

[54] SMALL OBJECT COUNTING APPARATUS

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[51] Int. Cl.² G06M 3/00

[58] Field of Search 235/92 PK, 98 C, 92 V; 221/211, 7; 198/287

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[57] ABSTRACT

Small objects, such as pharmaceutical capsules from a production stream, are counted with speed and accuracy. The objects are delivered to a hopper from which they are picked up by a rotating suction drum and transported through an orientation means to an object pick-off or drum stripping means. Following separation from the drum, the objects pass sequentially through an electro-optical sensing device which delivers electrical pulses to an electronic counter means which has the ability to display both count and rate of count. The counted objects are delivered to a suitable batch container.

4 Claims, 7 Drawing Figures

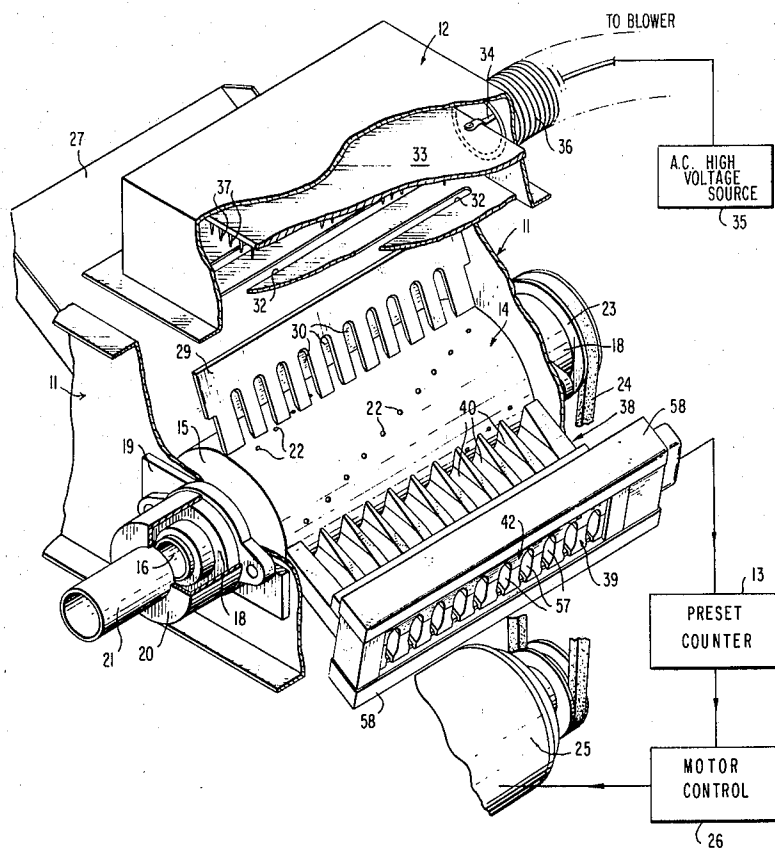


FIG. 2

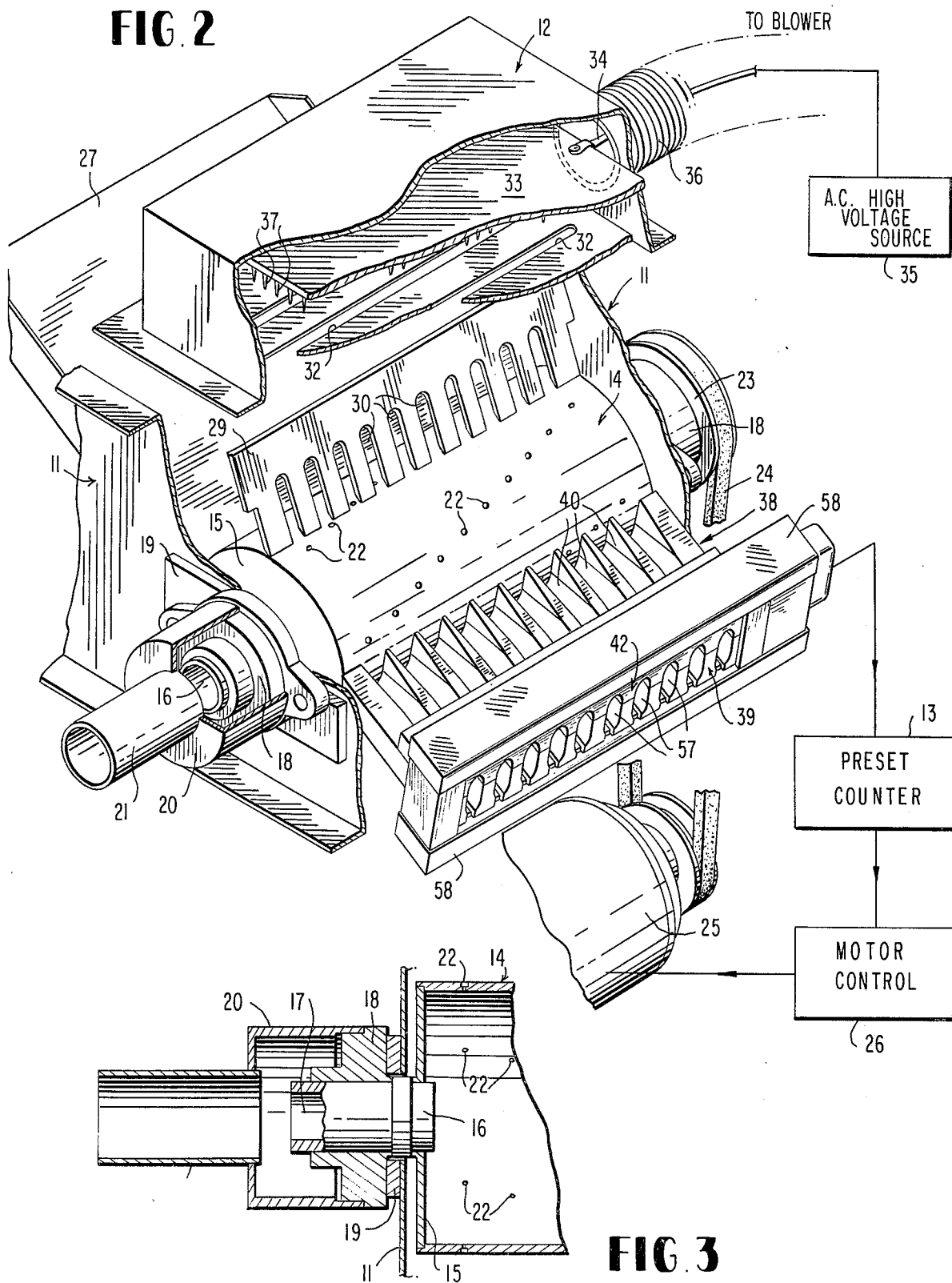


FIG. 3

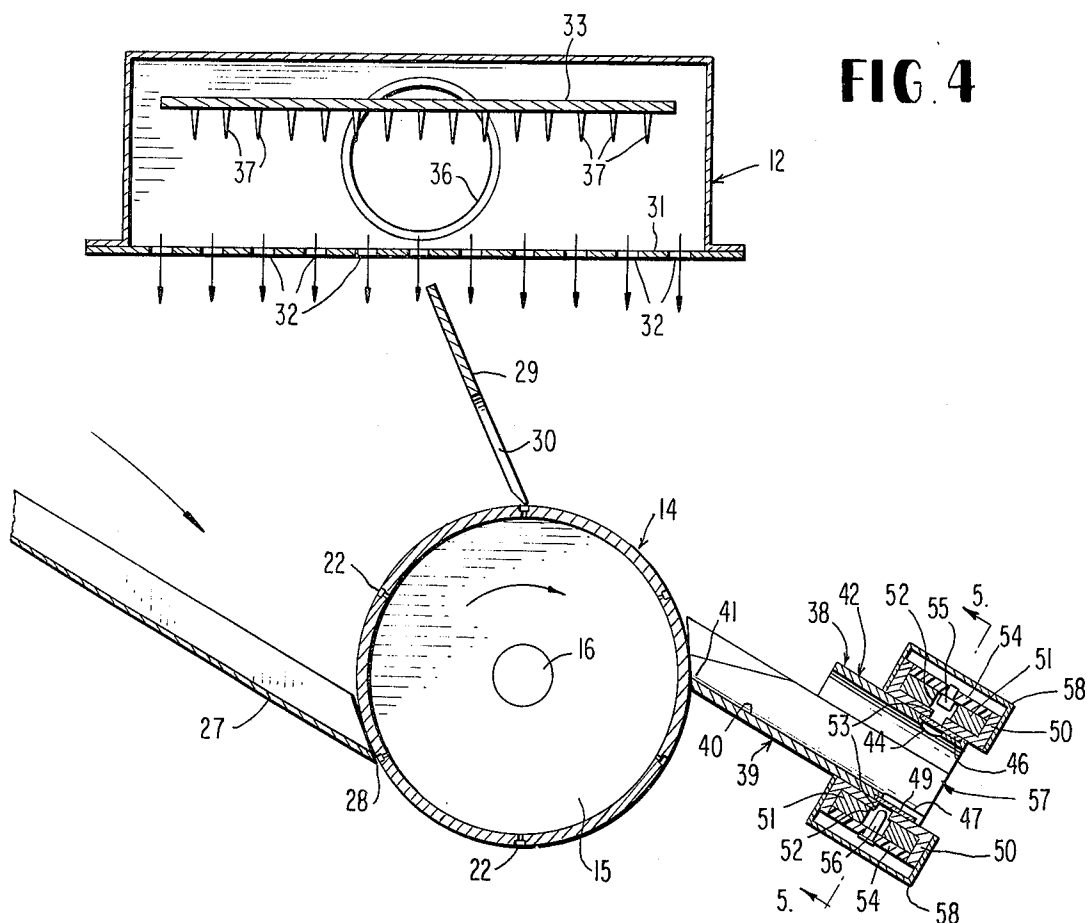


FIG. 4

FIG. 5

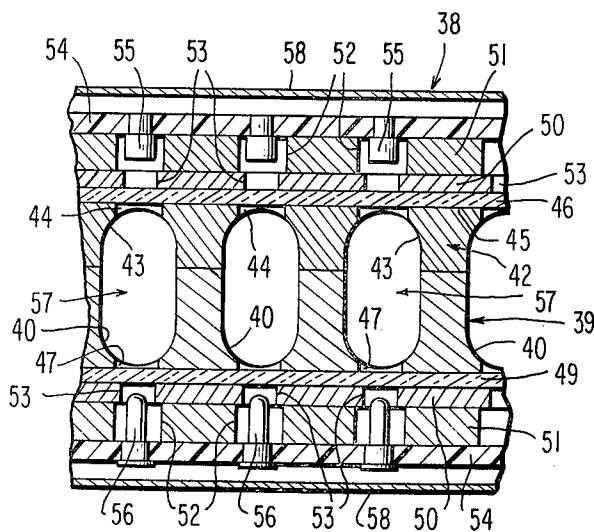
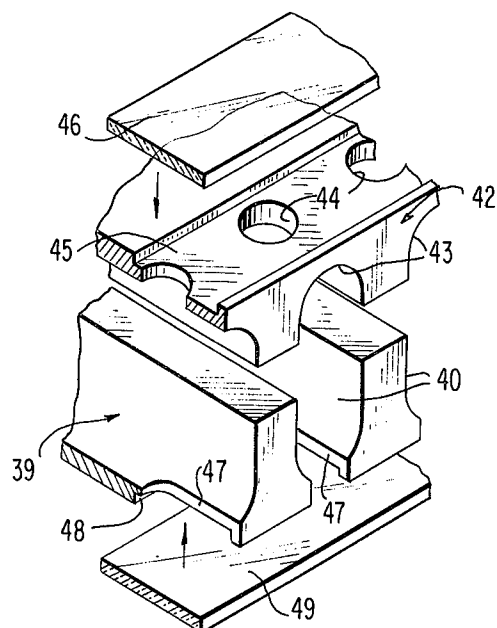


FIG. 6



SMALL OBJECT COUNTING APPARATUS

BACKGROUND OF THE INVENTION

The pharmaceutical industry, due to an ever-increasing demand for more reliable and uniform products, is experiencing an increasing need for automation processing and handling equipment. Among the specific needs being encountered by the industry is the necessity for a high speed apparatus to receive gelatin capsules or medicinal tablets from a production stream and to count them accurately in great number while delivering them to suitable batch containers.

