Jan. 7, 1969 W. H. MARLOW ET AL 3,420,282

LIQUID FILLING MACHINE

Filed June 2, 1966 Sheet 1 of 2

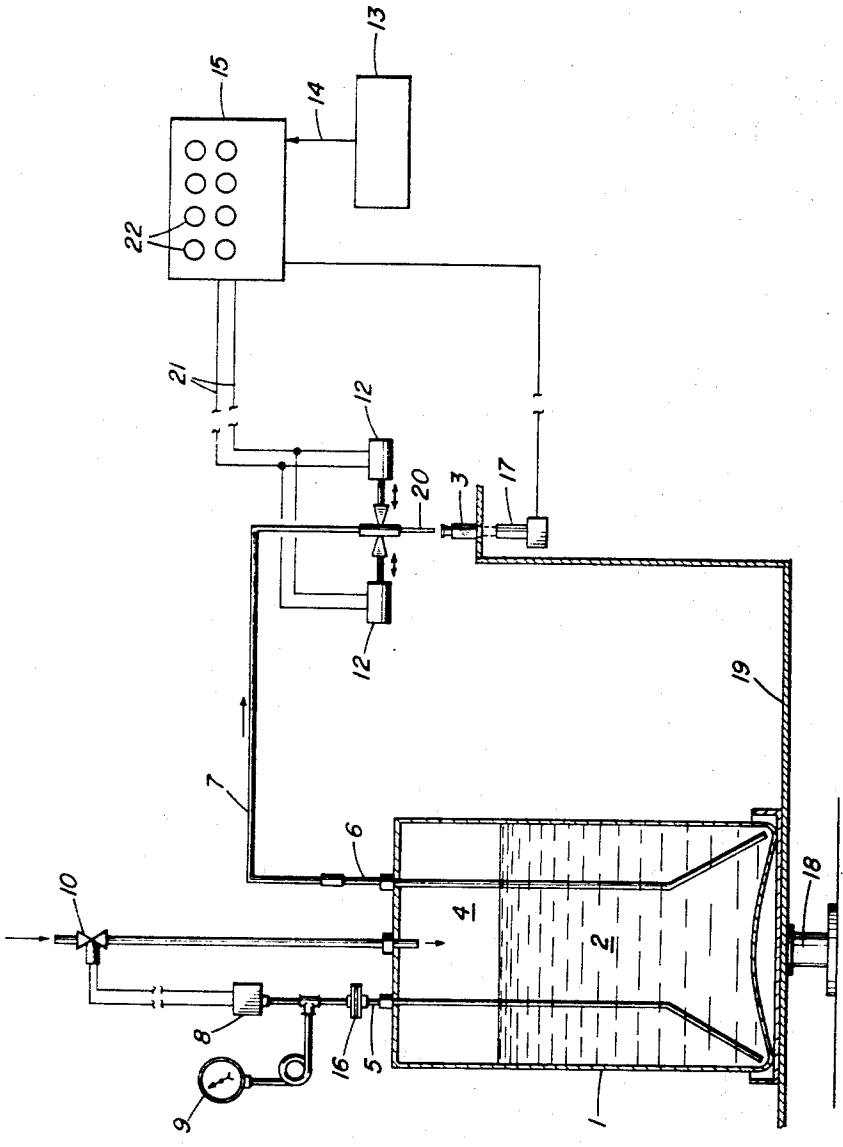


FIG-1

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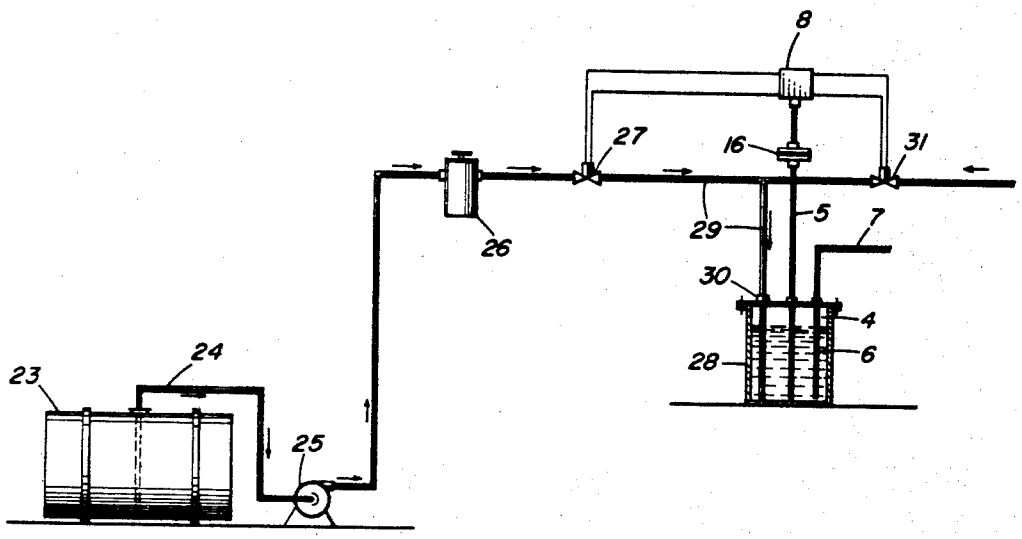


