United States Patent

[11] 3,601,616

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[33] Japan
[31] 43/6051

[54] **METHOD AND DEVICE FOR INSPECTING BOTTLE BY RADIANT ENERGY**
3 Claims, 19 Drawing Figs.

[52] U.S. Cl. 250/223, 356/198, 209/111.7
[51] Int. Cl. G01n 21/22
[50] Field of Search .... 250/222, 223 B; 356/196, 197, 198, 240; 209/111.7

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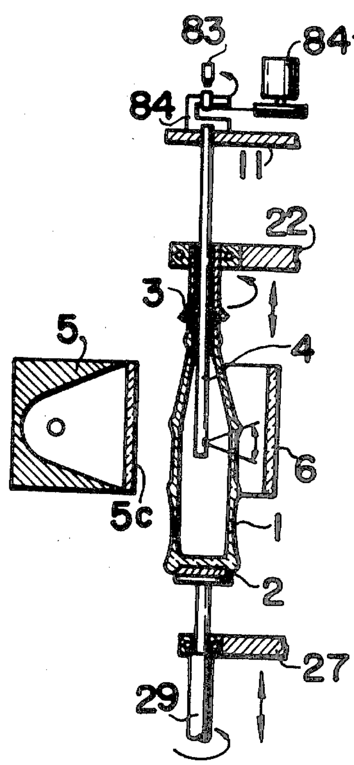
ABSTRACT: A method of inspecting bottles comprises directing diffused light rays on bottles to be inspected and scanning the bottles thus irradiated. The bottles, in each of which an optical system with a light receiving unit is inserted, are rotated for scanning.

A device for inspecting bottles is provided with a rotary turret, on which a plurality of bottle supports are rotatably and vertically movably arranged at regular angular intervals, irradiating units, optical systems with light receiving units arranged so as to enter into the bottles, and transducers for converting light signals received by the optical systems into electrical signals.

The use of diffused light rays makes it possible to eliminate the lens action of the bottle wall and to detect solely foreign particles or substances attached on the bottle walls.



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SHEET 01 OF 10

FIG. 1

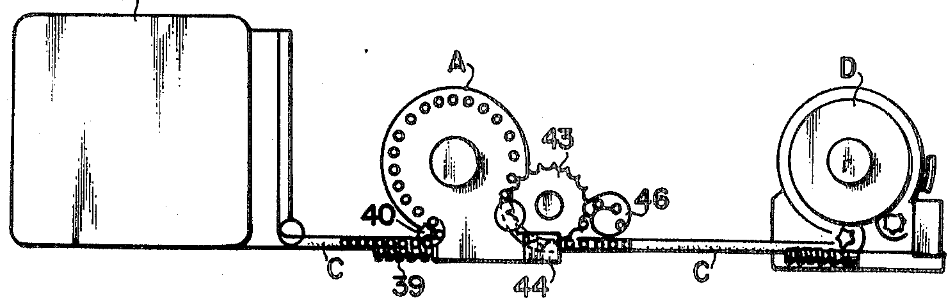

FIG. 2

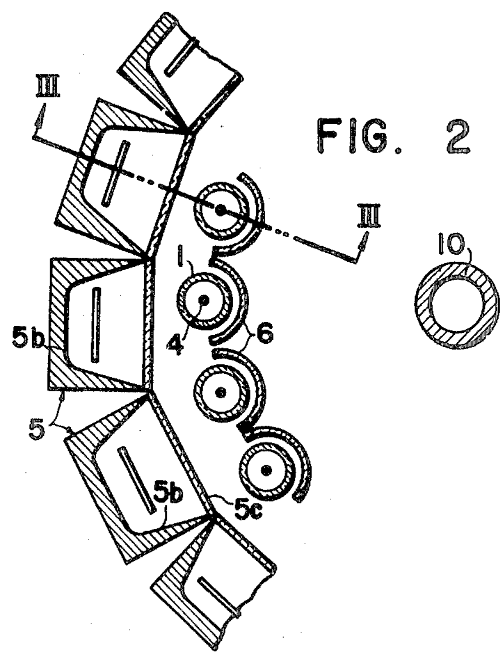

FIG. 3

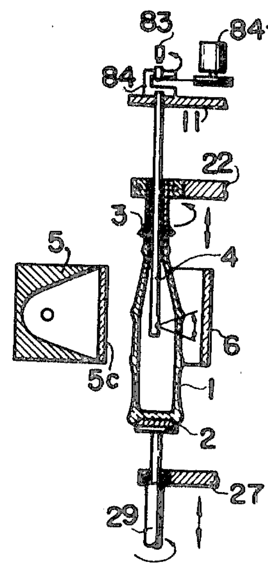

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FIG. 4

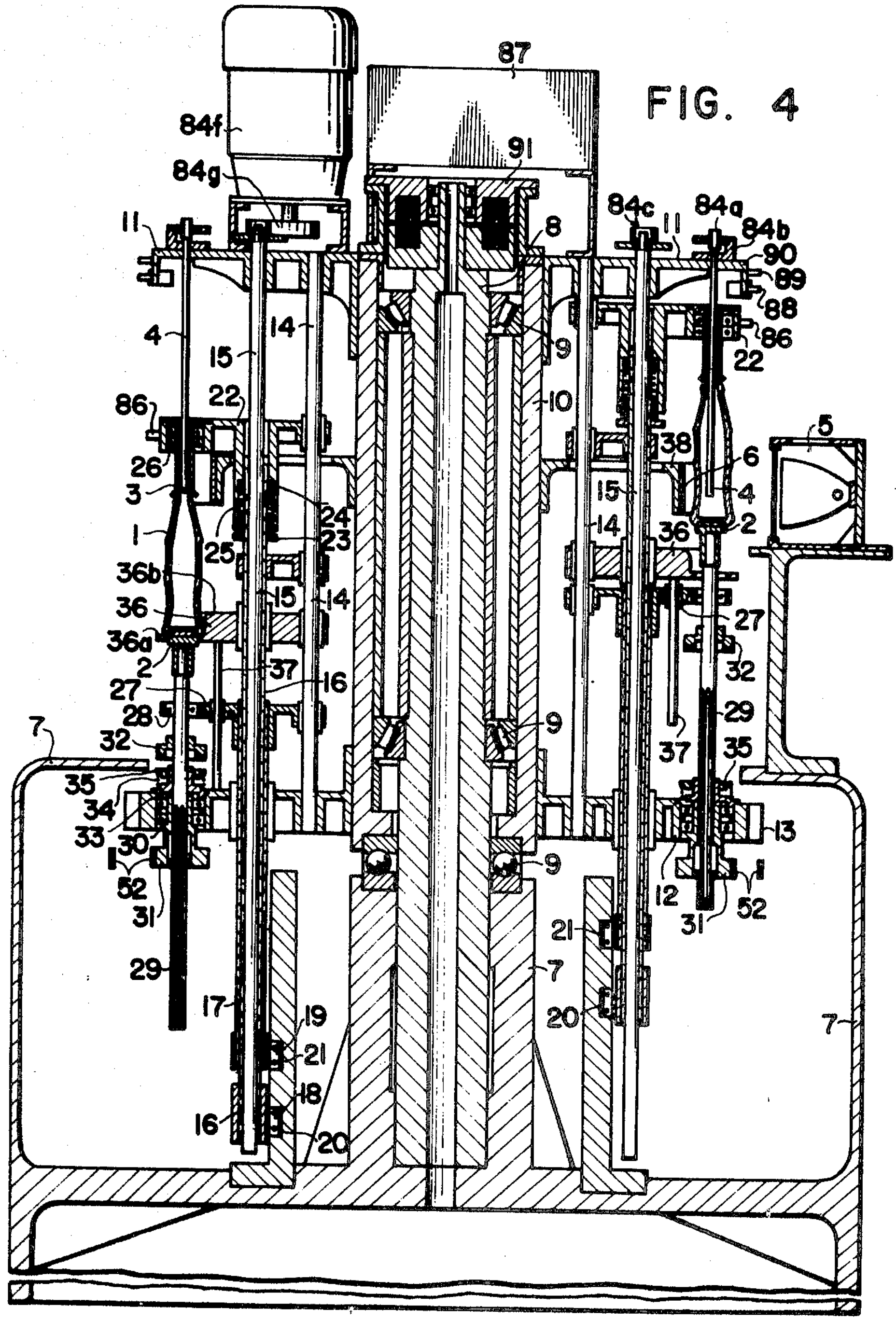
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FIG. 5

