ABSTRACT: Articles such as crops are sized while being moved past a photoelectric sizing station by a continuously moving conveyor. A set of spaced sizing cells at the sizing station gauge the dimensions of the article to emit a signal if the size and shape of the article is within a predetermined and adjustable range. Generation of the signal operates an ejection device to remove the article from the conveyor.
3,603,457

ELECTRONIC PRODUCT-SIZING APPARATUS

This invention relates to a photoelectric sizing device particularly useful for products such as potatoes, cucumbers, etc.

Dimensional sizing apparatus of the photoelectric type arranged to gauge the size and shape of an object as it is carried past a sizing station, is well known. However, the need exists for a relatively simple photoelectric sizing apparatus capable of being adjusted for different products, conveyor speeds and in accordance with different sizing tolerances.

In accordance with the present invention, the size and shape of products continuously conveyed past a sizing station are gauged by sizing cells and a source of light projecting a shadow onto a surface mounting the faces of the sizing cells. A set of inside "accept" cells when covered by the shadow of a product at the sizing station during an operational interval, causes illumination of an accept signal if any one of a corresponding set of outside "reject" cells are not covered by the shadow during the same interval of time. The outside set of reject cells may be adjusted relative to the inside set of cells in accordance with a desired sizing tolerance. Through adjustable time delaying devices, the signal generating circuit associated with the sizing cells may accommodate different photoelectric cell sizes and conveyor speeds. The signal generated when an article of predetermined size and shape is gauged, operates an ejection device to remove the product from the conveyor.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described, and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIG. 1 is a schematic front elevational view of the product sizing arrangement associated with the present invention.

FIG. 2 is a top plan view of the arrangement shown in FIG. 1.

FIG. 3 is an electrical circuit diagram associated with the product sizing apparatus of the present invention.

FIG. 4 is a graphical diagram illustrating the operational sequence associated with the product sizing apparatus.

Referring now to the drawings in detail, FIG. 1 illustrates a continuously moving conveyor 10 adapted to carry products or articles such as potatoes 12 past one or more sizing stations located close laterally spaced relation to the conveyor. A sizing head 14 is associated with each sizing station which also has associated therewith a source of radiation such as a tungsten filament lamp 16 disposed on one lateral side of the conveyor opposite the side of the conveyor on which the sizing head 14 is located. The light from the lamp 16 impinges on the sensing surface 18 of the sizing head which is disposed in a plane parallel to the direction of travel of the conveyor.

It will be apparent from FIGS. 1 and 2, that when a product 12 is at the sizing station, the lamp 16 will project a shadow of the product onto the sizing surface 18. The sizing head mounted a plurality of photoelectric sizing cells, the sensing faces of which are disposed in the plane of the surface 18. The sizing cells include a set of inside accept cells consisting of horizontally spaced cells 20 and 22 for gauging a length dimension parallel to the direction of travel of the conveyor and a cell 24 vertically spaced above the conveyor to gauge the height dimension of the product. If the product is within a predetermined size and shape, the inside cells 20, 22 and 24 will during a short interval of time be covered by the shadow of the product or disposed within its shadow outline 26 as shown in FIG. 1. Also, during the same interval of time the shadow of the product of predetermined size and shape does not cover any one of a set of outside reject cells 28, 30 and 32 adjustably positioned relative to corresponding accept cells 20, 22 and 24.

