Nov. 1, 1966 F. C. ROCK, JR 3,282,419

PHOTOELECTRIC SYSTEM FOR GRADING OBJECTS ACCORDING TO LENGTH AND WIDTH

Filed Nov. 30, 1964 2 Sheets-Sheet 1

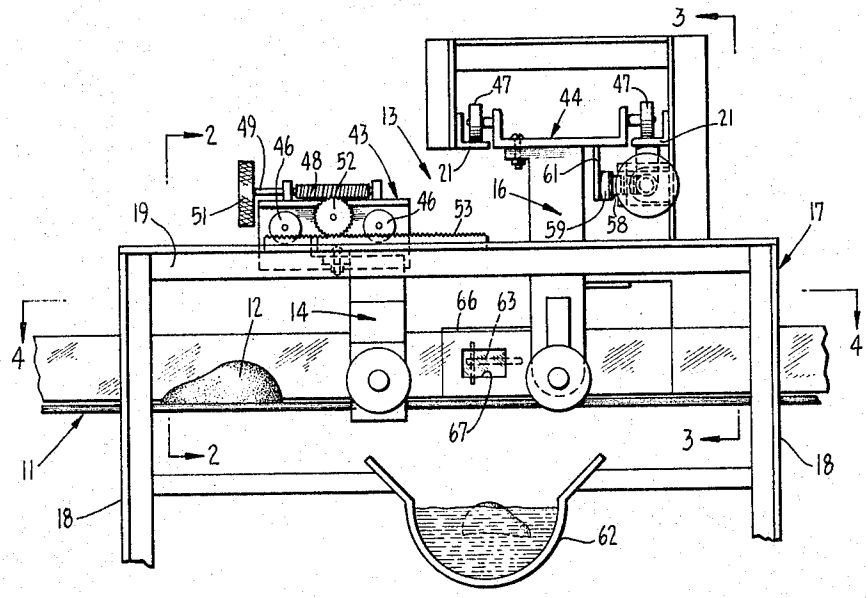


Fig. 1

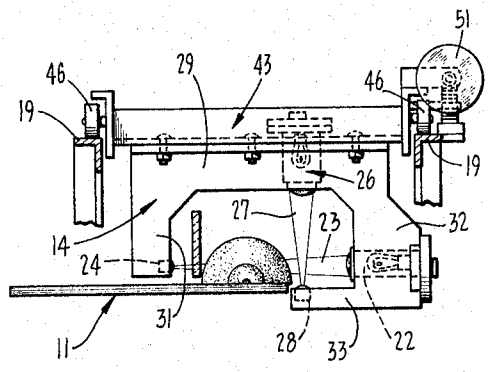


Fig. 2

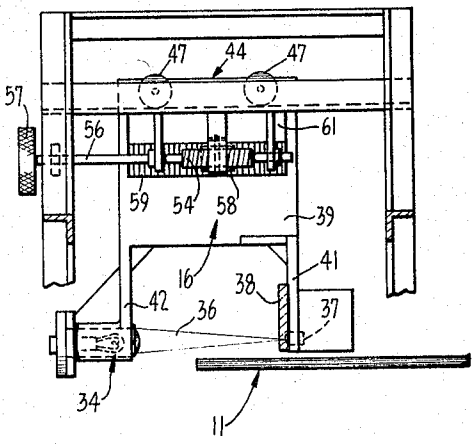


Fig. 3

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PHOTOELECTRIC SYSTEM FOR GRADING OBJECTS ACCORDING TO LENGTH AND WIDTH

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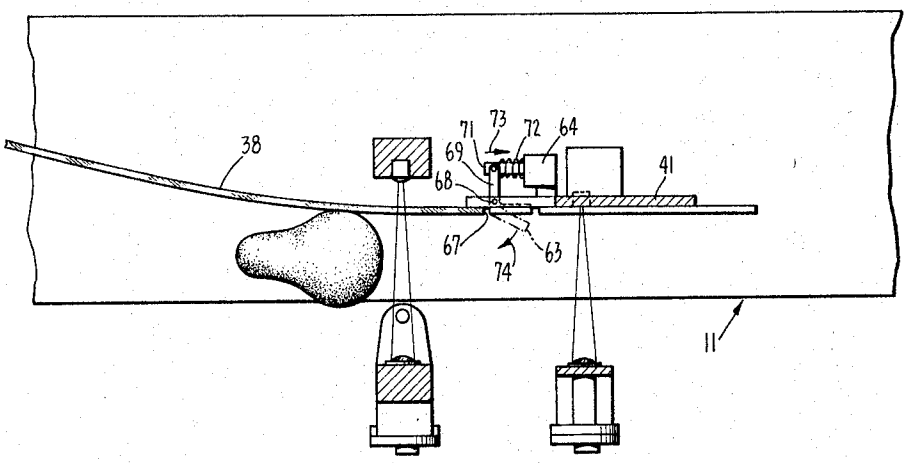