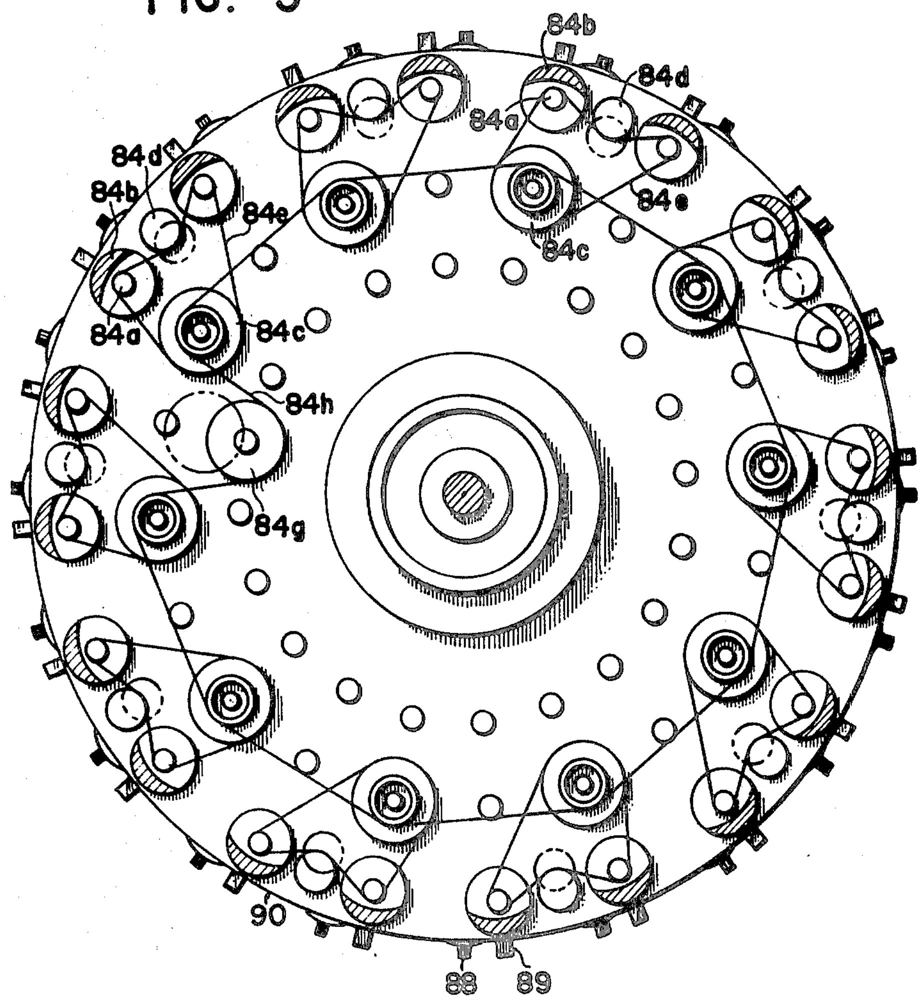
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FIG. 6

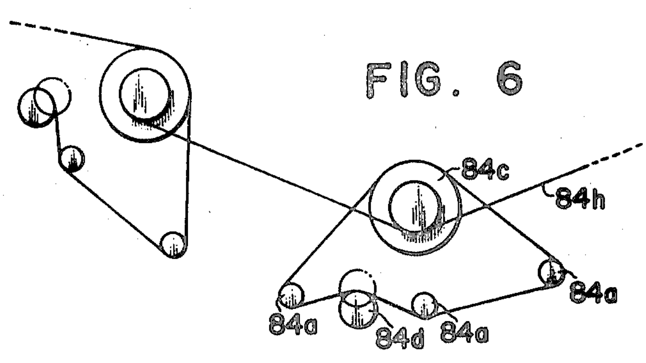
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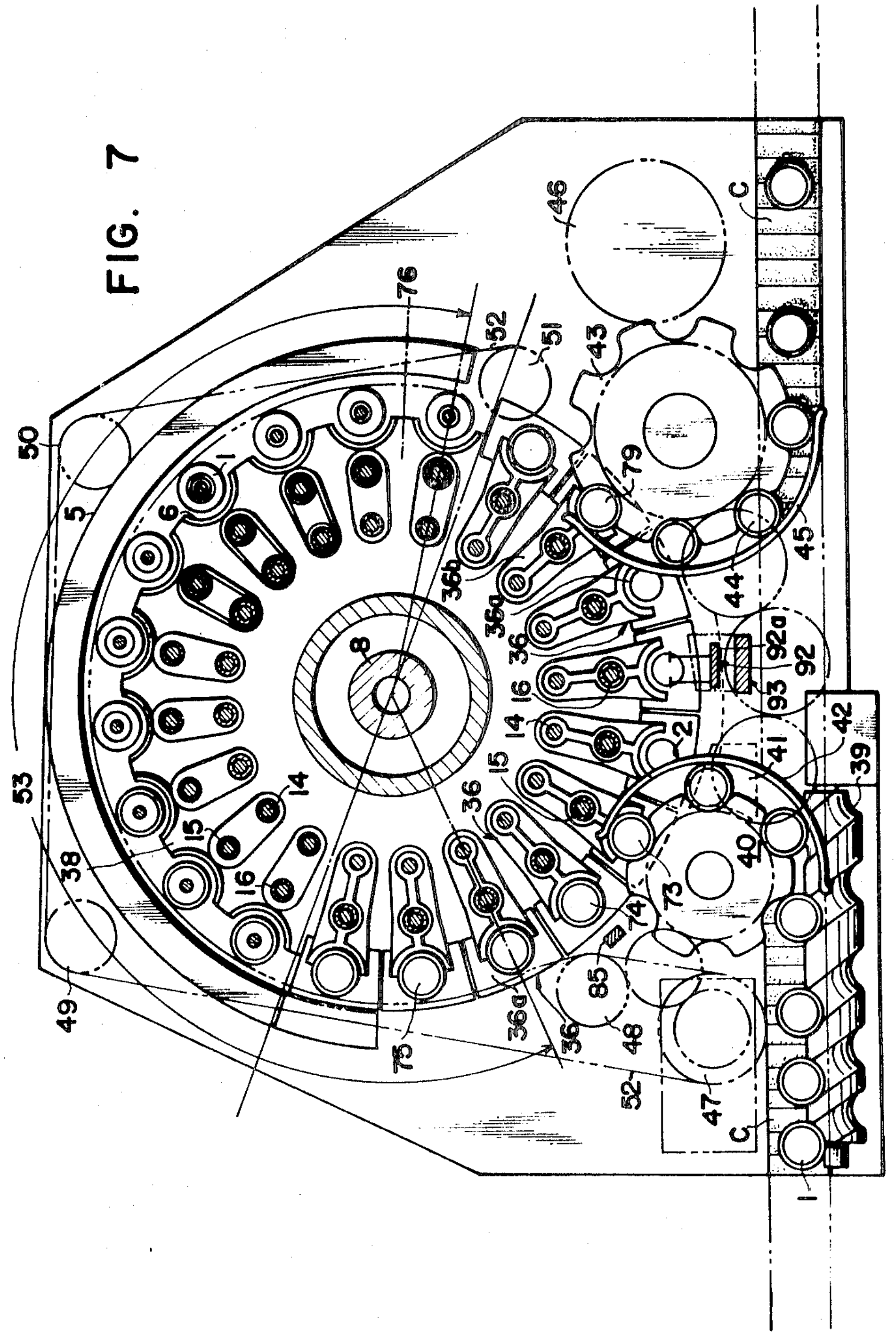
FIG. 7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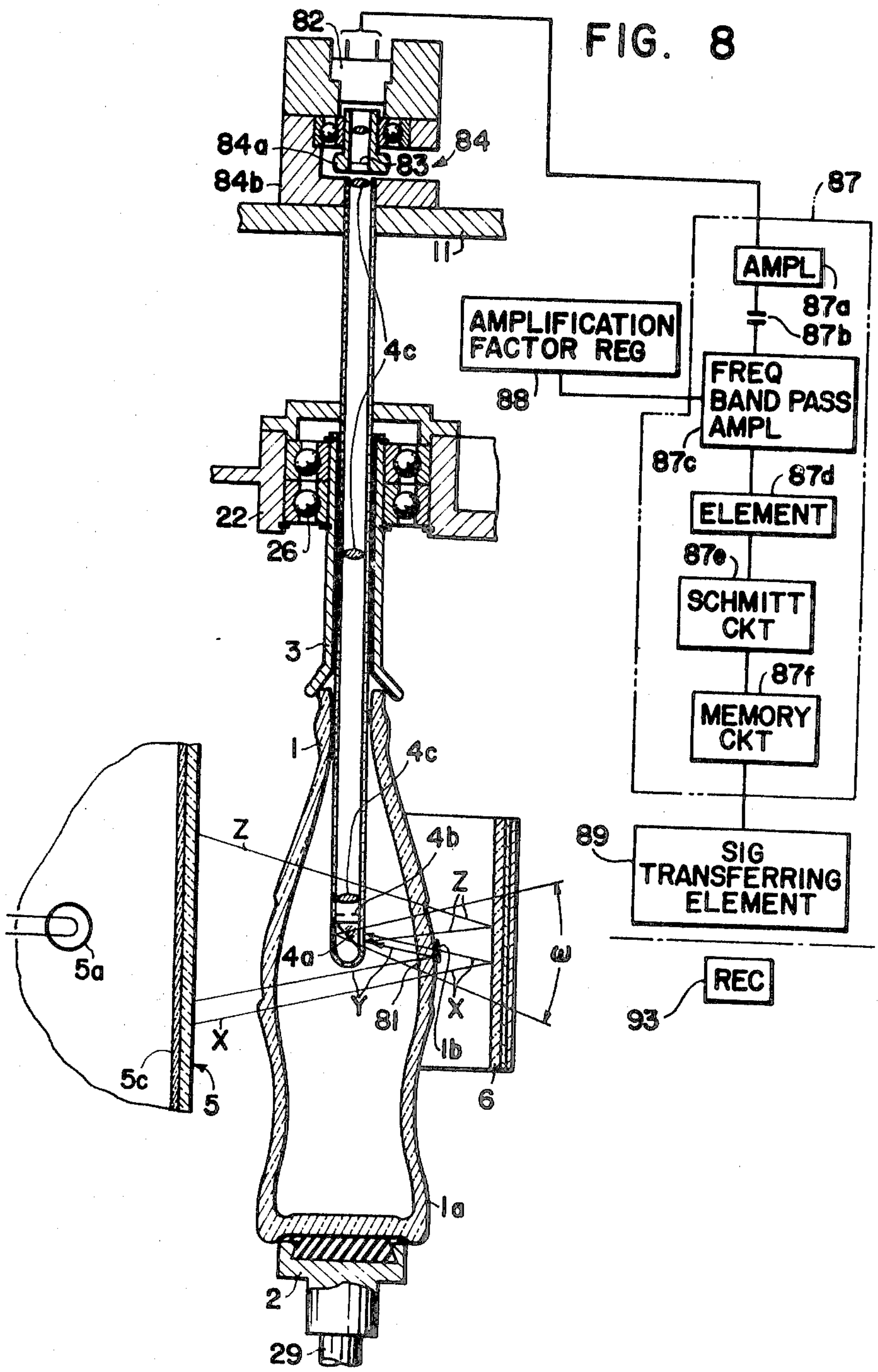
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FIG. 8