By adjusting the position of the outside reject cells, different sizing tolerances may be accommodated. Also, the spacing between the inside cells may be varied together with the outside reject cells in the respective sizing heads, if more than one is utilized, in order to remove products within different size ranges at each of the sizing stations. The products are removed from the conveyor by any suitable ejection device having an electromagnetically operated solenoid element 34 as shown in FIG. 3. The ejection solenoid 34 forms part of a control circuit housed within each of the sizing heads. By means of the circuit, a signal is generated to pulse the solenoid 34 whenever the shadow of a product at the sizing station covers the inside set of the cells 20, 22 and 24 but does not cover the outside set of reject cells 28, 30 and 32. Dependent upon the size and shape of the product and the speed of the conveyor, the inside set of cells will be covered by the shadow of the product at the sizing station for a predetermined exposure period 36 as graphically depicted in FIG. 4. After a first time delay period 42, a pulse 38 is generated having a predetermined pulse duration 40 terminating after the elapse of the exposure period 36. A second pulse 44 is generated at the end of a second time delay period at which time the pulse 38 is terminated and an ejection pulse 46 initiated. An operational cycle is completed at the end of the ejection pulse 46 automatically repositioning the circuit for another operational sequence. It will therefore be apparent, that the ejection solenoid 34 is pulsed after the product is sized as reflected by a signal pulse 38 of a sufficiently long duration to ensure proper spacing between cycles in order to avoid interference.

The circuit shown in FIG. 3, includes a DC source of voltage 48 varying within plus or minus 1 percent from a 21.5 VDC value. The positive terminal of the source 48 is connected by a fuse 50 to the contact 52 of a double pole, single throw power switch 54 having a second contact 56 connected by fused 58 to an AC source of voltage at 60. While the AC source of voltage 60 furnishes the power for the ejection solenoid 34, the DC source of voltage 48 supplies control voltage for generating a signal pulse under control of the photosensitive sizing cells as aforementioned.

The negative terminal of the DC voltage source 48 is connected through a current-limiting resistor 62 to one terminal of each of the cells 20, 22 and 24 and to the "off" contact 64 of a mode selector switch 66, having an "on" contact 68 engaged with the switch in the position illustrated in FIG. 3. In the "on" position illustrated, the mode selector switch 66 connects the cell 24 to the control electrode or base of an NPN-type transistor 70. The switch 66 in the "on" position connects cells 23 and 24 to the base of transistor 70 and is shunted by a load resistor 72 connected to the base. Connector assembly 74 connects the cell 22 to the switch 66 and also directly connects the cell 20 to the base bypassing the switch. Thus all three cells 20, 22 and 24 are connected in parallel to the base. When the mode selector switch 66 is in the "off" position engaging contact 64, the negative terminal of the DC source 48 is connected in series with the current-limiting resistor 62 and the photocells 22 and 24 to the base of the transistor shunted by the photocell 20. The "off" position of the switch 66 is utilized in order to regulate the circuit as will be explained hereinafter.

The inside photocells 29, 22 and 24 control the negative reverse bias applied by the DC source 48 to the base of transistor 70 to normally prevent current flow between the emitter and collector connected in series with the outside reject photocells 28, 30 and 32. The series connected reject cells are connected to a source of positive potential from which a forward bias is applied to the base through adjustable resistor 76 in series with a current-limiting resistor 78. The forward bias is supplied from the positive terminal of DC source 48 through power switch 54 and relay switch 80. When reverse bias is removed from the base, transistor 70 is rendered conductive to conduct current and complete a relay energizing circuit for the relay coil 86 thereby energized to close the normally open relay switch 82.

In the normal position of the relay switch 80, the positive terminal of the DC power source is connected through the series connected cells 28, 30 and 32, the transistor 70 and re-
sistor 84 to one terminal of the relay coil 86, the other termi-
nal being connected to the negative terminal of the power
source. While the phototransistors 28, 30 and 32 are ex-
posed to light from the lamp 16 as to maintain a low resistance value,
and reverse bias is removed from the base of the transistor 70
by an increase in the resistance values of the phototransistors 20, 22
and 24, an energizing current pulse will be conducted through
the relay coil 86 to close the normally opened relay switch 82.
The terminals of the relay coil 86 are, however, shutted by a
time delay capacitor 88 in parallel with resistor 90 and ad-
justable resistor 92. Resistor 92 is adjustable to vary the dura-
tion of the first time delay 42 before the current conducted by
transistor 70 causes energization of the relay coil 86. Thus, the
duration of the current pulse or conductive period of tran-
istor 70 must exceed the first time delay period 42. The
speed of the products, their sizes and irregular shapes, causes
the pulse to vary in strength and duration. The minimum pulse
strength for energizing relay coil 86 is established by the re-
sistor 90, while a minimum pulse duration is established by the
value of capacitor 88 and the resistor 84.

