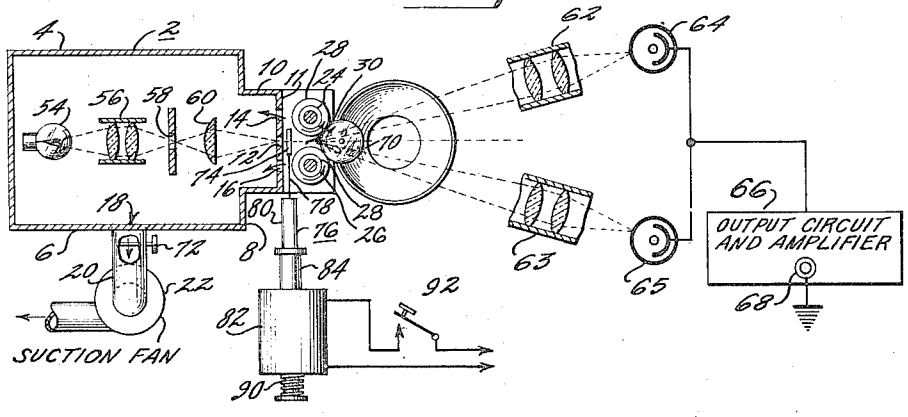
Nov. 28, 1950 J. F. PRICE 2,531,529

INSPECTION APPARATUS AND METHOD

Filed Sept. 30, 1949

Fig. 1



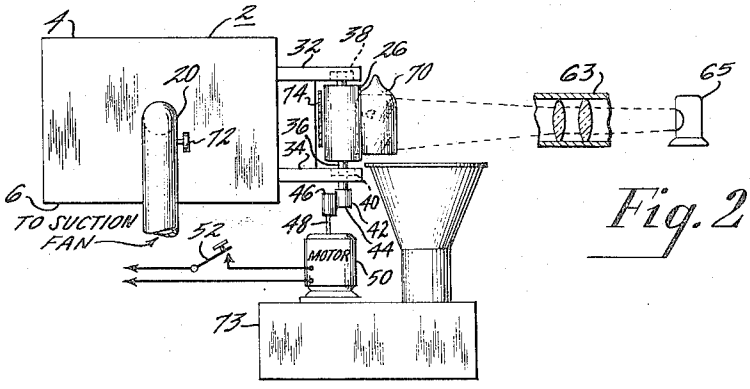


Fig. 2

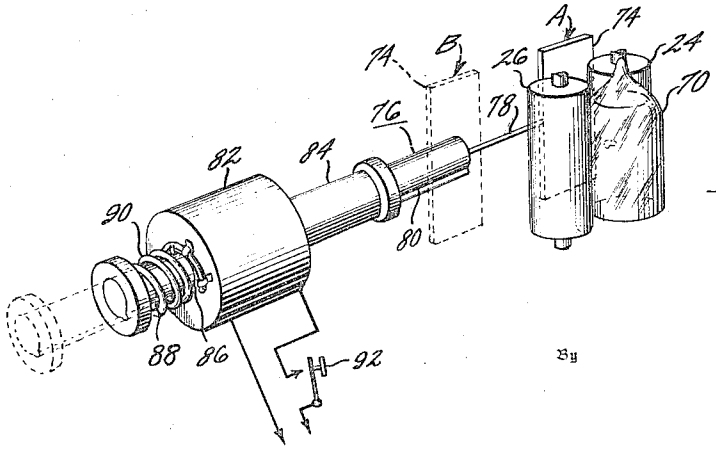


Fig. 3

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INSPECTION APPARATUS AND METHOD

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11 Claims. (Cl. 250—218)

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This invention relates to an improved method of and apparatus for inspecting the contents of light transmitting liquid-filled containers, such as medical ampules. More particularly, the invention relates to improvements in the general method and apparatus described and claimed in co-pending application, Serial No. 95,818, filed May 27, 1949, of E. W. Kellogg et al., although not limited to the particular form of apparatus described therein.

Serums and other liquids intended for therapeutic use are frequently packaged in small, hermetically sealed, substantially cylindrical containers made of glass or other transparent materials. It is usually necessary that the contents be of a high degree of purity and free of any suspended particles large enough to be visible to the unaided eye. However, in the processes of manufacturing many of these medicinals, many mechanical handling steps, such as filtration, are utilized. During these handling steps, foreign matter may be inadvertently introduced into the medicinal. Containers which contain any of this foreign matter must be discarded. The foreign matter may include tiny particles which have a specific gravity less than that of the liquid and which, therefore, float on the surface, and also particles having a specific gravity greater than that of the liquid, which latter kind tend to sink to the bottom.

