

[54] **DISPENSING APPARATUS HAVING PISTON AND CYLINDER DISPENSING ASSEMBLY WITH STROKE ADJUSTING MEANS**

[75] Inventors: **Michael E. Croslin**, Forest Hills; **Carl R. Blackman**, Westbury, both of N.Y.

[73] Assignee: **Grumman Data Systems Corporation**, Bethpage, N.Y.

[22] Filed: **Jan. 3, 1972**

[21] Appl. No.: **214,852**

Related U.S. Application Data

[62] Division of Ser. No. 883,573, Dec. 9, 1969, Pat. No. 3,665,980.

[52] U.S. Cl. **141/160, 222/37, 222/38, 222/309**

[51] Int. Cl. **B65b 43/56**

[58] Field of Search **417/577, 578; 141/83, 140, 156, 157, 159, 160; 222/36-38, 132, 309**

[56] **References Cited**

UNITED STATES PATENTS

3,437,051	4/1969	Hrdina	417/568
3,227,325	1/1966	Bates	222/309
3,397,642	8/1968	Petrucci et al.	417/568 X
3,242,881	3/1966	Schafer	222/132 X

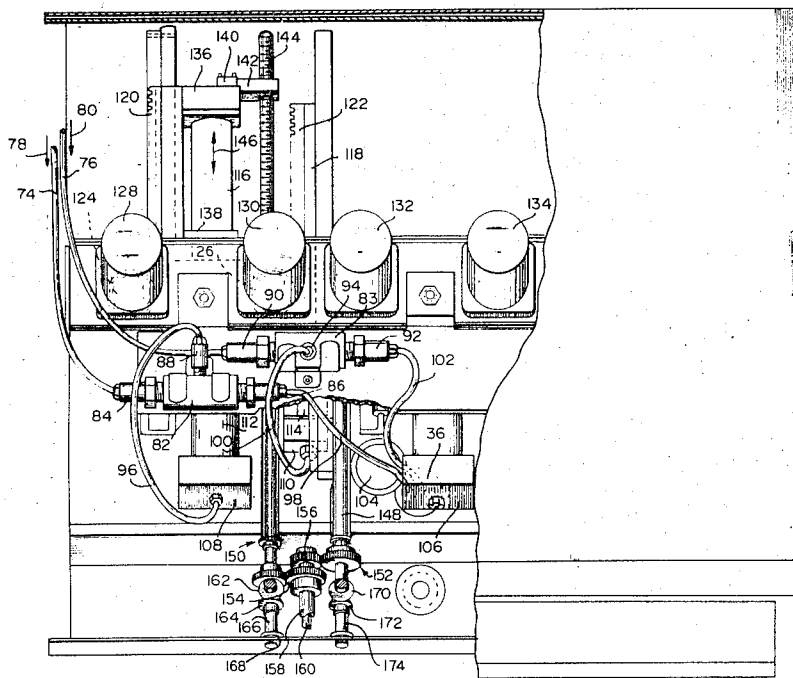
Primary Examiner—Robert B. Reeves
Assistant Examiner—David A. Scherbel
Attorney—Alan K. Roberts

[57]

ABSTRACT

A dispensing apparatus is provided which has various modes of operation including automatic, manual and prime modes. The dispensing apparatus includes coarse and fine metering devices consisting of cylinders with pistons displaceable therein, the displacement of the pistons being controlled by adjustable switches in turn controlling electronic circuits which reverse the direction of movement of the pistons. The metering devices are associated with dispensing nozzles beneath which can be stepped a tray in which are positions for vials or other such receptacles. A sensing switch is provided to detect the presence or absence of receptacles in the aforesaid positions to prevent attempts to dispense fluids into positions in which there are no receptacles. The tray is electronically controlled for automatic or manual modes of operation and a cam control switch is provided which determines whether the tray has been stepped to discrete positions for which dispensing operations might be effected. The apparatus employs a bi-directional, three port valve for enabling the withdrawal of one or more fluids from a source and for dispensing the thusly withdrawn fluids into the aforementioned receptacles. The dispensing apparatus is controlled by a logic circuit involving combinations of flip flops, OR gates and AND gates, and further including decade counters for counting the number of receptacles filled and comparing the count with a selected number in an electronic comparator whereby operation can be terminated after an appropriate number of cycles. The selected quantities for dispensing are indicated on conveniently positioned indexes.