Upon energization of the relay coil 86 closing the normally
open relay switch 82, the positive terminal of the DC voltage
source is connected through resistor 94 to one terminal of a
second relay coil 96, the other terminal of which is connected to
the negative terminal of the voltage source. The terminals of
the relay coil 96 are shutted by a second time delay capaci-
tor 98 in parallel with resistor 100 and adjustable resistor 102.
Thus, upon closing of the normally open relay switch 82, an
energizing circuit is completed for the relay coil 96 to cause
energization thereof after a second time delay determined by
the capacitor 98 and the setting of the adjustable resistor 102.
The resistor 100 limits the current flow to protect relay coil 86
from high current damage.

Energization of the relay coil 96 after the second time delay,
actuates its relay switch 80 to open the energizing circuit for the
relay coil 86. When actuated, the relay switch 80 also con-
nects the positive terminal of the DC voltage source through a
voltage reducing resistor 104 to one terminal of a voltage
isolating relay coil 106, the other terminal of which is con-
nected to the negative terminal of the DC voltage source. The
terminals of the relay coil 106 are shutted by a transient volt-
age-suppressing capacitor 108, so as to consequently be apparent
that energization of the relay coil 96 occurs after a second
delay of sufficient duration to insure that the product has
cleared the sizing station as diagrammed in Fig. 4 showing the
beginning of pulse 44 spaced from the exposure period 36.
Deenergization of the relay coil 86 at that time deactivates the
transistor 70 and relay 80 so as to allow completion of the cycle
and permit the components to stabilize. Also, the relay coil
106 is energized to initiate the ejection period.

Upon energization of the voltage-isolating relay coil 106,
the normally opened relay switch 110 associated therewith is
closed to supply triggering current from the AC voltage source
60 through voltage reducing resistors 112 and 114 to the con-
trol electrode of a triac 116. Energizing current will then be trans-
mitted by the triac from the voltage source 60 to the ejec-
tor solenoid 34. Transient line voltage protection is provided
for the triac 116 by resistor 118 and capacitor 120 connected in
series with each other across the triac input and output
terminals.

It will be appreciated that the foregoing operation occurs
only if the power switch 54 is closed connecting the neon lamp
122 across the terminals of the AC voltage source 60 so as to
indicate an illumination property that is available. Another neon
lamp 124 is connected across the terminals of the executor sole-
loid 34 and will flash each time the circuit cycles or will stay
on if the winding of the solenoid 34 is open. Thus, the lamp
124 provides an indication that a product is being sized. The
executor control air valve, nozzle or other electromechanical means associated with the
executor mechanism for removing products from the conveyor.

With the mode selector switch 66 in the "on" position en-
gaging contact 64, only the cell 20 will be effective to hold a
reverse bias on the base of transistor 70 until it is covered by
the shadow of the product initiating an operational cycle.
Through adjustable resistors 92 and 102, the duration of the
cycle from start to the beginning of the ejection period may be
adjusted. It should be appreciated that for this adjustment, the
photocell 20 is on the downstream side of the sizing head rela-
tive to the direction of travel of the conveyor. It will also be
apparent that the cycle begins only if the reject cells 28, 30
and 32 are not covered by the product shadow when the
photocell 20 becomes covered by the shadow. When the mode
switch 66 is displaced to the "on" position engaging contact
68, all of the inside photocells 20, 22 and 24 must be covered
by the shadow to enable initiation of a cycle, to completely
remove the negative reverse bias from the base of the trans-
istor 70 which then becomes conductive to begin a signal
pulse in view of the forward bias applied thereto through relay
switch 80 and resistors 76 and 78. The relay coils 86 and 96
are then sequentially energized as aforementioned before the
ejection period is begun by energization of the relay coil 106
supplying triggering voltage to the triac 116 operating as a
power switch to conduct current to the executor solenoid 34.
The relay energizing pulse 44 for the relay coil 96 is of short
duration sufficient to condition the circuit for automatic reset
at the end of the ejection period or executor solenoid pulse 46.
Operation of the circuit may be monitored by the neon lamps
122 and 124, lamp 124 indicating when the circuit is under-
going an operational cycle.

