

[54] **PHOTOELECTRIC SYSTEM FOR GRADING OBJECTS ACCORDING TO SIZE**

[75] Inventor: **Stephen P. Stephanos**, Oakland, Calif.

[73] Assignee: **George E. Lauer**, Oakland, Calif.

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[51] Int. Cl. **G06b 7/00**

[58] Field of Search..... 250/221, 222, 223 R, 250/223 B, 220 M, 219 DF, 219 LB, 219 WD, 219 TH; 209/111.5, 111.7

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Primary Examiner—James W. Lawrence

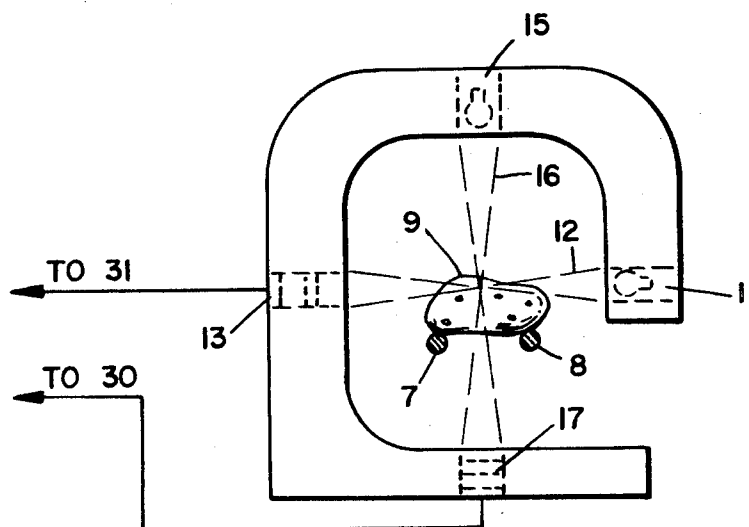
Assistant Examiner—D. C. Nelms

Attorney—Harris Zimmerman

[57] **ABSTRACT**

A device for sorting articles according to size in which the articles are conveyed through a photoelectric sensor. An article interrupts light beams which sense the length and width of the article. A pulse is generated for each linear increment the article advances, and the pulses are summed by digital counters while the length-sensing beam is interrupted. If the count has reached a predetermined range when the article passes out of the length-sensing beam, the article is of the desired length. If the width-sensing beam is interrupted, indicating the article is also greater in width than a predetermined minimum, the article is the desired size, and is ejected into an article collecting device.