FIG-2

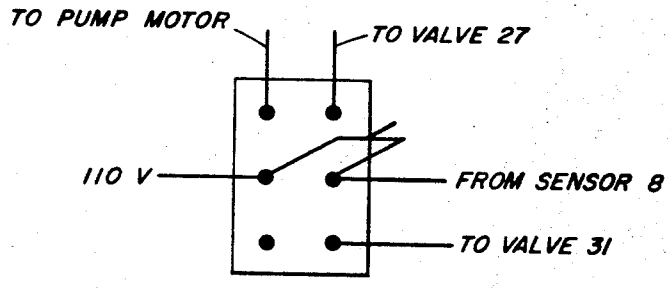


FIG-3

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United States Patent Office 3,420,282 Patented Jan. 7, 1969

3,420,282

LIQUID FILLING MACHINE

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Filed June 2, 1966, Ser. No. 554,885
U.S. Cl. 141—157 9 Claims
Int. Cl. B65b 21/08

ABSTRACT OF THE DISCLOSURE

A liquid filling machine for vials or other containers is provided with a reservoir which is mounted on a rotating table, the reservoir being connected to a source of sterile air. From the reservoir a conduit leads to a filling valve of the elastomer tube pinched type. Liquid is fed from the bottom of the container and the pressure at the filling nozzles is sensed and controls the supply of compressed sterile air to the container. This results in maintaining constant the pressure at the filling nozzles regardless of changes in level of liquid in the reservoir and hence changes in hydrostatic pressure. As the table turns, vials or other containers which are loaded on the table at one point pass successively below the filling nozzles. Their position is sensed by radiations so there is no contact with the container and no danger of knocking it over. When a container is properly located, an electric counting device is started which opens the pinch on the filling nozzle tube and counts a certain predetermined period of time which determines the amount of liquid filled into each vial. At the end of the time the tube at the filling nozzle is pinched closed and the table moves to bring another container into position.

Background of the invention

Pharmaceutical liquids which have to be filled into containers, often small containers such as vials, present a number of practical problems. These liquids require maintenance of sterility and avoidance of contamination and also require that each vial or container receive a definite amount of liquid. It has been proposed in the past to use a pump which is similar to a syringe and which can be precalibrated to draw up a definite volume of liquid from a reservoir and deliver it into the waiting container. This method is unsatisfactory from the standpoint of sterility because the plunger element of the pump is exposed to the atmosphere on the out stroke, which can result in contamination, and the moving parts of the pump tend to wear and produce small particles of friction, which may contaminate the liquid filling even though in some cases they may not be septic. The pump method also requires numerous valves, and the metering of the filling mechanism requires frequent maintenance. This is bad enough with pure liquids, but it is much worse if the product is a suspension, because the particles in the suspension tend to accumulate in valves and the like. Also, when viscous, tacky liquids are being filled, evaporation of the solvent may leave a residue in the pump mechanism. Generally this clogging of the pump or valves causes a breakdown of the system and requires cleaning out at the least and often replacement of damaged parts. Both are economically undesirable.

Another aspect of filling operations with pumps or metering devices is that essentially they are two-step processes; thus the pump is filled from the reservoir by the out stroke and then the liquid dose expelled into the package by the in stroke. Similarly, in metering filling machines the meter chamber is first filled to the set volume and this volume is then delivered to the package container. In both cases there is not a continuous flow but an interrupted flow, all the way back to the reservoir of the liquid. This interrupted operation adversely affects efficiency.