Ideally, an apparatus or machine for this purpose should be capable of counting the various small objects at rates in the range of 200,000 per hour and with a typical accuracy of plus or minus 0.01%. The apparatus should be able to handle a range of object sizes and shapes as well as objects possessing different degrees of translucency. In the interest of economy, the apparatus should occupy only a minimum of floor space which, in the case of the invention, is only 2 square feet approximately. It should be easy to operate with a minimum number of simplified controls and should possess an ability to visually display both the object count and the rate of count. The apparatus should also have the ability to process gelatin capsules and the like without damaging them in any way. The invention actually cleans the product during the counting process by removal of dust and product deionization. The apparatus should also be reasonably rugged and durable and should require minimum maintenance. In furtherance of these two objectives, the present invention features an absence of vibratory components which naturally tend over a long period of time to destroy a machine.

Accordingly, the object of the invention is to provide a small object counting apparatus which possesses all of the above-enumerated desirable features, plus others that will become apparent during the course of the following detailed description. The invention, for example, embodies a unique mechanical arrangement and coacting electrical controls whereby the statistical chance for simultaneous occurrence of electrical pulses being delivered to a counter by the electro-optical sensor is reduced substantially to zero. Another unique feature of the invention resides in the provision of a slow-acting automatic intensity control circuit which adjusts the brightness of each individual light source to maintain just enough brightness to be detectable at the associated phototransistor. This allows faithful detection of transparent objects which may produce only partial light beam interruption as well as objects having a greater degree of opacity.

Another significant feature of the invention embodied in the controls thereof is the ability of the apparatus to count objects up to within a small number, typically 20, of a desired total, and then to automatically slow down drum rotation to provide a mere trickle count up to the exact total, whereupon the object transporting drum is stopped and the flow of objects into the hopper may also be stopped upon reaching the desired count. In general, the apparatus embodying the invention possesses flexibility of operation and control, simplicity, compactness and economy, both in terms of manufacturing and usage including maintenance.

BRIEF DESCRIPTION OF DRAWING FIGURES

FIG. 1 is a perspective view of an apparatus for counting small objects in accordance with the present invention;

FIG. 2 is a fragmentary perspective view of the apparatus;

FIG. 3 is a fragmentary vertical section taken through a rotary suction drum, hollow shaft and associated parts;

FIG. 4 is a fragmentary vertical section taken transversely through the drum, object sensing unit and other associated parts;

FIG. 5 is an enlarged fragmentary cross section through the sensing unit taken on line 5—5 of FIG. 4;

FIG. 6 is a fragmentary exploded perspective view showing elements of the electro-optical sensing unit; and

FIG. 7 is a schematic view of a circuit for automatically adjusting the brightness of light sources in the object sensing unit in accordance with variations in the translucency of objects being counted.

DETAILED DESCRIPTION

Referring to the drawings in detail wherein like numerals designate like parts throughout, the complete apparatus as depicted in FIG. 1 embodies a floor-mounted housing 10 to enclose a rotary drum drive motor and associated controls and the like, to be described. Above the housing 10 is the central section of the apparatus including frame sides 11 which form a partial enclosure for the small object supply, transporting and pick-off means, all to be described in detail. Above this section of the apparatus and mounted thereon is an ionization chamber or section 12, and on top of this is mounted the object counter and display unit of the invention designated generally by the numeral 13. It may be pointed out here that the entire apparatus is typically constructed to be no more than about 40 inches in height by about 20 inches wide by approximately 20 inches deep, front-to-back. The apparatus is therefore very compact so that it will occupy the absolute minimum of floor space.