10 Claims, 4 Drawing Figures



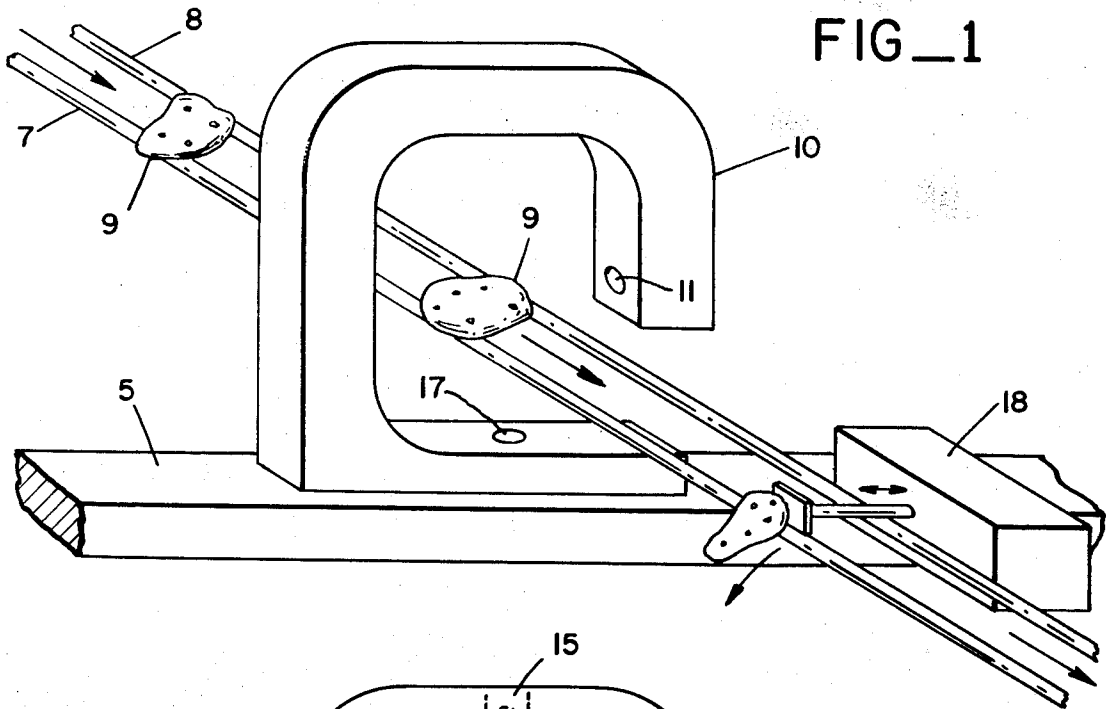


FIG_1

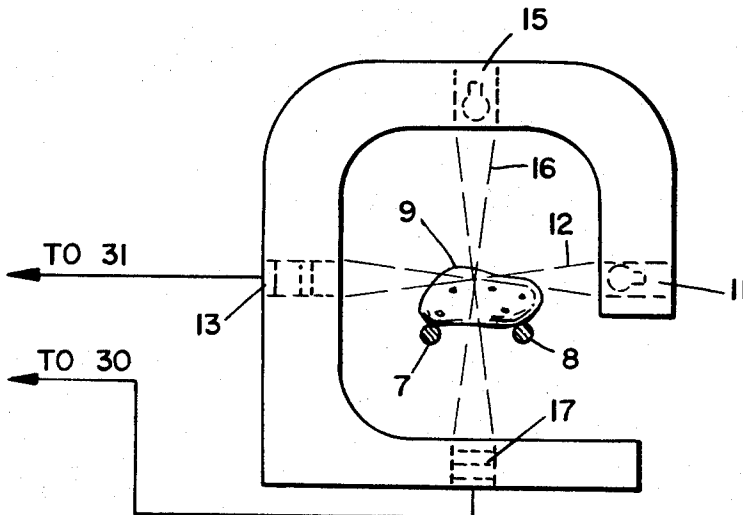


FIG_3

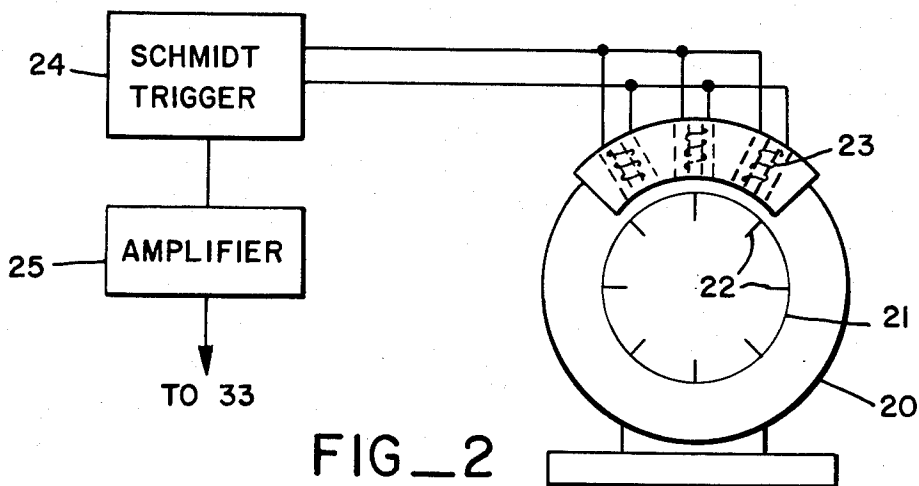


FIG_2

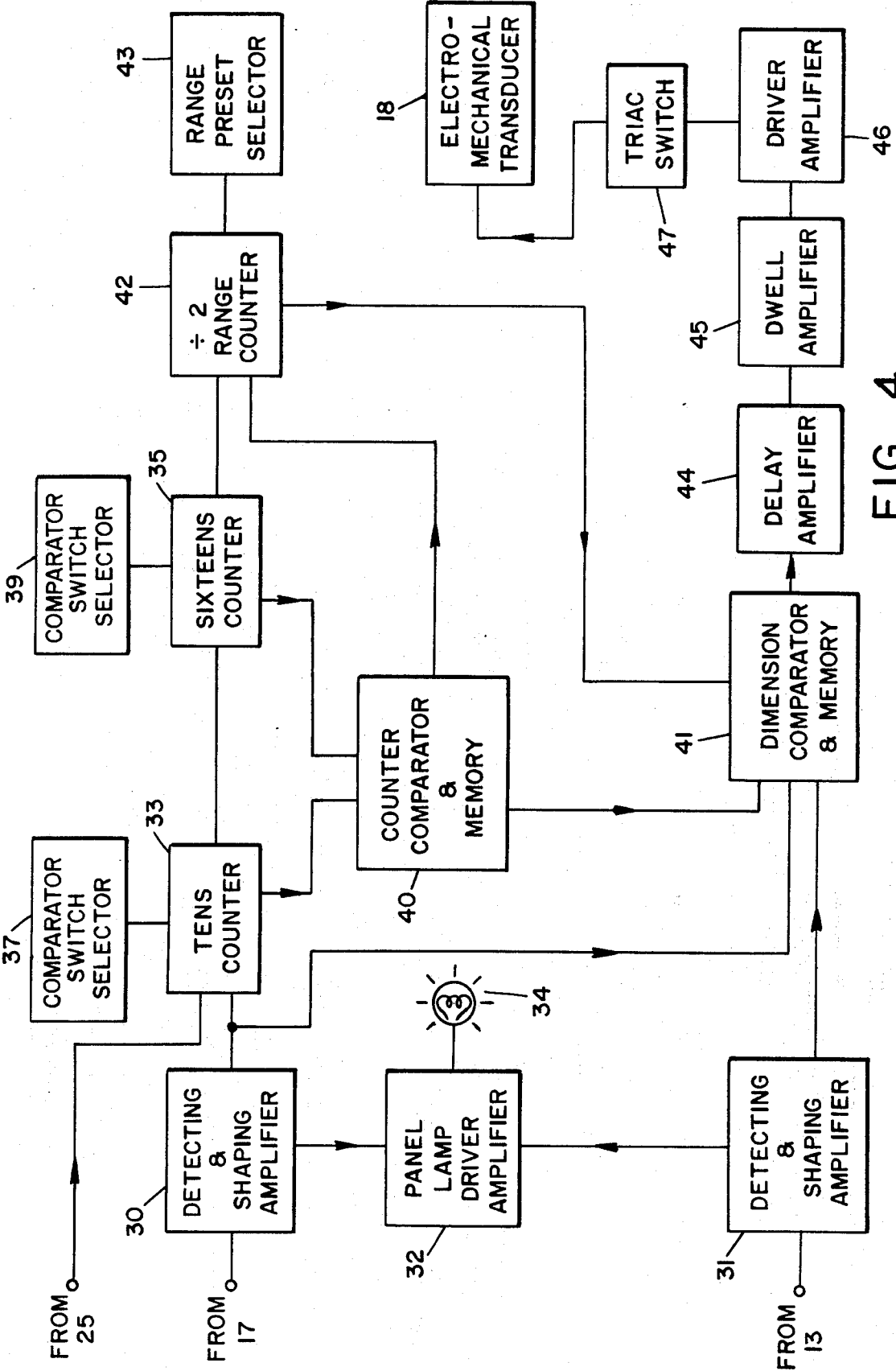


FIG 4

PHOTOELECTRIC SYSTEM FOR GRADING OBJECTS ACCORDING TO SIZE

BACKGROUND OF THE INVENTION

The process of sorting articles of varying sizes and weights poses many problems in a high-speed, automated operation. The usual methods of sorting varying sizes of product, such as fruit and/or potatoes, lumber or other objects, involve sensing the dimensions of each unit by measuring the time each unit interrupts a photoelectric beam as it passes along a conveyor. Because the conveyor in a modern, high speed packing plant travels at speeds greater than 300 feet per minute, the measurement of the time of the beam interruption must be extremely accurate. Practice has shown, however, extreme accuracy cannot be maintained. Due to extremes in operating temperature which affect timer repetition, and variations in conveyor speed which change the time-length relationship, timer based sorting mechanisms require expensive continual maintenance, supervision and readjustment. Yet dimensional tolerances of the sorted product are unsuitably large.

