ARTICLE COUNTING MACHINE WITH MEANS FOR PREVENTING MISCOUNT OF OVERLAPPING AND IRREGULARLY SHAPED ARTICLES

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ABSTRACT OF THE DISCLOSURE

An article counting machine embodying a photocell activated counter adapted to accurately count articles which are irregularly shaped, include holes, or tend to overlap in passing through the photocell station. Two complementary article sensors each consisting of a light source and a photocell are disposed and connected so as to generate a signal whose leading edge occurs when either light beam is interrupted by an article to be counted and whose trailing edge occurs when both beams are no longer interrupted. The control circuit also generates article count pulses having a width corresponding to the average transit time of articles past the sensors, the pulses being generated as a continuous train so long as one of the photocells is deprived of light.

This invention relates to article-counting machines and more particularly to an improved article-counting system.

The primary object of the present invention is to improve on article-counting apparatus of the kind described and claimed in U.S. Patent Re. 25,013, issued July 25, 1961, to E. G. Cleveland et al. for “Apparatus for Counting and Packaging Articles.” Such apparatus involves a light beam positioned to be intercepted by articles moving in single file along a predetermined path, a photocell positioned to receive the beam when it is not interrupted by a moving article, and an electronic counter for counting the number of times the photocell is deprived of the light beam and actuating associated mechanism each time a predetermined count is reached. Experience has demonstrated that such prior article-counting systems exhibit accuracy of a high order in counting solid symmetrically shaped articles but undergo a drop in performance when handling articles which are irregularly shaped, include holes, or tend to overlap.

Accordingly, a more specific object of the present invention is to provide an improved article-counting system which is consistent in accuracy regardless of the shape or size of the articles being counted.

Another specific object of the invention is to provide an improved article-counting system whose operation is readily adjusted to count articles of different sizes with equal accuracy.

Still another object of the present invention is to provide an electronic article-counting system having simple manually adjustable means for modifying counter operation according to the size and shape of parts to be counted.

Other objects and many of the attendant advantages of the present invention will become more readily apparent when reference is had to the following detailed specification which is to be considered together with the accompanying drawings wherein:

FIGS. 1A and 1B illustrate two different positions of a typical article handled by apparatus embodying the present invention;

FIG. 2 presents a plurality of wave forms illustrative of the counting problem presented by the article of FIGS. 1A and 1B and the manner in which the problem is solved by the present invention;

FIG. 3 schematically illustrates an article-counting apparatus embodying the present invention; and

FIG. 4 illustrates an electronic counting system constructed according to the present invention.

Turning first to FIGS. 1A and 1B, there are presented two views of a rectangular nut 2 having a circular aperture 4. Assume that this article is to be moved by a conveyor 6 in the direction shown by the arrow through a thin horizontal light beam (represented in cross-section by the circle 8). Assume also that the beam is directed at a photocell (not shown). It is believed to be apparent that if the nut is lying flat as in FIG. 1A, the light beam would be interrupted for the full time that it takes the nut to move through it. Hence the photocell would sense a single beam interruption and would produce a single output pulse. On the other hand, if the nut is standing on edge as in FIG. 1B, the light beam will not be blocked off completely for the full transit time of the nut, but will be sensed by the photocell during the time that the aperture 4 is passing through it. Hence the photocell output would be two pulses instead of one in the manner shown by waveform A in FIG. 2. This tendency to yield two pulses instead of one can be reduced by employing two electric eye systems displaced 90 degrees from each other. The two electric eye systems complement each other and by appropriate circuitry they will produce a single pulse for the article 2, regardless of whether it is on edge or flat. Such a pulse is represented by waveform B of FIG. 2; the leading edge of the pulse is generated when any one beam is first blocked off and the trailing edge occurs when both beams are no longer interrupted. Hence the width of the pulse represented by waveform B corresponds to the transit time of the article in passing through the electric eye zone. However, using two complementary electric eye systems in this manner makes it possible to have an erroneous count to occur when two articles overlap one another at adjacent ends. Waveform C illustrates this problem. Since the trailing edge of the signal derived from the dual electric eye system does not occur until both beams are restored, the second overlapping article will prevent the trailing edge from occurring when the first article has left the electric eye zone and instead will cause the pulse width to be extended by an amount corresponding to the additional time required for the second article to pass through the two beams. The extension of the pulse width caused by the trailing overlapping article is indicated by the broken line extension of waveform C.