The method and apparatus described in the above referred to copending application is satisfactory when the specific gravity of the foreign matter is either substantially equal to or less than that of the liquid contents of the container. However, it sometimes happens that the likelihood is present of introducing particles having a specific gravity considerably greater than that of the liquid. For reasons, which will be more apparent later, the method and apparatus of the present invention especially constitute an improvement in inspecting fluids which may contain the denser type of particle.

In general, the improved method of the present invention comprises rapidly rotating the fluid contents of a light transmitting container, whereby a vortex is incidentally caused to form, permitting the velocity of rotation of the fluid to diminish gradually, and inspecting only the lower portion of the fluid contents while it is still rotating but while the vortex is becoming shorter due to the diminishing speed of rotation. When the rotational speed has decreased to the point where no vortex is present, the entire fluid contents are inspected to determine the presence of particles

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which may be suspended or floating on the surface of the liquid. The invention also includes apparatus for carrying out the improved method.

One object of the present invention is to provide an improved apparatus for electronically inspecting the contents of individual, light transmitting, liquid-filled containers.

Another object of the invention is to provide an improved method of electronically inspecting the contents of a light transmitting, liquid-filled container.

Another object of the invention is to provide an improved method and apparatus especially adapted for inspecting the contents of liquid-filled containers of relatively small size.

Another object of the invention is to provide an improved method and apparatus for inspecting the contents of relatively small, liquid-filled light transmitting containers while the contents are rapidly whirling within the container.

A further object of the invention is to provide an improved method and apparatus for inspecting the fluid contents of a light-transmitting liquid-filled container for the presence of particles having a specific gravity greater than that of the liquid in the container.

These and other objects will be more apparent and the invention will be better understood with reference to the following description and the accompanying drawings, of which:

Figure 1 is a plan view, partly in section and partly diagrammatic, of the essential parts of an apparatus which may be used to perform the method of the present invention,

Figure 2 is an elevation view of part of the apparatus of Figure 1, and

Figure 3 is a detail end view of part of the apparatus of Figure 1 or 2.

Patent No. 2,132,447, of George Philip Stout, describes a method of and apparatus for inspecting the liquid contents of a bottle, the method including holding the bottle between rotatable chucks, rapidly spinning the bottle and its contents, suddenly stopping the rotation of the bottle and, immediately thereafter, photoelectrically inspecting the contents of the bottle while the liquid is still rotating but while the bottle is stationary. A beam of light is focused at a plane cutting through the bottle vertically and the light is directed through the bottle to a photoelectric cell on the other side. Any particle of contaminating matter suspended in the liquid moves rapidly back and forth through the light beam due to the whirling motion of the liquid and a signal is produced in the output circuit of the

photocell due to intermittent interruption of the passage of part of the light. The characteristics of the container, itself, do not influence the results of the inspection since the bottle is stationary during the inspection period and since the inspection apparatus responds only to intermittent interruption of the light beam.

In the previously mentioned copending application of E. W. Kellogg et al., there was disclosed and claimed a method and apparatus especially adapted to the inspection of the contents of relatively small, fragile ampules such as used for medicinals, which method and apparatus was an improvement on the method and apparatus described in the above referred to Stout patent. The invention described in the Kellogg et al., application includes particular apparatus for spinning a small cylindrically shaped ampule. This apparatus comprises a pair of driven rollers and means for holding the ampule thereagainst by the application of a pressure differential, or suction. Although the present invention does not depend upon the use of the particular apparatus described in the said copending application, it can be conveniently described and illustrated in connection with the type of apparatus therein disclosed.

Referring now to Figure 1, a preferred form of apparatus for carrying out the principles of the present invention may include a vacuum chest 2 of any suitable material such as sheet metal. This chest has a box-like portion 4, having sides, back, bottom and top walls 6, all of generally square or rectangular outline. The front wall 8 of the chest is provided with a protruding bay 10. The front wall 11 of the bay is provided with an opening 12 in the form of a narrow slit and may also be provided with additional openings 14 and 16, positioned on either side of the central opening.