Fig. 4

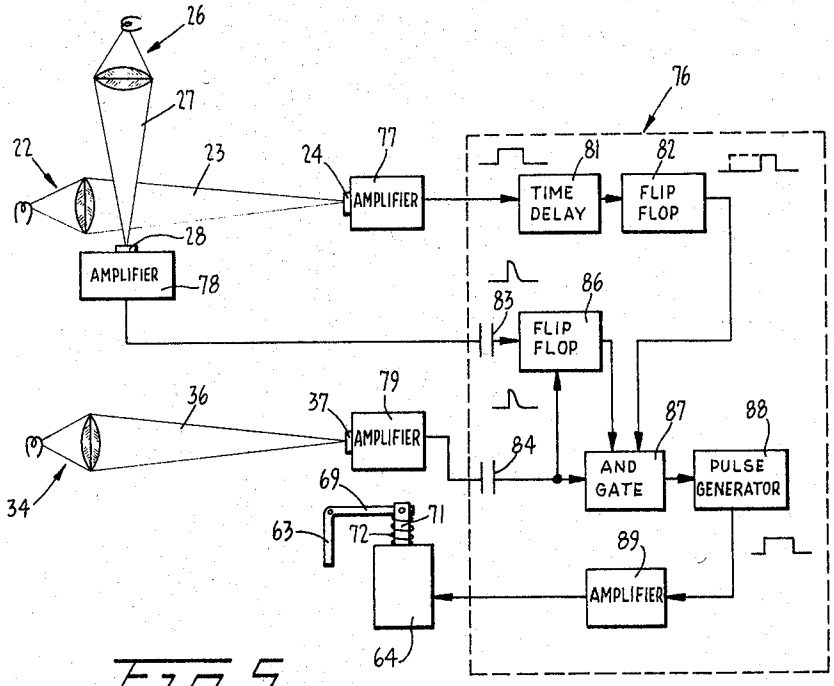


Fig. 5

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PHOTOELECTRIC SYSTEM FOR GRADING OBJECTS ACCORDING TO LENGTH AND WIDTH

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19 Claims. (Cl. 209—74)

This invention relates generally to systems for automatically grading objects such as fruit according to their size, and is more particularly directed to a photoelectric system of this type for grading irregular shaped objects such as pears or potates according to length and width so as to obtain objects of consistent size at a relatively high throughput and without damage to the objects.

In the food processing industry, and elsewhere, it is frequently of importance to separate items according to their size. In general, it is desirable to provide uniformity of size of fruit, or other objects, within a can, or other package. For a variety of reasons such as uniformity in cooking, saleability, and the like, large objects should not be mixed with small, etc. It is of course impractical to grade or sort objects by hand, and therefore various size grading systems have been advanced to accomplish this end automatically. Although these existing graders are satisfactory for nearly spherical objects, such as oranges or lemons, they have been found to be inadequate for oblong or irregular shaped objects such as pears or potatoes, particularly where the objects are to be graded according to both length and width.

It is therefore an object of the present invention to provide a system for automatically grading irregular objects, particularly pear halves, according to size.

Another object of the invention is to provide a grading system of the class described which employs photoelectric means to determine the size of the pear halves or other objects moving at a rapid rate on a conveyor belt and eject objects larger than a predetermined size standard therefrom.

It is still another object of the invention to provide a photoelectric grading system which may be selectively operated to grade objects according to only length or only width, as well as both length and width.

Yet another object of the invention is the provision of a grading system of the class described which is insensitive to the location of the widest portion of the object in its grading operation whereby reproducible pre-orientation of the objects is unnecessary.

A further object of the invention is to provide a photoelectric grading system of the class described which is so arranged that small objects closely following each other cannot be confused with single long objects and be erroneously ejected.

It is a still further object of the invention to provide a grading system of the class described which may be adjusted as to the length and width at which objects are separated from the main flow, even while the machine is in operation.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth in the following description of the preferred form of the invention which is illustrated in the drawings accompanying and forming part of the specification. It is to be understood, however, that variations in the showing made by the said drawings and description may be adopted within the scope of the invention as set forth in the claims.

FIGURE 1 is a side elevational view of a photelectric grading system in accordance with the present invention as employed in conjunction with a conveyor to grade pear halves moving rapidly thereon.

FIGURE 2 is a sectional view taken at line 2—2 of FIGURE 1, illustrating in particular details of grade length varying means of the system.

FIGURE 3 is a sectional view taken at line 3—3 of FIGURE 1, illustrating in particular details of grade width varying means of the system.

FIGURE 4 is a sectional view taken at line 4—4 of FIGURE 1, illustrating a pear half entering a grading station of the system and also an ejecting mechanism at the station.

FIGURE 5 is a block diagram of a preferred circuit of the system.

Considering now the invention in some detail and referring to the illustrated form thereof in the drawings, there will be seen to be generally provided a grading system which employs three light beams and associated photocells or equivalent photoelectric transducers to sense the length and width of pear halves, or other irregular shaped objects elongated in one direction, moving rapidly along a conveyor. The system is so arranged that an electric signal is generated in response to the photoelectric means sensing an object which is larger than a predetermined size. The signal is in turn employed to trigger an ejector means which is operable to displace the object from the conveyor to an underlying bin, adjacent take-off conveyor, or the like. In this manner, objects larger than the predetermined size are separated from the main flow of objects along the conveyor. A number of such sorting means may be provided at spaced intervals along the conveyor and respectively set for successively decreasing predetermined sizes in the direction of conveyor flow. As a result, the objects are graded according to size as they progress along the conveyor.

In basic respects the above noted sorting operation is accomplished by projecting two of the light beams transversely of the conveyor at predetermined longitudinally spaced positions thereof and at a level corresponding to the longest section of the object, for example in the case of pear halves carried cup down, a level as close to the conveyor surface as possible. The third light beam is projected vertically at a position adjacent an edge of the conveyor and adjacent the first horizontal beam and at a predetermined distance from a guide bar along which the pear halves or other objects flow during their progress along the conveyor. The three photoelectric transducers are then respectively disposed in receiving relation to the two horizontal and one vertical light beams. The transducers generate electric pulses in response to their associated light beams being interrupted by the pear halves or other objects on the conveyor. If the two length transducers generate pulses coincidentally and the pulse from the first of these transducers is initiated preconsecutively to the initiation of the pulse from the second transducer, the length of the object interrupting the horizontal beams is longer than the distance therebetween. Moreover, if the width transducer generates a pulse coincidentally with those of the two length transducers, a situation indicative of the object interrupting the vertical width sensing beam at some time during its movement between the horizontal length sensing beams, the object is wider than the distance between the vertical beam and the guide bar. Thus, the above noted coincidence of horizontal and vertical pulses is indicative of a pear half or other object that is longer and wider than a predetermined size. In order that objects of such a size, as sensed by the transducers, be separated from the conveyor flow, the transducers are coupled to a control circuit which is arranged to actuate ejector means in response to a coincidence of pulses from the transducers. It is of particular importance to note, moreover, that the circuit includes discriminating means which are operable to distinguish between a first pulse sequence wherein two pulses are consecutively

