# United States Patent

**Croslin et al.**

[15] **3,665,980**

[45] **May 30, 1972**


## [54] DISPENSING APPARATUS AND ASSOCIATED ELECTRONIC CONTROL FOR SELECTING DIFFERENT MODES OF OPERATION


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

[73] Assignee: **Grumman Data Systems Corporation**



[22] Filed: **Dec. 9, 1969**

[21] Appl. No.: **883,573**

[52] **U.S. Cl.** ..... **141/183,** 23/259, 222/63

[51] **Int. Cl.** ..... **B65b 43/54**

[58] **Field of Search** ..... 23/253 R, 259 R; 141/25, 26, 141/27, 128, 129, 130, 183–185, 146; 222/63, 252, 309, 310



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 1,739,252 | 12/1929 | Mojonnier et al. | 141/183 X |
| 2,220,707 | 11/1940 | Chapman | 141/146 |
| 2,658,644 | 11/1953 | Lowe | 222/63 X |
| 3,275,042 | 9/1966 | Strazdins | 141/27 |
| 3,364,959 | 1/1968 | Herman et al. | 141/183 X |
| 3,447,576 | 6/1969 | Gronlund | 141/183 X |
| 3,525,592 | 8/1970 | Buckley | 23/253 R |
| 3,536,449 | 10/1970 | Astle | 23/253 X |



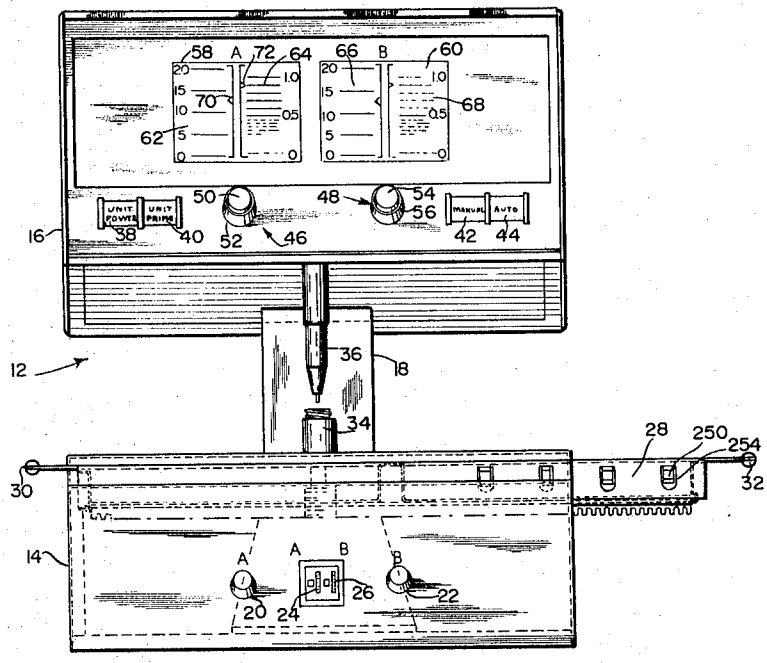
*Primary Examiner*—Edward J. Earls
*Attorney*—Posnack, Roberts & Cohen



[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 aforenoted 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.