The present invention overcomes the problem represented by waveform C by generating a pulse corresponding to waveform B and utilizing means for repeating that pulse if at the end thereof a particular signal derived from the electric eye system has not expired or been terminated. In essence, the present invention utilizes a system that generates a continuous train of pulses D so long as a light beam is interrupted, with the width of each of the pulses D corresponding to the average time that the photocell(s) are deprived of light by articles moving through the electric eye system.

Referring now to FIG. 3, the illustrated apparatus comprises a conventional bowl feeder 12 adapted to advance articles to a discharge chute 14 in response to the influence of a vibrator (not shown). The chute is adapted to de-
liver articles onto a moving endless conveyor 16. Associated with the upper run of the endless conveyor are two guide members 18 and 20 which co-operate to align articles on the conveyor so that they will pass in single file to an electric eye system identified generally at 22. The article to be scanned in the electric eye system is also discharged by the endless conveyor 16 into a collecting hopper 24. The collecting hopper is provided with a butterfly valve 26 which is operated by a rotary solenoid system 28. The construction of the hopper is such that in one position of the butterfly valve, e.g., the inclined position shown in FIG. 1, the articles are prevented from passing out of the open bottom end of the hopper by the butterfly valve. On actuation of the rotary solenoid system 28, the butterfly valve rotates to an almost vertical position so as to permit gravity discharge of articles from hopper 24 into a delivery chute 30. The latter may direct the articles to various types of apparatus. In the illustrated embodiment delivery chute 30 functions to direct articles from the hopper 24 to a packaging machine wherein a continuously moving folded web 32 is transformed into a series of packages 34 each containing a group of articles delivered by chute 30. Various forms of sealing mechanisms 36 may be utilized to transform the folded moving web 32 into packages. In the illustrated embodiment, the sealing mechanism comprises a pair of L shaped bars 36 disposed on opposite sides of the moving web. These bars are moved (by means not shown) into and out of engagement with the web, forming a transverse seal 38 and a longitudinal seal 40 each time they engage the web.

The electric eye system 22 comprises at least one and preferably two photocells 42A and 42B disposed at right angles and positioned to receive beams generated by light sources 44A and 44B respectively. The electric eye system 22 and the rotary solenoid system 28 are connected by suitable cables to an electronic counter 48. Each time that light beams are broken by a part dropping from the moving belt, a count is registered by the counter. The counter can be set by appropriate control dials 50 to emit an output control pulse to the rotary solenoid system 28 when a predetermined number of counts have been registered. The pulse transmitted to the rotary solenoid 28 is of sufficient amplitude and duration to cause the butterfly valve to move to its article discharging position and maintain it there long enough to allow discharge of all of the articles held in the hopper. The butterfly valve returns to its original position in time to catch the next article discharged from the conveyor 30.

To describe the apparatus of FIG. 3 is conventional and, except for the use of dual light beams, is substantially similar to the apparatus of said U.S. Patent Re. 25,013. However, it also differs materially from the patented apparatus in that the counter 48 includes the system of FIG. 4 which provides a mode of operation consistent with waveform D.