generated by the first transducer followed by a pulse from the second tranducer and a second pulse sequence wherein a pulse from the first transducer, not immediately preceded by a pulse from the first transducer, is followed by a pulse from the second transducer. The first sequence may be produced in response to two closely spaced small objects interrupting the length beams, the two objects breaking the first beam before the first object breaks the second beam. In the event the second object is interrupting the first beam at the instant the first object interrupts the second beam, it will be appreciated that the two objects could be confused with a single object of greater than the predetermined length and be erroneously ejected. However, the discriminating means is able to distinguish the first sequence from the second and operates to prevent actuation of the ejector means in response to simultaneous pulses from the first and second length transducers unless the pulse from the second transducer follows a pulse from the first transducer not immediately preceded by a pulse from the first transducer. In this manner, only objects greater than the predetermined length are ejected. As a further important feature of the invention provision is made for the ready adjustment of the longitudinal distance between the two horizontal beams and associated length transducers and of the transverse distance between the guide bar and the vertical beam and its associated width transducer. By varying these distances the grading means may be thus set for objects of different predetermined sizes.

Considering now the invention in greater detail as to preferred structure and referring to FIGURES 1–4, there is shown a belt conveyor **11**, or the like, carrying pear halves **12**, or equivalent irregular objects, at a substantial rate of speed, e.g., of the order of 400 feet per minute. At at least one position longitudinally of the conveyor there is provided a grading system **13** in accordance with the present invention for photoelectrically sensing the length and width of the pear halves **12** and ejecting halves of greater than a predetermined size from the conveyor in the manner generally outlined hereinbefore. More particularly, the grading means **13** preferably includes a pair of support members **14**, **16** containing the photoelectric size sensing elements and mounted upon a frame **17** overlying the conveyor **11**. The frame may include, for example, corner post members **18** in longitudinally spaced relation on opposite sides of the conveyor and having longitudinal rails **19** extending therebetween at positions upwardly displaced from the conveyor surface. The frame also includes structure mounted upon the longitudinal rails **19** including a pair of longitudinally spaced transverse rails **21** upwardly displaced from the conveyor surface. The support member **14** is mounted on the longitudinal rails **19** and support member **16** is mounted on transverse rails **21** for selective movement therealong, respectively, in a manner subsequently described.

The support member **14** carries a light source **22** for directing the first horizontal light beam **23** transversely of the conveyor **11** at a level upwardly adjacent the surface thereof, as well as the first length sensing photoelectric transducer **24** which is transversely spaced from source **22** at a position to receive the beam **23**. In addition, the support member carries a light source **26** for directing a light beam **27** vertically at a position laterally adjacent a side edge of the conveyor for receipt by the width sensing photoelectric transducer **28** which is vertically spaced from source **26**. More particularly, the member **14** preferably includes a transverse web portion **29** which bridges and is supported by the longitudinal rails **19**. Parallel spaced side portions **31**, **32** depend from the opposite ends of the web portion **29**, with the inner side portion **31** terminating just short of the surface of conveyor **11**. The outer side portion **32** is provided at its lower end with a horizontal shelf **33** which extends inwardly to a position just short of the side edge of the conveyor and is slightly subjacent the conveyor surface. The light source **22** is then housed in outer side portion **32** adjacent its lower end while transducer **24** is housed in inner side portion **31** at a position transversely opposite the source. Light source **26** is housed in the web portion **29** at a position vertically opposite the transducer **28** which is housed in the shelf **33** adjacent the tip thereof.

The support member **16** carries a light source **34** for directing the second horizontal light beam **36** transversely of the conveyor **11** at a level upwardly adjacent the surface thereof, as well as the second length sensing photoelectric transducer **37** which is transversely spaced from the source **34** in receiving relation to the beam **36**. The member **16** also carries a guide bar **38** which, in the longitudinal direction of conveyor travel, gradually curves outwardly from the central portions of the conveyor into relatively close inwardly spaced parallelism with the outer side edge thereof along a length in the vicinity of the support members **14**, **16**. The guide bar is positioned closely adjacent the conveyor surface and serves to channel the pair halves **12**, or the like, towards the outer edge of the conveyor as they approach the grading station **11**, and to orient the pair halves such that their longest dimension is approximately parallel to the direction of conveyor movement. The guide bar **38** is of clear plastic or equivalent transparent material for purposes subsequently described. In the preferred form of the member **16**, same includes a transverse web portion **39** which is supported by the transverse rails **21** and has transversely spaced parallel side portions **41**, **42** depending from its opposite ends. The inner side portion **41** terminates just short of the conveyor surface, while the outer side portion **42** is laterally spaced from the outer side edge of the conveyor and terminates at substantially the same level as the inner side portion. The guide bar **38** is secured to inner side portion **41** adjacent its lower end and the straight portion of the bar extends longitudinally of the conveyor intermediate the side portions **31**, **32** of support member **14**. The light source **34** is housed adjacent the lower end of the outer side portion **42** of member **16** and the transducer **37** is housed adjacent the lower end of the inner side portion **41**. Thus, the guide bar **38** is interposed between the sources **22**, **34** and transducers **24**, **37** and would normally intercept the beams **23**, **36**. However, since the bar is transparent the light beams are transmitted uninterrupted therethrough to the transducers.

With the light sources, photoelectric transducers, and guide bar carried by the support members **14**, **16** in the manner described above, it will be appreciated that longitudinal translation of member **14** varies the longitudinal spacing between the horizontal beams **23**, **36**, while transverse translation of member **16** varies the transverse spacing between the guide bar **38** and vertical beam **27**. As noted previously this varies the predetermined minimum length and width dimensions of pear halves **12**, or other irregular objects which will be ejected from the conveyor **11**.