20 Claims, 11 Drawing Figures



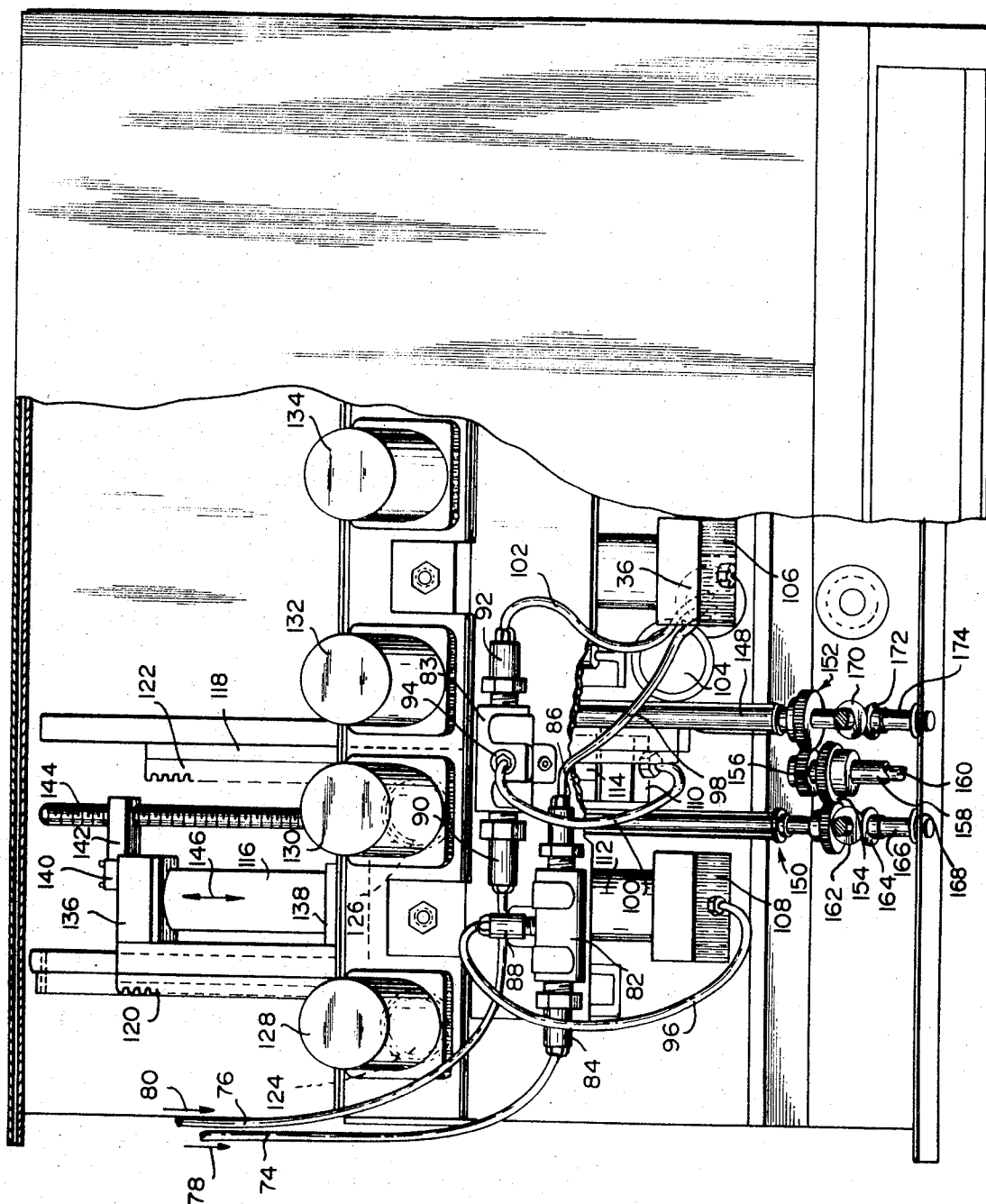


FIG. 2

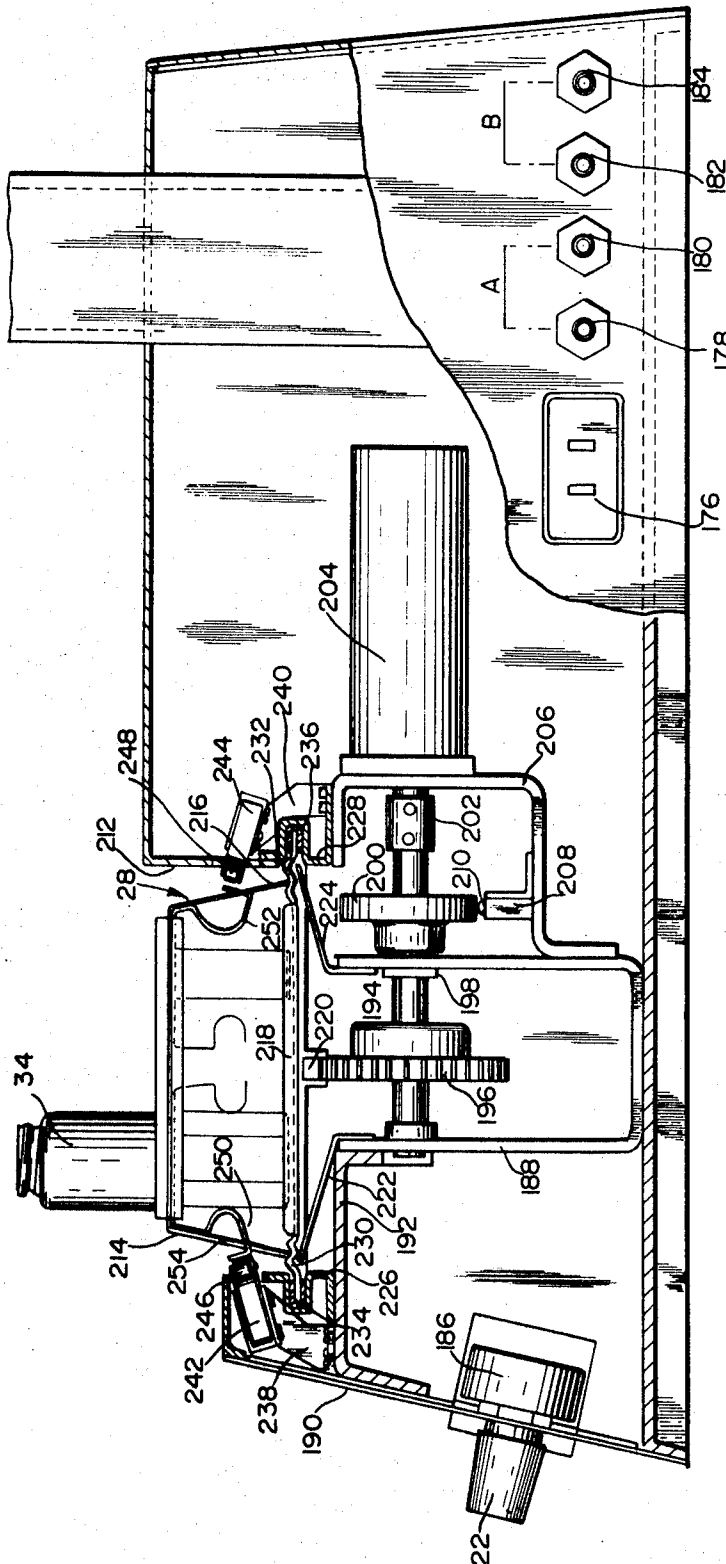


FIG. 3A

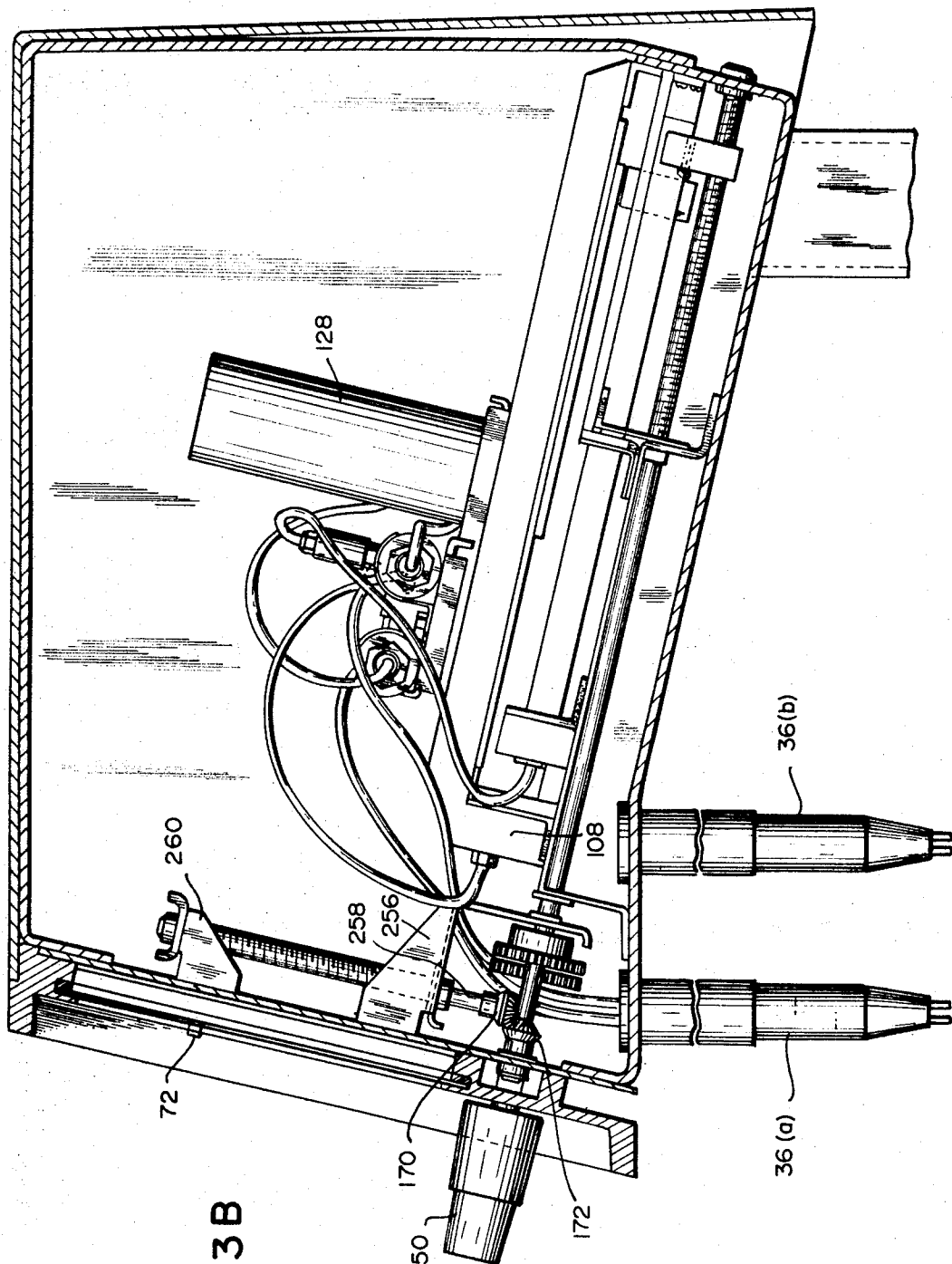


FIG. 3B

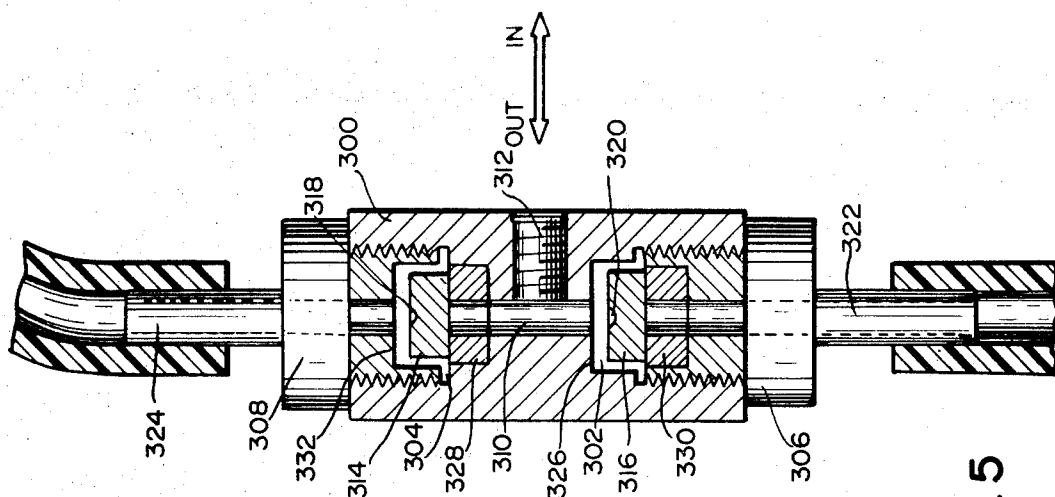


FIG. 5

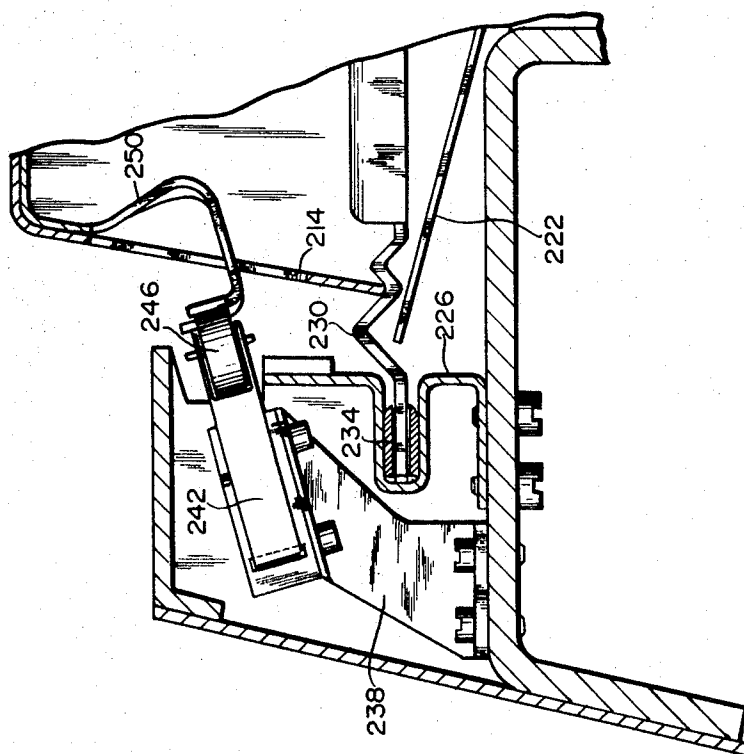


FIG. 4

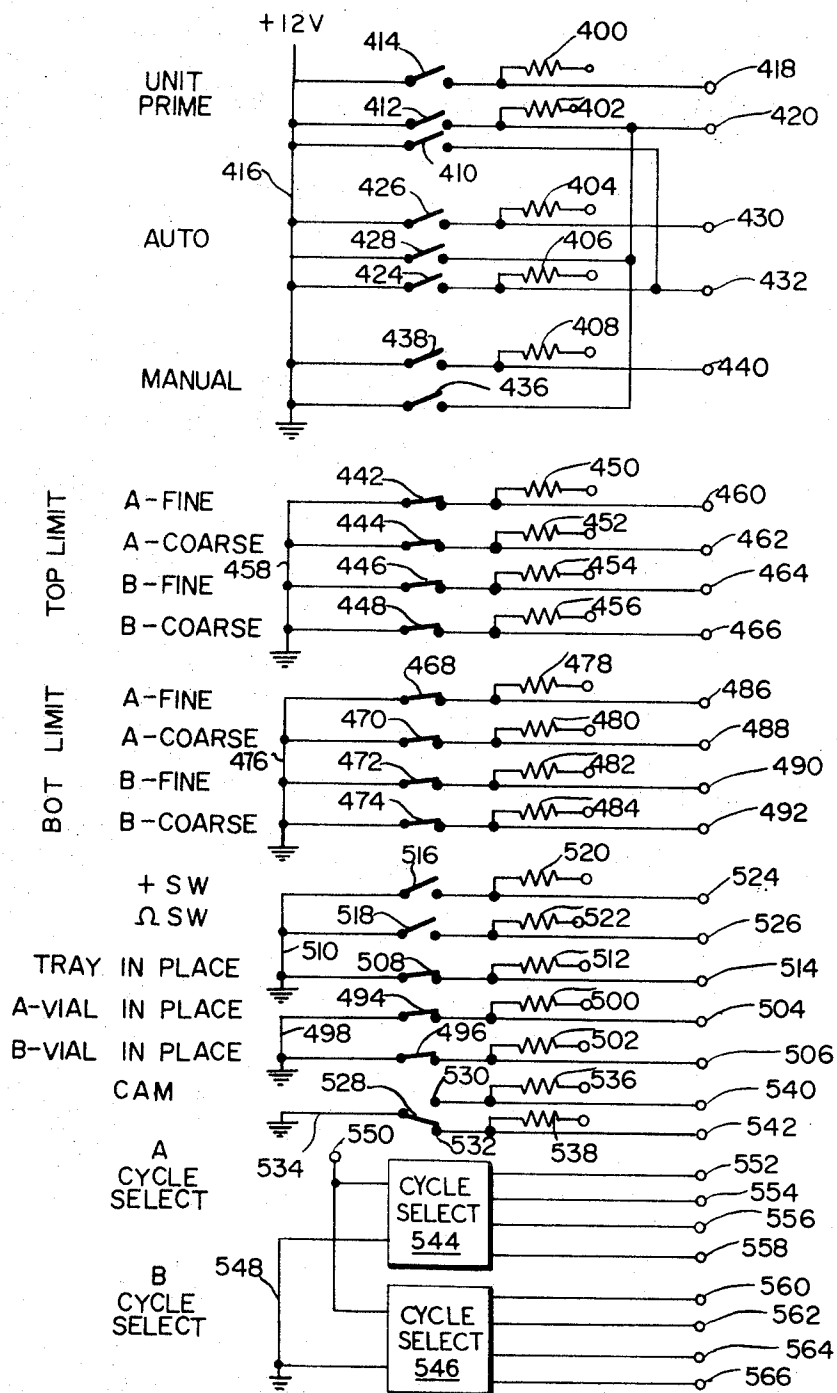


FIG.6

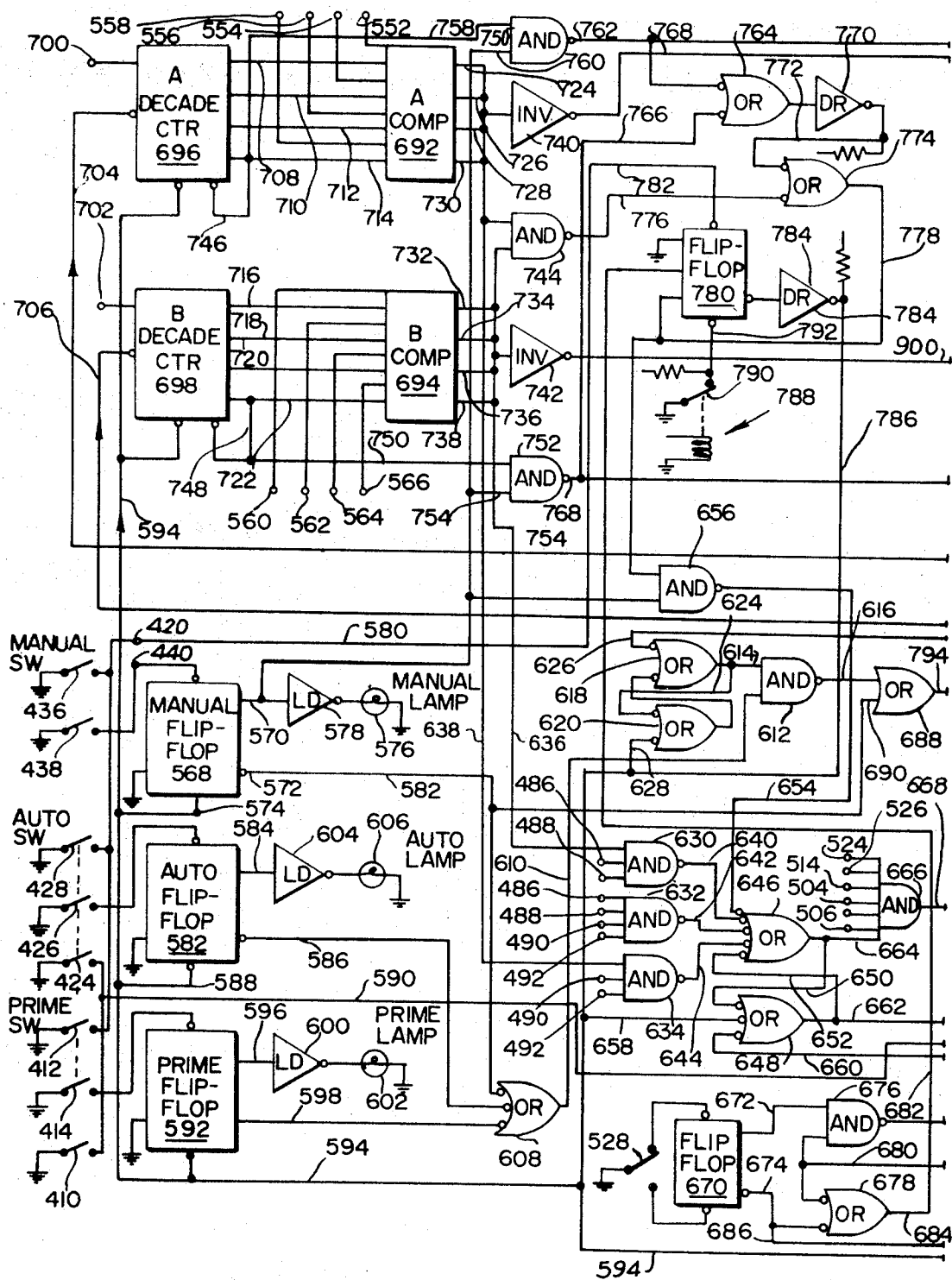


FIG. 7

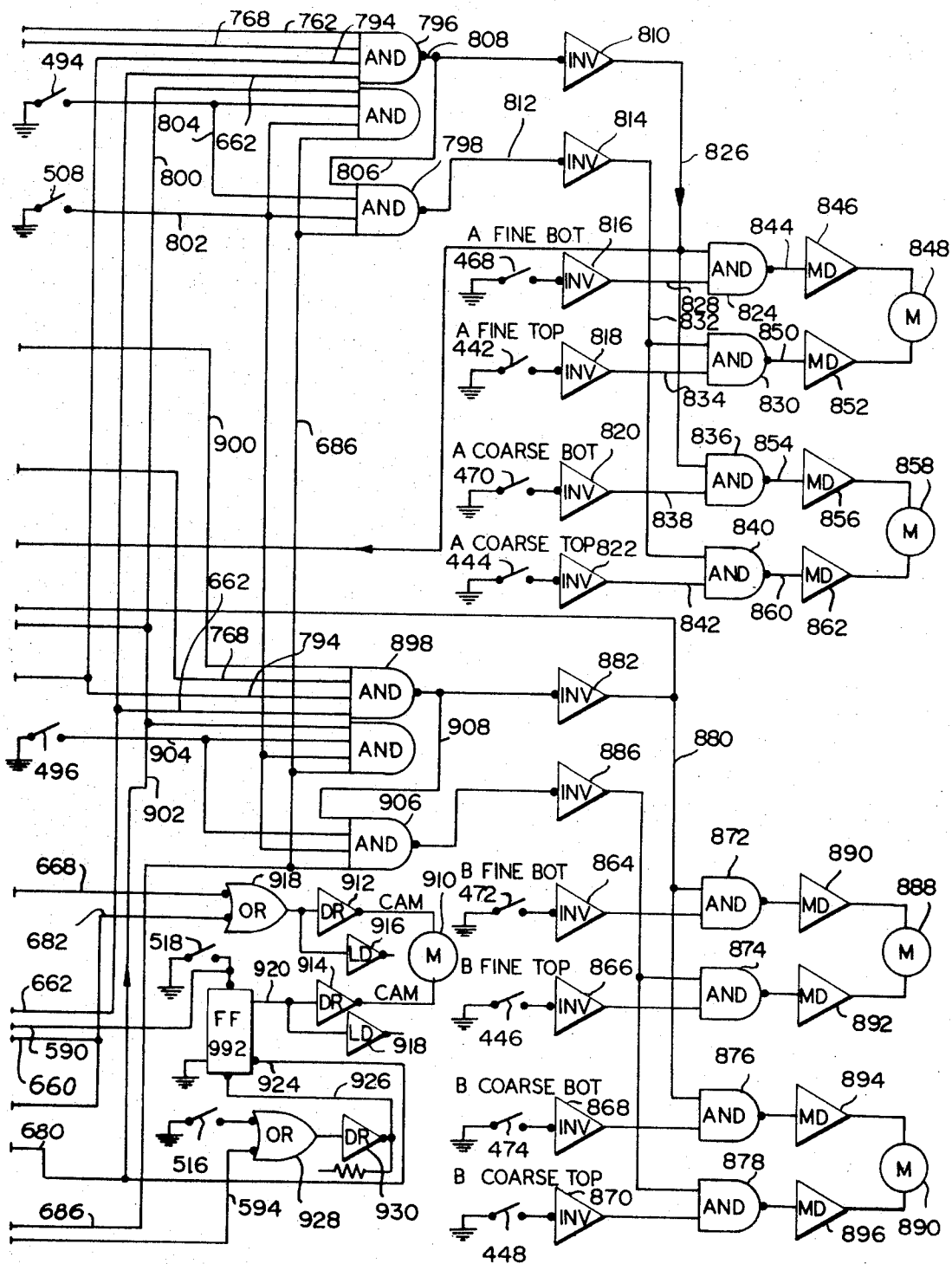


FIG. 8

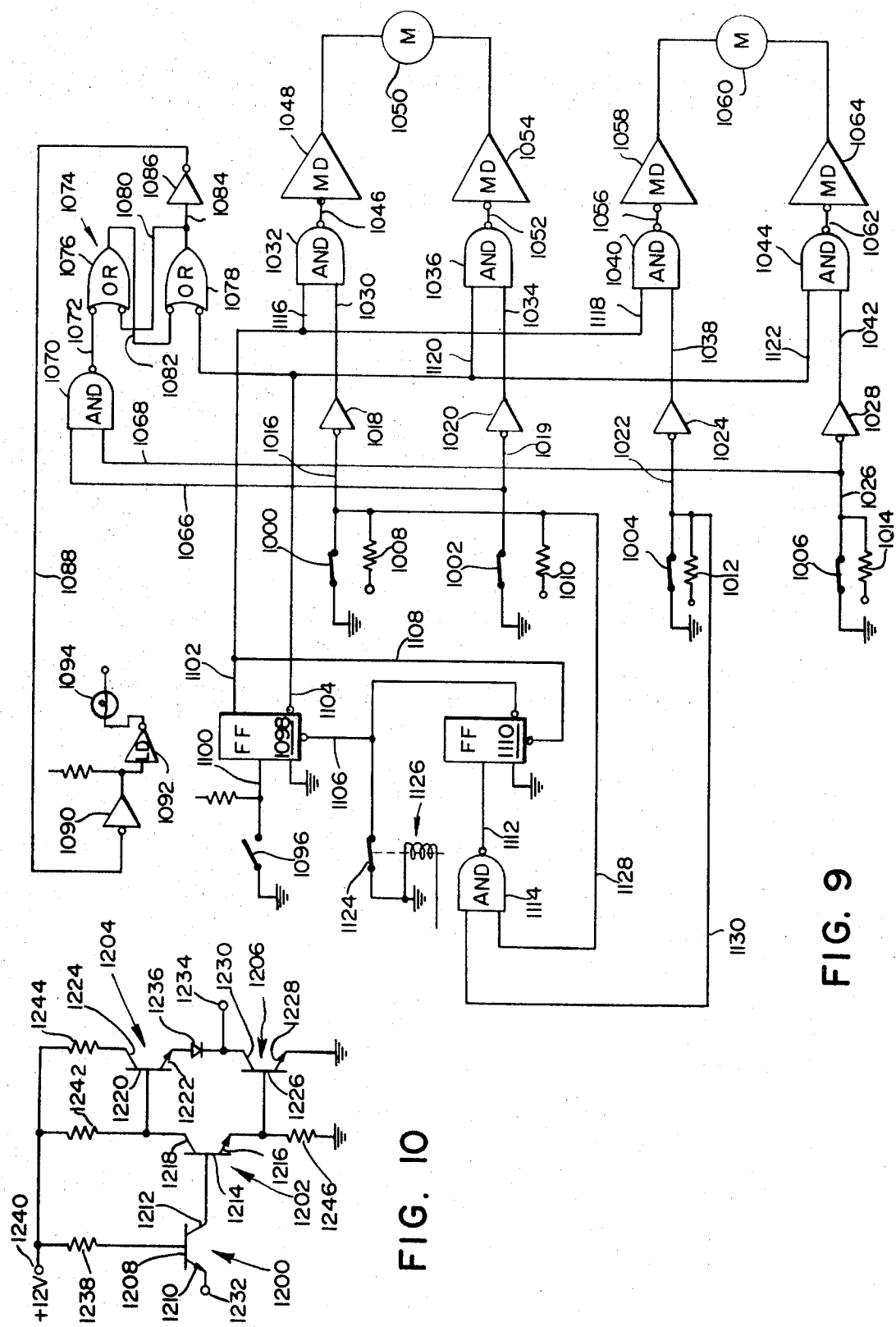


FIG. 10

FIG. 9

DISPENSING APPARATUS HAVING PISTON AND CYLINDER DISPENSING ASSEMBLY WITH STROKE ADJUSTING MEANS

This is a divisional of previously copending U.S. Pat. application Ser. No. 883,573 filed Dec. 9, 1969, now U.S. Pat. No. 3,665,980 issued on May 30, 1972.

FIELD OF INVENTION

This invention relates to dispensing apparatus and, more particularly, to automatic digital pipettes. The invention also relates to logical electronic control circuits for mode selection purposes with respect to the operation of digital pipettes and furthermore relates to control devices for enabling the selection of specific quantities of fluids which are to be dispensed in automatic and cyclical dispensing operations.

SUMMARY OF INVENTION

It is a general object of the invention to provide improved fluid dispensing apparatus.

Another object of the invention is to provide an improved automatic digital pipette.

Still another object of the invention is to provide an improved pipetting apparatus capable of functioning as a diluter and capable of dispensing microliter and ultramicro liter quantities of liquids.

Another object of the invention is to provide an automatic pipette which may be employed as the nucleus around which complete apparatus for biochemical and clinical laboratories of the microminiaturization type can be planned.

Still a further object of the invention is to provide an improved pipette which offers to researchers employing chromatography a means of obtaining accurate samples in the ultramicro liter range.

It is yet a further object of the invention to provide an improved dispensing apparatus which provides for multiple dispensing with dilution capabilities.