Another form of filler involves a pump in the form of a screw in a flexible conduit and a valve body which is periodically opened for a timed interval. The timing involves mechanical operation and exactly reproducible filling is not possible, variations of as much as ±7% being encountered. The presence of valves, of course, also involves the problems of plugging and contamination referred to above. Except that there is timed filling, the operation is no different from the other apparatus described above.

Summary of the invention

According to the present invention a reservoir of liquid is maintained with accurate and definite pressure on a conduit or conduits leading to container filling nozzles. The reservoir may be a large one containing the original bulk material to be filled and pressure maintained by slightly compressed air pumped into the liquid, or in the case of products which react with constituents in the air, the gas may be any inert gas, such as nitrogen. It should of course be sterile. The reservoir can also be a smaller reservoir fed from a larger bulk supply by controlled pumping. The intermediate reservoir, however, should have a sterile atmosphere of air or other slightly compressed gases which serves to prevent surges acting as a cushion. In any event, the conduit or conduits leading to filling nozzles from the reservoir are flexible or deformable at at least one point. Obviously, of course, the apparatus is sterilized before starting and additional precautions can be taken in the usual manner by providing a sterile area and by the use of sterilizing radiation, such as ultraviolet light of germicidal wavelengths.

Instead of providing valves or anything else which extends into the inside of the filling conduit, the flexible or deformable portion is mechanically pinched for an accurately predetermined time interval. This shuts off flow while a vial is moved into position by conveyor belts, rotary filling tables, or other conventional means, and then the conduit is fully opened for the predetermined time, thus filling a vial or container with an accurate dose of liquid. Then the conduit is pinched together mechanically, the flow ceases and does not resume until another vial is in filling position.

It will be noted that in the present invention the filling conduit is free from valves or other fittings in which residues can settle, and when it is filling the conduit is fully open. At the same time, nothing moving is introduced into the conduit and contamination from wear and tear is eliminated, or so greatly reduced over that encountered in pumping and metering systems that it no longer presents a real problem.

While the filling operation is continuous, in most cases there will be finite runs, for example an eight-hour shift. When the machine is not operating or has been disassembled and sterilized for a changed liquid, it is very easy to replace the filling conduit or the deformable portion thereof. Usually the deformable portion will be of a suitable elastomer, such as rubber, neoprene, nylon, and the like, which can be replaced at intervals, as they are cheap and can be thrown away after a suitable interval without any significant increase in overall cost. This is an added advantage of the present invention, as it permits periodic replacements of a very cheap element. Deformable conduits have far less wear and tear than pumps, but of course they do not last forever, and the possibility of periodic replacements long before they have worn out represents a very attractive and efficient procedure and

constitutes, therefore, one of the practical operating advantages of the present invention.

It should also be noted that deformable conduits can be of materials which are readily sterilized, have smooth surfaces, and are inert to most liquids. It is an advantage of the invention that the use of deformable conduit sections automatically provides some or all of the above advantages. This represents a very fortunate situation as often an improved machine is a compromise in which in order to obtain one desired result there may be offsetting disadvantages. In the case of the present invention there are not offsetting disadvantages, so that the improvement is obtained without paying the price of other drawbacks.

It will be seen that the measuring out of the filling does not involve precise adjustment of valves. In other words, it is not obtained by throttling or back pressure. The filling conduits, except for the nozzles, as will be described below, do not introduce any substantial or measurable back pressure. Therefore, as far as the conduits are concerned all that is necessary is maintenance of reasonably constant pressure in the conduits. The nozzles themselves, however, usually have small openings, and it is practically impossible to maintain these completely uniform. In other words, the nozzles will create a certain amount of back pressure and this will be slightly different with different nozzles. When filling large final containers, such as for example a 200 ml. container, the variation in back pressure between nozzles, which is quite small but not zero, can be disregarded as it will constitute too small a percentage of the normal filling to be significant. For example, if the variation in nozzles with constant timing of the opening of the deformable portions of the filling conduits created a variation in volume of 1 ml. or less, this would be so small a percentage that it need not be taken into consideration. However, with small containers, such as 2 ml., the variation may be sufficient to be of significance. For example, a variation of .2 ml. would be 10%. In such a case the machine can be calibrated by varying the time in the preferred form with electronic counting for the different nozzles to produce an exact amount. Timing circuits, in which the count is either with separate counting circuits or more economically with separate pick-offs in the case of multiple filling nozzles, can be precisely adjusted. This is an additional advantage of the present invention in its preferred modification using electronic counting circuits for determining the timing intervals. The precision with which counts can be varied and accurately maintained is orders of magnitude greater in standard counting circuits than the permissible variation in the volume filled. It is thus possible to calibrate exactly within the limits desired, and this calibration will hold because timing circuits are extremely stable. Ordinarily with multiple nozzles calibration need only be made at intervals, for example when starting up at the beginning of a shift or when there is a change in material to be filled. The calibration takes a very short time and is extremely precise, and this constitutes an additional practical advantage of the preferred modification of the present invention. The same possibility of varying filling volume with precision by varying electrical counts also permits changing rapidly and accurately from one size container to another. There is no delicate adjustment of throttling valves and the like, and the time interval, once set, remains constant.