Mounted between the intermediate vertical frame sides 11 or plates is a horizontal axis rotating transport drum 14 for the small objects being counted and the opposite end plates 15 of the drum carry shaft sections 16, one of which is hollow with a through bore 17, as shown in FIG. 3. The opposite end shaft section 16, FIG. 4, is solid. A pair of axially aligned bearings 18 for the drum shaft sections 16 are securely mounted as at 19 through a rigid plate on the outer sides of frame elements 11. The hollow shaft section 17 projecting from one end of the drum 14, FIG. 3, is enclosed by a cup-like housing 20 snugly fitted on the adjacent bearing 18. A tubular sleeve 21 secured to the housing 20 is adapted to connect to any external source of vacuum, not shown in the drawings.

As an important feature of the invention, the hollow drum 14 which is subjected to vacuum through the hollow shaft 17 during rotation is provided with a plurality of equidistantly circumferentially spaced spiral rows of small suction apertures 22. In the illustrated embodiment, the suction transport drum 14 may have six spiral rows of apertures with ten apertures per row, and each adjacent pair of apertures separated circumferentially of the drum by 6°. The importance of the spiral rows of apertures is in connection with the deliv-

3

ery of individual small objects sequentially and non-simultaneously to pick-off channels, yet to be described. The drum 14 rotates during the operation of the apparatus under the influence of a drive pulley 23 connected to the solid shaft end of the drum, the pulley being connected with a transmission belt 24, in turn driven by an electric motor 25 contained within the housing 10 together with a motor control assembly 26 shown diagrammatically in FIG. 2.

As inclined hopper tray 27 at the product input side of the drum 14 is suitably supported between the frame sections 11 with its leading transverse edge 28 disposed close to the periphery of the drum 14 somewhat below the horizontal rotational axis thereof. The hopper tray receives gelatin capsules or like small articles directly from a production stream, and the product readily gravitates down the inclined tray to pile up in a mass behind the rotating suction drum.

At the top of the drum, a single inclined comb-like orientation plate 29 having equidistantly spaced slots 30 is fixedly and interchangeably mounted between the frame sides 11. The slots 30 correspond in number to the apertures 22 of each spiral row of apertures and one slot 30 is aligned with one aperture of each row. As an individual capsule or like small article in the tray 27 is picked up by one of the suction apertures 22 and conveyed upwardly by the drum, the slotted member 29 will allow the passage of one and only one capsule beyond it and any other objects which might be adhering to the drum will be rejected and will fall back into the tray or hopper. The slots 30 are sized, therefore, to allow passage through them of only one object at a time of a given size. The plate 29 may be replaced in the apparatus by different plates having different sizes of slots so that the apparatus may be capable of counting various small objects differing in shape and size. The lower edge of the plate 29 is disposed close to the periphery of the rotating drum.

Immediately above the slotted member or plate 29 is the aforementioned ionization chamber 12 which is a box-like housing having a bottom wall 31 provided with a plurality of transversely elongated slots 32, most of which are above the hopper portion of the apparatus but several of which are on the downstream side of the plate 29 remote from the hopper. A stationary metal plate 33 within the ionization chamber 12 is connected by a wire 34 with an AC high voltage source 35. The wire 34 may extend through a conduit 36 receiving forced air from a suitable blower, not shown. Such air is delivered into the ionization chamber and picks up charged ions from a multitude of dependent needles 37 on the plate 33. These charged ions travel through the exit slots 32 at the bottom of the ionization chamber and are sprayed onto the small objects being transported. This ionized air bath assists in removing any static charge and/or dust from the objects, tends to blow rejected objects back toward the hopper and away from the plate 29, agitates the objects resting in the hopper, and assists the objects in passing through channels of the pick-off means and electro-optical sensor, yet to be described. Therefore, the ionization means serves several important purposes simultaneously during the operation of the apparatus.

At the discharge side of the drum 14 remote from the hopper or tray 27, there is mounted in the intermediate section of the apparatus defined by the frame sides 11 an object pick-off and sensing assembly designated broadly by the numeral 38. This is a very essential and

4

important component of the invention and it includes a fixed pick-off bar 39 having plural parallel equidistantly spaced channels or troughs 40 formed therein corresponding in number and spacing with the slots 30 and the apertures 22 in each spiral row. The product intake end 41 of the pick-off bar 39 is arranged close to the periphery of the drum so that the pick-off bar will scrape off and remove the capsules being transported by the suction apertures 22. One capsule or object will be separated from each aperture 22 and will be delivered to one of the channels 40 of the pick-off bar, which channels are inclined so that the small objects therein will gravitate downwardly.

