APPARATUS FOR AUTOMATICALLY DISTRIBUTING A DETERMINED AMOUNT OF LIQUID

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ABSTRACT

An apparatus for automatically distributing a determined amount of liquid in which a plate is pressed against a part of a tube made of flexible and resilient material along a certain length thereof to eject air in the pressed part of the tube. The plate is moved away from the tube with a pipette provided at the tube end being kept inserted into liquid in a liquid supply container to admit into the pipette the same amount of liquid as the ejected air. Then, under this condition, the pipette is inserted into a test tube and the plate is again pressed against the part of the tube to dispense the liquid in the pipette into the test tube.

4 Claims, 2 Drawing Figures
APPARATUS FOR AUTOMATICALLY DISTRIBUTING A DETERMINED AMOUNT OF LIQUID

BACKGROUND OF THE INVENTION

This invention relates to an apparatus for automatically distributing a determined amount of liquid into every one of a plurality of containers, and more particularly, to an apparatus in which a tube of flexible and resilient material is pressed along a predetermined length thereof and then released to admit liquid into the tube to distribute a determined amount of liquid into every one of a plurality of test tubes or the like.

There often arises a necessity of distributing, for instance, a determined amount of liquid medicine in a flask into every one of a plurality of test tubes or the like. However, it is usually very troublesome and time-consuming to supply such liquid medicine intermittently, and none of the known systems has been satisfactory in the accuracy of the amount supplied, the distributing speed and the responsiveness of the apparatus.

SUMMARY OF THE INVENTION

The present invention is a proposal to overcome the above-mentioned problems of the prior art, and a primary object is to provide an apparatus for automatically distributing a determined amount of liquid in which a part of a tube made of a flexible and resilient material is pressed and then released so as to admit a determined amount of liquid into the tube. Thereafter the tube is pressed again to discharge the liquid.

Another object of the present invention is to provide an apparatus of the type described in which a pipette is securely attached to the end of the tube and the pipette is moved between a flask and one of the test tubes to suck up liquid from the flask into the pipette and discharge it into test tubes to thereby effect intermittently transfer of liquid between the flask and the test tubes.

Still another object of the present invention is to provide an apparatus of the described type in which a push plate for pressing the tube along a predetermined length thereof is operated by a suitable drive so as to admit liquid into or eject it from the tube through a pipette provided at the end of the tube.

Still another object of the present invention is to provide an apparatus in which the liquid delivered is controlled by adjusting the inner diameter of the tube through the increase or decrease of the tube tension.

BRIEF DESCRIPTION OF THE DRAWINGS

Novel features and advantages of the present invention in addition to those mentioned above will become apparent to those skilled in the art from a reading of the following detailed description in conjunction with the accompanying drawings wherein similar reference characters refer to similar parts and in which:

FIG. 1 is a longitudinally sectional side elevation of an apparatus for automatically distributing a determined amount of liquid, according to the present invention; and

FIG. 2 is a plan view of the test tube mechanism of the apparatus of FIG. 1, with some parts shown in section.

DETAILED DESCRIPTION OF THE INVENTION

Referring in more particularity to the drawing, a fixed transparent flat plate I of plastic is partly punched to form circular holes Ho and Ho'. A flexible plastic tube T, comprising the primary portion of a pump, is fixed to the flat plastic plate I in contact therewith by fittings J, J and J'. The tube T has fins H and H so that tension may be imparted to the tube T as the end portion K of a lever K moves against the fin H. The fitting J' abuts the fin H to thereby prevent that end of the tube from moving with the other end of the tube when the lever K is manipulated. The lever K is arranged to swing about a fixed pivot P in accordance with forward or backward movement of a screw type manipulator N threaded through a threaded hole formed in a fixed plate O. The purpose of the lever K is to stretch or contract the flexible tube T to reduce or enlarge the inner diameter thereof to thereby adjust the amount of liquid drawn into or discharged out of the tube.

The tube T extends upward through the hole Ho' in the plastic plate I and then curves in the form of S above the plastic plate, as shown in the drawing. Tube T connects with a fine metal tube T'. The fine metal tube T' passes through the fixed metal fittings Me1, Me2 where it is horizontally supported. The end portion of the tube T' on the downstream side thereof is bent downwardly at a right angle, and a plastic pipette P is exchangeably inserted into the lowermost end of the downwardly bent portion of the tube T'.

The upper end portion of an upstream blocking means P1 terminates at a relatively obtuse-angled edge adapted to intersect at right angles with the horizontal portion of the tube T. The blocking means P1 is pulled downwardly, through a pin G3 provided inside thereof, an arm B3 and a pin G2, and a spring Sp1 fixed at its lower end by a fixing member Q to normally hold the blocking means P1 at an inoperative position relative to the tube T.

