E and G as indicated by pulse H' in FIG. 4. By providing an appropriate pulse monitoring device, each pin may be quickly and easily categorized as a short or a long pin. One such pulse monitoring device is illustrated in FIG. 5 as a logic circuit 128.

Connectors S and T are respectively connected to the C_p terminal of flip-flops 130 and 132. A Dual J-K Master-Slave Flip-Flop 134, Type SN7473, made by Texas Instruments Incorporated may be used for this purpose. The K terminal of each flip-flop 130, 132 is connected to the \bar{Q} of that flip-flop. The \bar{Q} terminal of flip-flop 130 is also connected to one of the inputs of NAND gates 136 and 138 and the \bar{Q} terminal of flip-flop 132 is connected to one of the inputs of NAND gates 140 and 142. The other inputs of NAND gates 136 and 140 are interconnected and also connected in series with NAND gate 144 and buse R. The outputs of NAND gates 136 and 140 are respectively connected to NAND gates 146 and 148.

The clear (or "C") terminal of flip-flop 130 is connected to the output of NAND gate 148 while the clear (or "C") terminal of flip-flop 132 is connected to the output of NAND gate 146. The outputs of NAND gates 138 and 142 are respectively connected to the unconnected input terminals of NAND gates 142 and 138.

Since current sinking logic is being used, it is understood that all unconnected inputs are assumed to be at a high ("1") level during operation of logic circuit 128. It is further understood that the NAND gates are of a type well known in the art and operate in the following manner. When both inputs of a NAND gate are at a high ("1") level, the output of the NAND gate is at a low ("0") level. If either or both inputs are at a low ("0") level, the output of the NAND gate is at a high ("1") level.

Briefly, the operation of the flip-flops 130 and 132 may be readily determined from the following table. A high signal level is indicated by "1" and a low signal level is indicated by "0".

Q_t	J	K	Q_{t+1}
0	1	1	1
1	1	1	0
0	0	1	0
1	0	1	0
0	1	0	1
1	1	0	1
0	0	0	0
1	0	0	1

Q_t is the state of the Q output at time t before a pulse is fed into the C_p input. Q_{t+1} is the state of the Q output at time " $t+1$ " after a pulse is fed into the C_p input. The "J" and "K" inputs are "inhibit" inputs and only work when placed at a low ("0") level. Each pulse to the C_p input reverses the state of Q unless inhibited by a "J" or "K" input. The state is reversed at the negative edge of the pulse being fed into the C_p input, i.e., the point at which the pulse goes from a "1" to a "0". A "0" to the

clear (or "C") input of the flip-flop sets Q to "0". It is of course understood that the signals from the \bar{Q} terminals is the opposite of the signal from the Q terminals of the flip-flops.

Briefly the logic circuit 128 operates as follows. The interruption of beam of light 38 to sensor 49 by an article clears the logic circuit so that a determination may be made as to whether the interrupting article is long or short. If the article is short, a beam of light 38 will project upon upper sensor 49 prior to the interruption of beam of light 40 thereby causing connector Z to go to a low ("0") level and connector Y to remain at a high ("1") level. If the pin is long, beam of light 40 will be interrupted prior to the projection of beam of light 38 on upper sensor 49 thereby causing connector Y to go to a low ("0") level and connector Z to remain at a high ("1") level.

FIG. 6 illustrates a switching circuit 150 which may be used in connection with the circuits illustrated in FIGS. 3 and 5. Connectors Y and Z are connected to a two pole switch 152 which may be used to allow either the signal from the Y or Z connector to activate circuit 150. Logic circuit 128 is protected by a series connected diode 154 poled to clamp any reverse voltage surges that may occur from circuit 150. An RC circuit 156 is connected to diode 154 and to the base of transistor 158 which is connected in common emitter configuration with a load resistor 160 in its collector circuit. A known 60Hz half-wave generator 162 is used to provide the needed current. A second load resistor 164 is connected in series with RC circuit 156 and half-wave generator 162. The collector of transistor 158 is connected to the base of another transistor 166 which in turn has its collector connected to a third transistor 168. Both transistors 166 and 168 are connected in common emitter configuration. A load resistor 170 is connected to the collector of transistor 166 and half-wave generator 162. The emitter of transistor 168 is connected in series with a variable resistor 172 which has its slide 174 connected to a coil 176 of a known electro-magnet shown as 178 in FIG. 2.