Toward the discharge end of the pick-off bar 39, FIG. 4, a relatively shorter inverted and mating pick-off bar cover 42 is fixedly mounted thereon and this cover has inverted channels 43 which register in assembly with the channels 40, see FIG. 5. Openings 44, for a purpose to be described, are formed through the top of the pick-off bar cover, and the top of the cover also has a continuous longitudinal recess 45 parallel to the drum axis for receiving and seating a transparent plate 46 in covering relation to the openings 44. Similarly, the pick-off bar 39 near its lower discharge end has slots 47 leading from its channels or troughs 40 and adjacent these slots the bottom of the pick-off bar 39 has a recess 48 similar to the recess 45 to receive and seat another transparent plate 49.

Channels bars 50 facing in opposite directions, FIG. 4, are secured to the top and bottom, respectively, of cover 42 and pick-off bar 39 and these channel bars receive spacer plates 51 which are apertured at 52 adjacent to each slot 47 of the pick-off bar and each opening 44 of the pick-off bar cover 42. The channel bars 50 are similarly apertured at 53 in alignment with the apertures 52, as clearly shown in FIG. 5.

Circuit panels 54, such as printed circuit elements, are mounted above and below the two spacers 51 in the electro-optical sensor which forms a part of the assembly 38. The upper panel 54 carries a plurality of infrared light point sources 55 corresponding in number to the channels or tunnels formed by the opposing pick-off bar 39 and cover 42, as shown in FIG. 5. Similarly, the lower panel 54 carries a like number of phototransistors 56 or equivalent elements and these phototransistors are optically aligned through the described openings and transparent plates 46 and 49 so that the phototransistors may be sensitive to infrared light generated by the sources 55 or the interruption of such light beams by capsules gravitating through the inclined tunnels designated 57 in FIGS. 4 and 5. The upper and lower units of the electro-optical sensing means are enclosed and protected by suitable covers 58.

The aforementioned counter and display assembly 13 at the top of the ionization chamber 12 is essentially conventional equipment like the motor control assembly 26 and need not be described in any great detail. It accepts the electrical signals generated by the described electro-optical sensing means of the pick-off assembly 38 which occur somewhat sequentially due to the spiral arrangement of apertures rows 22. Processing of these signals in the unit 13 to assure non-simultaneous occurrence is conventionally carried out. An electronic counter and comparator means allows totalization of the counted objects and comparison of the total with a preselected number. A precount counter of the unit 13 senses when the count of the objects is within a small number, typically twenty, of a desired total. This

allows generation of a signal by the unit 13 to slow down drum rotation by motor control assembly 26 and allow a trickle count of objects up to exactly the desired count or total. Outputs from the counter assembly 13 to motor control assembly 26 allow stopping of the drum 14, and auxiliary outputs will stop the flow of objects to the input hopper 27 when the desired count is reached. An internal time base in conjunction with another counter circuit allows display of the object passage rate in thousands per hour with an averaging time of typically 30 seconds. The motor control assembly 26 allows interfacing between drum drive motor 25 and the counter assembly outputs, as well as providing a manually adjustable drum drive speed.

A notable feature of the invention resides in the ability of the sensing unit 38 to compensate automatically for any variations in the translucency of the light paths between the elements 55 and 56 caused by dust accumulating on the plates 46 or for similar reasons. This feature enables the apparatus to count objects having different degrees of translucency. This important feature is embodied in the electronic circuit illustrated in FIG. 7 of the drawings. Referring to this figure, the light emitter or point source 55 illuminates phototransistor 56 across one of the viewing channels 40, FIG. 5. The phototransistor 56 conducts, causing the voltage at the base of a transistor 59 to decrease toward zero volts. Transistor 59 is an emitter-follower, whereby the voltage at its emitter is equal to its base voltage minus 0.7v. This emitter voltage is fed through the time constant network composed of capacitor 60 and resistors 61 and 62 to transistor 63.