SUMMARY OF THE INVENTION

The present invention is a system for automatically grading objects according to size. In accordance with the present invention, the objects to be graded are carried by a conveyor belt past a horizontal light beam. A first photoelectric transducer is positioned to receive the horizontal beam, which is interrupted by objects with a vertical dimension greater than a predetermined minimum. The signal from the first photoelectric transducer, representing the width of the object, is stored in a comparator memory.

A second, vertical light beam transverses the path of the conveyed objects and impinges on a second photoelectric transducer. As an object passes into the vertical beam, the interrupted signal from the second transducer actuates a digital counter, which begins counting the electrical pulses. The counter counts to a predetermined number, signals the comparator memory, and also actuates a short-count, preset length range counter. The object passes out of the vertical beam, and the re-established signal from the second transducer signals the comparator memory. The comparator memory evaluates the first and second transducer signals and the counter results according to a preset program, i.e., greater than or less than a predetermined length, within or outside a preset length range. If the object meets these criteria, the memory actuates an electromechanical transducer which ejects the object into a collecting device. If not, the object travels further on the conveyor to more sorting devices with different preset size criteria.

The conveyor belt is driven by a motor with which is associated a plurality of permanent magnets which rotate past a magnetic pickup device, creating electrical pulses. Such pulses thus represent rotational speed of the motor and consequently linear movement of the conveyor belt.

The use of comparison of pulses representing distance travelled by the object being sorted with interruption of the light beam overcomes the major disadvantages of the prior art, time-controlled devices. The length pulse system of the present invention has the further advantage that extremely close size tolerances can be maintained over long periods of time, and through

operating conditions which would cause other systems to fail. Because each pulse represents a definite increment of length of an object on the conveyor, and because many pulses can be generated within each inch of length travelled, the present invention can sort objects with extreme accuracy and reliability.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the sorting head and transducer of the present invention, employed with a conveyor carrying objects to be graded;

FIG. 2 is a schematic view of the pulse generating apparatus of the invention;

FIG. 3 is an elevational view of the sorting head shown in FIG. 1; and

FIG. 4 is a block diagram of the logic control circuitry.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1 and considering the present invention in detail, there is shown spaced apart moving hoses 7 and 8 forming a constantly moving, rail-type conveyor for carrying potatoes 9, or equivalent irregularly shaped fruit. The potatoes 9 travel at substantial velocity, i.e., up to 400 feet per minute. At least at one station longitudinally of the conveyor there is provided a photoelectric system for sensing the size of the potatoes 9 and for sorting them into selected groups of uniform sizes. The photoelectric system includes a sorting head 10 containing a first light source 11 which forms a focused, horizontal light beam 12 of constant intensity. The beam 12 is transverse to the direction of travel of the potatoes 9, and it impinges on a photoelectric transducer 13 mounted on the sorting head 10, as shown in FIG. 3. The vertical distance from the hoses 7 and 8 to the transverse beam 12 represents the width of potatoes that the head 10 is set to sense. This width dimension can be varied by moving vertically the support bar 5 on which the head 10 is mounted. The transducer 13 provides a constant signal output until a potato higher than the preset width interrupts the beam 12.

Also mounted in the sorting head 10 is a light source 15 projecting a light beam 16 vertically down, transverse to the path of potato 9. The beam passes between belts 7 and 8 and impinges on photoelectric transducer 17, mounted in the head 10 and located adjacent the moving belts 7 and 8, as shown in FIG. 3. The transducer 17 emits a constant signal response to illumination by the beam 16. Every potato moving past sorting head 10 will interrupt the beam 16 while the entire length of the potato passes through the beam. The signal from transducer 17 is thus interrupted, forming a basis for measuring the length of the potato.

An electromechanical transducer 18 is located adjacent the moving belts 7 and 8. If the potato sensed by the sorting head 10 is judged by the electronic circuitry to be within preset size criteria, the transducer 18 strikes the potato, knocking it off the belts 7 and 8 and into a collecting device. The collecting device, which forms no independent part of the present invention, is disclosed in U.S. Pat. No. 3,517,808, issued to George E. Lauer on June 30, 1970.