FIG. 4 illustrates a system adapted to produce the result represented by waveform D. Turning now to FIG. 4, the illustrated system comprises eight transistors Q1, Q2, Q3, Q4, Q5, Q6, Q7, and Q8. The collector of transistor Q1 is connected to a positive voltage source V1. The base of Q1 is connected to the same voltage source via a resistor 52. The base is also connected to ground via two series connected photodiodes 54 and 56. These photodiodes correspond to the photocells 42A and 42B. The emitter of transistor Q1 is connected via two series connected diodes 58 and 60 and a resistor 62 to ground. The junction of diode 58 and resistor 62 is connected to the junction of transistor Q2. The emitter of transistor Q2 is connected to the junction of diode 60 and resistor 62 by way of a diode 64. The junction of diode 60 and resistor 62 is also connected to the positive voltage source V1 by way of a suitable resistor 66. The base of transistor Q2 is connected to a negative voltage source V2 by way of a resistor 68. The collector of Q2 is connected to the same negative voltage source by way of another resistor 70. The collector 72 of transistor Q2 is also connected to the base of transistor Q3 by way of a resistor 74. The base of transistor Q3 is also connected to the positive voltage source V1 by way of a resistor 76. The emitter of the same transistor is connected to ground and its collector is connected to the negative voltage source V2 by way of a resistor 78. The collector of transistor Q3 also is connected to two different positive voltage sources 81 and 82. Switch 81 has two stationary contacts 78 and 80 and a movable contact 82. The corresponding contacts of switch 82 are identified as 84, 86, and 88 respectively. In one case the collector of Q3 is connected by a resistor 90 to terminal 78 of switch 81; in the other case it is connected to terminal 86 of switch 82 via a resistor 92. The movable contacts of the two switches are ganged together.

The junction of resistor 90 and switch contact 78 is connected by way of a resistor 94 to the positive voltage source V1. The movable contact 82 of switch 81 is connected to the base of transistor Q4, with the emitter of the latter connected to ground. The base and collector of transistor Q4 are connected by way of resistors 98 and 100 respectively to the negative voltage source V2. The collector of transistor Q4 is connected to a pre-settable digital counter 102 which drives a relay 103 and also a relay 104 that controls operation of the rotary solenoid system 28. The counter and indicator units are both conventional and form part of the electronic counter 48 of FIG. 3. The counter is of the type that emits an output and restores itself to zero when a predetermined limit is reached.

The movable contact 88 of switch 82 is connected to the base of transistor Q5. The collector of transistor Q5 is connected by way of a resistor 106 to positive voltage source V1. The collector of Q5 is also connected by way of a capacitor 108 and a parallel resistor 110 to the base of transistor Q6. The base of transistor Q6 is connected by way of a resistor 112 to negative voltage source V2. The base of Q5 is connected by a resistor 114 to negative voltage source V2. The emitters of both transistors Q5 and Q6 are coupled together and connected by way of a pair of series resistors 116 and 118 to negative voltage source V2. The collector of transistor Q6 is connected to positive voltage source V1 via a resistor 120; it also is connected (a) directly to contact 80 of switch 81 and (b) to the base of transistor Q5 by way of a capacitor 122 and a parallel resistor 124. Capacitor 122 and resistor 124 have the same values as capacitor 108 and resistor 110 respectively.

Resistor 120 is equal in value to resistors 116 and 118. Transistor Q7 has its collector connected to the collector of Q6 by way of a diode 128 and also to negative voltage source V2 by way of a capacitor 130. The emitter of transistor Q7 is connected by a fixed resistor 132 and a variable resistor 134 to positive voltage source V1. Its base electrode is connected to the junction of two resistors 136 and 138. The opposite end of resistor 136 is connected to ground while the opposite end of resistor 138 is connected by way of diode 140 to positive voltage source V1. A fixed resistor 142 is connected across resistor 138. Due to the current path afforded by Q7, the symmetry which includes an inductor and Q6 is unbalanced and, in the absence of an input signal at the base of Q5, the latter is off and Q6 is normally conducting.

The junction of capacitor 130 and the collector of transistor Q7 is connected to the emitter of transistor Q8. The latter is of the unijunction type, having one base electrode connected to the junction of resistors 116 and 118, while the other base electrode is connected by a resistor 134 to positive voltage source V1.

The foregoing electronic system comprises several discrete stages. The transistors Q1 and Q2 and the related circuitry form a detector stage; the transistor Q3 and related circuitry form a pulse shaper; the transistors Q5 and Q6 form together with transistor Q7 a gated oscillator that includes transistor Q8 as a reset pulse generator; the
transistor Q4 constitutes an output amplifier stage. The switches S1 and S2 make it possible to provide the output of the pulse shaper Q3 directly to the amplifier Q4 or to the gated oscillator, whereupon the output of the gated oscillator in turn is fed back to the amplifier Q4 via the switch Q6.