Still another object of the invention is to provide for the automatic indexing of vials and other receptacles.

Another object of the invention is to provide for the precise mixing of a plurality of different chemicals simultaneously.

Yet another object of the invention is to provide for a high degree of accuracy and repeatability.

It is a further object of the invention to provide for exceptional mobility for laboratory use.

Yet another object of the invention is to provide an improved dispensing apparatus which fills directly from floor or bench level reservoirs.

Another object of the invention is to provide an improved dispensing apparatus having the capability of filling either free flowing or viscous liquids.

Yet another object of the invention is to provide for instant and convenient selection of quantities to be dispensed.

Yet another object of the invention is to provide for the selection of the number of receptacles to be filled, such selection being possible with extreme convenience.

Still a further object of the invention is to provide an improved apparatus adapted for extended use with a minimum of maintenance and with a capability of maintaining extremely sanitary and antiseptic conditions.

In achieving the above and other objects of the invention, there is provided a dispensing apparatus which is

operative with one or more sources of fluid and which comprises a first means for drawing from such source or sources a quantity of fluid, the magnitude of which may be adjusted by the utilization of control means which are provided in operative association therewith, the means for drawing the fluid from the source or sources being coupled to dispensing means which are operative to dispense the thusly withdrawn fluid into vials or other such receptacles which are stepped past the dispensing means either automatically or under manual control as may be selected by the use of mode selector means. Provision is also made to select a priming mode of operation so that the fluid system involved can be flushed with the fluid to be dispensed to free the system of air bubbles or other such undesirable foreign substances.