The apparatus for generating pulses is shown in FIG. 2. It includes an electric motor 20 which supplies the motive power to the moving belts 7 and 8. Secured axi-

ally to the shaft of the motor 20 is a circular metal plate 21. A plurality of permanent magnets 22 are imbedded radially in the plate 21, spaced evenly around the circumference. Adjacent the plate 21 are pick-up coils 23, connected to each other in parallel relationship. Each of the magnets 22, as they rotate past the coils 23, induce a voltage pulse in each of the coils 23. These length pulses are shaped by the Schmidt trigger circuit 24, amplified by the amplifier circuit 25, and conducted to the logic control circuit. Because the motor 20 drives the belts carrying the potatoes 9, each rotation of the plate 21 bears a constant relationship with the advancement of the belts 7 and 8 during that rotation. The pulses generated during each rotation of the plate 21, therefore, represent increments of the advancement of the belts 7 and 8. By counting the pulses over a given time span, the distance the belts have moved during that time span can be determined very accurately. By knowing the distance a potato has travelled during the time it interrupts the light beam 16, the length of the potato can be calculated. This calculation is performed by the logic control circuitry.

The logic control circuitry receives the information from the photoelectric transducers 13 and 17 and the pulse generator of FIG. 2, evaluates it according to programmed sorting criteria, and actuates the electromechanical transducer 18 if appropriate. The signals from photoelectric transducers 17 and 13 are fed to detecting and shaping amplifiers 30 and 31, respectively. These amplifiers detect significant variations in the signals from the photoelectric transducers, switching from off to on in response to decreases in the photoelectric signals. The amplifier 31 sends its output signal to panel lamp driver amplifier 32 and the length, width and range comparator memory. The amplifier 30 sends its output signal to the panel lamp driver amplifier 32 and to the tens counter 33.

The panel lamp driver amplifier 32 receives the photoelectric signals and actuates lamp 34 whenever either photoelectric transducer 13 or 17 is not generating a signal. In normal operation the lamp 34 flickers as the potatoes are sorted. Constant illumination of the lamp 34 indicates that one or both of the photoelectric transducers beams 12 or 66 is blocked by dirt or debris.

The tens counter 33 continually receives length pulses from the amplifier 25. Upon receipt of a signal from the detecting and shaping amplifier 30, indicating a potato has entered beam 16, the tens counter 33 switches on and begins counting the length pulses. The tens counter 33 is ganged with a sixteens counter 35 to count up to 160 pulses. Associated with counters 33 and 35 are comparator switch selectors 37 and 39 respectively. These switch selectors are preset to the number of pulses to be counted, i.e., the desired length criterion. The count of the counters 33 and 35 is compared with the preset switch selectors 37 and 39 by the counter comparator and memory 40. When the count equals the preset number, the counter comparator and memory 40 sends a signal to the dimension comparator and memory 41, and also sends a signal to the range counter 42, causing the range counter 42 to commence counting.

Associated with the range counter 42 is a range preset selector 43 which is preset to the number of pulses to be counted by the range counter 42. The counter 42, receiving length pulses through counter 35, counts every other length pulse. When the count of the range

counter 42 equals the preset number of selector 43, the counter 42 sends a signal to dimension comparator and memory 41.

The dimension comparator and memory 41 also receives a signal from detecting and shaping amplifier 30 when the potato passes out of the beam 16, and the transducer 17 is re-illuminated. The signal from amplifier 30 also actuates the panel lamp driver 32, illuminating lamp 34, and it resets the counters 33 and 35 for the next sorting sequence.

The dimension comparator and memory 41 is a group of logic gates which perform logic operations on the signals from the counter comparator and memory 40, the range counter 42, and the amplifiers 30 and 31. If a potato passes out of the beam 16 before the counters 33 and 35 have reached their preset number, the signal from amplifier 30, arriving before the signal from counter comparator and memory 40 will prevent selection of that potato. Therefore the preset number of comparator switch selectors 37 and 39 represent the minimum length dimension. Similarly, if the dimension comparator and memory 41 receives no signal from the detecting and shaping amplifier 31, the potato has not met the minimum width criteria by interrupting the beam 12, and will not be selected. The dimension comparator and memory 41 may be programmed to select potatoes greater than or less than the preset range dimension of selector 43. That is, the logic circuits of 41 will be completed by the range counter reaching its preset count either before or after the potato passes out of beam 16, according to the connection of contact points which comprises the programming of dimension comparator and memory 41. Thus the dimension comparator and memory 41 may emit a selection signal after evaluating the width information from amplifier 31, the minimum length information from counters 33 and 35, and the range of length information from counter 42.