Operation of the system when the switches S1 and S2 are in the position shown in FIG. 4 is straightforward. So long as the light beams impinge on photodiodes S4 and S6, they conduct current to ground and thereby maintain transistor Q1 in a non-conducting condition. However, when the photodiodes are deprived of light, the base of transistor Q4 is no longer coupled directly to ground and will rise to a voltage determined by the magnitude of resistor S2. The base voltage will rise positively and in so doing will cause transistor Q1 to conduct. It is to be noted that the input signal voltage to Q1 produced by momentary interruption of a light beam by a moving article, is substantially rectangular in shape. The diodes S8 and 60 serve clamping and limiting functions while the diode D4 is essential for proper biasing of transistor Q2. Accordingly the resulting positive voltage pulse developed across resistor S2 also is substantially rectangular and has a width proportional to the time that the light beam is interrupted. This positive pulse causes Q2 to produce a negative voltage pulse at the base of transistor Q3. When this occurs, a positive rectangular voltage change occurs at the collector of Q3. The capacitor C3 and transistor Q4 as shown in FIG. 3 is applied by way of contact 78 of switch S1 to the base of transistor Q4, causing the latter to generate a negative pulse as an input to the counter unit 102. The width of the input pulse to the counter unit is determined by the time that transistor Q1 is on, and this in turn depends upon the length of time that one of the light beams is interrupted by a passing article. While not shown, it is to be understood that the input stage of the counter is adapted to respond to the positive going excursion of the pulse derived from the collector of transistor Q4 (which corresponds to the restoration of the light beam) and to register a count each time such an excursion occurs.

The foregoing mode of operation is altered when the switches S1 and S2 are reversed so that their movable contacts close on contacts 80 and 86 respectively. With the switches reversed, the pulse shaping transistor Q3 and transistor Q4. Thus the rectangular positive pulse that appears at the collector of transistor Q3 when an article interrupts the light beam, is applied to the base of transistor Q5. This positive input causes the collector of transistor Q5 to become negative, thereby producing a negative pulse at the base of transistor Q6. When this occurs, transistor Q6 flips off while the transistor Q5 flips on. This reversed state of operation will exist for a predetermined time and then Q5 and Q6 will be restored to their original states. If at the time they are restored to their original states the input signal still exists, they will immediately flip again to their previous reversed state for the same predetermined time. Thereafter they will be restored to their original states where the reversal may or may not recur, depending upon the presence or absence of the input signal. The exact time that the flip flop is in the "on" condition depends upon the RC circuit provided by capacitor 130 and resistors 134 and 136 operating through transistor Q7. Capacitor 130 charges through transistor Q7 when transistor Q6 is non-conducting, i.e., when the collector of transistor Q6 is at a high voltage. When capacitor 130 has charged to a predetermined level, the unjunction transistor Q8 fires and produces a sharp reset pulse, i.e., a spike, which is applied to the emitters of transistors Q5 and Q6 via resistor 116. The output spike from transistor Q8 is much larger in amplitude than the input signal pulses received by Q5; hence it will override any such input signal and cause both transistors to return to their original states. However, if when the reset pulse has passed, the base of transistor Q5 still has an input signal voltage applied to it, the flip flop will immediately reverse itself again. The flip flop will continue to undergo resetting and reversal so long as an input pulse is applied to the base of transistor Q5. After the input signal has expired, it will stay reset.

Changing the setting of resistor 136 alters the charging time of capacitor 130. The setting of resistor 136 varies with the length of the pieces or parts to be processed by the machine. The longer the length of the pieces to be cut, the more of resistance of resistor 136 must be used. Conversely, the shorter the piece the smaller the effective value of resistor 136 required to be coupled in series with capacitor 130. In practice the variable resistor 136 is a multturn potentiometer operated by a dial 150 provided on the front panel of the electronic counter 48 (FIG. 3). The dial 150 is calibrated in inches and fractional parts thereof, e.g., tenths, hundredths, etc. so as to facilitate adjustment by the machine operator of the charging time of capacitor 130 to correspond to the length of the articles to be counted.