Considering now means by which the support members **14**, **16** may be mounted for translation upon the rails **19** and **21**, respectively, and adjustably translated therealong, it is to be noted that member **14** is carried by a carriage **43**, while member **16** is carried by a carriage **44**. Carriage **43** is provided with longitudinally spaced rollers **46** on the opposite sides thereof which are supported upon the longitudinal rails **19**. Similarly, carriage **44** is provided with longitudinally spaced rollers **47** on the opposite sides thereof which are supported upon the transverse rails **21**. The carriages **43**, **44** and associated support members **14**, **16** are thus respectively readily translatable longitudinally and transversely of the frame **17**. Adjustable translation of support member **14** and its associated carriage is then facilitated as by means of a gear drive including a worm gear **48** journalled for rota-

tion about a longitudinal axis adjacent a side of the carriage. The worm gear is connected by a shaft **49** to a hand wheel **51** for facilitating the ready rotation of the gear. The worm gear engages a pinion gear **52** mounted upon the side of the carriage for rotation about a transverse axis, and the pinion in turn engages a rack **53** fixedly longitudinally secured to one rail **19** in unobstructing relation to the rollers **46**. Thus, in response to rotation of the hand wheel **51**, the worm gear **48** rotates the pinion **52** which, in its engagement with the fixed rack **53**, effects translation of the carriage **43** and support member **14** along the longitudinal rails **19**. In a comparable manner adjustable translation of carriage **44** and its associated support member **16** is facilitated as by means of a gear drive including a worm gear **54**. In this case, however, the worm gear **54** is journalled upon one rail **21** for rotation about a transverse axis and is connected by a shaft **56** to a hand wheel **57** provided at the side of the mounting frame. The worm gear **54** engages a pinion gear **58** carried by the rail **21** and rotatable about a vertical axis. The pinion in turn engages a rack **59** which is mounted in fixed position upon a depending bracket **61** of the carriage **44**. Responsive to rotation of the hand wheel **57** the worm gear **54** rotates the pinion **58** which in turn translates the rack **59** and therefore the carriage **44** carrying same. In this manner, the support member **16** and the guide bar **38** may be translated to different positions transversely of the conveyor **11**.

As noted previously, in response to the pear halves **12** or other objects interrupting the beams **23, 27, 36** in a predetermined manner, the associated photoelectric transducers **24, 28, 37** in conjunction with an electronic control circuit effect actuation of ejector means which operate to urge the pear halves off of the side of the conveyor. The pear halves may be received, for example, in a water filled collector bin **62** carried by the frame **17** at a position subjacent the conveyor **11** and extending laterally beyond the edge thereof. The ejector means may be variously provided as comprising, for example, an air jet nozzle controlled by a solenoid valve which admits compressed air to the nozzle in response to an electrical signal being applied to the valve solenoid from the electronic circuit. The resulting air jet from the nozzle blows an adjacent pear half or other object off of the conveyor. Alternatively, the ejector means may be provided in the manner illustrated in the drawings, as including a hinged push plate **63** which upon energization of a solenoid **64** pivots outwardly against an adjacent pear half **12**, or the like, on the conveyor to urge the object off the side of the conveyor into the bin **62**. More particularly, as best shown in FIGURES 1 and 4, the inner side portion **41** of support member **16** is preferably provided with an extension **66** at its lower end which projects longitudinally towards support member **14**. The extension **66** and guide bar **38** have a window **67**, and the plate **63** is disposed within the window and pivotally connected to the extension, as indicated at **68**, for rotation about a vertical axis adjacent one side of the window. An arm **69** projects right angularly from the rear face of the plate adjacent the pivot axis **68**. The solenoid **64** is mounted on the rear face of the extension **66** and has an associated plunger **71** pivotally connected to the arm **69**. The plunger is loaded as by means of a spring **72** to a normally extended position wherein the plate **63** is aligned with the extension **66** and enclosed within the window **67**. Upon energization of the solenoid **64**, the plunger is retracted against the loading of the spring **72** in the direction of the arrow **73** to thereby pivot the plate **63** outwardly as indicated by the arrow **74**. Since the plate **63** is positioned intermediate the length sensing beams **23, 36**, an object of greater than the predetermined length will be disposed adjacent the plate at the instant the beams are simultaneously interrupted and conditions are established for which the control circuit applies an ejection signal to the solenoid **64**. The plate **63** is at this time instantaneously pivoted outwardly to push the adjacent object off of the conveyor.

Considering now the control circuit which controls the operation of the ejector plate **63**, or other ejector means, in accordance with the pear half, or other object, size sensed by the photoelectric transducers **24, 28, 37**, it should be first noted that the circuit components are preferably housed within the support member **16** and coupled as by means of a disconnectable flexible cable (not shown) to the transducers **24, 28** contained in the support member **14**. In this manner, in the event of circuit breakdown or transducer breakdown, the cable may be disconnected and the support member containing the faulty components removed from the frame **17** and replaced by another unit. A minimum of shutdown time is hence required to restore the grading system to operation.