The delay amplifier 44 receives the selection signal and delays it for a time period sufficient to allow the selected potato to move on belts 7 and 8 from the sorting head 10 to the electromechanical transducer 18. The delayed signal goes to the dwell amplifier 45, which increases the duration of the delayed pulse to ensure actuation of the transducer 18. The delayed, expanded signal, amplified by driver amplifier 46, actuates the triac switch 47, which applies power to the electromechanical transducer 18. The transducer 18 strikes the selected potato, knocking it from the belts 7 and 8 into a collection device, shown in FIG. 1.

As is readily apparent from the foregoing description, the photoelectric sorting system of the present invention, by virtue of its use of length pulses to sense the size of objects, is a flexible and extremely accurate sorting device. Although the sorting system of the present invention was described in terms of some of the common grading operations performed on a particular type of produce, it can perform many other operations on other types of fruit, produce, lumber and other objects of non-uniform size.

1. A photoelectric system for grading objects according to size, comprising:

means to direct said objects along a path,

first photoelectric sensing means to generate a first photoelectric signal while each of said objects translate through a predetermined distance along said path;

pulse generator means, associated with said means to direct said objects along a path, to generate an electrical pulse for each uniform incremental distance translated by said objects;

counter means, associated with said first photoelectric sensing means and with said pulse generator means, for counting said pulses while said objects translate through said predetermined distance, said counter means including a minimum length counter for generating a minimum length signal upon counting a number of said pulses equal to a preset minimum length number, and further including a range counter activated by said minimum length signal for producing a range signal upon counting a number of said pulses corresponding to a preset length range;

logic means, associated with said counter means and said first photoelectric sensing means, for generating a sort signal upon receiving said first photoelectric signal, said minimum length signal and said range signal in a predetermined sequence; and transducer means connected to said logic means to remove said one of said objects from said path upon receiving said sort signal.

2. The photoelectric grading system of claim 1, wherein said means to direct said objects along said path comprises conveyor means driven by motor means.

3. The photoelectric grading system of claim 2 wherein said pulse generating means comprises magnet means, and magnetic pickup means adjacent said magnet means, said magnet means being driven by said magnetic pickup means and inducing electrical pulses in said magnetic pickup means.

4. The photoelectric grading system of claim 3, wherein said pulse generating means further includes trigger circuit means to shape said pulses induced in said magnetic pickup means, and amplifier means connected to said trigger circuit means to amplify said

shaped pulses.

5. The photoelectric grading system of claim 3, further including second photoelectric sensing means for sensing the width of said objects on said conveyor means, said second photoelectric sensing means generating a second photoelectric signal upon sensing an object greater in width than a predetermined minimum width.

6. The photoelectric grading system of claim 5, wherein said logic means receives said second photoelectric signal, the generation of said sort signal being prevented without reception of said second photoelectric signal.

7. The photoelectric grading system of claim 6, further including warning light means, actuated by receiving either said first or said second photoelectric signal, to indicate actuation of at least one of said photoelectric sensing means.

8. The photoelectric grading system of claim 6, further including delay amplifier means, interposed between said logic circuit means and said transducer means, to delay said sort signal and delay actuation of said transducer means.

9. The photoelectric grading system of claim 8, further including dwell amplifier means, interposed between said delay amplifier means and said transducer means to increase the duration of said sort signal.

10. The photoelectric grading system of claim 1, wherein said first photoelectric sensing means comprises a first light source forming a first light beam projected transversely through said path, a first photoelectric transducer receiving said first light beam after it transverses said path and generating said first photoelectric output signal when said first light beam is interrupted by said objects passing through said first light beam, said predetermined distance being the distance travelled by said objects while interrupting said first light beam.

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