While there is an advantage in flexibility and versatility when the timing of the opening and pinching of the deformable sections of filling conduits is effected by electronic timing circuits, in a more broad aspect the invention is not limited thereto and any other interval timing may be used provided it is accurate. The accuracy is an important and essential feature of the present invention, but the exact electronic or other constructions of the timing intervals is not and any suitable accurate timing mechanism may be used. However, because of the extreme precision of electronic counting circuits and their flexibility for adjustment, this method is preferred and presents many practical advantages. The fact that the timing mechanisms are all well known and usually commercially available stock items is an added advantage of the present invention.

It is also an advantage of the invention that the design of container filling may be varied. Thus, for example, vials may be moved intermittently under fixed filling nozzles, for example by continuously moving smooth container belt with retarding devices such as fences for stopping the movement of vials in synchronism with the filling operation; or the filling nozzles may move with the vials, for example through a suitable arc on a rotating container feeding device, which eliminates intermittent motion and lends iself to automatic feeding of empty containers and removing of filled containers. The continuous method, therefore, has practical operating advantages which more than offset its sometimes slightly higher constructional cost. Both types of filling will be specifically described below, but it should be understood that these are just examples of the basic requirement that the filling nozzles at the end of the conduits be accurately maintained over the mouth of the vial or container being filled during the filling operation. The flexibility in choice of actual mechanism is an added practical advantage.

Brief description of the drawings

FIG. 1 is a partially diagrammatic sectional representation of a continuous filling modification of the present invention;

FIG. 2 is a similar representation of an intermediate reservoir type; and

FIG. 3 is a simplified electric circuit for starting and stopping a run.

Description of the preferred embodiments

FIG. 1 shows a bulk container **1** with the liquid to be filled at **2** and an air space above at **4**. Surrounding the reservoir is a rotating table **19**, which is shown partly broken away to illustrate the loading of only one vial at a time in order not to complicate the drawing. The table and the reservoir on it are continuously though slowly rotated about an axis **18** by conventional drive, (not shown). A tube **5** extends to the bottom of the reservoir **1** and leads, through an isolating diaphragm **16**, to a pressure sensor **8** provided with a gauge **9**. This sensor is of conventional design and is therefore shown only diagrammatically.

A source of substantially sterile air or other gas under pressure connects through an ON and OFF valve **10** into the space **4** above the liquid **2** in the reservoir. This valve is actuated electrically from the pressure sensor **8** and, of course, opens the valve when the pressure sense drops below a predetermined value and closes when it has reached it again. Needless to say, the compressed air container is sufficiently large and maintained at a sufficient pressure so that the preset pressure on the sensor **8** is maintained even when the liquid in the reservoir has reached the bottom. It will be seen that the sensor **8** is at substantially the level of the tube **7** leading to the filler, and as both the tube **6** and the tube **5** lead from the bottom of the tank **1**, the sensor senses a pressure which is the sum of the gas pressure in the space **4** and of the hydrostatic head of the liquid **2** to be filled. In other words, pressure is maintained at the nozzle constant regardless of the level of liquid in the tank **1**.