The foregoing is considered as illustrative only of the prin-
ciples of the invention. Further, since numerous modifications
and changes will readily occur to those skilled in the art, it is
not desired to limit the invention to the exact construction and
operation shown and described, and accordingly all suitable
modifications and equivalents may be resorted to, falling
within the scope of the invention.

What is claimed as new is as follows:

1. In combination with a conveyor moving articles past at
least one sizing station, apparatus for removing articles of
a predetermined size and shape from the conveyor including
means for sensing the presence of an article at the sizing
station, pulse generating means connected to the sensing
means for producing a signal pulse of a duration dependent upon
the size, shape and speed of the article approaching and departing
from the sizing station, means for terminating said signal pulse
following departure of the article from the sizing station, ejec-
tor means rendered operative to displace the article from the
conveyor during an ejection period of predetermined dura-
tion, and means responsive to termination of said signal pulse
for rendering the executor means operative.

2. The combination of claim 1 wherein said sensing means
includes a first set of spaced photosensitive devices having
sensing faces aligned in a common plane parallel to the
direction of movement of the article, disabling means con-
necting said first set of photosensitive devices to the pulse-
generating means for normally preventing development of the
signal pulse, a second set of spaced photosensitive devices
having sensing faces aligned in said common plane, and means
connecting the second set of photosensitive devices to the
pulse-generating means for limiting the strength of the signal
pulse.

3. The combination of claim 2 wherein the sensing means
further includes a source of radiation adapted to be blocked
by the article and detected by the photosensitive devices,
and means for directing the radiation from said source onto
the common plane intersecting the article while at the sizing
station, whereby only articles at the sizing station having said
predetermined size and shape prevent radiation from imping-
ning on the first set of photosensitive devices.

4. The combination of claim 3 wherein said second set of
photosensitive devices are adjustably positioned relative to
the first set of photosensitive devices.

5. The combination of claim 4 wherein said pulse generating
means includes a source of control voltage, a current control
device having power electrodes connected in series with the
5. The combination of claim 5 wherein said signal pulse terminating means includes relay means for disconnecting the source from the power electrodes when energized, and time delay means for energizing the relay means in delayed response to conduction of current through the current control device.

7. The combination of claim 6 including indicating means connected to the ejector means and rendered operative during the entire operational cycle.

8. The combination of claim 1 wherein said sensing means includes a first group of cells from which radiation is blocked, during an operational interval, by articles corresponding to shadows of predetermined size and shape and a second group of cells exposed to radiation during said operational interval.

9. In combination with a conveyor continuously moving articles along a path of travel past at least one sizing station, apparatus for gauging the size and shape of said articles at the sizing station including a source of radiation laterally spaced from the conveyor at the sizing station, a radiation receiving surface spaced from said path of travel onto which a shadow is projected by the source of radiation during movement of each of said articles at the sizing station, a plurality of accept cells having radiation-sensing faces in the plane of said receiving surface, a plurality of reject cells closely spaced from said accept cells, means responsive to covering of all of the accept cells by the shadows of said articles during operational intervals at the sizing station for generating signals, means responsive to covering of at least one of the reject cells by said shadows during said operational intervals for preventing operation of the signal-generating means, delay means for delaying operation of the signal-generating means, delay means for delaying operation of the signal generating means until each article passes the sizing station, and delay means for delaying operation of the signal generating means until a preceding one of the articles passes the sizing station.