In operation switch 152 is engaged with either the Y or Z connector. A "0" signal from the connector inhibits transistor 158. By adjusting slide 174 along resistor 172 the strength of the current flow through coil 176 may be varied to vary the strength of magnet 178.

If switch 152 is connected to the Z connector the magnet 178 will be activated each time the Z connector goes to a "0", i.e., whenever the presence of a short pin is indicated by logic circuit 128. The magnet 178 will redirect the path of the falling pin to one side onto a known slide arrangement 180 so that the short pin may fall into a short pin container 182. If a long pin is indicated by logic circuit 128 the Z connector will be at a "1" and the magnet 178 will not be activated. The long pin will therefore fall straight into a long pin container 184. If desired, switch 152 may be engaged with the Y buse in order that the long pins will be deflected to the side instead of the short pins.

FIG. 7 schematically illustrates another embodiment of the invention where a laser 186 is used to project a non-diverging, coherent beam of light 188 against a diverging lens 14. The lens is used to diverge the beam in two dimensions to project a line of light against upper and lower sensors 49 and 51. A separator-feeder

apparatus 190, similar to the one disclosed in FIG. 2, is used to feed pins or other articles, one at a time, intermediate lens 14 and sensors 49 and 51. An electrical circuit similar to the one illustrated in FIGS. 3, 5 and 6 may be used to activate an electro-magnet or other similar device 192 to deflect one size of pins onto a slide 193 and a container 194. Sensors 49 and 51 may be moved horizontally, vertically and angularly relative to the projected beam of light 188. The operation of this unit is similar to the one illustrated in FIG. 2.

The comparator ratio of the system of FIG. 7 is the ratio of the horizontal distance from the focal point of lens 14 to the vertical plane of sensors 49 and 51 (indicated as L_1 in FIG. 8) divided by the distance from the focal point of lens 14 to the edge of the part that is to be measured (indicated as L_2 in FIG. 7). The edge of the part that is closest to lens 14 is used for this purpose.

The comparator ratio may be used in vertically spacing the sensors 49 and 51. For separating pins of two sizes, the distance between the center of the sensors may be adjusted to be equal to the comparator ratio multiplied by the quantity of the length of the decision point, which is normally one-half of the difference between the two lengths of the pins that are to be sorted plus the length of the shortest pin. If the light-optic measuring system is used for size tolerance inspection, the length of the decision point is equal to the length of the maximum acceptable tolerance limit of the parts. In order that maximum comparator ratios can be used, it is desirable to be able to adjust the placement of cylinder lens 14 and the location of the center line A—A of separator 190.

Because of the triangular nature of the shadow of the system of FIG. 7, such things as surface finish, flatness, squareness of corners, and edges radii on the ends of the articles to be measured may affect the accuracy of the system.

Another embodiment of the invention is schematically illustrated in FIG. 8. A laser 198 projects a beam of non-diverging coherent light 200 against a two dimensional diverging lens 14. The diverged beam is then projected through a second lens 202 which collimates the light rays. The articles to be sorted are fed vertically through the horizontal beam of light 200 intermediate the second lens 202 and upper sensor 49, intermediate sensor 204 and lower sensor 51, which are mounted in a vertical plane. The additional sensor 204, which may also be used in the apparatus illustrated in FIGS. 2 and 7, permits the system of FIG. 8 to sort pins or other articles into three classes, i.e., a given size pin, oversize pins and undersize pins.

Briefly, the system of FIG. 8 operates in the following manner. When the light is interrupted to the lower sensor 51, a pulse signal is created by a circuit. The pulse signal activates a logic circuit 206. At the instant that the logic circuit 206 is activated, a decision is made by it as to the state of upper sensor 49 and intermediate sensor 204. If both sensors 49 and 204 are located in a shadow at the time the pulse is created, the article is considered to be long. If upper sensor 49 has light projecting against it but intermediate sensor 204 is in a shadow, the article is considered to be at the desired or given length. If neither one of the sensors 49 and 204 are in a shadow, the part is considered to be short. Ap-

propriate deflection devices are connected to the logic circuit 206 to deflect long articles in one direction, short articles in another and permit the desired or given length articles to fall straight down.