FIG. 9

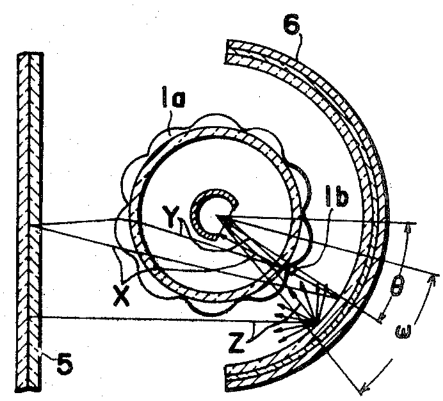


FIG. 10

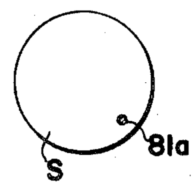


FIG. 11

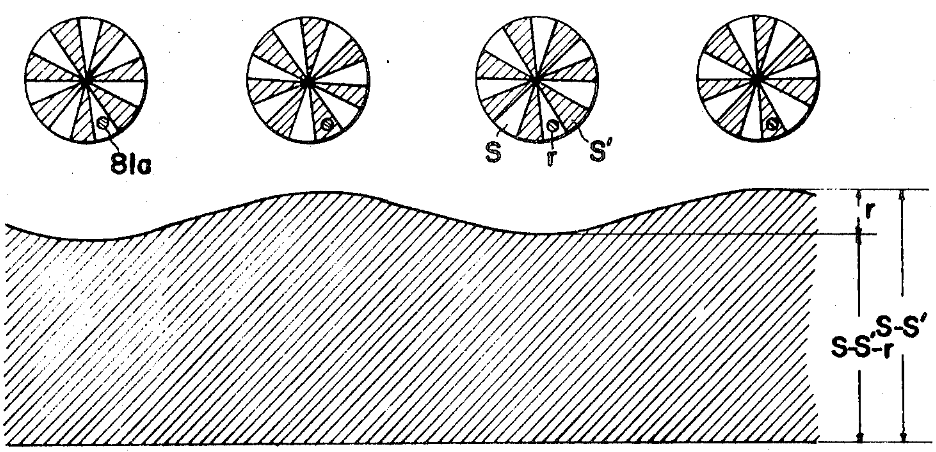


FIG. 12

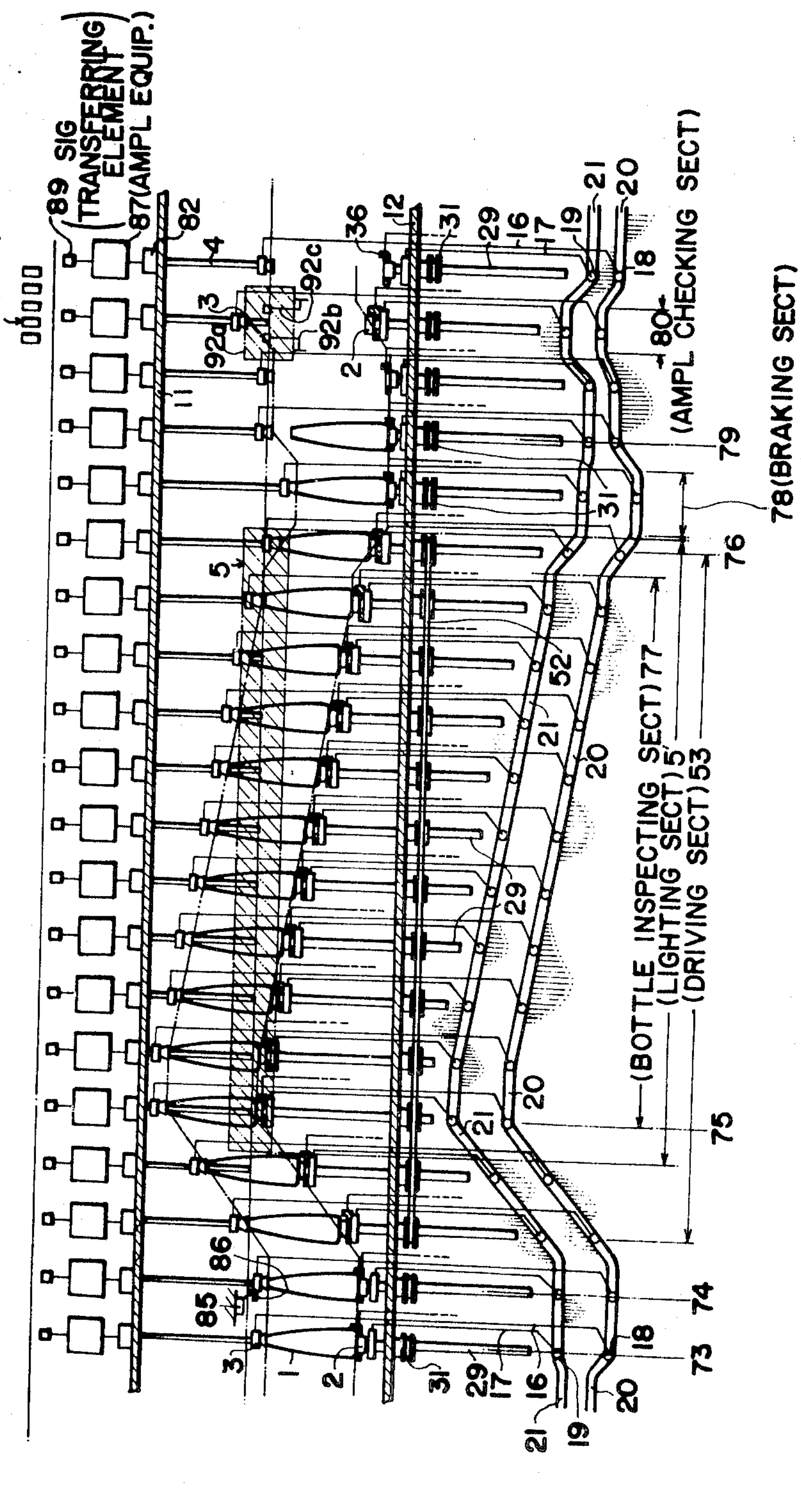
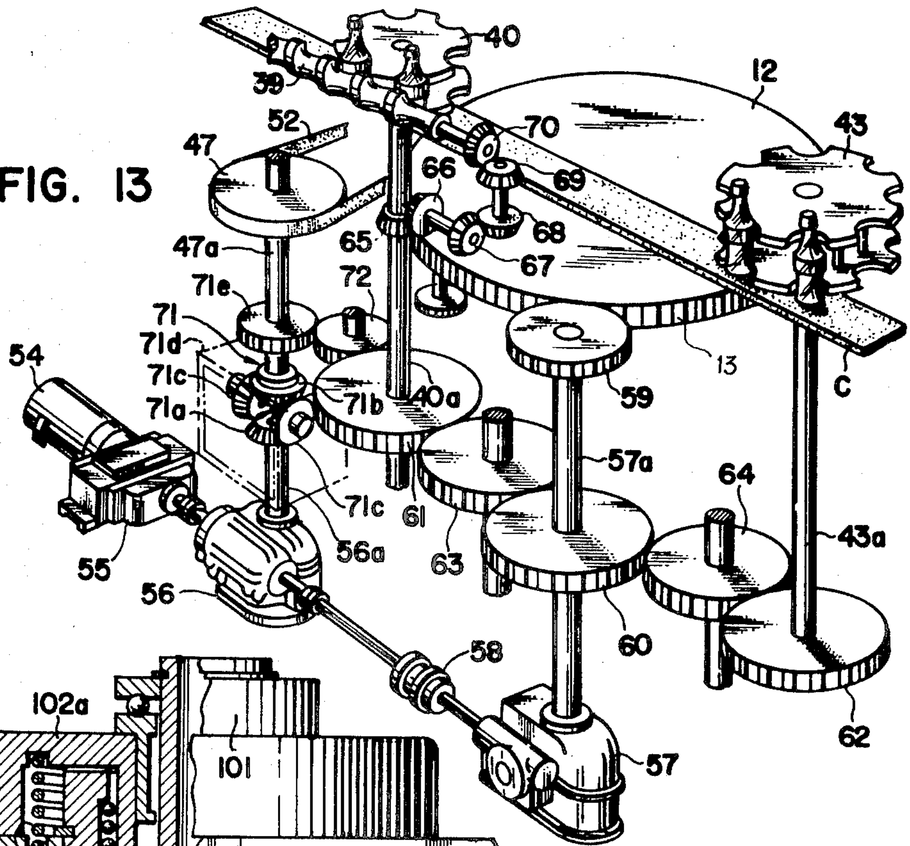