The technical aspects of the control circuit will become apparent upon consideration of the block diagram of FIGURE 5 wherein the circuit is indicated at **76** and schematically illustrated in operative association with the light beams and photoelectric transducers, as well as the ejector mechanism. Preferably, the transducers **24, 28, 37** are respectively associated with amplifiers **77, 78, 79** which are in turn coupled to inputs of the control circuit **76**. The amplifiers **77, 78, 79** apply pulses to the control circuit which persist for the durations their associated light beams **23, 27, 36** are interrupted by a pear half **12**, or the like, in being moved along the conveyor. The control circuit input from the amplifier **77** is provided with a time delay **81** in turn coupled to a flip-flop **82** which is arranged to be set by the leading edge of a pulse from the time delay, and reset by the trailing edge thereof. The time delay, moreover, is of a type which only delays the leading edge of a pulse from the amplifier **77** and has no effect on the trailing edge. Thus, the flip-flop **82** is turned on a predetermined delay time after a pulse from amplifier **77** is initiated, and turned-off substantially simultaneously with termination of this pulse. In other words, the flip-flop generates an output pulse which is initiated a predetermined delay time after the first horizontal beam **23** is interrupted by the leading end of a pear half **12** or the like and is terminated at substantially the time the trailing end of the pear half moves out of the beam.

The control circuit inputs from amplifiers **78, 79** are respectively provided with capacitors **83, 84**, or equivalent differentiating means, which generate extremely short duration spike pulses in correspondence with the leading edges of pulses from the amplifiers. Capacitor **83** is connected to the set input of a flip-flop **86** while capacitor **84** is connected to the reset input thereof. Flip-flop **86** is hence turned on in response to the leading edge of a pulse from amplifier **78**, and turned off in response to the leading edge of a pulse from amplifier **79**. Thus, a pulse is generated by flip-flop **86** in response to a pear half **12** interrupting the vertical beam **27**, and the pulse persists until the pear half interrupts the second horizontal beam **36**.

The pulses from flip-flops **82, 86** and from capacitor **84** when compared on a common time base include sufficient intelligence that pear halves **12**, or other objects, of greater than a predetermined size can be differentiated from objects less than the predetermined size without error by means of a simple and gate **87**. In this regard, the outputs of flip-flops **82, 86** and capacitor **84** are connected to inputs of the gate. In order for the gate to be opened and an output pulse to be generated therefrom, there must be a coincidence of pulses at all three inputs. This situation only occurs when a pear half is greater than the predetermined size, i.e., a pear half which has a width greater than the distance between the vertical beam **27** and guide bar **38** and a length greater than the distance between the horizontal beams **23, 36**.

More particularly consider a pear half having less than the predetermined width. Such a pear half does not interrupt the vertical beam 27 and therefore flip-flop 86 is not turned on with the result that no pulse is applied therefrom to the and-gate 87. The gate hence remains closed and no pulse is generated from its output.

Next consider a pear half having greater than the predetermined width, but less than the predetermtned length. In this case, at some time during passage of the pear half between the horizontal beams, the vertical beam is interrupted and flip-flop 86 turned on to apply a pulse to the gate 87. The pulse persists until the leading end of the pear half interrupts the second horizontal beam 36 and the resulting spike pulse from capacitor 84 is applied both to the flip-flop to reset same, and to the gate. Instantaneously the spike pulse and flip-flop pulse are in coincidence at the gate. However, at this time no pulse exists at the third input of the gate. More particularly, the trailing end of the short pear half moves out of the first horizontal beam 23 before the leading end enters the second horizontal beam 36. Thus the pulse applied to the gate from flip-flop 82 terminates before the spike pulse is applied to the gate from capacitor 84. Hence, the gate is not opened and no output pulse is generated therefrom.

Now consider the case of a pear half of greater than the predetermined size. It is first to be noted that the predetermined delay time of time delay 81 is selected with respect to the rate of travel of conveyor 11 to be slightly less than the time required for the leading end of a pear half to be conveyed between the horizontal beams 23, 36. Thus the pear half is conveyed most of the way to the second beam 36 before the pulse from flip-flop 82 resulting from interruption of the first beam 36 is initiated. With the circuit thus arranged, the leading end of the pear half interrupts the first horizontal beam 23, and after the predetermined time delay a pulse is applied from flip-flop 82 to the gate 87. This pulse persists until the trailing end of the pear half leaves the first beam. At some time before this occurs, the pear half interrupts the vertical beam 27 and a pulse is applied from flip-flop 86 to the gate. This latter pulse persists until the leading end of the pear half interrupts the second horizontal beam 36 and a spike pulse is applied from capacitor 84 simultaneously to flip-flop 86 and gate 87. Inasmuch as the length of the pear half is greater than the distance between the horizontal beams, the spike pulse is generated before the pulse from flip-flop 82 is terminated, the leading end of the pear half interrupting the second beam before the trailing end has moved out of the first beam. Thus at the instant the spike pulse is initiated, there is a coincidence of pulses at all inputs of the gate and an output pulse is accordingly delivered therefrom.

Another situation that may occur is that of two relatively short, yet sufficiently wide, pear halves closely following each other on the conveyor such that the trailing pear half is interrupting the first horizontal beam 23 when the leading pear half interrupts the second horizontal beam 36. As previously noted this situation may be erroneously interpreted as a single pear half of greater than the predetermined size in the absence of means for distinguishing consecutive interruptions of the first beam followed by interruption of the second beam from an interruption of the first beam at a time intermediate interruptions of the second beam. Two closely following short pear halves would interrupt the first beam twice in succession before the second beam is interrupted. A pear half of greater than the predetermined size would interrupt the first beam, subsequent to an interruption of the second beam by a previous pear half, and then interrupt the second beam such that two interruptions of the first beam do not occur consecutively, but rather interruption of the second beam is consecutive to interruption of the first. The foregoing sequences of beam interruptions are distinguished in the illustrated embodiment of the control circuit 76 by means of the time delay 81.