Also provided in accordance with the invention is a control device to control the rate of dispensing of the fluid through the dispensing means. Additionally, associated with the first means is a coarse fluid withdrawal means and a fine fluid withdrawal means, these being collectively or independently operable and associated with a dispensing nozzle by means of which fluid is dispensed into the aforesaid vials or receptacles.

Coarse and fine adjustment means are provided in accordance with the invention, these being effective to control the positioning of switches which are associated with movable members in pumps to be operated by these movable members to initiate pump control functions.

In further accordance with the invention there are provided receptacle conveyance devices having a plurality of positions in which receptacles for the fluid to be dispensed may be positioned. According to a feature of the invention, switching means are provided to sense the presence or absence of receptacles in the aforesaid positions to prevent the dispensing of fluids into any position lacking a receptacle.

In accordance with still a further feature of the invention a selection is provided to select the number of receptacles into which fluid is to be dispensed and to terminate dispensing of fluid when fluid has been dispensed into the selected number. To accomplish this there is provided in accordance with the invention a decade counter or the like, the output of which is transmitted to an electronic comparator wherein the actual count is compared with the selected count to generate a control signal which terminates the dispensing of fluid.

The receptacle conveyance device of the invention may be such as to afford the capability of dispensing into two or more rows of vials or receptacles simultaneously. Whether one or a plurality of rows of receptacles is employed, the apparatus of the invention will provide for discrete conveyance steps, the integral character of which must be indicated before a dispensing operation can take place.

The electronic circuitry of the invention consists of a combination of flip flops and OR gates and AND gates which are cooperatively operable under the control of switches to perform the various functions which are required.

According to a further feature of the invention, two pumps will be associated with each dispensing device, said pumps including cylinders of different diameters with pistons in these cylinders driven by associated motors to offer coarse and fine adjustment capabilities. An

arrangement of concentric dials and gear trains is provided to enable convenient control of the aforesaid pumps.

According to a further feature of the invention, the motors controlling the aforesaid pistons are speed-controlled to control thereby the rate of dispensing of the fluid. Thus the dispensing rate is controllable without the need for controlling the geometry of the dispensing means themselves.

The invention offers the unique advantage of mechanical regulation in combination with logic control circuitry, as a result of which extended longevity is provided without encountering the possibility of loss of memory. Moreover, in view of the use of the logic control circuitry, the functions of the apparatus of the invention can be remotely controlled by the simple expedient of paralleling the switch arrangements to be discussed hereinafter.

Other objects and features, as well as advantages, of the invention will be seen in the detailed description which follows hereinafter.

BRIEF DESCRIPTION OF DRAWING

FIG. 1 is a front view of an automatic digital pipette provided in accordance with a preferred embodiment of the invention;

FIG. 2 is a top view of the apparatus of FIG. 1 with the top cover removed;

FIGS. 3(a) and 3(b) cooperatively illustrate a side view of the apparatus partially broken away and partially in section;

FIG. 4 illustrates on enlarged scale a detail of FIG. 3(a);

FIG. 5 illustrates in partly sectional view a valve employed in the apparatus of FIGS. 1-4;

FIG. 6 shows an assembly of switches and related circuitry as is employed in the apparatus of FIGS. 1-4;

FIGS. 7 and 8 cooperatively show the logical circuitry employed in controlling the apparatus of FIGS. 1-4;

FIG. 9 shows an alternate embodiment of the invention involving a simplified logical control circuit; and

FIG. 10 is a schematic diagram of a power supply or drive circuit employed in the logical circuits of FIGS. 7-9.

DETAILED DESCRIPTION

The automatic digital pipette apparatus illustrated in FIG. 1 comprises, as will be shown, a dispensing means for filling simultaneously two rows A and B of vials. It is capable of stepping automatically from vial to vial into each of which an exactly identical amount of fluid will be dispensed. The quantity to be dispensed can be controlled individually for each of the rows and the rate at which fluid is dispensed into the vials of the respective rows can likewise be controlled.

Provision is made for priming the fluid system of the apparatus to rid the same of air bubbles and like foreign substances. Provision is, moreover, made for selecting the number of vials to be filled in each of the rows and a scale or index is provided with respect to each of the rows for indicating visually the amounts of fluid to be dispensed into the vials of each of the rows.

More particularly, the dispensing apparatus of the invention is indicated generally at 12. It comprises a base section 14 and an upper section 16, the upper section

being supported on the lower section by a post or channel 18.

On the base section 14 are provided controls 20 and 22. These are respectively dispensing controls for rows A and B. They control the rate of speed at which fluid is dispensed into the vials in the respective rows. As will be shown, they enable controlling the rate of dispensing without actually controlling the geometry of the dispensing means employed.

Also mounted on the base 14 are thumbwheel controls 24 and 26 which similarly relate respectively to rows A and B. These are cycle-select controls and enable, as will be shown, the selection of a specific number of dispense cycles to be effected with respect to the individual rows. Stated otherwise, the use of controls 24 and 26 enable selecting the number of vials which are to be filled in each of the rows.

The base 14 is shown as supporting a tray 28 having handles 30 and 32. By the use of these handles the tray may be manipulated when not supported on the base 14. In its illustrated position, however, the tray 28 is positioned to be stepped incrementally through the base 14 from left to right in a manner which will be indicated in greater detail hereinafter. The purpose of this stepping of the tray is to convey receptacles such as the vial 34 discretely to positions under the dispensing nozzles such as indicated at 36 for purposes of the pipetting or dispensing functions with which the apparatus of the invention is concerned.

On the upper section 16 are disposed a number of controls. These include a unit power switch 38, a unit prime switch 40, a manual switch 42 and an automatic switch 44. The unit power switch provides for control of the supply of power to the unit. The unit prime switch provides for priming the fluid system of the apparatus by flushing the same with the fluid to be dispensed. The manual switch provides for the manual stepping of the tray 28 position by position under the dispensing nozzle 36. The automatic switch provides for the automatic stepping of a series of vials underneath the dispensing means whereby each of such vials is filled with a selected quantity of fluid.

Also mounted on upper section 16 are controls 46 and 48. Control 46 includes concentric knobs 50 and 52, whereas control 48 includes concentric knobs 54 and 56. The concentric knobs provide for coarse and fine adjustments respectively. Control 46 provides for the control of row A, whereas control 48 provides for control of row B.

On the front face of the upper section 16 are scales or indices 58 and 60 respectively associated with rows A and B. Scale 58 includes a coarse section 62 and a fine section 64 and similarly scale 60 includes a coarse section 66 and a fine section 68. These scales are indications of the quantities of fluid to be dispensed into the vial displaced beneath nozzles 36. More particularly, and with illustrative reference to scale 58, selection can be made of the coarse amount of fluid to be dispensed on the left hand side of the scale at 62 and to the fine amount of fluid to be dispensed on the right hand side of the scale 64. Knobs 50 and 52 constitute the means of selection and control various components to be described hereinafter, while pointers such as seen at 70 and 72 indicate the selected amounts.

In the above description reference has been made to two rows of vials and what is intended to constitute these rows will be made more apparent hereinafter.

However, it is to be understood that the illustrated number of rows is shown by way of example only since three or more rows of vials also can be readily processed within the scope of the invention.

FIG. 2 illustrates some of the interior components housed in the upper section 16 which operate to perform dispensing functions in accordance with the invention and with regard thereto it will be noted that the dispensing functions of the invention can be performed with respect to an internally combined source or reservoir of fluids or with an externally located source or reservoir. As a matter of fact, it is not required in accordance with the invention to limit the source to its being a source of a single fluid since two or more fluids can be simultaneously dispensed by apparatus provided in accordance with the invention.

In FIG. 2 are illustrated tubes 74 and 76. These tubes lead from one or two sources of fluid as indicated by arrows 78 and 80. While only two tubes 74 and 76 are shown, it is to be understood that this is duplicated in the right hand side of FIG. 2. Tubes 74 and 76, which may be made of any suitable plastic capable of providing antiseptic or other necessary characteristics lead to valves 82 and 83 respectively, the details of which will be shown hereinafter. For purposes of the present discussion, however, it will be noted that valve 82 is provided with three ports 84, 86, and 88, whereas valve 83 is provided with ports 90, 92 and 94.

Fluid is, for example, drawn from the associated reservoir through tube 74 through valve 82 and through port 88 by a pump to be described in greater detail hereinafter and is then dispensed through port 88 and out through port 86 to the associated dispensing means. Similarly, fluid is drawn through tube 76 into valve 88 and out through port 94 by a pump to be later described and is then transmitted back through port 94 into valve 88 and out through port 92 by the very same pump. The quantity of fluid drawn through and dispensed out of valve 82 is controlled by the coarse control referred to hereinabove, whereas the quantity of fluid drawn through and dispensed out of valve 83 is controlled by the fluid control referred to hereinabove.

To enable the valves to perform the functions noted hereinabove, a plastic tube 96 is connected to port 88, whereas a plastic tube 98 is connected to port 86. Similarly, plastic tube 100 is connected to port 94 of valve 83 and plastic tube 102 is connected to port 92 of this valve.

Tubes 98 and 102 pass through an opening 104 in the bottom of upper section 16 and extend jointly into dispensing nozzle 36, of which there are two, as will be shown hereinafter. Dispensing nozzle 36 has a single opening 106 through which are discharged the quantities of fluid dispensed through both of tubes 98 and 102.

Tubes 96 and 100 are respectively coupled to heads 108 and 110 of two pumps which respectively comprise cylinders 112 and 114. In these cylinders are displaceably accommodated pistons such as, for example, piston 116 which is accommodated within cylinder 112. These piston and cylinder combinations provide for the withdrawal of fluid from an associated reservoir and there are two such pumps for each row A and B, one pump for each row being a coarse pump and the other pump of such row being a fine pump. The piston for cylinder 104 is indicated at 118.

Attached to each of the pistons are racks 120 and 122 respectively. These racks are driven through spur gears 124 and 126 which in turn are driven by motors 128 and 130. Motors 132 and 134 are also illustrated. These motors are associated with the second row of vials.

The length of the reciprocal strokes of the pistons 116 and 118 are controlled by the use of switches, these switches being engaged, for example, by means of a member 136 mounted on an extremity of the associated piston. This location of such member is exemplary only since the member can be located in any convenient position as required.

At the top of the stroke of the piston, member 136 will come into contact, for example, with the microswitch 140 which is supported on member 142 in turn adjustably located or positioned by lead screw 144. Upper and lower switches are provided for the pistons of each pump and one adjustable lead screw is also provided for each pump. Thus, there will be coarse and fine lead screws for row A and coarse and fine lead screws for row B. The manner in which these lead screws are adjusted will be discussed hereinafter.

First, however, it is of interest to note, by way of example, that the piston 116 reciprocates in the direction indicated by arrow 146. In the one direction member 136 will strike against the actuator or microswitch 140 and in the other direction it will strike against the actuator 138. These switches control associated electronic circuits which function to control the associated motor and thereby drive and reverse the directions of the piston 116.

In order to control lead screw 144 and its companion lead screw 148, there are provided gear trains 150 and 152. These gear trains are respectively controlled by spur gears 154 and 156 which in turn are controlled or rotated by concentric shafts 158 and 160. Shafts 158 and 160 are specifically controlled by control knobs 52 and 50 (FIG. 1).

As will appear from what has been stated above, rotation of shaft 160 by knob 50 will rotate spur gear 156 which in turn will actuate gear train 152 which will rotate lead screw 148 which will position the associated microswitch. Similarly, rotation of knob 50 will rotate outer shaft 158 which will rotate spur gear 154 which will actuate gear train 150 which will rotate lead screw 144 and thereby adjust the position of microswitch 140.

Gear train 150 includes bevel gears 162 and 164, the latter being mounted on stub shaft 166 rotatably supported in front panel 168 of upper section 16. Gear train 152 includes bevel gears 170 and 172, the latter being mounted on stub shaft 174 likewise rotatably mounted in front panel 168. The purpose of these bevel gears will become apparent hereinafter.

It will be noted that the aforesaid arrangement is duplicated in the right hand section of the apparatus as illustrated in FIG. 2 for row B which has been mentioned hereinabove.

FIG. 3(a) illustrates in greater detail various of the components accommodated in lower portion 14 of the apparatus. Power may be supplied to the apparatus through female receptacle 176 and other electrical connections may be made through connections such as indicated at 178, 180, 182 and 184.