A lever B3 pivotted by a fixed pin G3 is connected at one end to the arm B3 by the pin G2 at the other end to a shaft S1 through a pin G1 and a wire W.

The shaft S1 extends downward through a fixed metal support M1, with the intermediate portion of the shaft passing through and being fixed to an iron core F1 in a solenoid coil C1. The solenoid coil C1 is fixed and arranged in such a manner that when energized it pulls the core F1 downwardly. As the core F1 moves in a downward direction, the shaft S1 is also pulled downwardly thereby pulling the pin G1. Downward movement of the pin G1 pushes the upstream blocking means P1 to its operative position so as to squeeze the tube T.

In order to avoid rapid movement of the core F1 upon activation of the solenoid coil C1, an oil damper D1 is associated with the shaft S1, the oil damper being filled with buffer oil to offer resistance to movement of piston d1 secured to the shaft S1. Packings R1 are provided for preventing oil leakage.

A push plate P2 has a flat top face of predetermined length and is arranged to press and squeeze the tube T against the horizontal flat plate I along the entire length of the flat top face of the push plate P2. The mechanism for operating the push plate P2 is substantially the same as that for operating the blocking means P1, while the former has two solenoids, both of which are energized or de-energized simultaneously to move the push plate
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P₁ up or down, respectively. An auxiliary push plate P₂ provided downstream from the push plate P₁ is substantially the same as the plate P₁ in both structure and operation, except that the former is moved by one solenoid rather than two.

The metal tube T₁ has a fin connected to a T-shaped lever B₂ by a pin G₂' inserted through an elongated hole formed in the fin. The lever B₂ is swingable about a fixed pin G₂' to move the metal tube T₁ horizontally by a spring-solenoid combination similar to that used in connection with the upstream blocking means P₁. That is, as apparent from the drawing, the pipette P stays above the test tube t₁ when the solenoid coil is de-energized, but when the coil is energized, the pipette P is moved to a location immediately above a liquid supply container FL supported on a stand U fixedly mounted atop a shaft S₃ which extends through a fixed metal support M₂. The shaft S₃ is directly connected to an iron core F₃ of a solenoid coil C₃. The shaft S₃ further extends from the core F₃ into an oil damper P₃. A spring S₃ is fixed at its lower end to a fixing member Q₃ and is joined at a point V₃ to the stand U to always pull it downwardly. In the thus arranged mechanism, the stand U is forced upwards when the coil C₃ is energized.

A disc-shaped turntable Ta is shown in section in the drawing. This turntable Ta is so designed that a plurality of test tubes may be placed erect along the circumference of the table. The turntable Ta is connected to a ratchet Ra through a shaft S₅ so that the turntable is rotatable around the shaft S₅ supported on a fixed base plate Ba. The turntable moves intermittently by amount equal to the distance from one test tube receiving station to the next with one motion of the ratchet Ra.

The solenoid coil C₄ functions to move the piston S₄ vertically to push up one of the test tubes t₁. It is essential for this purpose that, when the solenoid coil is de-energized, the top end of the piston S₄ extends through a hole provided in the base plate Ba and stays flush with the upper surface of the plate Ba. Arrangement is also made in such a manner that the piston S₄, when operated, pushes the test tube upwardly to the optimum position for the test tube to receive liquid from the pipette P.

FIG. 2 is a plan view of the right half portion of the turntable Ta for feeding the test tubes together with the left half portion of the driving structure therefor.

The liquid supply container FL is supported on the stand U as described above in conjunction with FIG. 1. The ratchet Ra has teeth equal in number to the holes formed in the turntable for holding the test tubes erect therein and is adapted to turn the turntable Ta via the shaft S₅ intermittently through the distance from one hole to another at each movement. A pawl X engages the ratchet Ra and the pawl is located at one end of a spring Y secured at its other end to a block Z so that the ratchet is held securely at a determined position after every motion thereof. A lever Xₐ having a pawl S for driving the ratchet Ra is pivotally mounted by a pin G₅ on a bar B₅ normally pulled by a spring S₅ fixed at its end opposite to the bar side. The bar B₅ is retained in the position shown in the drawing in contact with an end of a screw S₅ threaded through a fixed block Z₁. Thus, when the solenoid coil C₅ is energized, the iron core F₅ is attracted into the coil to pull the bar B₅ toward the coil through a bar B₅', a pin G₅', a bar B₅', and a pin G₅'. The bar B₅ swings about the shaft S₅ until it engages the end of a screw S₅ threaded through a block Z₅. At this position, the pawl S at the end of the lever Xₐ is allowed to advance over one tooth of the ratchet Ra and is then fitted between the one tooth and the next tooth by the action of a spring S₆. When the coil C₅ is de-energized, the bar B₅ is returned to its original position by the action of spring S₆, and, accordingly, the lever Xₐ pushes the engaged tooth of the ratchet Ra which allows it to turn with the turntable in the direction of the arrow of FIG. 2 through a distance sufficient to bring the next piece of test tube to the position below the pipette P.