The first of the two short pear halves interrupts the first beam 23 and a delayed pulse is generated by flip-flop 82 which terminates when the pear half leaves the first beam at a time prior to the leading end of the pear half interrupting the second beam 36. The leading end of the second short pear half then interrupts the first beam to subsequently produce a second delayed pulse at the output of flip-flop 82. The time for which the pulse is delayed is much greater than the time required for the first pear half to move to a position wherein its leading end interrupts the second beam and a short duration spike pulse is applied to the gate from capacitor 84. By the time the flip-flop pulse is initiated, the spike pulse has already terminated. Accordingly there is no coincidence of pulses at the gate and no output pulse is generated. When the second pear half leaves the first horizontal beam, the flip-flop pulse is terminated at a time prior to the generation of a subsequent spike pulse resulting from the leading end of the second pear half interrupting the second beam. There is thus no coincidence of pulses at the gate due to the second pear half alone and no output pulse is generated. It will be thus appreciated that the control circuit readily distinguishes between a single pear half of greater than the predetermined size and two closely following short pear halves.

In order that the pear size determination made by the and-gate 87 be employed to correspondingly control the ejector plate 63, the output of the gate is coupled in triggering relation to a pulse generator 88. The pulse generator is of a type which generates a pulse of predetermined length in response to an input trigger pulse such as the short duration spike pulse output of the gate. Thus, the pulse generator may be, for example, a monostable multivibrator, or the like. The output of pulse generator 88 is coupled to an amplifier 89, the output of which is in turn coupled to the solenoid 64. Thus, in response to an output pulse from the gate, an amplified pulse generator pulse of predetermined length energizes the solenoid 64 to thereby pivot the plate 63 outwardly and eject the adjacent pear half from the conveyor into the bin 62. Upon termination of the pulse, the solenoid is deenergized and the spring 72 effects return of the plate to its normal position in the window 67. Inasmuch as the gate only generates an output pulse when pear halves of greater than the predetermined length and width interrupt the light beams, the plate 63 is only actuated to eject these pear halves. Pear halves of less than the predetermined length and width continue unimpeded along the conveyor.

In some instances it may be desirable to sort out all pear halves or other objects of greater than a predetermined width, irregardless of length. Similarly, under certain conditions, it may be desirable to sort out all objects of greater than a predetermined length without regard to width. To these ends, auxiliary switches (not shown) may be provided respectively in association with the flip-flops 82, 86 for selectively locking same in the "on" position. Thus, with flip-flop 82 locked on, the system operates to eject objects of greater than a predetermined width without regard to length. With flip-flop 86 locked on, the system ejects objects of greater than a predetermined length regardless of their width.

What is claimed is:

1. A size grading system comprising first and second longitudinally spaced photoelectric means for generating electric pulses in response to objects to be graded passing the positions thereof, third photoelectric means adjacent said first photoelectric means for generating electric pulses in response to said objects passing the position thereof, means for guiding said objects lengthwise past the positions of said first, second, and third photoelectric means and at a predetermined transverse distance from said third photoelectric means whereby an object having a length greater than the distance between said first and second photoelectric means causes pulses to be respectively generated therefrom with a time coincidence and an object

having a width greater than said predetermined transverse distance causes a pulse to be generated from said third photoelectric means, a control circuit coupled in receiving relation to said first, second, and third photoelectric means for generating an output pulse only in response to a coincidence of pulses from said first and second photoelectric means and a pulse from said third photoelectric means initiated at a time preceding the initiation of a pulse from said second photoelectric means, and ejector means coupled in receiving relation to the output of said control circuit for ejecting objects passing said photoelectric means in response to output pulses from said control circuit.

2. A size grading system according to claim 1, further defined by said control circuit including discriminating means for distinguishing between a first pulse sequence of two consecutive pulses from said first photoelectric means and a subsequent pulse from said second photoelectric means having a time coincidence with the second of the pulses from said first photoelectric means and a second pulse sequence of a pulse from said second photoelectric means following a pulse from said first photoelectric means not immediately preceded by a pulse from said first photoelectric means with the pulse from said second photoelectric means having a time coincidence with the pulse from said first photoelectric means, said discriminating means preventing the generation of an output pulse from said control circuit in response to said first pulse sequence while permitting the generation of an output pulse from said control circuit in response to said second pulse sequence.

3. A size grading system according to claim 1, further defined by means for varying the distance between said first and second photoelectric means and varying said predetermined transverse distance.

4. A system for grading objects moving longitudinally on a conveyor according to size comprising means for directing first and second horizontal light beams transversely of said conveyor at longitudinally spaced positions thereof, means for directing a vertical light beam laterally adjacent a side edge of said conveyor at a position adjacent said second horizontal light beam, guide means for orienting said objects with their lengths longitudinally of said objects through said horizontal light beams with a distal side of each object relative to said side edge of said conveyor at a predetermined transverse distance from said vertical light beam, first and second length sensing photoelectric transducers respectively disposed in receiving relation to said first and second horizontal light beams and generating electric pulses in response to said objects interrupting said beams, a width sensing photoelectric transducer disposed in receiving relation to said vertical light beam and generating electric pulses in response to said objects interrupting said vertical beam, a control circuit coupled in receiving relation to said transducers for generating an output pulse in response to pulses from said first and second length sensing transducers having portions in time coincidence together with a pulse from said width sensing transducer initiated prior to initiation of said pulse from said second length sensing transducer, and ejector means disposed adjacent said guide means at a position intermediate said horizontal beams and coupled to said control circuit for urging said objects transversely outwardly of said conveyor beyond said side edge thereof in response to output pulses from said control circuit.

5. A system according to claim 4, wherein said control circuit includes discriminating means for distinguishing between a first pulse sequence of two consecutive pulses from said first length sensing transducer and a subsequent pulse from said second length sensing transducer having a time coincidence with a portion of the second pulse from said first length sensing transducer and a second pulse sequence of a pulse from said second length sensing transducer following a pulse from said first length sensing transducer not immediately preceded by a second pulse from said first length sensing transducer with said pulse from said second length sensing transducer having a time coincidence with a portion of said pulse from said first length sensing transducer, said discriminating means preventing the generation of an output pulse from said control circuit in response to said first pulse sequence while permitting the generation of an output pulse from said control circuit in response to said second pulse sequence.