The control knob 22 which is visible in FIG. 3(a) is the control for a potentiometer 186. This potentiometer

eter is connected to one of the aforesaid motors and controls the speed of operation of the same. This, as will now be apparent, controls the speed of displacement of the piston in the associated pump and therefore controls the rate of speed at which fluid is dispensed. It will, of course, be appreciated that the rate of speed is controlled without need for changing the geometry of the associated dispensing nozzle such as by increasing or decreasing the size of the opening thereof or by adjusting a valve associated therewith. This may have important consequences with respect to viscosity and other characteristics of the fluid being dispensed.

FIG. 3(a) illustrates the U-shaped channel 188 which extends transversely through the base section 14. Said U-shaped channel is mounted on the front panel 190 by means of a bracket 192. A shaft 194 traverses the interior of the U-shaped channel 188 and is mounted for rotation thereon. A spur gear 196 is mounted for rotation on shaft 194.

The shaft 194 extends through a bushing 198 externally of the U-shaped channel 188 and outside of this channel supports a cam 200 adjacent which the shaft is connected by a coupling 202 to a motor 204. Motor 204 is mounted on a bracket 206 connected to U-shaped channel 188 and bracket 206 supports a microswitch 208 adjacent cam 200 which engages the actuator 210 of switch 208. The tray 28 which was originally mentioned with respect to FIG. 1 fits into an opening 212 provided in base section 14. The tray 28 has two depending sides 214 and 216 which are angularly disposed and which give the tray a cross section in the general form of a trapezoid. At the bottom 218 of the tray is rigidly attached a rack 220 which is engaged by and driven by the aforementioned spur gear 196. Thus the motor 204 has the capability of driving the tray transversely through the base section 14.

With reference now also to FIG. 4, it is seen that a splash pan consisting of sections 222 and 224 is mounted on U-shaped channel 188. It is also seen that brackets 226 and 228 respectively support corrugated elements 230 and 232 on which the lower extremities of sides 214 and 216 rest. Corrugated elements 230 and 232 are respectively accommodated by resilient elements 234 and 236 to provide a certain yielding accommodation of the weight of the tray.

Also seen in FIGS. 3(a) and 4 are brackets 238 and 240. These brackets respectively support microswitches 242 and 244 provided with roller actuators 246 and 248 respectively. Roller actuators 246 and 248 are adapted for being engaged such as for example by leaf spring indicators 250 and 252. These leaf spring indicators are mounted on and integral with the sides of the tray and are adapted to extend through corresponding openings 254 when engaged by a vial such as, for example, the vial 34 illustrated in FIG. 3(a). Thus, for example, it will be noted that leaf spring actuator 250 is extended through opening 254 due to the presence of vial 34, whereas indicator 252 is not so extended due to the absence of a vial in the corresponding position. It will thus be seen that the tray employed in base section 14 is provided with a plurality of openings or supports at which vials may be located and that the presence or absence of a vial in a given position is indicated by a leaf spring indicator of the type noted hereinabove, which in turn operates one of switches 242 or 244. Such switches are positioned in correspondence with the associated dispensing nozzles so that it

is thus determined whether or not a vial is in position with respect to such nozzle to receive fluid dispensed therefrom.

Switches 242 and 244 cooperate with switch 208 which indicates by rotation of cam 200 whether spur gear 196 has been rotated by an amount sufficient to step the tray through discrete amounts necessary to bring vials to position beneath the associated dispensing nozzles.

FIG. 3(b) illustrates that there are two dispensing nozzles 36a and 36b, each being associated with one of the aforementioned rows A and B. Each of these nozzles can dispense one or more fluids in precisely metered amounts so that vials passing therebeneath will receive precisely metered amounts of one or more fluids. If, for example, two different fluids are provided through each nozzle a precisely metered combination or mixture of fluids will result.

Also appearing by way of example in FIG. 3(b) are the motor 128, the associated pump head 108 and the associated pistons, lead screws and so forth. FIG. 3(b), moreover, illustrates by way of example, bevel gears 170 and 172. It will be herein seen that bevel gear 170 is fixed to a lead screw 256 supported in a bracket 258. Mounted on lead screw 256 is a follower 260 to which is connected one of the aforesaid pointers, for example, pointer 72. Thus, rotation, for example, of bevel gear 172 by operation of knob 50 will rotate bevel gear 176 and will cause pointer 172 to move inwardly or downwardly along the associated scale to indicate the selected quantities of fluid to be metered. It will of course be recalled that simultaneous rotation of the knob will adjust the positioning of an associated microswitch which will in turn control the magnitude of the stroke of the associated piston.

Operation of the automatic digital pipette of the invention is extremely simple. The power supply is controlled by use of the unit power switch 38 noted hereinabove. The three mode pushbutton switches 40, 42 and 44 have already been indicated. The dual volumetric control micrometer, for example, 50 and 52 or 54 and 56, have also been indicated above.

Power is supplied to the unit simply by pressing the power pushbutton which will preferably light when power is on and extinguish when power is off. The logic electronic circuits employed will be automatically reset when the power is turned on with the digital logic and the motors ready for operation and with the tray in a discrete useful position when the power is turned on. The two rows A and B are representative of two independent sections, each having a volumetric control micrometer adjustable over a range, for example of 0.2 milliliters to 21.0 milliliters. The illustrated model includes a tray assembly accommodating twenty vials or ampules in two rows of ten each. This is exemplary only as a greater number of vials is clearly possible within the scope of the invention and the use of any number of rows is likewise possible.

When the unit prime switch is actuated, fluid is pumped through the tubing connecting the reservoir to the nozzle forcing all air or other foreign substances out of the system. A tray of empty vials is employed to collect the fluid until the same flows freely without air bubbles or other foreign substances therein. For prime mode operation, the volumetric control micrometer may be set to any desired volume. However, the greater the volume setting the faster the unit will be primed.

The number of cycles of dispensing in this mode of operation is determined by the setting of the cycle-select switches. Any number of cycles for each section A or B may be chosen from zero through 10 or from zero to the maximum number of cycles permitted in the specific apparatus concerned.

As to the power control switch, the prime mode pushbutton will preferably light when depressed and will extinguish when the number of cycles selected for both sections has been completed. Each section will function for the number of cycles set upon its respective cycle-select switch. Each section will dispense a total volume equal to the setting of the volumetric control multiplied by the number of cycles selected. Before the unit is completely primed, the dispensed fluid will be mixed with air or other foreign substances trapped in the tubing before prime mode operation. Thereafter the system will be free of such foreign substances. A section will not operate when its respective cycle-select switch is set to zero. Should a vial be missing from a row in the tray, the apparatus will automatically position the tray to the next vial present, thereby avoiding accidental spilling of the fluid but still satisfying the requirements for the actual number of vials to be filled in each section. Fluid of course will not be dispensed if the tray is not in position. The operation will terminate with the tray in the next sequential position after the position for the last vial which was filled.

The automatic mode is intended to fill a predetermined number of vials of the total number of vials in the respective rows. The tray must be properly seated in position for the operation to begin. The volumetric control micrometer is set to the desired volume. Any number of vials in each row may be filled by setting the corresponding cycle-select switch to the desired number. Operation of this mode is started by pressing the auto pushbutton. This pushbutton will light when pressed and will extinguish when the number of cycles selected for both rows is completed. Each selection will function for the number of cycles set on the cycle-select switch. A section will not operate when its cycle-select switch is set to zero. Operation of the auto or automatic mode will always start with the leftmost vials. The tray will automatically position itself to these first vials before any of these vials are filled with fluid. Should a vial be missing from the tray, the apparatus will automatically position the tray to the next present vial. Accidental spilling of the fluid will thus be avoided. In the last case, the apparatus will still satisfy the actual number of vials selected to be filled in each row. Fluid will not be dispensed if the tray is not in operation. Operation will end with the tray at the next sequential position following the last filled vial. If not enough vials are placed in the tray to accommodate the selected cycle-select number, operation will end at the last available vial.

The manual mode of operation is intended to fill one vial at a time in each section. The tray must be properly seated in position for this operation to begin. This mode is similar to the auto mode. However, no more than one vial in each section can be filled for each pressing of the manual pushbutton. Once again the volumetric control micrometer is set to the desired volume. If one row is not required, the corresponding cycle-select switch is set to zero. Operation of this mode is commenced by pressing the manual pushbutton which will light when pressed and will extinguish when

one cycle has been completed. Operation of the manual mode will always start with the vial beneath the corresponding nozzle at the time the pushbutton is pressed. Operation will always end with the tray in the next position following the last filled vial. Should a vial be missing from the tray, the apparatus will automatically advance the tray to the next present vial. Accidental spilling of the fluid will be avoided and the fluid will furthermore not be dispensed if the tray is not in position.

The apparatus noted above is a unit having a greatest degree of mobility. It can be readily mounted on a laboratory cart. The unit may also be a table top unit which can be mounted, for example, on a laboratory bench. A more simple type of unit can be provided in which the dispensing mode is limited to a single cycle. In all models the unit is preferably provided with the volumetric control micrometer which can be set to any desired volume. The logical control circuitry which enables the apparatus to function as above will be described hereinafter.

However, before the electronic circuitry is described, the above mentioned valve construction will be explained in greater detail with reference to FIG. 5.

In FIG. 5 is shown a bi-directional three port valve of the type mentioned hereinabove. It consists of a cylindrical body 300 having therein chambers 302 and 304 in which are positioned plug members 306 and 308. These plug members differ somewhat from the corresponding elements illustrated in FIG. 2, but perform the same function and can be provided with threads or the like in correspondence with the aforementioned valves.

Chambers 302 and 304 are connected by a channel 310 having a further channel 312 intersecting at a right angle. Inside of chambers 302 and 304 are located floating valve members 314 and 316, these being provided with appropriately located grooves 318 and 320 to permit the escape of fluid in appropriate direction.

Channel 312 constitutes the port which is connected to the corresponding pump. Fluid is supplied through the bore 322 in plug member 306. It is dispensed via the bore 324 in the plug member 303.

Assuming that suction is applied to channel 312, floating member 316 will be moved upwardly against seat 326. The diameter of member 316 is less than that of member 304 and thus fluid will be enabled to move laterally around member 316. Groove 320 will enable this float to move inwardly through channel 310 and thence into channel 312 into the associated pump. At the same time this suction will draw floating member 314 against seat 328 so that no fluid will be able to pass outwardly via bore 324.

On the reciprocal stroke of the pump fluid will be urged outwardly through channel 312 into channel 310. Member 316 will be forced outwardly against the seat 330, whereas member 314 will be forced outwardly against the seat 332. The diameter of member 314 is less than the corresponding diameter of chamber 304 and hence fluid will be able to escape laterally around member 314 and outwardly via groove 318 into bore 324 whereby the metered amount of fluid will be dispensed.

FIG. 6 illustrates the arrangement of controls which are employed in the apparatus of FIGS. 1-4 including some additional and optional controls. Resistors 400, 402, 404, 406 and 408 are connected at respective

ends thereof to a source of positive voltage such as, for example, plus 5 volts.

The unit prime control referred to hereinabove consists of poles 414, 412 and 410 connected together for simultaneous action, and forming parts of switches connected to a grounded bus 416. The other side of the switch is connected to terminals 418, 420 and 422.

The auto control referred to hereinabove consists of three poles 426, 428 and 424 connected at one side to bus 416 and at the other side to terminals 430, 432 and 434. The manual control referred to hereinabove consists of poles 438 and 436 connected together for common action, pole 438 being connected at one side to bus 416 and at the other side to terminal 440, whereas pole 436 when operated connects bus 416 to the aforementioned terminal 420.

Also illustrated are the top limit switches 442, 444, 446 and 448, these being connected via resistors 450, 452, 454 and 456 to sources of positive voltage such as, for example, plus 5 volts. The switches 442, 444, 446 and 448 connect a grounded bus 458 to terminals 460, 462, 464 and 466 respectively.

Switch 442 is the switch for the fine pump employed in connection with row A. Switch 444 is the switch employed in connection with the coarse pump of row A. Switch 446 is the switch employed in connection with the fine pump for row B. Switch 448 is the switch employed for the coarse pump of row B. By way of example, switch 444 in FIG. 6 corresponds to switch 138 in FIG. 2.

The bottom limit switches are also illustrated in FIG. 6, these including switches 468, 470, 472 and 474, said switches being connected on the one side to grounded bus 476. On the other side the switches are connected via resistors 478, 480 and 484 to sources of positive voltage such as, for example, plus 5 volts. Switches 468, 470, 472 and 474 are respectively connected to terminals 486, 488, 490 and 492.