Pipes **6**, only one of which is shown in the figure, extend also about to the bottom of the liquid in the reservoir **1**. These pipes are developed into deformable conduits **7** leading to filling orifices **20**, shown positioned over a vial **3** to be filled. Just above the filling nozzle **20** is a compression sleeve actuated by two solenoids **12** which can compress it to pinch the deformable tubing **7** closed or to open it wide. The tubing is, of course, of suitable elastomer so that when the solenoids **12** are in the un-

pinched position, which is shown in the drawing, the inside of the tubing **7** is fully opened. When a vial **3** is moved into position under a particular nozzle **20**, an electric eye **17** turns on the counting circuit **15**, which is of conventional design and therefore illustrated diagrammatically. As the electric eye senses the position of the vial by radiation without mechanical contact therewith, no force is exerted on the vials which would tend to tip them over. The counter receives an input through wire **14** from an accurate pulse generator or oscillator **13**, which is also of conventional design and indicated diagrammatically. It may, for example, be a crystal controlled oscillator which oscillates at a suitable frequency. Pick offs for each pair of solenoids **12** are shown as going out through wires **21** from the counting circuit. These wires are shown broken and are connected to their respective solenoids through conventional slip rings on the rotating loading table (not shown). In order not to complicate the drawing, only one set of wires **21** is shown, but there are of course a set constituting a pick off for each pair. The count for each pick off is shown on dials **22** which indicate through conventional indicators the number of counts for each pickup. To simplify the drawing only eight counting dials are shown, although in a large machine the table would ordinarily be provided with more than eight filling nozzles in one or more rows. Also, two separate solenoids **12** are shown for simplicity in understanding the operation of the invention. Commercial solenoids are known in which the pinching is effected in a single structure, but the drawing is intended to illustrate the operation of the present invention rather than to show exact design of standard solenoid pinch valves, the particular mechanical and electrical design of which forms no part of the present invention.

As has been mentioned above, when a vial **3** comes into position under its filling nozzle at a loading station on the table **19**, which is illustrated on the drawing, the electric eye **17** turns on the counting circuit for the particular pair of solenoids **12** and they open, the position shown on the drawing. Now as the table turns and with it the nozzles and vials, material flows through the nozzle **20** for a time determined by the particular number of counts set for this particular pickup. Any desired number can be set by conventional selectors on the timing circuit console **15**. As these are standard items they are not shown, as their particular design again forms no part of the present invention. As has been described above, a different number of counts can be set for the different nozzles **20**; or if the nozzles happen to be uniform or if the volume of material filled is so large that it is not necessary to adjust individual nozzles for a particular count, the flow continues until the particular pickup registers the pre-set number of counts. The solenoids **12** are then moved together, shutting off the flow, and the filled vial **3** is then removed. The conventional timing console **15** automatically resets each pick off when the pre-set number of counts have been counted, and it is of course ready to start again when another empty vial is placed under its particular nozzle at the point indicated on the drawing. Since the pressure in the air space **4** is maintained constant, or rather the pressure of liquid in the tube **6**, for the latter is determined by a combination of the pressure in the air space **4** and the hydraulic head of liquid **2**, the filling of each vial is precise because the flow has continued for the accurately pre-set time interval.

If a vial fails to be put under its filling nozzle, the electric eye **17** does not send out a signal and, therefore, the pickup for this particular pair of solenoids is not actuated and accordingly they remain closed until the table has made another revolution and a vial is actually positioned under the filling device. This prevents filling if there is no vial there, which would spill liquid or other material over the loading table. It should be noted that in the modification shown in FIG. 1 the vials and filling nozzles move continuously. Hence this presents advantages and permits maximum filling speed. However, the mechanism is somewhat more complicated and so the machine may be more expensive. Where filling lines are in existence using a conveyor and intermittent blocking of vials under stationary nozzles, such operation can be effected, but of course the movement of the vials is then intermittent; the possibility of a vial falling on its side during filling is not completely excluded and, therefore, normally lower speeds are used. However, the fixed nozzles, fixed conduits and unmoving reservoir are simpler structures and, as has been pointed out above, a more economical machine is possible, particularly if the conveying machinery is already in existence, as is often the case where other types of filling mechanisms have been used before and are replaced with the improved form of the present invention. Needless to say, the vials do not resume intermittent motion the instant the solenoids pinch closed, and a very brief hesitation permits any last drops on a nozzle to drop into the container. This is simply a matter of timing of the intermittent motion and is not an unknown device. It is mentioned here merely to illustrate that when the principles of the present invention are incorporated in more or less normal or standard filling mechanisms, no undesirable drawbacks are introduced.