This transistor 63 conducts current through another resistor 64 and light emitter 55. The amount of conduction current and thus the intensity of brightness is proportional to the voltage applied to the time constant network. The time constant network is adjusted so that the source current can respond only to slowly varying changes in time constant input voltages, typically more slowly than about 2 seconds.

In operation, the brightness is automatically adjusted to maintain about +1.1 volts at the emitter of transistor 59. This is +1.1 volts is also coupled through diode 65 and resistors 66 and 67 to produce about +0.4 volts at the base of second transistor 68. This +0.4 volts is too small to cause conduction of transistor 68, and its collector voltage is about 5 volts.

If an object 69, such as pharmaceutical capsule, rapidly interrupts the beam between infrared light emitter 55 and phototransistor 56, the voltage at the base and emitter of transistor 59 increases toward +5 volts. If the time of interruption of the light beam is of the order of a fraction of a second, no change in the light source brightness is produced through transistor 63 because of its relatively long time constant.

The increasing voltage at transistor 59 emitter is also coupled through diode 65 to the base of transistor 68. If the increase is as much as 0.3 volts, this transistor will conduct to a saturation point. Its collector voltage then changes rapidly from +5 volts to near 0 volts.

This change to 0 volts triggers integrated circuit 70. Once triggered, this circuit generates one pulse at its pin numbered 8 of a fixed time duration. This time duration, set by capacitor 71 and resistor 72, typically 70 milliseconds, is designed to be longer than the maximum interruption time of the object 69 being counted as it passes between the elements 55 and 56. This insures that only one fixed time pulse at the pin num-

bered 8 of element 70 is generated for each beam interruption.

Integrated circuit 73 is arranged as a differentiator, forming one very short duration pulse which occurs at the positive-going transition of the 70 millisecond input pulse, before mentioned. The output zero-going pulse is typically 70×10^{-9} seconds.

Ten of the above-described automatic brightness control circuits are employed in the counting system. Output pulses from each circuit are parallel gated (summed) into one stream by other conventional circuits, not shown, and then fed to one counter circuit as a time-serial series of pulses to be counted, as indicated generally at 74 in FIG. 7.

Summary of Operation

Objects, such as capsules 69, enter the hopper formed by tray 27 and adjacent side walls from a production stream, and are picked up at the suction ports 22 of the rotating transport drum 14. A comb-like element 29 strips excess picked-up objects from each suction port, so that only one object will be transported by one port beyond the element 29. Static charges and dust are removed from the objects during pick-up and transport, both by the overhead ionized air bath from slots 32 and the vacuum being drawn through the ports 22.

The objects are carried by the drum 14 to the pick-off and sensing assembly 38 where they are scraped from the drum at 41. FIG. 4, and slide through the viewing channels 40 of pick-off bar 39 with an air-assist from the overhead chamber 12. The generally sequential passage of objects through the channels 40 produces sequential beam interruptions between the elements 55 and 56 of each channel and sequential electrical pulses into the counter assembly 13. These pulses may overlap in time due to various uncertainties involved in object passage through the channels 40. However, the beginning of occurrence of the pulses, occupying an extremely brief period of time, is utilized. Statistically, the chance of simultaneous occurrence of the beginning pulse of any one channel with that of another channel, and thus not being distinguishable as two separate counts, is virtually zero. Consequently, these short beginning pulses are serially counted in one direct electronic counter.

This process continues with the drum 14 rotating at a selected fast speed, picking up and discharging objects through the channels 40, and with the count accumulating until reaching a count of, typically, 20 less than the quantity selected by the front panel switches on counter assembly 13, see FIG. 1. At this count, signals are sent out by the counter assembly to slow down drum rotation and interrupt the object input drive system, not shown. The action continues as before, but at a greatly reduced speed until exactly the desired object count is obtained. At this time, the drum drive is caused to stop completely.