FIG. 9 schematically illustrates a diagram of a logic circuit 206 and a feed circuit 208 which may be used to sort articles into three different lengths. Lower sensor 51, which may be a photo-transistor, has its output connected to the "B" input of a SN74121 TTL Integrated Circuit 208 made by Texas Instruments, Incorporated. The "A1" and "A2" inputs are maintained at a low ("0") level. When a shadow is cast on sensor 51, circuit 208 gives a high ("1") level pulse signal at output "Q".

Output "Q" of circuit 208 is connected to one input of NAND gates 210 and 212 located in circuit 214 and to one input of NAND gate 216 located in circuit 218. An SN7400 TTL Integrated Circuit and an SN7420 TTL Integrated Circuit made by Texas Instruments, Incorporated are used respectively for circuits 214 and 218.

The output of sensor 49 is connected to one input of NAND gate 210 and to one input of NAND gate 220 located in circuit 218. NAND gate 220 has its output connected to one input of NAND gate 216.

The output of intermediate sensor 204 is connected to one input of NAND gate 222 in circuit 214. The output of NAND gate 222 is connected to one input of NAND gate 212. One input of NAND gate 216 is also connected to the output of sensor 204.

Two other SN7400 Integrated Circuits generally designated 224 and 226 are also used in logic circuit 206. The output of NAND gate 210 is connected to one input of NAND gate 228 in circuit 224 and one input of NAND gate 230 in circuit 226. The output of NAND gate 212 is connected to one input of NAND gate 232 in circuit 224 and one input of NAND gate 234 in circuit 226. One input of each NAND gate 230 and 232 is also connected to the output of NAND gate 216.

NAND gate 236 is connected in series with NAND gate 232 and NAND gate 238. The output of NAND gate 238 is connected to an input of NAND gate 228 while the output of NAND gate 228 is connected to an input of NAND gate 238.

An input of NAND gate 240 is connected to the output of NAND gate 230. The output of NAND gate 240 is connected to an input of NAND gate 242. The output of NAND gates 234 is connected to an input of NAND gate 242 and the output of NAND gate 242 is connected to an input of NAND gate 234.

The outputs of NAND gates 238 and 242 are respectively connected to inputs of NAND gates 244 and 246 located in power interface circuit 248 which may be a Peripheral Driver SN75451P TTL Integrated Circuit made by Texas Instruments Incorporated. The output of each NAND gate 244 and 246 is respectively connected to a base of transistors 250 and 252. The transistors 250 and 252 have their emitters connected in series and their collectors respectively connected to a long coil 254 and a short coil 256 which are used to activate known electro-magnets 258 and 260 (FIG. 8) to redirect a falling part onto one of the slides 262 for separation purposes. Variable resistors 264, used to increase or decrease the line voltage, are connected in series with each coil and collector. Diodes 266 are used to block current flow toward voltage supply "Va"

which is used to power the electro-magnets 258 and 260. A voltage supply "Vcc" is connected to circuit 248 in a known manner. Another power supply (not shown) is connected to the other circuits in a known manner to provide the needed electrical power.

It is understood that all unused inputs in circuit 206 are assumed to be at a high ("1") level during operation. The three inputs of NAND gate 216 must all be at a high ("1") level before a low ("0") level signal is achieved at the output of the gate. All other combinations of high ("1") level and low ("0") level inputs will result in a high ("1") level output from NAND gate 216.

A high ("1") level signal to either transistor will activate the corresponding coil. A low ("0") level signal will deactivate the coil. Each coil in turn will activate the corresponding magnet to deflect articles in one direction or the other or permit articles to continue to fall straight.

It is understood that although the invention has been described in conjunction with the measuring of articles such as pins it may be adapted for other purposes. For example, the distance between two holes in an object may be measured as well as the length between two pins in a roller chain. If desired, three or more laser beams may also be used in a manner similar to that previously explained to measure the distance between several points on an object or article. It is further understood that measurements of transparent articles may also be made with the disclosed invention.