The number of reversals of the flip flop is sensed by counter unit 102. This is achieved by the coupling effected between the collector of transistor Q6 and the base of transistor Q4 by switch S1. A test jack 152 (FIG. 4) permits sampling the output of the oscillator so as to test "on" time of transistor Q6 as determined by the RC charging circuit that includes transistor Q4. In addition to the improvement in results which it provides, a particular advantage of the system of FIG. 4 is that it can be incorporated with minimum cost in existing article-counting apparatus, as for example, the apparatus described and claimed in reissue Patent No. Req. 25,013. If desired, only one light beam and photocell may be used in place of the dual system embodied in the illustrated apparatus. Because the system is essentially an information rather than a power handling system, it lends itself well to printed circuit board design; this means not only economy of space but also ease of maintenance. A printed circuit board can be removed and replaced by another board containing the identical circuitry, within a few minutes time.

A further advantage of the system of FIG. 4 is that the counter and indicator units may be of conventional design. Thus, for example, the indicator unit may be of the type employing NiXie® tubes. By using an adjustable counter, the relay 104 will be actuated each time the count reaches a predetermined amount, and will restore itself after a predetermined time interval so as to cause the solenoid system 28 to operate in the manner previously described. It is also contemplated that the hopper 24 may be designed so that its butterfly valve does not stop or interrupt movement of articles through the hopper but simply diverts flow.

Of course, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts specifically described or illustrated, and that within the scope of the appended claims, it may be practiced otherwise than as specifically described or illustrated.

I claim:

1. An article counting system comprising means for transporting articles of a given length in serial fashion past a predetermined point, means for directing a beam of radiant energy through said point so as to be interruptable by articles passing through said point, means for producing an output signal commencing with interruption of said beam and having a period substantially equal to the time that said beam remains interrupted, means responsive to said output signal for producing a pulse train commencing substantially simultaneously with said output signal wherein each pulse is of fixed duration substantially equal to the average transit time of an article through the beam, said pulse train terminating re-
sponsively to the termination of said output signal where- 
by when a plurality of said articles continuously in-
rupts said beam a pulse train is produced having a num-
ber of pulses equal to the number of beam-interrupting 
articles, and means for counting said pulses.

2. An article counting system as defined by claim 1 
including means for modifying the duration of said 
pulses so that said system may be used to count ar-
ticles having a length different than said given length.

3. An article counting system as defined by claim 2 
wherein said last-mentioned means is calibrated in units 
of length of articles to be counted.

4. A system counting system comprising means for 
transporting articles of a given length in serial fashion 
past a predetermined point, first means for directing a 
beam of radiant energy so as to be interrupted by articles 
passing said point, second means for sensing when said 
beam is interrupted by an article passing said point, 
third means responsive to said sensing means for produc-
ing an output signal each time said beam is interrupted 
with said output signal having a time duration propor-
tional to the time of interruption of said beam, fourth means re-
sponsive to said output signal for generating pulses each 
equivalent in pulse width to the average transit time of 
single article through said beam, said fourth means 
being adapted to terminate generation of said pulses in 
response to termination of said output signal, and fifth 
means for counting said pulses as they occur.

5. An articles counting system as defined by claim 4 
wherein said fourth means includes means for varying 
the width of said pulses so that said system may be used 
to count articles having a length different than said given 
length.

6. An article counting system as defined by claim 4 
including sixth means for directing a second beam of 
radiant energy so as to be interrupted by articles passing 
said point, and seventh means for sensing when said sec-
ond beam is interrupted by an article passing said point, 
and further wherein said third means is responsive to said 
seventh means as well as said second means so that said 
output signal is produced upon interruption of either beam.

7. An article counting system as defined by claim 6 
wherein said first and sixth means direct beams of light 
and said second and seventh means comprise first and 
second photodiodes connected in series and, further 
wherein said third means is connected to said photodiodes 
so as to produce an output signal whenever one of said 
photodiodes is deprived of light as a result of interrup-
tion of one of said beams.