In most container filling machines, such as for example for filling vials, it is common to provide automatic stoppering machines which introduce stoppers or other closures on the filled vials. The mechanism of these devices is not affected at all by the present invention, and therefore they have not been shown in the drawing. In any automatic filling line, however, they will normally be used because of the great saving of time effected and the desirable elimination of further manual handling, with possible contamination or compromise of sterility.

It will be noted that no human hands touch the vials or any other part of the machine during the filling operation. Only in loading and unloading may manual contact with the outside of the vial take place, and even this can be effected automatically, as is a common procedure with many filling systems. Sterility, therefore, can be maintained and there is no danger of any undesired septic contamination. As with most operations where sterility is required, the room, working space, and the mechanism is normally maintained in a sterile or substantially sterile environment, for example by suitable germicidal lamps and the like. It is an important advantage of the present invention that complete sterility can be maintained, but of course the environment of the room is not changed by the present invention. Also, it is possible to use the present invention for filling of materials which do not have to be filled under sterile conditions. This adds a flexibility to the present invention, but of course its greatest and most important single field is in sterile filling.

FIG. 2 illustrates a different modification for transfer of liquid to the filling conduits. It may be used either with a rotating, continuous filling table or with intermittently actuated movements. Therefore, only the portion up to the tube **7** is illustrated. Similar elements, such as pressure sensor and the like, are given the same numbers as in FIG. 1.

A large bulk container, such as a tank or drum containing 1,000 or more liters, is shown at **23**. From this drum a tube **24** extending to the bottom leads to a pump **25**, which may be of conventional design and is therefore shown only diagrammatically. The drive of the pump is through an electric motor, (not shown). The output of the pump **25** passes through a sterile filter **26** of conventional design, which is also shown diagrammatically. The filtered output passes through a valve **27**, which is of the ON and OFF type and, except for its design to handle liquid, is similar to the valve **10** in FIG. 1. As in that figure it is controlled by a sensor **8** which connects to the bottom of an intermediate reservoir **28**, which may be of much smaller size, for example a few liters. As in FIG. 1, the sensor **8** responds to a pressure which is the sum of

the pressure in the air space **4** and the hydrostatic head on the liquid in the reservoir **28**. Accordingly, it does not change with variations of level in the reservoir. The conduit **29** from the valve **27** also extends to the bottom of this reservoir, which is provided with an air space **4** which performs an analogous function to the air space **4** in FIG. 1, namely to provide for smooth pressure maintenance, though the mechanism by which the pressure is produced is slightly different, as will be described below.

As has been mentioned, the pipe **6** and conduit **7** are essentially the same as the corresponding elements in FIG. 1 and lead through a deformable portion and timed pinching means to filling nozzles. These are not shown as they are no different from the corresponding elements in FIG. 1. Of course a number of tubes **6** or a number of conduits **7** branching off from a single tube **6** are provided, one for each filling nozzle. The modification of FIG. 2 lends itself particularly to stationary filling nozzles, although the reservoir **28** may be rotated in the same manner as is described in FIG. 1, the inlet tube **29** of course being axial and requiring seal **30**.

When a vial is under a particular filling nozzle, the electric eye or other sensor senses it in the same manner as in FIG. 1 and sends a signal to the counting circuit or pick off for the particular nozzle. This opens the solenoids for the precisely determined time interval, exactly as described in connection with FIG. 1. There is, however, a small difference in the manner in which the pressure in the conduit **7** is maintained. Instead of maintaining it by air pressure, as shown in FIG. 1, it is maintained by periodic pumping through the valve **27** which opens and closes in accordance with the changes of pressure resulting from the flow of liquid into the filling conduit **7**. As the pressure is maintained constant, the valve **27** lets in liquid at approximately the same rate at which it is filled into containers. The air space **4**, which is confined, performs its function as a surge preventer or cushion exactly as in FIG. 1.