93 (REC)
89 SIG TRANSFERRING ELEMENT
87 (AMPL EQUIP.)
80 (AMPL CHECKING SECT)
78 (BRAKING SECT)
(BOTTLE INSPECTING SECT) 77
(LIGHTING SECT) 5
(DRIVING SECT) 53

FIG. 13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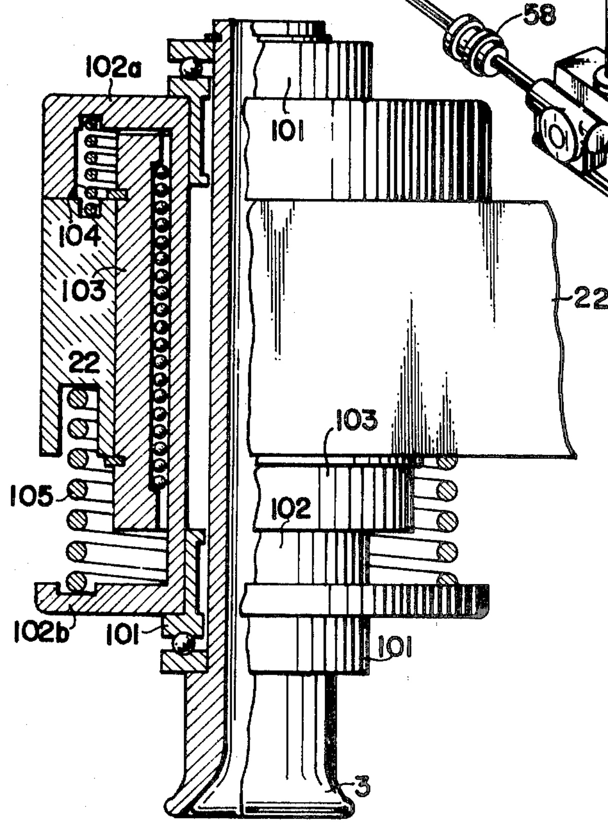
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FIG. 14