In the operation of the thus arranged apparatus, first a plurality of test tubes t₁, t₂, t₃, etc., are set erect on the turntable as shown in FIG. 2. Then sample liquid is put into the flask FL and the pipetting operation is performed automatically to pour a predetermined amount of the liquid in the flask FL into every one of the test tubes. The pipetting operation is described in detail below.

For effecting the operation, electric current is supplied to or cut-off from the respective solenoid coils in given sequence, and such electric current may be controlled by a cam and limit switch mechanism. The upstream blocking means P₁ is kept in its operative position to block the tube T throughout the operation of the apparatus. To this end, an electric current is kept applied to the solenoid coil C₁ through a separate switch throughout the operation.

Then, electric current is supplied to the respective coils associated with the push plate P₁ and tube T₁ which together constitute the liquid dispensing mechanism. The plate P₁ is raised up while the pipette P is moved to a location right above the flask FL. Then the flask FL is raised up so that the end of the pipette P is submerged in the liquid in the flask. Thereafter, the push plate P₁ is moved downwardly to its inoperative position to thereby suck a determined amount of liquid into the pipette P. The flask FL is then moved down to its original position and the pipette P is moved back to its position above the test tube t₁. Then the shaft S₄ is raised up to push up the test tube t₁, so that the end of the pipette P is inserted into the test tube t₁. Thereafter, the push plate P₁ is again actuated to press the tube T to discharge the liquid in the pipette P into the test tube t₁. Then the auxiliary push plate P₃ is also brought into its operative position to squeeze the tube T to ensure perfect discharge of liquid in the pipette P. The shaft S₅ is then lowered to bring the test tube t₁ down to its original position.

Upon completion of the above-mentioned operation, an electric current is applied to the coil C₃ and then cut-off so as to effect one motion of the ratchet Ra for bringing the next test tube t₂ to the position of t₁ on the turntable. This is followed by movement of the push plate P₃ and auxiliary push plate P₂ to their respective inoperative positions, thus completing one cycle of operation.

With repetition of such cycle of operation, the liquid in the flask FL is distributed accurately in a predetermined amount into every one of the test tubes. For energizing or deenergizing all of the coils in the above-mentioned sequence and at suitable time intervals for accomplishing the above-mentioned operation, it is possible to use a usual interrupter composed of a cam and switch combination, as is well known.
What is claimed is:

1. An apparatus for automatically distributing a predetermined amount of liquid from a liquid supply container into each one of a plurality of containers comprising in combination: a tube made of flexible and resilient material and disposed along a flat plate, an end-opened pipette connected to the downstream end of the tube, upstream blocking means closing the tube, a primary push plate between the pipette and the upstream blocking means arranged to reciprocate between an operative position where the push plate presses a section of the tube against the flat plate and an inoperative position where the push plate is away from the tube which allows the tube to return to its original shape, an auxiliary push plate adjacent the primary push plate constructed and arranged to squeeze the tube after the primary push plate moves to its operative position to ensure discharge of the liquid in the pipette, and driving means for moving the pipette between the liquid supply container and the plurality of containers into which the liquid in the supply container is to be distributed.

2. An apparatus as in claim 1 wherein the connection of the pipette to the flexible and resilient tube includes a stiff tube slidably disposed between the pipette and the flexible tube, the flexible tube being disposed horizontally along the flat plate and the lower end of the pipette being open, and wherein the driving means is also connected to move the metal tube in a longitudinal direction whereby the liquid supply container and one of the plurality of containers into which the liquid in the supply container is to be distributed are alternatively moved up and down at predetermined intervals in the vertical direction immediately below the pipette.

3. An apparatus as in claim 1 wherein the flexible and resilient tube is fixedly secured to the flat plate at a portion of the tube, and means for adjusting the length of the tube by stretching that tube portion.

4. An apparatus as in claim 2 wherein the plurality of containers into which the liquid is to be distributed are arranged annularly along the circumference of a turntable so as to be disposed immediately below the pipette one after another, and support means for the container disposed immediately below said pipette for elevating the container at that location.