One of the sidewalls is provided with an opening 18 leading to a conduit 20, which is connected to means 22 for creating a reduced pressure within the chest. The means for creating the reduced pressure may be any device, such as a suction or exhaust fan, which is adapted to produce a low vacuum.

Two cylindrically shaped rollers 24 and 26, having outer surfaces 28 of a resilient material, such as rubber, are mounted on the front of the bay 10 such that one is positioned on either side of the central opening 12. An opening 30 is provided between the rollers, the opening having a width approximately equal to that of the central opening 12. As more particularly illustrated in Figure 2, the rollers are rotatably mounted between a top bracket 32 and a bottom bracket 34 which may be mounted on the top and bottom walls, respectively, of the bay 10. The rollers are spaced a short distance from the front wall 11 of the bay and each roller is provided with an axle 36 which rotates within top and bottom ball bearings 38 and 40, carried by the top and bottom mounting brackets 32 and 34, respectively.

A light source and optical system are provided within the vacuum chest. The light source may be a lamp 54 mounted adjacent the end of the chest opposite the bay 10. Between the light source and the central slit 12, which serves to define the light beam, is an optical system comprising a set of condensing lenses 56, another optical slit 58, and a cylindrical lens 60, which system is for the purpose of focusing the beam of light from the light source at a plane just beyond the opening between the rollers.

The light which is thus focused is directed through the container 70 being inspected, the container being held in frictional contact with the rollers 24 and 26.

The remainder of the complete optical system preferably comprises two more similar sets of lenses 62 and 63, positioned beyond the rollers outside the vacuum chest. Each set of lenses is positioned outside the direct beam emerging from the container 70 so that direct light from this beam does not enter the lenses. Beyond each set of lenses 62 and 63 at or near their respective focal points are positioned photocells 64 and 65, respectively. The anodes of these photocells are connected in parallel and the common output is provided with a conventional output circuit 66, including an amplifier. The common output circuit is also connected to an indicating device 68 such as a signal light or buzzer. It is preferable, of course, to shield the photocell from the effects of stray light and spurious reflections.

In accordance with the present invention, and as illustrated in Figures 1 and 3, means are also provided for shielding all but about the lower one-third portion of the contents of the container 70 being inspected, during part of the inspection cycle. This means may comprise a vane 74, positioned between the front wall 11 of the bay 10 and the rollers 24 and 26. The vane is spaced from the wall of the bay and from the rollers. The vane is mounted at the end of a plunger 76 which may have a thin rod portion 78, adjacent the vane 74, and a thickened portion 80 adapted to reciprocate within a solenoid 82. A sleeve 84 is provided to guide the movement of the vane and the sleeve may be provided with a keyway 86 adapted to receive a key portion 88 of the plunger to prevent rotation of the plunger and the vane. A spring 90 is provided to bias the plunger to an extended position such that the vane is in the path of the light beam directed through the central opening 12 in the vacuum chest 2 when no current is flowing in the solenoid. This is the position indicated at A in Figure 3. When current flows in the solenoid, the plunger 76 is retracted against the biassing force of the spring 90 and the vane is withdrawn to position B, thus no longer being in the path of the inspection beam. A key 92 may be provided for manually operating the solenoid and plunger, as will be more fully explained later.

Referring now to Figure 2, means is also provided for rapidly rotating the container, the contents of which are being inspected. Each of the rollers 24 and 26 has an axle 36 extending downward through the bottom bearings 40. Each axle has a downwardly protruding portion 42 extending beyond the lower mounting bracket. Each of the protruding portions is provided with a thickened sleeve 44. Bearing against both sleeves is a rubber tired driving wheel 46, which is rotated by means of a shaft 48 driven by a motor 50. The motor is connected to a power source (not shown) and may be turned on and off by means of a key or switch 52. The motor is preferably a universal type having brushes and commutator. Since the driven parts are relatively light in weight and fit tightly, their motion can be started and stopped relatively abruptly.