Switches 494 and 496 correspond to switches 242 and 244 in FIG. 3(a) and are adapted to sense respectively whether vials are in place in rows A and B. These switches are connected on one side to grounded bus 498 and on the other side via resistors 500 and 502 to sources of positive voltage. These switches are also connected to terminals 504 and 506. A switch 508, not heretofore illustrated, is intended to sense whether there is a tray in position in the base section of the apparatus. This switch is connected on the one side to grounded bus 510 and via resistor 582 to a source of positive voltage. It is also connected to a terminal 514. Two optional switches may also be coupled to bus 510. These are the switches 516 and 518 which may be employed optionally as indicated hereinafter for purposes of reversing the tray drive motor. These switches are connected via resistors 520 and 522 to sources of positive voltage and are also connected to terminals 524 and 526.

Switch 528 is the cam operated switch and corresponds to switch 208 in FIG. 3(a). It makes contact selectively with one of two terminals 530 or 532 which it connects to ground via bus 534. Contacts 530 and 532 are respectively connected via resistors 536 and 538 to sources of positive voltage and are also connected to terminals 540 and 542.

In FIG. 6, are moreover illustrated cycle-select controls 544, 546 corresponding to controls 24 and 26 of FIG. 1. The ground for these controls is provided by

bus 548 and a positive voltage is supplied to these units via terminal 550. Each of these units has four outputs. Unit 544 provides outputs via terminals 552, 554, 556 and 558, whereas unit 546 provides its outputs at terminals 560, 562, 564 and 566. As is conventional, the four terminals of each of units 544 and 546 may stand for binary representation of quantities and since there are four terminals, each unit may provide for a selection of fifteen vials inasmuch as the sixteenth combination will be used for zero.

The aforementioned switches are also to be found in FIGS. 7 and 8 whereat they are shown in combination with the associated electronic logic circuitry. It is seen in FIG. 7 that the manual switch consisting of poles 436 and 438 is connected via terminal 440 to a flip flop 568. This flip flop as is conventional has two output states, either of which may be presented at output terminals 570 and 572, the outputs of these two terminals being interchangeable. Thus, for example, the flip flop 568 will have two levels such as a high level signal and a low level signal as will be true throughout the entire logic circuitry. Moreover specifically, however, when terminal 570 provides a high signal and terminal 572 will provide the low signal and when the flip flop is set by a signal received from terminal 440, a low level signal will appear at terminal 570 and a high level signal will appear at terminal 572. Terminal 574 is the reset terminal for flip flop 568 and a signal received from terminal 574 will act to restore the condition which existed in flip flop 568 before this flip flop was set by a signal received from terminal 440.

The flip flop circuitry discussed hereinabove and the notations employed in connection therewith will be common to the flip flops discussed hereinunder as to which it may be assumed that similar connections likewise constitute set and reset terminals and output terminals.

Associated with flip flop 568 is a lamp 576 connected through a lamp driver 578 to terminal 570 which is also connected to line 580. Terminal 572 is connected to line 582.

The auto control as noted above consists of poles 424, 426 and 428. Pole 428 is connected to terminal 432, whereas pole 426 is adapted to make connection with flip flop 582 which provides outputs on lines 584 and 586 and which receives a reset signal via line 588. Pole 424 is connected to line 590.

Of the prime selector switch, pole 412 is connected to terminal 420, whereas pole 410 is connected to line 590. Pole 414 is connected to the set terminal of flip flop 592 which receives a reset signal via line 594. The outputs of flip flop 592 appear on lines 596 and 598, line 596 feeding signals to a lamp driver 600 which feeds a lamp 602. The output of flip flop 582 feeds through line 584 through lamp driver 604 feeding a lamp 606.

An OR gate 608 receives input signals from lines 582, 586 and 598 and passes any of such input signals via line 610 to an AND gate 612. The other input to AND gate 612 is received via line 614 and as is conventional the AND gate will pass signals through onto line 616 only when input signals are present at one of its input terminals. The input to AND gate 612 is the output of a flip flop consisting of OR gates 618 and 620 connected in feedback relationship by lines 622 and 624. Set signals are received by this flip flop via line 626 whereas reset signals are received via line 628.

The circuit, moreover, includes AND gates 630, 632 and 634. AND gate 630 has three inputs, one of which is received via line 636 and the others of which are supplied via terminals 486 and 488. In other words, AND gate 630 is fed both bottom signals of the A row. AND gate 634 has four input terminals, two of which are the terminals 486 and 488 (shown separately for the sake of clarity) and the other two of which are terminals 490 and 492. AND gate 634 is provided with three signals, one of which is received via line 638 and the other two of which are connected to terminals 490 and 492. Thus AND gate 632 receives all four bottom signals from the A and B rows, whereas AND gate 634 receives the bottom signals of the B row.

The outputs of AND gates 630, 632 and 634 are respectively transmitted via lines 640, 642 and 644 to an OR gate 646 connected in feedback relationship with OR gate 648 by lines 650 and 652 to constitute a flip flop. Another input to the flip flop is received via line 654 which constitutes the output of an AND gate 656. OR gate 648 receives input signals via lines 658 and 660. The output of OR gate 648 is transmitted via lines 662 whereas the output of OR gate 646 is transmitted via line 664 to AND gate 666 which has five other inputs respectively connected to terminals 524, 526, 514, 504 and 506. The output of AND gate 666 is transmitted via line 668. The cam switch 528 is connected to flip flop 670 and provides signals alternatively to the set and reset terminals thereof. The outputs of flip flop 670 are transmitted via lines 672 and 674 and AND gate 676 and OR gate 678 respectively. Second inputs to gates 676 and 678 are received via line 680. The output of AND gate 676 is transmitted via line 682, whereas the output of OR gate 678 is transmitted via line 684. The output of flip flop 670 transmitted via line 674 into OR gate 678 is also transmitted via line 686.

An OR gate 688 receives two input signals respectively from line 616 and from a line 690 connected via line 582 to flip flop 568.

Terminals 552, 554, 556 and 558, noted hereinabove with respect to cycle-select 544 in FIG. 6, are connected to A comparator 692. Terminals 560, 562, 564 and 566 described in connection with cycle-select 546 in FIG. 6, are connected with B comparator 694.

The circuit of FIG. 7 also comprises an A decade counter 696 and a B decade counter 698. Voltage is supplied to counter 698 via terminal 702. Inputs are transmitted into counter 696 and 698 via line 594 and also via lines 704 and 706 respectively.

Output signals from counter 696 are transmitted to comparator 692 via lines 708, 710, 712 and 714. These four signals will constitute a binary representation of the number of vials counted and such binary representation will be compared in comparator 692 with signals received via terminals 562, 564, 566 and 568.

Similarly, the output of counter 698 is transmitted to comparator 694 via lines 716, 718, 720 and 722. A comparison of the binary count represented on these lines will be compared in comparator 694 with the signals received via terminals 560, 562, 564 and 566.

It will thus appear that comparators 692 and 694 function to compare the selected number of vials to be filled with the actual count of the vials which have been filled. Output signals are transmitted from comparator 692 via lines 724, 726, 728 and 730 and from comparator 694 via lines 732, 734, 736 and 738. These output

signals pass into inverters 740 and 742 and also into AND gate 744, as well as onto lines 636 and 638.

It will also be noted that line 746 is connected in feedback relationship in counter 696 as is line 748 in counter 698, the latter line also feeding line 750 which is connected as an input to AND gate 752, the other input of which is supplied via line 754 connected to line 580.

AND gate 756 receives one input via line 758 connected to line 714 and the other input via a line 760 connected to line 580.

The output of AND gate 756 is transmitted via line 762 as an input to OR gate 764, the other input to which is received via line 766 from line 768 which is connected to the output of AND gate 752. Inverter 740 transmits an output signal via line 768. OR gate 764 feeds a driver 770 whose output is connected via line 772 to an OR gate 774. OR gate 774 has a second input received via line 776 which constitutes the output of AND gate 744. The output of OR gate 744 is transmitted via line 778 which is an input into AND gate 656 as well as into flip flop 780 which receives a set signal via line 782 from terminal 420. The output of flip flop 780 is transmitted via inverter 784 onto line 786 constituting an input into OR gate 620, OR gate 648 and flip flop 592, as well as to flip flops 568 and 682. An initial reset relay 788 is provided having an armature 790 connected via line 792 to the reset terminal of flip flop 780. The output of OR gate 688 is transmitted via line 794.

In FIG. 8 are illustrated switches 494 and 496 which, as indicated hereinabove, indicate whether a vial is in place in rows A and B respectively. These switches are now seen to be connected respectively to AND gates 796 and 798. Other inputs to AND gate 796 are lines 762, 768, 794, 662 and a line 800, as well as a line 802 leading to switch 496 and line 686.

Inputs to AND gate 798 are received from switches 494 and 496 via a line 804 and the line 802 respectively. A further input to AND gate 798 is received via line 686 and via a line 806 which is connected to output line 808 of gate 796 which output is also connected to an inverter 810. The output of AND gate 798 is transmitted via line 812 to inverter 814.

Further illustrated in FIG. 8 is the row A fine bottom switch 468, the row A fine top switch 442, the row A coarse bottom switch 470 and the row A coarse top switch 444. These switches respectively feed into inverters 816, 818, 820 and 822.

An AND gate 824 receives an input via line 826 from inverter 810 and via line 828 from inverter 816. An AND gate 830 receives an input via line 832 from inverter 814 and via line 834 from inverter 818. An AND gate 836 receives an input via line 826 and via a line 838 from inverter 820. An AND gate 840 receives an input via line 832 and via line 842 from inverter 822.

The output of AND gate 824 is transmitted via line 844 to a motor driver 846 connected to motor 848. This motor might correspond, for example, to motor 130 in FIG. 2. Motor driver 846 is intended to drive motor 848 in forward direction to control the fine supply for row A.

The output of AND gate 830 is transmitted via line 850 to motor driver 852 also connected to motor 848. Motor driver 852 controls the reverse drive of motor 848 for row A for the fine supply.

The output of AND gate 836 is transmitted via line 854 to motor driver 856 connected to motor 858 which is the motor for the coarse supply of row A. Driver 856 drives motor 858 in the forward direction.

The output of AND gate 840 is transmitted via line 860 to motor driver 862 also connected to motor 858 to drive the same in reverse direction.

Similarly illustrated in FIG. 8 are the row B fine bottom switch 472, the row B fine top switch 446, the row B coarse bottom 474 and the row B coarse top switch 448. These are connected to inverters 864, 866, 868 and 870 which in turn transmit input signals to AND gates 872, 874, 876 and 878. Gates 872 and 876 also receive input signals via line 880 constituting an output of inverter 882. And gates 874 and 878 receive input signals via line 884 constituting an output of inverter 886.

Motors 888 and 890 are respectively motors for fine supply and for coarse supply. Motor 888 is driven in forward direction by motor driver 890 and in reverse direction by motor driver 892 which are respectively connected to AND gates 872 and 874.

Motor 890 is respectively driven in forward or reverse direction by motor drivers 894 and 896 which are respectively connected to AND gates 876 and 878.

Inverter 882 receives an input signal from AND gate 898. Inputs to AND gates 898 are received via line 900 which is an output of inverter 742 of FIG. 7, via line 768 which is an output of gate 752 of FIG. 7, and via line 794 which is an output of OR gate 688 of FIG. 7.

Further inputs are received via line 662, a line 902 and line 904 which is connected to switch 496 which indicates when a vial is in place in the B row.

Inverter 886 receives its input from AND gate 906 which receives one input via line 908 from the output of AND gate 898. Other inputs are received from line 904, line 802 and line 686.

The motor 910 in FIG. 8 corresponds to the motor 204 in FIG. 3(a). It is driven in forward direction by driver 912 and in reverse direction by driver 914. Associated with these drivers are lamp drivers 916 and 918.

Driver 912 receives an input signal from an OR gate 918 whose input signals are received via lines 668 and 682. The input signal to motor driver 914 is received via line 920 from flip flop 922 which transmits another output signal via line 924 which is connected to the line 680 in FIG. 7, as noted hereinabove. A reset signal for flip flop 922 is received via line 926 and set signals are received either via line 590 or from switch 518.

An OR gate 928 feeds an output signal to driver 930 whose output is transmitted onto line 926. Inputs to OR gate 928 are received via line 594 and also from switch 516.

The above described circuits of FIGS. 7 and 8 operate as follows:

Flip flop 780 provides a reset signal for all of the other flip flops and counters when the unit is not in operating mode. Driver 784 provides the low level signal when flip flop 780 is reset.