FIG. 15

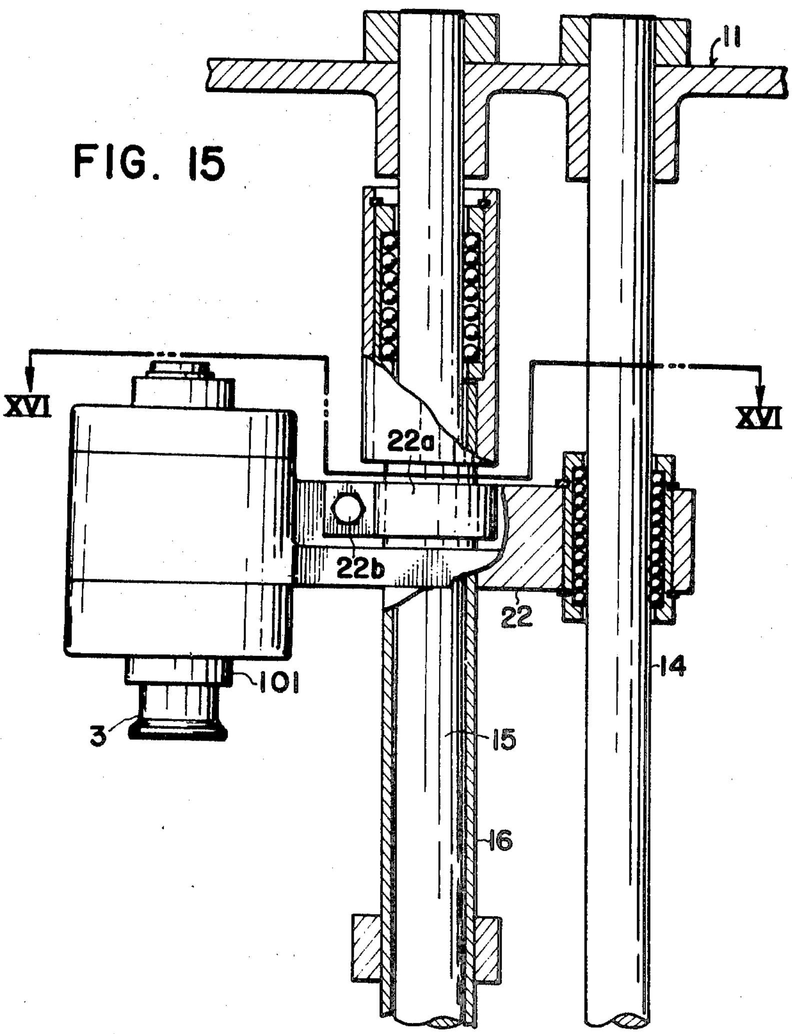


FIG. 16

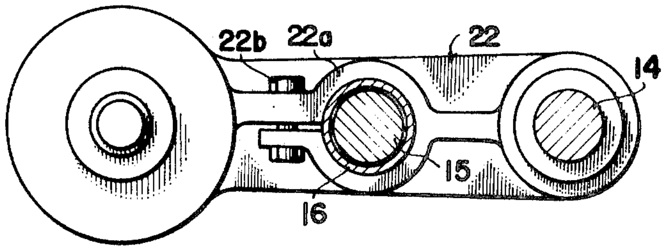


FIG. 17

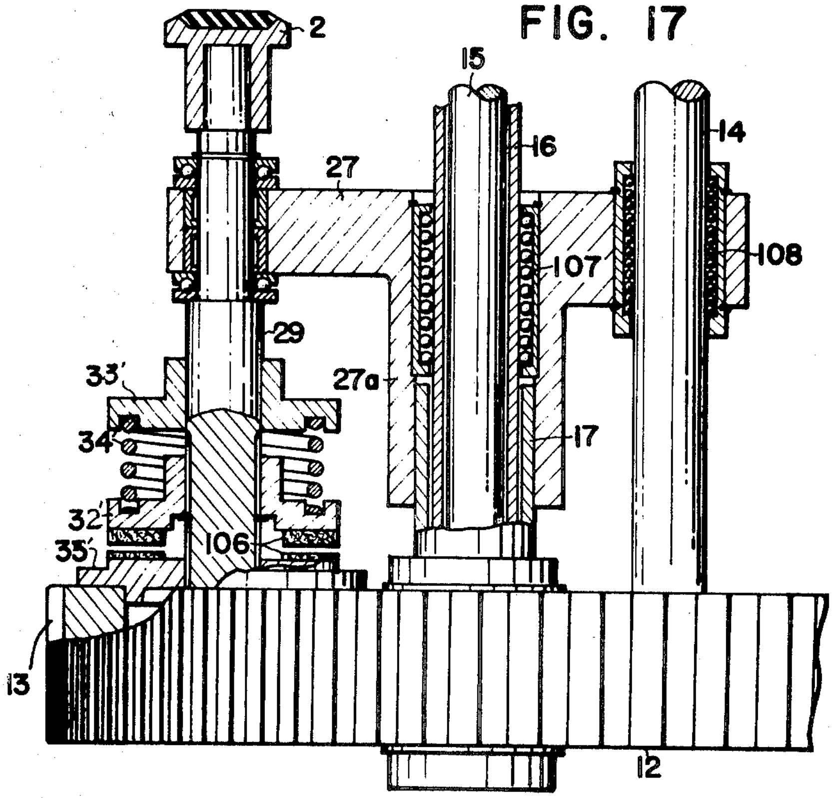


FIG. 18

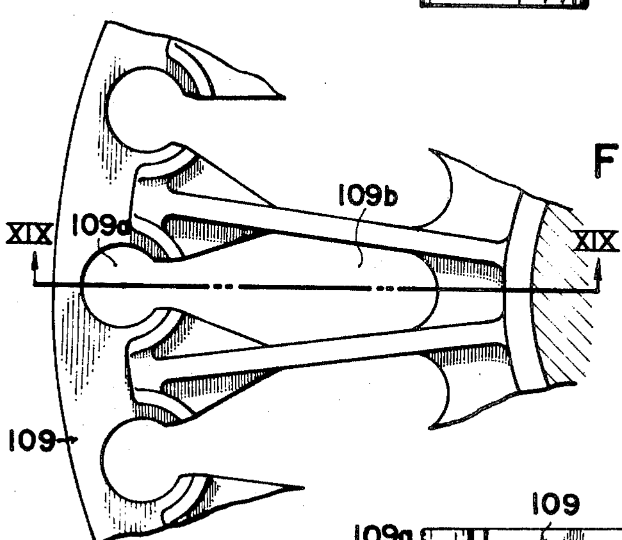
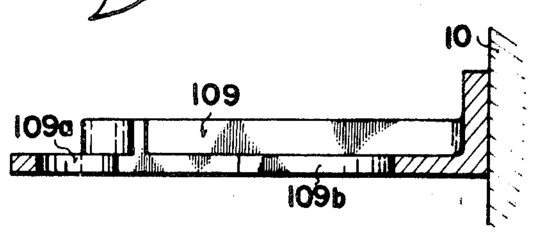


FIG. 19



METHOD AND DEVICE FOR INSPECTING BOTTLE BY RADIANT ENERGY

BACKGROUND OF THE INVENTION

The present invention relates to a method and a device for inspecting bottles adapted to detect optically foreign particles or substances attached on the walls of bottles for cooling drinks, wine, milk, or the like.

In a conventional device for inspecting bottles, light rays are directed on first sides of rotating bottles to be inspected and received at light receiving devices on the other sides of said bottles. The reduction of a light quantity transmitted through the bottle, due to foreign particles or substances attached on the wall thereof, is detected at the light receiving device, and the faulty bottles are removed in response to a signal from the receiving device.

In such a conventional device in which the transmitted light quantity is detected, when bottles whose inner and outer surfaces are formed unevenly or printed with figures, trademarks, or the like, the light quantity received at the receiving device, although foreign particles or substances are not attached on the surfaces of the bottles, changes owing to the lens action due to the uneveness of bottles or the light absorption in the prints, whereby the clean bottles are liable to be removed which results in an imperfect inspection of bottles.

OBJECT OF THE INVENTION

It is a general object of the invention to propose a novel method for inspecting bottles which makes it possible to detect solely foreign particles or substances attached on the bottles while eliminating the lens action due to the uneveness of the bottle surfaces or the absorption of light rays by printed matters on the bottles.

It is a further object of the invention to provide a novel device for inspecting bottles which makes it possible to remove only faulty bottles with foreign particles or substances attached thereon.

SUMMARY OF THE INVENTION

In accordance with the invention, diffused light rays are directed on bottles to be inspected each placed at a certain position, and optical systems inserted in the respective bottles scan the bottles while relative rotation is effected between the optical systems and the respective bottles. Because diffused light rays are directed on bottles from the outsides thereof, although the surfaces of the bottles are formed uneven, the lens action due to the uneveness can be eliminated so that the diffused light rays can be uniformly transmitted into the bottles. Since scanning of the bottles is carried out while the optical systems and bottles are rotated relative to each other, the light rays can be uniformly received by the optical systems regardless of the uneveness of the bottles. The optical systems detect foreign particles or substances attached on the bottles and which have shielded the diffused light rays, whereby the foreign particles or substances can be surely detected.

In accordance with another aspect of the invention, the diffused light rays are directed on bottles to be inspected each in rotating motion at a certain position and then reflected by diffusing reflecting members arranged opposite to sources for the diffused light rays through interposition of said bottles, the reflected light rays being scanned by optical systems which are inserted in the bottles so as to face the diffusing reflecting members. Thus, the bottles having uneven surfaces can be inspected as in the case where the diffused light rays impinge directly on the bottles. Moreover, although bottles to be inspected are provided with prints, the influence of light-shielding caused by the printed portions can be eliminated, and the foreign particles or substances can be detected by the use of irradiating light rays having a suitable wave length and of reflecting members having an adequate reflection factor in order that the sum of the quantity of light rays which fall upon the optical system after having been reflected on the diffusing reflecting members and then transmitted through the printed portions on the bottles and the quantity of light rays which fall upon the optical systems after having been transmitted through the walls of the bottles and reflected on the printed portions may become equal to the quantity of light rays which fall upon the optical systems after having been transmitted through the transparent portions of the bottles without prints.

In accordance with a further aspect of the invention, bottles to be inspected are transferred onto a plurality of bottle supports installed on a rotary turret, and said bottles are rotated and moved upwards and downwards while being irradiated with diffused light rays on the turret. Optical systems inserted in the respective bottles in motion scan the bottles for detecting foreign particles or substances, the optical detecting signals from the optical systems being converted into electrical signals which are utilized to remove only faulty bottles having foreign particles or substances adhered thereto. Since the bottles are scanned for detecting foreign particles or substances in the state described above, not only bottles having smooth surfaces but also bottles having uneven surfaces can be inspected, while the lens action due to the uneven portions of the bottles is eliminated so that the inspection of a large number of bottles can be continuously carried out with a high efficiency. Moreover, the faulty bottles can be automatically selected by converting the optical detecting signals from the optical systems into electrical signals and removing only faulty bottles with the foreign particles or substances attached thereon in response to said electrical signals. Furthermore, the accuracy of detection for foreign particles or substances can be greatly improved by making narrow the range for receiving light of the optical system.

In accordance with a further aspect of the invention, a bottle inspection device is provided with at least one diffused light source for irradiating each bottle to be inspected placed at a certain position, an optical system inserted into the bottle and a driving mechanism for rotating the bottle and/or the optical system thereby providing relative rotation therebetween. Thus, foreign particles or substances adhere on bottles, through the bottles have uneven portions, can be surely detected while eliminating the lens action due to said uneven portions.

In accordance with another aspect of the invention, a bottle inspection device comprises a turret mechanism provided with a plurality of bottle supports, transferring means for delivering bottles to the turret mechanism or accepting them from the turret mechanism, lifting and rotating mechanisms for the respective bottle supports, at least one diffused light source for irradiating each of the bottles on the supports, an optical system inserted into one of the bottles, and a control means for converting an optical signal generated at the optical system in response to the existence of foreign particles or substances on the bottles into an electrical signal and transmitting an instruction signal for taking away faulty bottles from the main route to a faulty bottle carryout mechanism. This construction makes it possible to continuously and efficiently inspect a large number of bottles and to automatically select and remove only bottles having foreign particles or substances adhered thereto.

The invention will be more fully understood from the following detailed description of preferred embodiments taken in connection with the accompanying drawings, and its scope will be pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a schematic plan view illustrating a bottle detecting device embodying the present invention;

FIG. 2 is an enlarged plan view of a part of FIG. 1;

FIG. 3 is a vertical sectional view taken along the line III—III of FIG. 2;

FIG. 4 is a vertical sectional view of the turret mechanism in FIG. 1;

FIG. 5 is a plan view of the upper portion of the turret in FIG. 1;

FIG. 6 is a plan view of a part of an alternative form of the turret mechanism;

FIG. 7 is a schematic sectional plan view illustrating the flow of bottles in the turret mechanism;

FIG. 8 is a diagram for explaining the principle of bottle inspection;

FIG. 9 is a horizontal sectional view of a detecting part;

FIG. 10 shows an image of a foreign particle or substance detected by an optical system;

FIG. 11 is a diagram for explaining the function of a reticule;

FIG. 12 is a development view showing the turret mechanism operating in engagement with cams;

FIG. 13 is a perspective view of a driving gear mechanism;

FIG. 14 is a vertical view, partly in section, of an alternative form of the bottle mouth holding mechanism;

FIG. 15 is a vertical view, partly in section, of the lifting mechanism for a bottle mouth holding bracket;

FIG. 16 is a horizontal sectional view taken along the line XVI—XVI of FIG. 15;

FIG. 17 is a vertical view, partly in section, of an alternative form of the bottle support braking mechanism;

FIG. 18 is a plan view of an alternative form of the bottle guide mechanism; and

FIG. 19 is a vertical sectional view taken along the line XIX--XIX of FIG. 18. DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to FIG. 1, the reference character A denotes a device for inspecting bottles according to the invention. Bottles are fed from a bottle washing machine B to the bottle inspecting device A by means of a conveyor C, where faulty bottles containing foreign particles or substances adhere thereto are selected to be removed, while clean bottles are sent to a bottling machine D and automatically bottled.