8. An article counting system as defined by claim 7 
wherein said third means comprises a multi-electrode 
variable impedance device having one of its electrodes 
connected in series with said photodiodes and means 
biassing said device so that it is in a relatively low current 
conducting state so long as said light beams impinge on 
both of said photodiodes and assumes a relatively high 
current conducting state when at least one of said light 
beams is prevented from impinging on at least one of said 
photodiodes as a result of interruption by one of said 
articles.

9. An article counting system as defined by claim 8 
wherein said device is a transistor having a base electrode 
connected in series with said photodiodes and further 
wherein said output signal is produced in response to a 
change in state through said transistor.

10. An article counting system as defined by claim 4 
further including means for collecting articles downstream 
of said point, and means for releasing said articles when 
the number of pulses counted has reached a predeter-
mined value.

11. An article counting system as defined by claim 4 
wherein said counting means comprises a counter that 
resets to zero when the number of articles counted reaches 
a predetermined value.

12. An article counting system comprising means for 
transporting articles in serial fashion through a prede-
termined discharge point at a substantially constant speed, 
means for directing a beam of radiant energy through 
said point, means for sensing said beam of radiant energy, 
means connected to said sensing means for producing an 
output signal of predetermined polarity whenever and so 
long as said beam is interrupted, first and second variable 
impedance current conducting devices connected for flip-
flop operation, means for applying said output signal to 
said first device so as to cause it to undergo a first change 
in conduction, means for causing said second device to 
undergo a second opposite change in conduction at the 
same time as said first device undergoes said first change 
in conduction, means responsive to said second opposite 
change in conduction for generating and applying to at 
least one of said devices after a time interval equal ap-
proximately to the time that said beam is interrupted by 
an article passing through said discharge point at said 
speed a sharp reset signal pulse having an amplitude su-
ficient to cause said devices to change back to their 
original conduction states notwithstanding continued ap-
lication of said output signal to said first device, said 
devices being adapted to remain in said original conduc-
tion states on expiration of said reset signal pulse if said 
output signal has previously terminated and, means con-
ected to one of said devices for registering a count rep-
resentative of a single article each time said one device is 
restored to its original conduction state.

13. An article counting system as defined by claim 12 
including additional means for directing a second beam of 
radiant energy through said point at an angle to said 
first beam and additional means for sensing said second 
beam of radiant energy, further wherein said means for 
producing said output signal is responsively connected to 
said additional sensing means so that said output signal 
is produced whenever and for so long as at least one beam 
is interrupted.

14. An article counting system comprising means for 
delivering articles of given length in serial fashion through 
a predetermined location at a given speed, means for 
establishing a field of radiant energy directed so that it 
is attenuated by articles passing through said location, 
means for sensing attenuation of said field and produc-
ing a substantially rectangular signal of predetermined 
polarity with a period corresponding to the time that 
said field is attenuated, pulse generating means re-
sponsive to an input signal for producing a pulse train com-
mencing substantially simultaneously with said input signal 
wherein each pulse is of fixed duration substantially equal 
to the time that said field is attenuated by an article pass-
ing through said location at said speed, said pulse train 
terminating responsively to the termination of said input 
signal whereby the number of pulses in said train is deter-
mined by the period of said input signal, means for apply-
ing said rectangular signal as an input to said pulse gen-
erating means, an amplifier with input and output ter-
minals, means for applying said pulse train to the input 
terminal of said amplifier, a counter with an input ter-
minal, and means connecting the output terminal of said 
 amplifier to the input terminal of said counter for apply-
ing the output of said amplifier to said counter so that 
said counter registers a count in response to each amplifi-
ced pulse received from said amplifier.

15. An article counting system as defined by claim 14 
wherein said counter is adapted to respond to the trailing 
edge of each amplified pulse.

16. An article counting system as defined by claim 15 
further including selectively operable means for applying 
said rectangular signal as an input to said amplifier in-
stead of to said pulse generating means, so that said 
counter registers a count in response to the trailing edge 
of said rectangular signal.

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<table>
<thead>
<tr>
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<th>10</th>
</tr>
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