Flip flop 568 provides the manual mode signal to the logic circuits for the entire length of the manual mode. Flip flop 582 provides the auto mode signal to the circuit for the entire length of the automatic mode. Flip flop 592 provides the prime mode signal to the logic circuit for the entire length of the prime mode. OR gate 608 provides a high signal on line 610 when any of flip flops 568, 582, or 592 are set. Flip flop 670 provides

a signal indicating when switch 528 indicates that the aforementioned tray is in a discrete position.

Flip flop 922 provides a signal which indicates that the tray has reached the last vial or when the prime or auto modes have been selected.

The flip flop including OR gate 618 provides a signal when flip flop 922 is set. The AND gate 612 provides a low signal when the flip flop including OR gate 618 is set and when OR gate 608 is satisfied.

OR gate 688 provides a high signal when AND gate 612 is satisfied or when the manual mode is selected and flip flop 568 is set.

The driver 914 provides a low signal when the flip flop 922 is set in order to drive the motor 910 in reverse.

OR gate 928 provides a high signal when flip flop 780 is reset or when the tray closes switch 516. Driver 930 provides a low signal when OR gate 928 is satisfied.

AND gate 656 provides a low signal when the manual mode is chosen and when the last cycle is completed such that a signal is received via line 778.

AND gate 632 provides a low signal when all bottom limit switches are open with the pistons being driven to their bottommost positions by their respective motors.

AND gate 630 provides a low signal when the A section bottom limit switches are held open by the A section motors driving their pistons to the bottom positions and when the B section number of cycles is completed.

AND gate 634 provides a low signal when both B section bottom limit switches are held open by the operation of the B section motors driving their pistons to the bottom and when the A section number of cycles is completed.

The flip flop including OR gate 646 provides an output signal when AND gates 630, 632 or 634 are satisfied. AND gate 666 provides a low signal when all of the top limit switches are held open by their respective pistons driven to their uppermost positions by their respective motors and when the flip flop including OR gate 646 is set.

AND gate 676 provides a low signal when the flip flop 670 is set and the flip flop 922 is reset to move the tray 28 forward (see FIG. 1).

OR gate 678 provides a high signal to reset the flip flop 780 when the flip flop 670 is reset or when the flip flop 922 is set. This takes place when the number of cycles selected for the A and B rows is completed.

The OR gate 918 provides a high signal when the AND gate 666 is satisfied or when the AND gate 676 is satisfied. This also moves the tray 28 forward.

The driver 912 generates a signal to drive motor 910 in forward direction when the OR gate 918 is satisfied.

Decade counter 696 for the A row counts the number of cycles of the A row taking place since the initiation of the mode. Decade counter 698 counts the number of cycles for the B row since following the initiation of the mode.

As was noted hereinabove, the comparator 694 compares the output of counter 698 to the setting of the B row cycle-select switch and provides an output signal when they are equal. The cycle-select switch setting generates signals on terminals 552, 554, 556 and 558.

The comparator 694 compares the output of counter 698 to the setting of the B row cycle-select switch which provides signals on terminals 560, 562, 564 and

566. The comparator 694 provides a high output signal when the compared figures are equal.

And gate 756 provides an output signal which is a low level signal when the manual mode is selected and when the A row completes one cycle. These signals are received by gate 756 via line 580 and line 758.

AND gate 752 provides an output signal of low level magnitude when the manual mode is selected and when the B row completes one cycle. AND gate 752 receives these signals via lines 750 and 754.

OR gate 764 provides an output signal of high level magnitude when either the AND gate 756 or the AND gate 752 is satisfied. The OR gate 752 receives its input signals via lines 762 and 766.

The driver 770 provides an output signal of low level magnitude when the OR gate 764 is satisfied. The inverter 740 provides an output signal of high level magnitude when the A section has completed the number of cycles selected. Inverter 742 provides a signal of high level magnitude when the B row has completed the number of cycles selected.

AND gate 744 provides an output signal of low level magnitude when both the A and B rows have completed the respective number of cycles selected.

OR gate 774 provides an output signal of high level magnitude when A sections have completed the respective number of cycles selected. AND gate 796 provides an output signal of low level magnitude when the A section motors are required to turn forward. Inverter 810 provides an output signal of high level magnitude when the AND gate 796 is satisfied and at the same time increments the A decade counter 696.

An output signal of high level magnitude is generated by the inverter 816 when the A fine bottom limit switch 468 is not open which indicates that the A section fine motor is not at the bottom of the stroke. AND gate 824 provides an output signal of low level magnitude to turn the A section fine motor forward when AND gate 796 is satisfied and the A section fine motor 848 is not at the bottom of the stroke.

The inverter 820 provides an output signal of high level magnitude when the A coarse bottom limit switch 470 is not open which indicates that the A section coarse motor 858 is not at the bottom of the stroke.

An output signal of low level magnitude is provided by AND gate 836 to turn the A section coarse motor 858 forward when the AND gate 796 is satisfied and when the A section coarse motor 858 is not at the bottom of the stroke.

AND gate 798 provides an output signal of low level magnitude when both A section motors 848 and 858 are required to turn in reverse direction.

Inverter 814 provides an output signal of high level magnitude when the AND gate 798 is satisfied.

Inverter 818 provides an output signal of high level magnitude when the A section fine top limit switch 442 is not open and thus when the A section fine motor 848 is not at the top of the stroke.

AND gate 830 provides an output signal of low level magnitude to turn motor 848 in reverse when AND gate 788 is satisfied and when also motor 848 is not at the top of its stroke.

Inverter 822 provides an output signal of high level magnitude when the A section coarse top limit switch 494 is not open thus indicating that the A section coarse motor 858 is not at the top of its stroke.

AND gate 840 provides an output signal of low level magnitude to turn the A section coarse motor 858 in reverse when the AND gate 798 is satisfied and when the motor 858 is not at the top of its stroke.

An output signal of low level magnitude is generated by the AND gate 898 when both B section motors 888 and 890 are required to turn in forward direction. Inverter 882 provides an output signal of high level magnitude when AND gate 898 is satisfied. This also increments the B section counter 698.

Inverter 864 provides an output signal of high level magnitude when the B section fine bottom limit switch 472 is not open thus indicating that the motor 888 is not at the bottom of the stroke.

AND gate 872 provides an output signal of low level magnitude to turn the motor 888 forward when the AND gate 898 is satisfied and when the motor 888 is not at the bottom of its stroke.

Inverter 868 provides an output signal of high level magnitude when the B section coarse bottom limit switch 474 is not open thus indicating that the B section coarse motor 890 is not at the bottom of its stroke. AND gate 876 provides an output signal of low level magnitude to turn the motor 870 forward when the AND gate 898 is satisfied and when the motor 890 is not at the bottom of its stroke.

AND gate 906 generates an output signal of low level magnitude when the B section motors 880 and 890 are required to turn in reverse direction. Inverter 886 generates an output signal of high level magnitude when the AND gate 906 is satisfied. Inverter 866 provides an output signal of high level magnitude when the B section fine top limit switch 446 is not open thus indicating that the motor 888 is not at the top of its stroke.

AND gate 874 generates an output signal of low level magnitude to turn the motor 888 in reverse direction when the AND gate 906 is satisfied and when the motor 888 is not at the top of its stroke.

An output signal of high level magnitude is generated by the inverter 870 when the coarse top limit switch 448 is not open thus indicating that the motor 890 is not at the top of its stroke. AND gate 878 generates an output signal of low level magnitude to turn motor 890 in reverse direction when the AND gate 870 is satisfied and when the motor 890 is not at the top of its stroke.

From the above it will be readily seen that the logical electronic circuitry illustrated in FIGS. 6, 7 and 8 provides for the various modes which have been enumerated hereinabove. The operation of the manual pushbutton enables vials to be stepped beneath the dispensing nozzles one by one under the control of the operator. The selection of the auto or automatic mode by operation of the corresponding pushbutton enables the automatic stepping of vials selected by the cycle-select switch for each row. The priming function is also readily effected by simply operating the unit prime pushbutton.

Whereas a somewhat sophisticated system has been described above with respect to enabling the selection of a number of modes of the operation, there is also contemplated within the scope of the invention electronic circuitry to enable the apparatus of FIGS. 1-4 to be used in single dispensing operations. Such a circuit is illustrated by way of example in FIG. 9.

In FIG. 9 are illustrated the fine bottom switch 1000, the fine top switch 1002, the coarse bottom switch 1004 and the coarse top switch 1006. The switch 1000

is connected via resistor 1008 to a source of positive voltage and switches 1002, 1004 and 1006 are likewise connected to said source of positive voltage via resistors 1010, 1012 and 1014, respectively.

Switch 1000 is connected via line 1016 to an inverter 1018. Switch 1002 is connected via line 1019 to an inverter 1020. Switch 1004 is connected via line 1022 to inverter 1024 and switch 1006 is connected via line 1026 to inverter 1028.

The output of inverter 1008 is connected via line 1030 to AND gate 1032. The output of inverter 1020 is connected via line 1034 to AND gate 1036. The output of inverter 1026 is connected via line 1038 to AND gate 1040.

The output of inverter 1028 is connected via line 1042 to AND gate 1044.

AND gate 1032 transmits its output via line 1046 to motor driver 1048 in turn connected to motor 1050 which operates the pump for the fine pump. The output of AND gate 1036 is transmitted via line 1052 to motor driver 1054 which drives motor 1050 in reverse direction.

AND gate 1040 transmits its output via line 1056 to motor driver 1058 which drives coarse motor 1060 in forward direction. AND gate 1044 transmits its output via line 1062 to motor driver 1064 which drives coarse motor 1060 in reverse direction.

Lines 1018 and 1026 are connected via lines 1066 and 1068 respectively to AND gate 1070, the output of which is connected via line 1072 to flip flop 1074 consisting of OR gates 1076 and 1078 connected by lines 1080 and 1082 in feedback relationship. The output of OR gate 1078 (or of flip flop 1074) is connected via line 1084 to inverter 1086 the output of which is connected via line 1088 to inverter 1090 which is connected to lamp driver 1092 to dispense lamp 1094.

The dispense control switch 1096 is connected to flip flop 1098 via line 1100 the outputs of which are transmitted via lines 1102 and 1104. The reset terminal for flip flop 1098 receives signals via line 1106. Line 1102 is connected via line 1108 to the reset terminal of a further flip flop 1110, which receives an input signal via line 1112 from an AND gate 1114. Flip flop 1098 also has line 1102 connected via lines 1116 and 1118 to AND gates 1032 and 1040 respectively. Line 1104 connected to the second output of flip flop 1098 is connected via lines 1102 and 1122 respectively to AND gates 1036 and 1044. The armature or switch 1124 of relay 1126 is connected to line 1106 and provides for the initial resetting of flip flop 1098.

AND gate 1114 receives input signals via lines 1128 and 1130 from switch 1000 and switch 1004 respectively.

From what has been stated above, it will now be seen that AND gate 1114 sets flip flop 1110 when switches 1000 and 1004 are closed, this enabling the resetting of flip flop 1098 which is previously set by operation of dispense control switch 1096.

The operation of dispense control switch 1096 sets flip flop 1098, thereby transmitting a signal via line 1102 and lines 1116 and 1118 to AND gates 1032 and 1040 respectively enabling motors 1050 and 1060 to be driven in forward direction.

When flip flop 1098 is reset by a signal received via line 1106 from flip flop 1110, an output signal is transmitted via line 1104 and thence via lines 1120 and 1122 to AND gates 1036 and 1034 which operate

through motor drivers 1054 and 1064 respectively to drive motors 1050 and 1060 respectively in reverse direction.

When switches 1002 and 1006 are closed signals are sent via lines 1066 and 1068 to AND gate 1070 which being thereafter satisfied transmits an output signal via line 1072 to OR gate 1076 of flip flop 1074. A signal is transmitted via lines 1084 and 1088 to lamp driver 1096 to extinguish lamp 1094 if it has been previously lit. Lamp 1094 is illuminated when a signal is transmitted via flip flop 1098 via line 1104 to the OR gate 1078 of flip flop 1074 from which a signal is transmitted via lines 1084 and 1088 to lamp driver 1092 to illuminate lamp 1094.

Since the operation of flip flop 1098 is the heart of the circuit in FIG. 9, it follows that single operations of switch 1098 will provide single complete cycles of motors 1050 and 1060. Accordingly, the circuit of FIG. 9 is a much simplified version of the circuits appearing in FIGS. 6-8.

FIG. 10 illustrates a motor driver circuit to be employed as the motor drivers in the above described circuits.