Referring at first to FIGS. 2 to 3 and FIGS. 8 to 10, the principle of inspecting bottles with a surface formed unevenly or printed, for example, Coca Cola (trademark) bottles will be described. Bottles 1 to be inspected are so arranged as to be rotated and at the same time moved vertically as they are put between bottle supports 2 and bottle mouth holders 3 arranged respectively at regular angular intervals on the outer periphery of a rotary turret so as to face each other in the vertical direction. Inner surface inspecting mirrors 4, which are vertically fixed on the turret, are arranged so as to be removably inserted into the bottles through the bottle mouth holders 3.

The reference numerals 5 denote a plurality of irradiating units, which are fixed along the outer periphery of the turret and each comprises a light source lamp 5*a*, a casing 5*b* for housing the lamp 5*a* and a screen made of opal glass fitted on the front surface of the casing. The light rays emitted from the lamp 5*a* become nonoriented diffused light rays after passing through the screen 5*c*. In order to increase the degree of diffusion of the light rays, a diffusion lens (not shown) may preferably be arranged between each lamp 5*a* and screen 5*c*. Semicylindrical reflecting plates 6 are installed at the positions nearer to the center of the turret than the bottles 1 held by the bottle supports 2 so as to face the irradiating units 5, respectively. Each reflecting plate 6 consists of a conventional mirror coated on its rear side with a metal such as silver or aluminum by vacuum evaporation and a protective layer thereon, and is laminated on its surface with a milk-colored glass having a good diffusing character, such as opal glass, so that the incident light rays on this reflecting plate may be diffusely reflected.

Furthermore, each inner surface inspecting mirror 4 is composed of a prism 4*a* so arranged at the lower end thereof as to face the center of the turret in the angular range of θ, a diaphragm 4*b* arranged close to the prism 4*a* and three lenses 4*c* arranged at a predetermined interval in the vertical direction, and is capable of receiving light rays in the angular range ω, as shown in FIG. 8. The light rays irradiated from the unit 5 and reflected by the reflecting plate 6 are now nonoriented diffused light rays, so that, although the light rays passing the sidewall 1*a* of the bottle 1 having the uneven outer surface are refracted, owing to the uneveness of the surface, like a lens, the light rays falling upon the bottle wall 1*a* are still nonoriented. Thus, the lens action of the bottle wall is eliminated, and the light quantity to be received is uniformly distributed on the inner surface inspecting mirror 4.

Further, although the surface of the wall 1*a* of each bottle 1 is printed with white-colored letters 1*b*, trademarks, or the like, the light shielding effect due to the printed portion 1*b* can be eliminated. For this purpose, the wavelength distribution of light rays irradiated from the irradiating unit 5 is appropriately selected, and the diffusing layer of the reflecting plate 6 has the same white color as the print 1*b* while the reflection factor of the reflecting plate 6 is selected to a proper value. Thereby the sum of the light quantity x, of light rays X falling upon the inner surface inspecting mirror 4 after having been irradiated from the irradiating unit 5, diffusely reflected by reflecting plate 6 and then transmitted through the printed portion 1*b* of the bottle wall 1*a*, and the light quantity y of, light rays Y falling upon the mirror 4 after having been irradiated from the irradiating unit 5 and passed twice through the wall 1*a* of the bottle and reflected on the printed portion 1*b*, is made equal to the light quantity z, of light rays Z falling upon the mirror 4 after having been irradiated from the irradiating unit 5, diffusely reflected by reflecting plate 6 and then passed through the unprinted transparent portion of the bottle wall 1*a*, as shown in FIGS. 8 and 9.

Assuming that L is the brightness of light rays irradiated from the irradiating unit 5, α is the reflection factor of the reflecting plate 6, β is the reflection factor of the printed portion 1*b* on the bottle wall 1*a*, γ is the transmission factor of the printed portion 1*b*, and δ is the transmission factor of the glass of the bottle wall 1*a*, then the light quantity x transmitted through the printed portion 1*b* is:

$$x=L\cdot\alpha\cdot\gamma\cdot\delta\cdot,$$

and the light quantity y reflected on the printed portion 1*b* is:

$$y=L\cdot\delta^{3}\cdot\beta,$$

Moreover, the light quantity z transmitted through the transparent portion without prints is:

$$z=L\delta\cdot$$

$\alpha\cdot\delta$

Accordingly, from the relation $z=x+y$, the reflection factor α of the reflecting plate 6 is given as follows:

$$\alpha=(\delta^{2}\cdot\beta)/(1-\gamma).$$

If a reflecting plate 6 having such a reflection factor α is employed, the influence of light-shielding due to the printed portion on the bottle wall 1*a* can be entirely eliminated.

When foreign particles or substances adhere to the bottle wall 1*a*, the above relation at the printed portion 1*b* no longer holds, and the light quantity received on the inner surface inspecting mirror 4 changes so that the adherence of foreign particles or substances can be detected.

The structure of the bottle inspecting device A will now be explained in detail. In FIG. 4 showing the turret mechanism, a hollow shaft 10 is rotatably in bearings 9 on a stationary central shaft 8 vertically fixed on a foundation 7. Flanges 11, 12 are fitted unitarily on the upper end and the lower end, respectively, of the hollow shaft 10. A ring gear 13 is provided on the outer periphery of the lower flange 12, so that the flanges 11, 12 are rotated about the central shaft 8 by a driving mechanism (not shown) in engagement with the ring gear 13. Vertical guide rods 14, whose opposite ends are fitted in the flanges 11 and 12, are arranged at regular angular intervals, and outer guide rods 15 are fixed in vertical planes passing through the guide rods 14 and the axis of the turret and on a outer circle concentric with the circle on which the rods 14 lie.

On each of the outer guide rods 15, there are slidably fitted and serially arranged a bottle mouth lifting tube 16 and a bottle support lifting tube 17. The lifting tubes 16, 17 are provided with cam followers 18, 19, respectively, which are in engagement with cam slots 20, 21, having the contours shown in the development view of FIG. 12, on the outer periphery of the foundation 7, and move upward and downward with rotation of the turret.

At the upper portion of each bottle mouth lifting tube 16 there is mounted, for relative vertical movement, a bottle mouth bracket 22. A compression spring 25 is interposed between an adjusting member 23, screwed into the lower end of the bracket 22, and a ring 24, fitted on the upper end of the lifting tube 16. A bottle mouth holder 3 is rotatably mounted on the bracket 22 through a bearing 26 so that, when the mouth holder 3 abuts the mouth of the bottle 1 upon downward movement of the bottle mouth lifting tube 16, the bottle mouth bracket 22 together with the bottle mouth holder 3 is displaced upwards with respect to the bottle lifting tube 16 due to the bias of the spring 25, whereby the bottle 1 may be held with an adequate pressure by the bottle mouth holder 3.

On the other hand, at the top of each bottle lifting tube 17 there is fitted a bottle support lifting bracket 27, in which a bottle support lifting rod 29 is rotatably mounted through a bearing 28. A driving pulley 31 is rotatably supported in the lower flange 12 through a bearing 30 and fitted on the splined portion of the bottle support lifting rod 29 so that the rotation of the driving pulley 31 may be transmitted to the bottle support lifting rod 29 independently of the vertical movement of the rod 29.

A brake rotor 32 is fixed on the bottle support lifting rod 29 as one body, and a brake stator 35 is installed on a carrier 33 loosely fitted on the bottle support lifting rod 29 and at the same time biased onto the lower flange 12 through a spring 34, whereby the brake rotor 32, upon downward movement of the rod 29, is pressed against the brake stator 35 so that the bottle support 2 is braked to stop together with the bottle support lifting rod 29.

Furthermore, a bottle guide member 36 is vertically movably along bottle mouth lifting tube 16 and the guide rod 14, and between the bottle mouth bracket 22 and the bottle support bracket 27. A supporting shaft 37 is so formed integral with the bottle guide member 36 as to project downwards therefrom, and is slidably fitted in the bottle support bracket 27. When the bracket 27 takes the lowermost position as shown at the left of FIG. 4, the lower end of the supporting shaft 37 comes into contact with the flange 12 to hold the bottle guide member 36 at a predetermined height, and, when the bottle support bracket 27 takes the uppermost position as shown at the right of FIG. 4, the upper end of the shaft 37 comes into contact with the bottle support bracket 27 to hold the bottle guide member 36 in the raised position.