The method of carrying out the process of the present invention is as follows. An ampule 70,

containing liquid which is to be inspected for the presence of foreign matter, is placed in frictional contact with the resilient outer walls of the rollers 24 and 26 such that the ampule extends across the opening 12 between the rollers. At the same time, the suction means is placed in operation such that there is a suction of about 0.5 to 1 ounce per square inch at the opening between the rollers. Since there is a lowered air pressure just within the opening between the rollers, the ampule is held in position against the rollers by the relatively higher outside atmospheric pressure pressing against the ampule. The openings 14 and 16 in the front wall of the bay 10, which are positioned on either side of the central optical slit 12 enable a larger volume of air to be drawn through the vacuum chest. The differential in air pressure may also be said to increase the frictional contact between the ampule and the rollers so that the ampule is held firmly against the rollers. The rollers are then spun rapidly for a short period of time. This is accomplished by closing the motor switch 52. Spinning the rollers also causes the ampule and its contents to rotate rapidly. The rotation of the rollers is then abruptly stopped by opening the motor switch 52 and causing the motor 50 to stop. This, of course, causes the rotation of the ampule to be suddenly halted, but the liquid content continues to whirl for a time due to its own inertia. At this instant, no current is flowing in the solenoid 82 and the vane is held in position A across the central opening 12 by the pulling force of the spring 90 on the plunger 76. The light source 54 is turned on and a light beam would ordinarily be focused on the entire length of the ampule if it were not for the presence of the vane. However, the vane cuts off all light to about the upper two-thirds portion of the liquid content of the ampule, permitting light to pass through about the lower one-third portion of the content, only.

During this interval which is the beginning of the inspection period, the inspection system comprising the photocells and their output circuits and indicating means is in operational condition. If a particle of foreign matter is suspended in the liquid near the bottom of the container in that portion not masked by the vanes 74, the movement of the particle back and forth across the light beam will cause a signal to be generated in the output circuit of the photocell. The output circuit must, of course, be set to amplify changes in the intensity of the light beam rather than a steady condition. Since the lens systems 62 and 63 which focus light on photocells 64 and 65 are not in the direct path of the light beam emerging from the container 70, no light will be directed to these lens systems and to the photocells unless a particle of foreign matter is present in that part of the liquid being inspected. The presence of a foreign particle, however, will cause flashes of light to be reflected or refracted at an angle to the axis of the direct beam and these flashes will be directed through either or both of the lens systems to the respective photocells. The angle which has been found most suitable for the positioning of the lens system is about 15° with respect to the axis of the direct beam. Although the containers which can be inspected differ in diameter and although the filled container, itself, acts as part of the optical system to focus the inspection beam, the 15° angle has been found generally suitable. In general, the angle should be just large enough so that no direct light from the beam will strike the photocells. This, of course, is understood to be a preferred form of the apparatus. With less satisfactory results because of lower sensitivity, a lens system and a single photocell can be placed directly in the path of the inspection beam.

During the above described part of the inspection process, larger size foreign particles will be detected which have a specific gravity relatively greater than that of the liquid contained in the ampule. Particles of this type dive rapidly to the bottom as soon as the rotation of the ampule is halted and the rotation of the contents begins to slow down. During this period the contents of the upper part of the ampule cannot be inspected because of the vortex which is normally present in any liquid whirling rapidly. The vortex, of course, gradually disappears as the rotational velocity decreases and, naturally, disappears from the bottom portion first. If the inspection period is not begun until the vortex has completely disappeared, in those ampules having a capacity of, say, 5 to 10 cc., the relatively large and dense particles will have already dropped to the bottom of the container and, since their motion is stopped thereby, will not be detected by the inspection process.

The inspection process continues after the vortex has disappeared completely, by deactivating the output circuit of the photocell, removing the vane completely from across the central opening, and then reactivating the output circuit and inspecting the entire contents of the container.

The vane is moved to position B, out of the path of the inspection beam, by closing the solenoid switch 92, which activates the solenoid and retracts the plunger 76 having the vane mounted thereon.

If a foreign particle of sufficient size is detected during either of the two inspection periods, the signal generated in the output circuit of the photocell is amplified and may be made to operate a suitable indicating means to indicate that the container should be rejected. The indicating means may be a signal light or buzzer 68 or may be an automatic separating device of conventional design which directs all "passed" containers to one receptacle and all "rejects" to another.

After the end of the inspection period, the suction may be released either by stopping the operation of the suction device or by closing a valve 72 in the suction conduit 20. The container will then drop away from the rollers into any receptacle 73 provided to receive it.