In FIG. 10 appear transistors 1200, 1202, 1204 and 1206. Transistor 1200 includes base 1208, emitter 1210 and collector 1212. Transistor 1202 includes base 1214, emitter 1216, and collector 1218. Transistor 1204 includes base 1220, emitter 1222 and collector 1224. Transistor 1206 includes base 1226, emitter 1228 and collector 1230.

The input of the circuit is via terminal 1232 connected to emitter 1210 of transistor 1200. The output of the circuit is taken from terminal 1234 connected to collector 1230 of transistor 1206. A diode 1236 is connected by the collector 1222 of transistor 1204 and collector 1230 of transistor 1206.

The base 1208 of transistor 1200 is connected via a resistor 1238 to a terminal 1240 connected to a positive source of voltage such as plus 12 volts. A resistor 1242 connects bases 1214 and 1220 of transistors 1202 and 1204 respectively to terminal 1240. Resistor 1244 connects collector 1224 of transistor 1204 also to terminal 1240.

The collector 1212 of transistor 1200 is connected to the base 1214 of transistor 1202. Collector 1216 of transistor 1206 is connected directly to base 1226 of transistor 1206 and also via resistor 1246 to ground.

The circuit of FIG. 10 constitutes a power amplifier activated by signals received by transistor 1200 via terminal 1232 the output being amplified by the action of transistors 1202 and 1204 to enable a motor driving signal to be obtained at terminal 1234.

From what has been described above, it appears that there is provided in accordance with the invention a dispensing apparatus which is operative with a source of one or more fluids and comprising a pump for drawing fluid from such source with dispensing devices being coupled to the pump for dispensing the quantity of fluid drawn from the source, there being moreover provided control devices coupled to the pump for adjusting both the magnitude of the quantity drawn from the source as well as the rate at which the quantity is dispensed.

There is also provided a structure for moving the plurality of vials of receptacles past the dispensing nozzles, the pump being arranged and controlled to dispense se-

lected and equal quantities of fluid into the receptacles or vials in sequence.

Further in accordance with the invention there is provided a bank of mode selection switches coupled through logic circuits to the pump and to a receptacle conveyance device to enable the receptacle to be moved past the dispensing nozzles automatically or under manual control.

The apparatus and circuitry described above are arranged and controlled to enable priming the pump and associated fluid circuits and dispensing nozzles with the fluid to be thereafter dispensed, this arrangement being present in order to remove air bubbles and foreign particles from the system.

It will be noted from the above description that the rate of dispensing is controllable without the need for adjusting the dispensing nozzles although such type of control could readily be included in apparatus of the invention if found necessary. However, the invention instead and preferably provides for rate of control of dispensing by controlling the rates of speed of the various pumps.

In accordance with the invention there are, moreover, provided a coarse fluid withdrawal pump and a fine fluid withdrawal pump, these being further used to dispense coarse and fine amounts of fluids as selected by respective controls. In the preferred embodiment of the invention, a single control nozzle is coupled to both the fine and coarse fluid withdrawal pumps whereby it is possible to use the same for mixing a plurality of fluids.

As a feature of the invention, sensing devices are provided to sense the absence of receptacles from positions in the aforementioned tray 28 in order to avoid the dispensing of fluid into any position from which a receptacle is absent.

As will also be seen in the above description, the invention provides switches for selectively controllably selecting the number of receptacles into which fluid is to be dispensed and to terminate the dispensing of fluid when fluid has been dispensed into the selected number of receptacles.

It also appears in the above description that dispensing trays may be provided in accordance with the invention for simultaneously dispensing fluid into a plurality of rows of vials.

In accordance with a feature of the invention, electronic circuits are provided for counting the number of vials into which fluid has been dispensed, the controls for selecting the number of vials into which fluid is to be dispensed being connected to electronic comparators which compare the selected and counted numbers.

According to a further feature of the invention, there is provided a unique bi-directional valve having three ports, two, of which are respectively coupled to the source of fluid and to the dispensing means with the pump being coupled to the other of the ports for withdrawing fluid from the source and for dispensing of the same.

From the description of the circuits in FIGS. 7 and 8 above, it will be seen that a further feature of the invention includes the operation of a logical circuit by the use of a plurality of flip flops which are all put into reset condition in response to the turning on of the power supply feeding the logical circuit as well as the electrically operated components of the mechanical portion of the apparatus.

The invention employs a unique arrangement of a pump including a piston and cylinder in combination with an adjustably positioned switch to control the dispensing of fluid, the piston being the movable member, the switches adjustably located in the path of movement, of the same and the location of the switch can be controlled for conveniently adjusting the amount of fluid to be withdrawn and dispensed.

With respect to the electronic circuitry of the invention, the invention according to one aspect thereof may be considered as providing apparatus comprising supply means for supplying receptacles to a dispensing means and electronic control means comprising automatic mode, manual mode and prime mode select means with flip flops being coupled to and set by the select means to generate signals for controlling the supply means and also for controlling the metering portion of the apparatus. As has been noted hereinabove, the metering means will include a number of devices each including a cylinder with a piston displaceable therein and a motor for driving the piston, there being a switch adjustably positionable in the path of the piston to be operated by the latter and there further being drive means to drive the motor in opposite directions at least partly under control of the aforementioned switch.

The electronic circuits of the invention may comprise a gate coupled to the aforesaid drive means to actuate the same, the gate being coupled to the aforesaid switch, there being moreover provided a comparator coupled to the gate and further coupled to a cycle-selector and a counting device as had been described hereinabove.

The invention also proposes the use of a second gate between the comparator and the first gate with a switch means sensing the absence of receptacles from their respective positions to control the second said gate.

In addition, the invention provides a means for stepping the above noted tray past the dispensing means in discrete steps, there being additionally provided a switch to determine the alignment of the receptacles with the dispensing means and being effective to operate the second said gate.

Another feature of the invention includes the utilization of an end-of-cycle flip flop coupled to the second said gate to operate the same. It will also be noted that the various mode select means are coupled to the second said gate to enable signals to be passed through the latter.

As still a further feature of the invention, it will be noted that the drive means for the various motors include four transistors coupled together in the specific manner set forth and cooperating with a diode to produce a suitable output signal for driving of the associated motor or motors.

There will now be obvious to those skilled in the art many modifications of the various mechanical and electronic arrangements set forth hereinabove. These modifications and variations will not depart from the scope of the invention if defined by the following claims.

What is claimed is:

1. Dispensing apparatus operative with a source of at least one fluid and comprising first means for drawing from said source a quantity of said fluid, dispensing means coupled to said first means for dispensing the quantity of fluid drawn from said source, and control means coupled to said first means for controllably ad-

justing the magnitude of said quantity; said first means including a pump including piston and cylinder members and a motor for displacing one of said members relative to the other, one of said members being fixed and the other movable and said control means including an adjustably positioned switch to limit the amount of movement of the movable member, said switch being coupled to said motor and being located in the path of movement of the movable member, said first means including a second switch coupled to said motor and also being located in the path of movement of the movable member to provide a second limit of movement for the same, and gates coupling the switches to said motor and counting means coupled to said gates and blocking said gates after a selected number of dispensing operations have been performed.

2. Apparatus as claimed in claim 1 comprising means for moving a plurality of receptacles past said dispensing means, said first means including means for dispensing equal quantities of fluid into said receptacles in sequence, gate means coupled to the first said gates, and receptacle detector means coupled to said gate means to block said gates in the absence of a receptacle positioned to receive fluid from said dispensing means.

3. Apparatus as claimed in claim 2 wherein said means for moving the receptacles past said dispensing means comprises a base with an opening therethrough, a tray slidable through said opening, a toothed rack on said tray, a gear engaged with said rack, a motor for driving said gear, a cam driven by said motor, and a switch actuated by said cam to measure the movement of said tray.

4. Apparatus as claimed in claim 3, wherein said first means includes a motor controlling the rate of dispensing of fluid, said apparatus further comprising a control on said base for controlling the speed of said motor.

5. Apparatus as claimed in claim 3 wherein said tray has openings for the insertion of receptacles and includes spring members in positions of interference with inserted receptacles and adapted to be displaced by the latter and a switch positioned in correspondence with said dispensing means and adapted to be operated by said spring members, when the latter are displaced, to indicate the presence of a receptacle by the dispensing means, said switch being coupled to said first means to enable the selective dispensing of fluid.

6. Apparatus as claimed in claim 1 comprising a rotatable lead screw supporting the first said switch for adjustable positioning the same, a dial for rotating said lead screw, and an index for indicating the position of the switch in terms of volume.

7. Apparatus as claimed in claim 1 wherein said first means includes two pumps both connected to said dispensing means, said pumps including cylinders of different diameters and pistons in said cylinders, and motors to drive the pistons in said cylinder, said cylinders being coupled to said source and to said dispensing means; said control means including switches to limit the strokes of the pistons in said cylinders, lead screws adjustably supporting said switches for actuation of said pistons, concentric dials for adjusting said lead screws, and spur gears on said lead screws and operated by said concentric dials.

8. Apparatus as claimed in claim 7 comprising concentric shafts connected with said concentric dials and spur gears on respective of said shafts and in engagement with respective of the first said spur gears.

9. Apparatus as claimed in claim 7 comprising indices including pointers driven by respective of said dials.

10. Apparatus as claimed in claim 7 comprising separate tubes leading from said pumps to said dispensing means, said dispensing means including a nozzle into which said tubes extend.

11. Apparatus as claimed in claim 1 wherein said switches are microswitches which include roller actuators.

12. Apparatus as claimed in claim 1 comprising a count selector means for selecting a number of dispensing cycles, and a comparator coupled to said selector means and counting means and to said gates which are operated by said comparator and switches.

13. Apparatus as claimed in claim 12 comprising gate means between said comparator and said gates, tray means providing a plurality of positions for receptacles adapted to receive fluid, and switch means to sense the absence of a receptacle from a position and operating said gate means to prevent dispensing fluid into a position in which there is no receptacle.

14. Apparatus as claimed in claim 13 comprising a guide for said tray means and switch means to determine when said tray means is positioned in said guide, the latter said switch means being coupled to and operating said gate means.

15. Apparatus as claimed in claim 13 comprising a guide for said tray means, means for stepping said tray means past said dispensing means in discrete steps to bring said positions into alignment with said dispensing means, and switch means to determine the alignment of positions with said dispensing means, the latter said switch means being coupled to and operating said gate means.

16. Apparatus as claimed in claim 15 comprising end-of-cycle flip flop means coupled to said gate means to operate the same; and manual mode select means, automatic mode select means and prime mode select means also coupled to said gate means to operate the same.

17. Apparatus as claimed in claim 16 comprising an OR gate and an AND gate in series between said select means and gate means, and a flip flop providing an input signal to said AND gate, said flip flop being coupled to and controlled by the latter said switch means.

18. Apparatus as claimed in claim 11, wherein the means for stepping said tray means includes a motor and drive means for driving the same, comprising an OR gate coupling said end-of-cycle flip flop and prime mode select means to the latter said drive means to actuate the same.

19. Apparatus as claimed in claim 18, wherein each of said drive means includes a source of voltage; first, second and third transistors each comprising a base, emitter and collector in operative association; a first resistor coupling the base of the first transistor to said source; second and third resistors coupling the collectors of the second and third transistors to said source; the emitter of the first transistor being adapted to receive an input control signal, the collector of the first transistor being coupled to the base of the second transistor, the collector of the second transistor being coupled to the base of the third transistor; and a fourth transistor including a base coupled to the emitter of the first transistor, a collector coupled to said diode and an emitter coupled to ground, the collector of the fourth

25

transistor being further coupled to the associated motor.

20. Apparatus as claimed in claim 1, wherein said first means includes a plurality of pumps, a plurality of motors driving the pumps and a plurality of drive means for driving the motors and wherein each of said drive means includes a source of voltage; first, second and third transistors each comprising a base, emitter and collector in operative association; a first resistor coupling the base of the first transistor to said source, second and third resistors coupling the collectors of the second and third transistors to said source; the emitter

26

of the first transistor being adapted to receive an input control signal, the collector of the first transistor being coupled to the base of the second transistor, the collector of the second transistor being coupled to the base of the third transistor; a diode coupled to the emitter of the third transistor; and a fourth transistor including a base coupled to the emitter of the first transistor, a collector coupled to said diode and an emitter coupled to ground, the collector of the fourth transistor being further coupled to the associated motor.

* * * * *

15

20

25

30

35

40

45

50

55

60

65