The irradiating units 5 are mounted on the top of the foundation 7 as shown in FIG. 4 and arranged circumferentially in the range shown in FIG. 7. The reflecting plates 6 are mounted on the outer periphery of a supporting flange 38 secured on the hollow shaft 10 so as to rotate as a unit with the turret mechanism.

In FIG. 7, a screw conveyor 39 is provided along the conveyor C leading to the bottle washing machine B. A bottle infeed star wheel 40 is arranged facing conveyor 39. Across the conveyor C and the flat portion 36*a* of one of the bottle guide members 36 lying at the same height, there is provided an arcuate supporting plate 41, one which a guide wall 42 is provided concentrically with the star wheel 40. The screw conveyor 39 and the star wheel 40 are rotated in synchronism with the rotation of the turret mechanism, whereby the bottles 1 are held one by one with the bottle guide members 36 and at the same time supported on the bottle supports 2.

A bottle outfeed star wheel 43 is provided between the portion of the conveyor C leading to the bottling machine D and the terminal of the turret mechanism. Across the flat portion 36*a* of the bottle guide member 36 and the conveyor C, there is provided a bottle-bottom inspecting device 44 of a known structure. A guide wall 45 similar to the guide wall 42 is also provided. Around the star wheel 43 there are provided suction devices (not shown) which, when foreign particles or substances adhered on bottles 1 are detected by means of the bottle inner surface inspecting device and the bottle-bottom inspecting device 44, carry away the faulty bottles onto an accumulator table 46.

At the same height as the driving pulley 31, there are pivoted a prime mover pulley 47 and guide pulleys 48, 49, 50, 51 on the foundation 7, as shown with chain line. A belt 52 is entrained around the driving pulley 31, the prime mover pulley 47 and the guide pulleys 48, 49, 50, 51, and thus the rotating torque of the pulley 47 is transmitted to the driving pulley 31 along the bottle driving section 53. The extent of the bottle driving section 53 can be adjusted by changing the positions of the guide pulley 48, 51, while the tension of the belt 52 can be adjusted by changing the position of one or both of the guide pulleys 49, 50.

The driving system for the turret mechanism, the screw conveyor 39 and the star wheels 40, 43 will be explained with reference to FIG. 13. In series to the output shaft of an electric motor 54, there are connected reduction gears 55, 56 and 57, and between the latter gears 56 and 57 there is provided a clutch brake 58. A pinion 59 is fixed on the upper end of the output shaft 57*a* of the reduction gear 57 and meshes with the ring gear 13 on the outer periphery of the lower flange 12 of the turret mechanism. Further, a gear 60 is fixed on the output shaft 57*a* of the reduction gear 57 and drives with gears 61, 62, on drive shafts 40*a*, 43*a* of the star wheels 40, 43 through intermediate gears 63, 64, respectively. A bevel gear 65 on the star wheel drive shaft 40*a* is interconnected to the screw conveyor 39 through bevel gears 66, 67, 68, 69 and 70. Thus the star wheels 40, 43 and the screw conveyor 39 are driven in synchronism with the turret mechanism.

The driving pulleys 31 mounted in the turret mechanism are rotated with a speed corresponding to the sum of the speed of the belt 52, driven by the prime mover pulley 47, and the peripheral speed of the rotating turret mechanism so that, in order to rotate the bottles 1 at a constant speed by the driving pulleys 31 independently of the rotating speed of turret mechanism, it is necessary only to provide differential gear unit 71 which drives a prime mover pulley 47 at a speed corresponding to the difference between the speed of the output shaft 56*a* of the reduction gear 56, rotated at a constant speed, and that of the gear 60 intermittently rotated by the clutch brake 58.

Namely, the input bevel gear 71*a* of the differential gear unit 71 is fixed on the output shaft 56*a* of the reduction gear 56, while the output bevel gear 71*b* is fixed on the shaft 47*a* of the prime mover pulley 47. Both planetary bevel gears 71*c* meshed with the input and output bevel gears 71*a*, 71*b* are rotatably mounted in a gear casing 71*d*. A bevel gear 71*e* is mounted fixedly on shaft 47*a* and drives gear 61 of the star wheel 40 through a gear 72.

Next, the shapes of the cam slots 20, 21 for lifting the bottle mouth lifting tubes 16 and the bottle support lifting tubes 17 will be described in connection with FIGS. 7 and 12. The bottle mouth lifting cam slot 20 lies at the lowermost position immediately after the angular position 73 in the plane passing through the axis of the central shaft 8 of the turret and the axis of the star wheel 40 so that the bottle holder 3 depresses the mouth of bottle 1 through the cam follower 18, the bottle mouth lifting tube 16 and the bottle mouth bracket 22. On the other hand, the bottle support lifting slot 21 takes a position slightly higher than its lowermost position so that the bottle support 2 is lifted slightly through the cam follower 19, the bottle support lifting tube 17, the bottle support bracket 27 and the bottle support lifting rod 29. Thus the bottle 1 is tightly held between the mouth holder 3 and the bottle support 2.

Then, after checking whether the bottle - is surely held or not by means of the hold checking mechanism (described hereinafter) at the positions 74, the cam slots 20, 21 ascend in parallel with each other so that the bottle 1 is lifted. The cam slots 20, 21 descend slowly between the beginning position 75 and the end position 76 of a bottle inspecting section 77, and then descend suddenly to a horizontal braking section 78, in which the bottle supports are braked to stop. The bottle mouth lifting cam slot 20 ascends suddenly up to the position 79 in the plane passing through the axis of the central shaft 8 of the turret and the axis of the star wheel 40, while the bottle support lifting cam slot 21 descends slightly. Both cam slots 20, 21 extend horizontally past the position 79, and then upwardly offset. In a predetermined section 80 of the offset route an amplifier checking device, which will be explained later, operates.

To improve the accuracy of detection, the inspecting field ω of the inner surface inspecting mirror 4 is selected small. However, if the area γ of the image 81*a* of a foreign particle or substance 81 shown in FIG. 10 is small with respect to the area S of the entire field of the inner surface inspecting mirror 4, the signal ratio γ/S detected by a light receiving element 82 of the mirror 4 is so small that the foreign particle or substance may not be detected. To cope with this, a reticule 83 as shown in FIGS. 10 and 11 is rotated between each mirror 4 and each light receiving element 82. Thus, if the sectional area S′ of the light flux falling upon the light receiving element 82 is made small, the image 81*a* of the foreign particle or substance 81, upon rotation of the reticule 83, is shielded by the reticule 83 and appears between its legs so that an output signal having the sine wave form as shown in FIG. 11 is generated at the light receiving element 82. Moreover, the signal ratio detected by the light receiving element 82 becomes ($\gamma/S-S'$), that is, larger than the signal ratio (γ/S), and, therefore, the foreign particle or substance can be more surely detected.

Driving mechanisms 84 for the reticules 83 are shown in FIGS. 5 and 8. Pulleys 84*a* carrying the reticules 83 are rotatably supported on the support members 84*b*. Belts 84*e* are each entrained around the large diameter portion of a stepped pulley 84*c* on the top of every other guide rod 15, two of the pulleys 84*a* and a tension pulley 84*d*. Further a belt 84*h* is entrained around the small diameter portions of all the stepped pulleys 84*c* and a pulley 84*g* of on electric motor 84*f* (FIG. 4). All the reticules 83 are simultaneously rotated by the motor 84*f*.

In FIG. 5, each belt 84*e* is entrained around two pulleys 84*a* carrying the reticule. However, it may be entrained around three pulleys 84*a* as shown in FIG. 6.

A hold checking element 85 is provided at the position 74 slightly apart from the position 73 at which the bottle 1 is held, as shown in FIGS. 7 and 12, and a protruding piece 86 is mounted on the upper bracket 22.

When the bottle mouth holder 3 holds the mouth of a bottle 1 at the moment of arrival of bracket 22 at the position 74, the holding of the bottle is confirmed by that the protruding piece 86 comes into abutment on the hold checking element 85. On the contrary, when the bottle mouth holder 3 holds no bottle mouth 1, the bracket 22 is moved by the force of the spring 25 to move away the protruding piece 86 from the hold checking element 85 so that the nonholding of the bottle is detected. Then, the clutch brake 58 in the driving mechanism in FIG. 13 is actuated to stop immediately the turret.

In the hold checking mechanism described above, the switch of the checking element 85 is closed at every passage of the bottle supports 2, but it remains open in the intermediate state so that a complicated discriminator circuit is additionally required.

If the hold checking element 85 is so arranged below the protruding piece 86 that the protruding piece element 85 only when bottle mouth holder 3 is not holding the mouth of a bottle, whereby the checking element 85 generates a signal only in case of incorrect holding of bottle, the circuit construction for hold checking can be very much simplified.