During counting, the rate of object passage is visually displayed on the front panel of the counter assembly 13. Controls on the counter assembly allow manual starting, stopping of counter, pausing and resuming operation without resetting the count.

It is to be understood that the form of the invention herewith shown and described is to be taken as a preferred example of the same, and that various changes in the shape, size and arrangement of parts may be resorted to, without departing from the spirit of the in-

vention or scope of the subjoined claims.

We claim:

1. An apparatus for counting large quantities of small objects with accuracy comprising an object infeed hopper, a horizontal axis object transport drum having plural spiral rows of suction ports mounted for rotation at the object discharge end of the hopper, means to turn the drum on its horizontal axis in one direction, means to create a partial vacuum in the drum during its rotation so that said suction ports may pick up objects from the hopper, an excess object rejection device fixedly mounted relative to the periphery of the drum and spaced from the hopper and allowing only one object to be transported by each suction port of the drum beyond said device, an object pick-off member fixedly mounted at the side of the drum remote from the hopper and spaced from said device and having inclined object guidance channels corresponding in number to the number of suction ports in each spiral row on said drum, said pick-off member removing objects from said suction ports with a scraping action during rotation of the drum and causing such objects to slide through said channels, electro-optical object sensors on the pick-off member adjacent to each channel thereof responding to the sequential passage of objects through the channels and producing sequential electrical pulses representative of the number of objects passing through the channels, counter means electrically coupled to said electro-optical sensors for totalizing the number of objects sequentially passing through all of said channels until a present count is obtained, means arranged above said hopper, drum and pick-off member for directing ionized air downwardly to agitate and clean objects resting in the hopper and for aiding the passage of objects through said object guidance channels, and said last-named means comprising an ionization chamber having a slotted bottom wall, a metal plate having a multiplicity of dependent needles positioned within said chamber above said slotted bottom wall, means for applying high voltage alternating current to said plate, and means for directing air forcibly into said chamber.

2. The apparatus of claim 1, and said excess object rejection device comprising a comb-like member extending axially of said drum for substantially its entire length and having plural equidistantly spaced equal width slots formed therein and said slots corresponding in number to the suction ports in each spiral row and aligned with the ports circumferentially of the drum.

3. An apparatus for counting large quantities of small objects with accuracy comprising an object infeed hopper, a horizontal axis object transport drum having

plural spiral rows of suction ports mounted for rotation at the object discharge end of the hopper, means to turn the drum on its horizontal axis in one direction, means to create a partial vacuum in the drum during its rotation so that said suction ports may pick up objects from the hopper, an excess object rejection device fixedly mounted relative to the periphery of the drum and spaced from the hopper and allowing only one object to be transported by each suction port of the drum beyond said device, an object pick-off member fixedly mounted at the side of the drum remote from the hopper and spaced from said device and having inclined object guidance channels corresponding in number to the number of suction ports in each spiral row on said drum, said pick-off member removing objects from said suction ports with a scraping action during rotation of the drum and causing such objects to slide through said channels, electro-optical object sensors on the pick-off member adjacent to each channel thereof responding to the sequential passage of objects through the channels and producing sequential electrical pulses representative of the number of objects passing through the channels, counter means electrically coupled to said electro-optical sensors for totalizing the number of objects sequentially passing through all of said channels until a present count is obtained, said electro-optical sensors each comprising a light source disposed on one side of each guidance channel and a photo-sensitive element on the other side of each channel optically aligned with the light source for that channel, each channel having a light transmitting passage extending thereacross adjacent to said light source and photo-sensitive element, and an automatic brightness intensity control circuit for each light source electrically connected with the source and the associated photo-sensitive element, whereby a reliable count for objects of varying translucency may be had, each brightness control circuit being a transistorized circuit including a time constant network constructed so that the source current can respond only to relatively slowly varying changes in time constant input voltages.

4. The apparatus of claim 3, and said brightness control circuit additionally comprising a single pulse generator which generates a pulse of a longer time duration than the maximum light beam interruption time of an object being counted thus insuring that only a single fixed time pulse is generated for each beam interruption, said brightness control circuit additionally comprising a differentiator circuit adapted to form short duration pulses which may be gated into a single counter circuit.

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