Although the system which has been described is one in which an operator is required to operate switches during different steps in the cycle, it is obvious that the entire process may be carried out automatically. Any conventional mechanical or electronic timer may be set to operate suitable relays closing and opening the switches at the proper times and all that the operator need do is place each container against the rollers in succession and trip a switch starting the complete process. Whether automatically or manually operated, there has been described an improved process of inspecting the fluid contents of light transmitting containers as well as improved aparatus which may be used for carrying out the process.

I claim as my invention:

1. A method of inspecting the fluid contents of a light transmitting container, comprising rotat-

ing said fluid rapidly while simultaneously examining said fluid by, first, passing a beam of radiant energy through the lower portion, only, of said fluid, then passing radiant energy through both upper and lower portions of said fluid, and detecting abrupt changes in the intensity of said energy.

2. A method of inspecting the liquid contents of a light transmitting container, comprising rotating said liquid rapidly whereby a vortex forms in the upper portion thereof, and, while said liquid is rotating, examining said fluid by, first, passing a beam of radiant energy through the lower portion, only, of said fluid below said vortex, then, after the disappearance of said vortex, passing radiant energy through both upper and lower portions of said liquid, and detecting changes in the intensity of said energy.

3. A method of inspecting the fluid contents of a light transmitting container, comprising rotating said fluid rapidly, passing a beam of radiant energy through the lower portion, only, of said fluid and onto a radiant energy responsive means, and then passing radiant energy through both upper and lower portions of said fluid and onto a radiant energy responsive means.

4. A method of inspecting the fluid contents of a light transmitting container comprising rapidly rotating the container and its contents, abruptly halting the rotation of the container while the contents remain in rotation, and, while said contents are rotating, first, passing a beam of radiant energy through the lower portion, only, of said fluid, then passing radiant energy through both upper and lower portions of said fluid and detecting abrupt changes in the intensity of said energy.

5. A method of inspecting the fluid contents of a light transmitting container comprising rapidly rotating the container and its contents, abruptly halting the rotation of the container while the contents remain in rotation and then, while said contents are rotating, photoelectrically inspecting the lower portion of said contents before inspecting the upper portion thereof.

6. A method of inspecting the fluid contents of a light transmitting container, comprising rotating said fluid rapidly at a predetermined velocity, permitting the velocity of rotation to decrease gradually and photoelectrically inspecting the lower portion of said fluid before inspecting the upper portion thereof.

7. In apparatus for inspecting the fluid contents of a light transmitting container, which apparatus includes means for rapidly rotating said container and its contents, whereby a vortex is formed in the upper portion of said contents, means for halting the rotation of said container while said contents remain in rotation, means for passing a beam of radiant energy through said contents while said contents are rotating and said vortex is present, and photoelectric means positioned in the path of said beam for detecting changes in the intensity thereof after it has passed through said contents, the combination of means for temporarily cutting off only that part of said beam which strikes said upper portion of said contents including said vortex.

8. In apparatus for inspecting the fluid contents of a light transmitting container, which apparatus includes means for rapidly rotating said container and its contents, whereby a vortex is formed, means for abruptly halting the rotation of said container, means for passing a beam of radiant energy through said contents while said contents are still rotating and said vortex is present, and photoelectric means for detecting changes in the intensity of said beam after it has passed through said contents, the combination of means for cutting off only that portion of said beam which strikes the upper portion of said contents including said vortex, means for photoelectrically inspecting said contents while said upper portion of said beam is cut off, and means for subsequently inspecting all of said contents after said vortex has disappeared.

9. Apparatus for inspecting the fluid contents of a light transmitting container comprising means for directing a beam of light energy to said contents, means for rotating said contents, retractile means for preventing light in said beam for striking the upper portion of said contents, and means for detecting changes in the intensity of light in said beam after passing through said contents.

10. Apparatus for inspecting the fluid contents of a light transmitting container for the presence of foreign particles comprising means for directing a beam of light energy to said contents, means for rotating said contents, retractile means for preventing light in said beam from striking the upper portion of said contents, and means for detecting changes in the intensity of light in said beam which has impinged upon one of said foreign particles.

11. Apparatus for inspecting the fluid contents of a light transmitting container comprising means for directing a beam of light energy to said contents, means for rotating said contents, a light opaque vane, means for positioning said vane in the path of that part of said beam directed to the upper portion of said contents, means for withdrawing said vane from the path of said beam, and means for detecting changes in the intensity of light in said beam which has passed through said contents.

JAMES F. PRICE.

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