On the top of the turret mechanism there is provided an amplifier unit 87, as shown in FIG. 4, which consists of an amplifier 87*a* connected to the output of a photoelectric element 82, a frequency band-pass amplifier 87*c* connected to the output of the amplifier 87*a* through a condenser 87*b*, an element 87*d*, a Schmitt trigger circuit 87*e* provided with a level for separating noise signals, and a memory circuit 87*f*, as shown in FIG. 8. The frequency band-pass amplifier 87*c* is provided with an amplification factor regulator 88, and the memory circuit 87*f* has a signal transferring element 89. Regulator 88 and element 89 are mounted on a plate 90 comprised by the outer periphery of upper flange 11 of the turret. A rotary transformer 91 is provided at the top of the central shaft 8, as shown in FIG. 4, the primary side thereof being fixed on the central shaft 8, while the secondary side is mounted on the upper flange 11 of the turret and the electric potential for energizing the motor 84*f*, for the reticule, and the amplifier unit 87.

In the amplifier checking section 80 shown in FIG. 12, there is provided an amplifier checking mechanism 92 consisting of a lighting device 92*a* for checking, a very small light shielding piece 92*b* which generates an output responsive to foreign particles or substances on the bottle wall and a very small light shielding piece 92*c* responsive to nonexistence of foreign particles or substances of the bottle wall. When the inner surface inspecting mirror 4 faces the light shielding piece 92*b*, if the amplifier unit 87 operates normally, an output signal appears at the signal transferring element 89, and, if the unit 87 is in trouble, no output signal appears. Further, when the inner surface inspecting mirror 4 faces the very small light shielding piece 92*c*, if the amplifier unit 87 is normal, no output signal 89 appears, and, if the unit 89 is in trouble, an output signal appears. These outputs are discriminated by logic circuits, whereby the operation of the amplifier unit 87 is checked.

A signal receiving mechanism 93 is provided facing the signal transferring plate 90 and adjacent to the very small light shielding piece 92, as shown in FIG. 7. In the lighting section 5′ in which the irradiating units 5 irradiate bottles, the foreign particles or substance 81 on bottles 1 are detected by the inner surface inspecting mirror 4 and the light receiving element 82 so that a signal is transmitted to the signal transferring element 89 and then received by the signal receiving mechanism 93. Thus faulty bottles are selected out by the carryout device for faulty bottles provided at the star wheel 43. A checking signal of the amplifier unit 87 detected by the amplifier checking mechanism 92 is also received to energize an indicator (not shown), whereby nonoperation of the amplifier unit 87 can be immediately informed.

The whole device is brought into operation by starting the motor 54 in FIG. 13 and the motor 84*f* for, reticules, through the rotary transformer 91 in FIG. 4 and energizing the irradiating units 5 and amplifier unit 87.

Upon operation of the infeed star wheel 40 and the screw conveyor 39, bottles 1 are fed one by one to the bottle supports 2 through the flat portions 36*a* of the bottle guide members 36, and each held tightly between the bottle support 2 and bottle mouth holder 3 immediately after the position 73 shown in FIG. 7 and 12. The bottles, after inspection of their holding at the position 74, ascend suddenly while each is being held between a bottle support 2 and a bottle mouth holder 3 and being rotated about its own axis by means of the driving belt 52, and go into the lighting section 5 in which the irradiating units 5 operate.

Then, the wall 1*a* of each bottle 1 is scanned helically from its bottom to its top by means of the inner surface inspecting mirror 4 for detecting foreign particles or substances adhered thereon.

When the foreign particles or substances are detected, an output signal is generated at the light receiving element 83, and is amplified and stored in the amplifier unit 87.

The bottle supports 2, after passing the bottle inspecting section 77, the driving section 53 and the lighting section 5′, are braked in the braking section 78 to stop. The bottles 1 are transferred from the bottle supports 2 and the flat portions 36*a* of the bottle guide members 36 to the bottle bottom inspecting device 44.

The signal, which has been sent from the light receiving element 82 in the bottle 1 held between the bottle supports 2 and the bottle mouth holders 3 and stored in the amplifier unit 87, is transmitted from the turret mechanism by the signal receiving mechanism **93**, so that the faulty bottle is moved away to the table of the accumulator **46** by means of the suction means provided at the outfeed star wheel **43**. The faulty bottle, on whose bottom foreign particles or substances are adhered, is, of course, removed by means of the bottom inspecting device **44**. Clean bottles without foreign particles or substances are transferred onto the conveyor C. On the other hand, when the inner surface inspecting mirror **4** comes to face the amplifier checking mechanism, it checks whether the amplifier unit **87** operates normally or not, and, if the unit **87** is normal, the operation thereof is carried on while if abnormal, the indicating unit (not shown) acts to stop immediately the device, for the inspection of the faulty part.

In the above embodiment, each bottle mouth holder **3** is so mounted through the bearing **26** to the bottle mouth bracket **22** that it can not be moved in the vertical direction with respect to the bottle mouth brackets **22**. However, as shown in FIG. **14**, each bottle mouth holder **3** may be rotatably supported in an inner sleeve **102** through axial bearings **101**, which sleeve is in turn fitted in the bottle mouth bracket **22** through a slide bearing **103** which is also slidable in the axial direction, and compression springs **104**, **105** are interposed between the upper and lower flanges **102***a*, **102***b* of the inner sleeve **102** and the bracket **22**, respectively, whereby the bottle mouth holder **3** is not only movable in the vertical direction but also rotatable.

If the bottle mouth holder **3** is vertically movably mounted in the bracket **22** in the above manner, each bottle mouth bracket **22** may be fixed on the bottle mouth lifting tube **16** as a unit therewith, so that the elastic supporting mechanisms **23**, **24**, **25** in FIG. **4** can be omitted, as shown in FIG. **15**. In this case, the clamping portion **22***a* of the bracket **22** for the bottle mouth lifting tube **16** is split and fastened together by means of bolts and nuts **22***b*, so that the position in the vertical direction of the bottle mouth support **3** may be easily adjusted. This is particularly effective for inspecting bottles having a different height by a single device.

In the embodiment shown in FIGS. **1** to **13**, the brake rotor **32** is mounted on each bottle mouth lifting rod **29** as one body, while the brake stator **35** is mounted on the carrier **33** through interposition of the spring **34**. However a brake rotor **32'** may be slidably fitted on the splined bottle mouth lifting rod **29** and biased downwardly by means of a coil spring **34'** whose upper end engages a carrier **33'** fixed on the rod **29**, as shown in FIG. **17**. Brake shoes **106** may also be provided on the upper surface of the brake stator **35'** and on the lower surface of the brake rotor **32'**.

Further, the bottle support bracket **27** for each support lifting tube **17** may be formed at its mounting portion **27***a* in the shape of a cylinder extending downwards, the portion **27***a* being connected fixedly with the upper end of the bottle support lifting tube **17**. A slide ball bearing **107** is provided between the bottle support bracket **27** and the bottle mouth lifting tube **16**. Further a slide ball bearing **108** is also provided between the bracket **27** and the guide rod **14**. Such a construction permits the bottle supports **2** to move easily and smoothly in the vertical direction.

In place of the massive base portion **36***b* of each bottle guide member **36**, a guide member **109** may be formed with notches **109***a* adapted, for insertion of the bottle support **2**, and slits **109***b* opening thereto, adapted to pass the bottle support bracket **27**, as shown in FIGS. **18** and **19**. Thus, the height of the turret mechanism can be considerably reduced.

What we claim is:

1. A method of inspecting bottles for adherent foreign matter, comprising the steps of directing diffused light rays, from an external light source, laterally through bottles to be inspected; rotating the bottles relative to the light source; diffusely reflecting light rays which have passed through the bottles at locations on the opposite sides of the bottles from the light source; directing the diffused reflected light rays on the bottles; and optically scanning, interiorly of the bottles, the reflected diffused light within the bottles during such rotation.

2. A method of inspecting bottles for adherent foreign matter, comprising the steps of moving the bottles in spaced relation along a path of travel while rotating and axially reciprocating the bottles; during travel of the bottles along the path, directing diffused light rays, from an external source of light, laterally through the bottles to be inspected; simultaneously optically scanning, interiorly of the bottles, the diffused light within the bottles during such rotation and axial reciprocation to provide optical output signals corresponding to the scanned diffused light within the bottles; converting the optical output signals into electrical signals; responsive to the electrical signals, separating bottles having adherent foreign matter from bottles free of adherent foreign matter; diffusely reflecting light rays which have passed through the bottles from locations on the sides of the bottles opposite the light source; directing the reflected diffused light rays on the bottles; and optically scanning the reflected diffused light within the bottles.

3. Apparatus for inspecting bottles for adherent foreign matter, comprising, in combination, at least one external light source; means operable to direct diffused light rays from said source laterally through the bottles to be inspected; at least one optical system insertable into the bottles to optically scan, interiorly of the bottles, the diffused light within the bottles; driving mechanism operable to effect relative rotation of said bottles and said optical system during such optical scanning; and reflecting means positioned on the sides of said bottles opposite said light source and operable to diffusely reflect light rays, which have passed through the bottles, on the bottles; said optical system scanning the reflected diffused light within the bottles.