6. A system according to claim 4, further defined by means for selectively moving said means for directing said first horizontal beam and said first length sensing transducer, and said means for directing said second horizontal beam and said second length sensing transducer, longitudinally with respect to each other, and by means for selectively moving said guide means, and said means for directing said vertical beam and said width sensing transducer, transversely with respect to each other.

7. A system according to claim 4, further defined by said control circuit including an and-gate having three inputs and an output, said gate producing a pulse at said output only in response to a coincidence of pulses at all three inputs, means coupling said first length sensing transducer to a first of said gate inputs, means coupling said second length sensing transducer to a second of said gate inputs, means coupled between said width sensing transducer and a third of said gate inputs for applying an input pulse to said third input in response to a pulse from said width sensing transducer with the input pulse persisting until a subsequent pulse is generated by said second length sensing transducer, and means coupling the output of said gate in triggering relation to said ejector means.

8. A system according to claim 7, further defined by said means coupling said first length sensing transducer to said first gate input including means for delaying the leading edges of pulses generated by said first length sensing transducer for a time slightly less than the time required by said objects to move longitudinally between said first and second horizontal light beams.

9. A system for the size grading of objects moving longitudinally on a conveyor comprising means for directing first and second horizontal light beams transversely of said conveyor at longitudinally spaced positions thereof, means for directing a vertical light beam laterally adjacent a side edge of said conveyor at a position adjacent said second horizontal light beam, guide means for orienting said objects with their lengths longitudinally of said conveyor and channeling said objects through said horizontal light beams with a distal side of each object relative to said side edge of said conveyor at a predetermined transverse distance from said vertical light beam, first and second length sensing photoelectric transducers respectively disposed in receiving relation to said first and second horizontal light beams, a width sensing photoelectric transducer disposed in receiving relation to said vertical light beam, an and-gate having three inputs and an output, a time delay for delaying the leading edge of a pulse applied thereto, said time delay connected to said first length sensing transducer, a flip-flop having an input connected to said time delay and an output connected to a first of said gate inputs, said flip-flop set by the leading edge of a pulse from said time delay and reset in response to the trailing edge thereof, differentiating means coupling said second length sensing transducer to a second of said gate inputs, a second flip-flop having set and reset inputs and an output, said output of said second flip-flop connected to a third of said gate inputs, said reset input connected to said second gate input, differentiating means coupling said width sensing transducer to said set input of said second flip-flop, a pulse generator coupled to the output of said gate for generating a pulse of predetermined length in response to an output gate pulse, and ejector means disposed adjacent said guide means at a position intermediate said horizontal beams for urging said object transversely outwardly of said conveyor beyond said side edge thereof in response to electrical energization, said ejector means coupled to said pulse generator for energization by the pulses therefrom.

10. A system according to claim 9, further defined by means for selectively moving said first horizontal light beam directing means and first length transducer, and said second horizontal light beam directing means and second length transducer, longitudinally with respect to each other, and by means for selectively moving said guide means, and said vertical beam directing means and width sensing transducer, transversely with respect to each other.

11. A system for grading objects moving longitudinally on a conveyor according to size comprising a frame mounted in overlying relation to said conveyor, a first support member depending from said frame and selectively movable longitudinally of said conveyor, said member having an upper web portion extending transversely of the conveyor and depending parallel spaced inner and outer side portions with said outer side portion spaced transversely outward from a side edge of said conveyor, said outer side portion having an inwardly transversely projecting shelf terminating adjacent said side edge of said conveyor subjacent the surface thereof, a first horizontal light source carried by said outer side portion of said member and directing a first horizontal light beam towards the inner side portion of said member, a first length photoelectric transducer carried by said inner side portion of said member in receiving relation to said first horizontal beam, a vertical light source carried by said web portion and directing a vertical light beam towards said shelf portion of said member, a width photoelectric transducer carried by said shelf portion of said member in receiving relation to said vertical beam, a second support member depending from said frame at a position longitudinally displaced from said first support member in the direction of conveyor movement, said second support member selectively movable transversely of said conveyor, said second support member having web portion extending transversely of the conveyor and depending parallel spaced inner and outer side portions, a second horizontal light source carried by said outer side portion of said second support member and directing a second horizontal light beam towards the inner side portion thereof, a second length photoelectric transducer carried by said inner side portion of said second member in receiving relation to said second horizontal beam, a transparent guide bar secured to said inner side portion of said second member and extending longitudinally toward said first support member and between said inner and outer side portions thereof to then gradually curve inwardly of said conveyor, said guide bar disposed in close spaced relation to the surface of said conveyor, ejector means disposed adjacent said guide bar intermediate said first and second support members for urging said objects transversely outward beyond said side edge of said conveyor, and a control circuit coupled in receiving relation to said transducers for generating an output pulse in response to pulses from said first and second length transducers having portions in time coincidence together with a pulse from said width transducer initiated prior to initiation of said pulse from said second length transducer, said control circuit having its output coupled to said ejector means to trigger actuation thereof in response to said output pulses.

12. A system according to claim 11, wherein said control circuit includes discriminating means for distinguishing between a first pulse sequence of two consecutive pulses from said first length transducer and a subsequent pulse from said second length transducer having a time coincidence with a portion of the second pulse from the first length transducer and a second pulse sequence of a pulse from said second length transducer following a pulse from said first length transducer not immediately preceded by a second pulse from said first length transducer with said pulse from said second length sensing transducer having a time coincidence with a portion of said pulse from said first length transducer, said discriminating means preventing the generation of an output pulse from said control circuit in response to said first pulse sequence while permitting the generation of an output pulse from said control circuit in response to said second pulse sequence.