With the exception of the visible reading arrangement of FIG. 1 it is not necessary to use light that is visible to the human eye. Non-visible radiation (such as infra-red light) may also be used. The sensors, of course, must be able to detect the presence or absence of the given radiation used.

It should also be appreciated that sensors may be used in the arrangement of FIG. 1 instead of the described screen 22. The presence or absence of light against each sensor would be used to determine a dimension of the article. If desired each sensor could be wired to activate a light bulb which could be used by an operator to indicate the dimension of the article.

As used in the appending claims, the word "end" refers to a point on an object or article to be measured which is capable of permitting the passage of a given portion of a beam of light while blocking another portion of that beam of light. For example, the "end" may be an end of a pin, a surface of a hole through an object or the side of a cylindrical can.

What is claimed is:

1. In a method of measuring, the steps of providing two groups of sensors having means for detecting light and dark conditions caused by the presence and absence of light, providing a primary beam of non-diverging coherent light, splitting said primary beam into two secondary beams, one of which diverges upon one group of sensors and the other of which diverges on the other group of sensors, and guiding an object through the light between the sensors and the source of said primary beam to interrupt light to the sensors.

2. In the method claim 1 the further step of diverging each beam of light intermediate the sensors and the position where an object is guided through the light.

3. In a device for measuring articles, the combination of first and second beams of coherent, non-diverging light, a group of sensors in the path of the first beam and a single sensor in the path of the second beam, positioning means for locating articles one at a time in the light to interrupt the light and thereby shade the sensors, two dimensional lens means for diverging the light upon the sensors, and means operatively connected to the sensors to divert articles comprising signal means to produce a signal at the instant the second beam of light to the single sensor is interrupted, logic means actuated by the signal to create one of a number of logic signals in response to the shading of the sensors in the path of the first beam of light, and deflection means operatively connected to the logic means to deflect an article along one of a number of paths in response to the logic signal.

4. In a device for measuring articles, the combination of first and second beams of coherent, non-diverging light, first and second sensors respectively located in the first and second beams, positioning means for locating articles one at a time in the light to interrupt the light and thereby shade the sensors, two dimensional lens means for diverging the light upon the sensors, and means operatively connected to the sensors for diverting articles along one of a number of paths in response to the shading of the sensors by the article, said diverting means comprising pulse means to produce a pulse at the instant light is projected upon the first sensor, a pulse at the instant light is interrupted to the first sensor, and a pulse at the instant light is interrupted to the second sensor, logic means to create one of a number of logic signals in response to the location of the pulses relative in time to one another, and deflection means operatively connected to the logic means to deflect an article along one of a number of paths in response to the logic signal.

5. In a device for measuring articles, the combination of sensors responsive to the presence and absence of light, at least one source of coherent, non-diverging light, two dimensional lens means for diverging the light upon the sensors, positioning means above the source for locating articles one at a time in the light intermediate the source and the sensors and thereby shade certain sensors, the positioning means comprising a horizontal entrance passage, an upwardly inclined passage connected to the entrance passage, a separation passage connected to the inclined passage, the separation passage being partially defined by an upper and a lower radial surface, and a vertically positioned exit passage that is substantially perpendicular to the entrance passage, the exit passage having converging, parabolic shaped side surfaces that are tangent to the upper and the lower radial surfaces, and means operatively connected to the sensors for diverting articles along one of a number of paths in response to the shading of sensors by the article.

6. A separator for separating and spacing elongated articles comprising a substantially straight entrance passage, an upwardly inclined passage communicating with the entrance passage, a separation passage communicating with the inclined passage, the separation passage being partially defined by a first and a second radial surface, and a vertical exit passage communicating with the separation passage, the exit passage having

parabolic shaped side surfaces that are tangential to the first and the second radial surfaces, whereby articles are forced in an end to end orientation into the entrance passage and fall by the force of gravity downwardly out of the exit passage.

7. A separator according to claim 6 wherein the passages of the separator are defined on two sides by surfaces which lie in two spaced parallel planes.

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