When the large bulk container **23** is empty, this is signalled either to the operator or there is an automatic operation of the necessary switches, which will be described in more detail below in connection with FIG. 3. It should be noted, of course, that when the bulk container **23** is empty, there is still liquid in the container **28**, and it becomes desirable to empty this container. The same may occur at the end of a filling operation, such as the end of a shift, even though the bulk container **23** is not necessarily empty. This is effected by a second ON and OFF valve **31** which is connected to a source of compressed sterile gas and is also actuated from the sensor **8**, as will be described in connection with FIG. 3. FIG. 3 shows in schematic form a double pole, double throw switch. The movable portion of one of the pairs of poles is connected to the sensor **8**. The other movable pole is connected to a source of power, shown on the diagram as 110 volts. When the switch is in its upper position, it will be seen that power is connected to the motor which drives the pump **25** and signals from the sensor **8** are connected to the valve **27**, producing the operation which has been described above. Now, however, if it is the end of a shift and it is desired to empty reservoir **28**, the switch is thrown to its lower position, which therefore stops liquid from the sterile filter **26** flows back into the container **23** through its by-pass, which is standard and which is not specifically shown in the diagrammatic representation of FIG. 2. The other pole of the switch is now connected to valve **31**, as has been described, and sterile air or other gas is introduced through the conduit **29** at the rate called for by the sensor **8** in order to fill the remaining liquid from the reservoir **28** into the containers. This results in emptying the container, which can be signalled by a conventional signal or noted by the operator through a sight glass, and the whole operation is shut down. The small reservoir **28** can then be conveniently removed and cleaned and resterilized for the next run. This leaves the container **28** full of air or other sterile gas, and when things are started up on the next run, liquid is pumped in by the pump **25** until the air in the space **4** is compressed to the pressure for which the sensor **8** is set. Another operation follows as described above.

We claim:

1. An unthrottled liquid filler for containers, suitable for sterile filling, comprising in combination:

(a) a reservoir of liquid to be filled,

(b) at least one container filling conduit extending into the liquid substantially to the bottom of the reservoir and leading to a filling nozzle,

(c) means for sensing the total pressure of liquid in the conduit including the component of pressure due to hydrostatic head of liquid and for maintaining the liquid in the conduit at a predetermined pressure, regardless of varying liquid levels,

(d) the conduit having at least a section which is elastically deformable, and

(e) means for pinching the deformable section closed and opening it to unrestricted flow for a precisely predetermined time interval whereby a predetermined volume of liquid flows through the conduit each time the deformable section is unpinched.

2. A liquid filling machine according to claim **1** in which the means for pinching the deformable section is an electrical means and the time interval is determined by electronic counting circuit.

3. A liquid filling machine according to claim **2** in which means are provided for loading containers under the nozzles with noncontact, radiations actuated sensing means sensing when a container is properly positioned and means actuated by said sensing means for initiating filling by opening the pinching means and starting the electronic counting for the particular nozzle in question whereby if a container is not loaded under a particular nozzle, the filling cycle for that nozzle does not occur and spillage is prevented.

4. A liquid fiiling machine according to claim **2** in which there is provided a plurality of filling nozzles and the counting circuits for each nozzle are adjustable to provide for different counts for different nozzles.

5. A liquid filling machine according to claim **1** in which pressure in the filling conduits is maintained by pressure controlled pumping means from a large bulk container.

6. A liquid filling machine according to claim **2** in which pressure in the filling conduits is maintained by pressure controlled pumping means for a large bulk container.

7. A liquid filling machine according to claim **6** comprising a source of sterile gas under pressure and selectable means for introducing either sterile gas or liquid into the top of the reservoir.

8. A liquid filling machine according to claim **3** in which the means for loading containers under the nozzles comprises a rotating plate on which vials can be mounted and means for mounting the reservoir coaxially with the rotating plate whereby when the plate rotates the reservoir rotates therewith.

9. An unthrottled liquid filler for containers, suitable for sterile filling, comprising in combination:

(a) a reservoir of liquid to be filled,

(b) at least one container filling conduit extending into the liquid in the reservoir and leading to a filling nozzle,

(c) means for maintaining the liquid in the conduit at a predetermined pressure,

(d) the conduit having at least a section which is elastically deformable,

(e) means for pinching the deformable section closed and opening it to unrestricted flow for a precisely predetermined time interval whereby a predetermined volume of liquid flows through the conduit each time the deformable section is unpinched, and

(f) means for loading containers under the nozzles comprising noncontact, radiation actuated sensing means sensing when a container is properly positioned and means actuated by said sensing means for initiating filling by opening the pinching means, and the means for providing unrestricted flow for a precisely predetermined time interval comprise electrical means for pinching the deformable conduit section and electronic counting means for maintaining the deformable section in unpinched condition during a filling cycle, both electrical means being actuated by the means for sensing the proper positioning of a container under the nozzles.

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U.S. Cl. X.R.

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