13. A system according to claim 11, further defined by said ejector means having an actuating solenoid and by said control circuit including an and-gate having three inputs and an output, said gate producing a pulse at said output only in response to a coincidence of pulses at all three inputs, means coupling said first length transducer to a first of said gate inputs, means coupling said second length transducer to a second of said gate inputs, means coupled between said width transducer and a third of said gate inputs for applying an input pulse to said third input in response to a pulse from said width transducer with the input pulse persisting until a subsequent pulse is generated by said second length transducer, and means coupling the output of said gate in triggering relation to said solenoid.

14. A system according to claim 13, further defined by said means coupling said first length transducer to said first gate input including means for delaying the leading edges of pulses generated by said first length transducer for a time slightly less than the time required by said objects to move longitudinally between said first and second horizontal light beams.

15. A system according to claim 13, further defined by said means coupling said first length transducer to said first gate input including a time delay coupled to said first length transducer for delaying the leading edges of pulses therefrom, and a flip-flop having an input connected to said time delay and an output connected to said first gate input, said flip-flop set by the leading edge of a pulse from said time delay and reset by the trailing edge thereof, said means coupling said second length transducer to said second gate input comprising a capacitor, said means coupled between said width transducer and third gate input comprising a second flip-flop having set and reset inputs and an output, said output connected to said third gate input, said reset input connected to said second gate input, and a capacitor coupled between said width transducer and said set input of said second flip-flop, and said means coupling the output of said gate in triggering relation to said solenoid comprising a pulse generator for generating an output pulse of a predetermined length in response to an input trigger pulse, said pulse generator having its input coupled to the output of said gate and its output coupled in energizing relation to said solenoid.

16. A system for grading objects moving longitudinally on a conveyor according to size comprising a frame mounted in overlying relation to said conveyor including parallel transversely spaced longitudinal rails and parallel longitudinally spaced transverse rails, a first support member having an upper web portion disposed transversely of the conveyor and depending parallel spaced inner and outer side portions with said outer side portion spaced transversely outward from a side edge of said conveyor and having an inwardly transversely projecting shelf terminating adjacent said side edge of said conveyor subjacent the surface thereof, a carriage dependently mounting said support member upon said longitudinal rails for translation therealong, manually operable gear drive means associated with said support member and said frame for selectively translating the former along said longitudinal rails of the latter, a first horizontal light source carried by said outer side portion of said member and directing a first horizontal light beam towards the inner side portion of said member, a first length photoelectric transducer carried by said inner side portion of said member in receiving relation to said first horizontal beam, a vertical light source carried by said shelf and directing a vertical light beam towards said web portion of said member, a width photoelectric transducer carried by said web portion of said member in receiving relation to said vertical beam, a second support member having an upper web portion disposed transversely of the conveyor

at a position longitudinally displaced from said first support member in the direction of conveyor movement and having depending parallel spaced inner and outer side portions, a second carriage dependently mounting said second support member upon said transverse rails for translation therealong, manually operable gear drive means associated with said second support member and said frame for selectively translating the former along said transverse rails of the latter, a second horizontal light source carried by said outer side portion of said second support member and directing a second horizontal light beam towards the inner side portion thereof, a second length photoelectric transducer carried by said inner side portion of said second member in receiving relation to said second horizontal beam, a transparent guide bar secured to said inner side portion of said second member and extending longitudinally toward said first support member and between said inner and outer side portions thereof to then gradually curve inwardly of said conveyor, said guide bar disposed in close spaced relation to the surface of said conveyor, ejector means disposed adjacent said guide bar intermediate said first and second support members for urging said objects transversely outward beyond said side edge of said conveyor, and a control circuit coupled in receiving relation to said transducers for generating an output pulse in response to pulses from said first and second length transducers having portions in time coincidence together with the occurrence of a pulse from said width transducer initiated prior to initiation of said pulse from said second length transducer, and a control circuit having its output coupled to said ejector means to trigger actuation thereof in response to said output pulses.

17. A system according to claim **16**, wherein said inner side portion of said second support member has a longitudinal extension projecting towards said first support member adjacent said guide bar, said extension and guide bar having a window therethrough, and said ejector means comprises an ejector plate pivotally mounted in said window for rotation about a vertical axis adjacent one side thereof, an arm projecting right angularly from said plate adjacent the pivot axis thereof inwardly of said conveyor, a solenoid mounted on the inner face of said extension adjacent said window, a plunger operatively associated with said solenoid and pivotally connected to said arm, said plunger movable in a direction to pivot said plate outwardly of said conveyor in response to energization of said solenoid, and means spring loading said plunger in a direction to normally maintain said plate in said window, said output of said control circuit coupled in energizing relation to said solenoid.

18. A system for grading objects moving longitudinally along a conveyor comprising first and second photoelectric means disposed at longitudinally spaced positions of said conveyor for generating electric pulses in response to objects to be graded passing the positions thereof, means for guiding said objects past said first and second photoelectric means with the lengthwise dimension of each object disposed longitudinally, and-gate means having inputs and an output, said gate means adapted to generate a pulse at said output in response to a coincidence of pulses at said inputs, means coupling said first and second photoelectric means to said inputs of said gate means including discriminating means for closing said gate means in response to a first pulse sequence of two consecutive pulses from said first photoelectric means and a subsequent pulse from said second photoelectric means having a time coincidence with a portion of the second of the pulses from said first photoelectric means and opening said gate means in response to a second pulse sequence of a pulse from said second photoelectric means following a pulse from said first photoelectric means not immediately preceded by a second pulse from said first photoelectric means said pulse from said second photoelectric means having a time coincidence with a portion of the pulse from said first photoelectric means, and ejector means coupled to the output of said gate means for ejecting objects passing said photoelectric means in response to output pulses from said gate means.

19. A system according to claim **18**, further defined by said discriminating means comprising time delay means coupling said first photoelectric means to one input of said gate means and delaying the leading edge of a pulse from said first photoelectric means for a time slightly less than the time required for one of said objects to pass between said first and second photoelectric means, and differentiating means coupling said second photoelectric means to a second input of said gate means.

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