**9 Claims, 11 Drawing Figures**



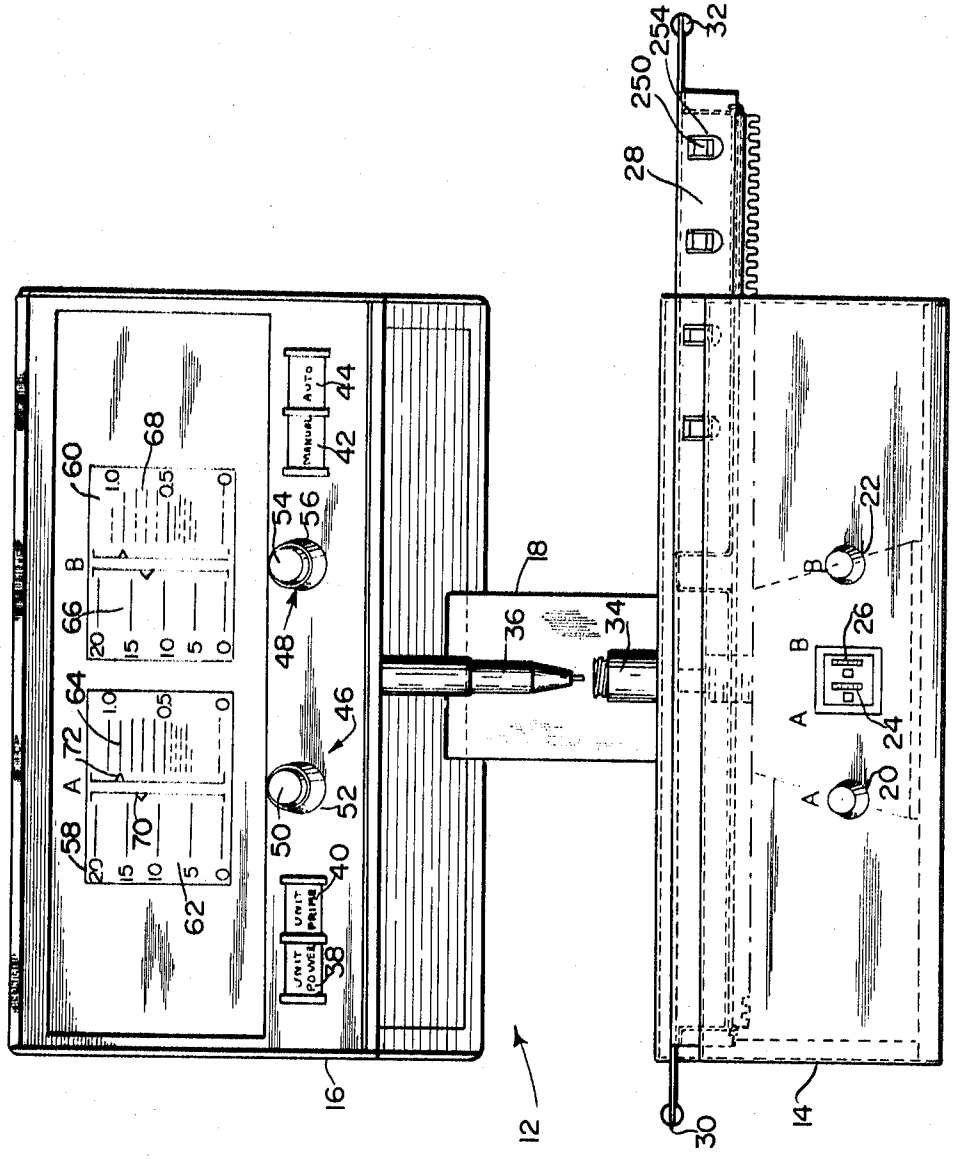



FIG. 1

INVENTORS
MICHAEL E. CROSLIN
CARL R. BLACKMAN

BY

Pennack, Roberts & Cohen

ATTORNEYS

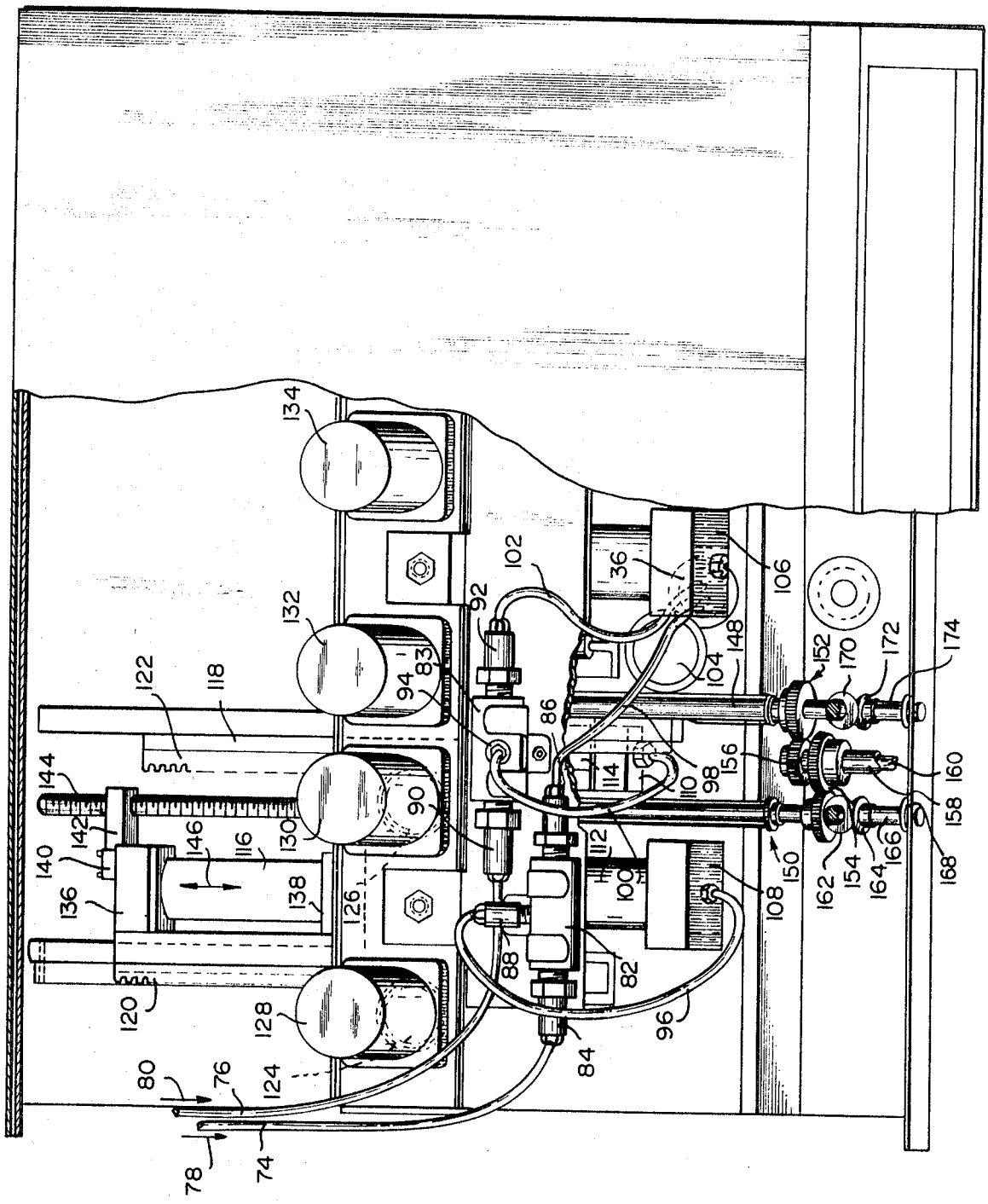



FIG. 2

INVENTORS
MICHAEL E. CROSLIN
CARL R. BLACKMAN
BY
Posnack, Roberts & Cohen
ATTORNEYS

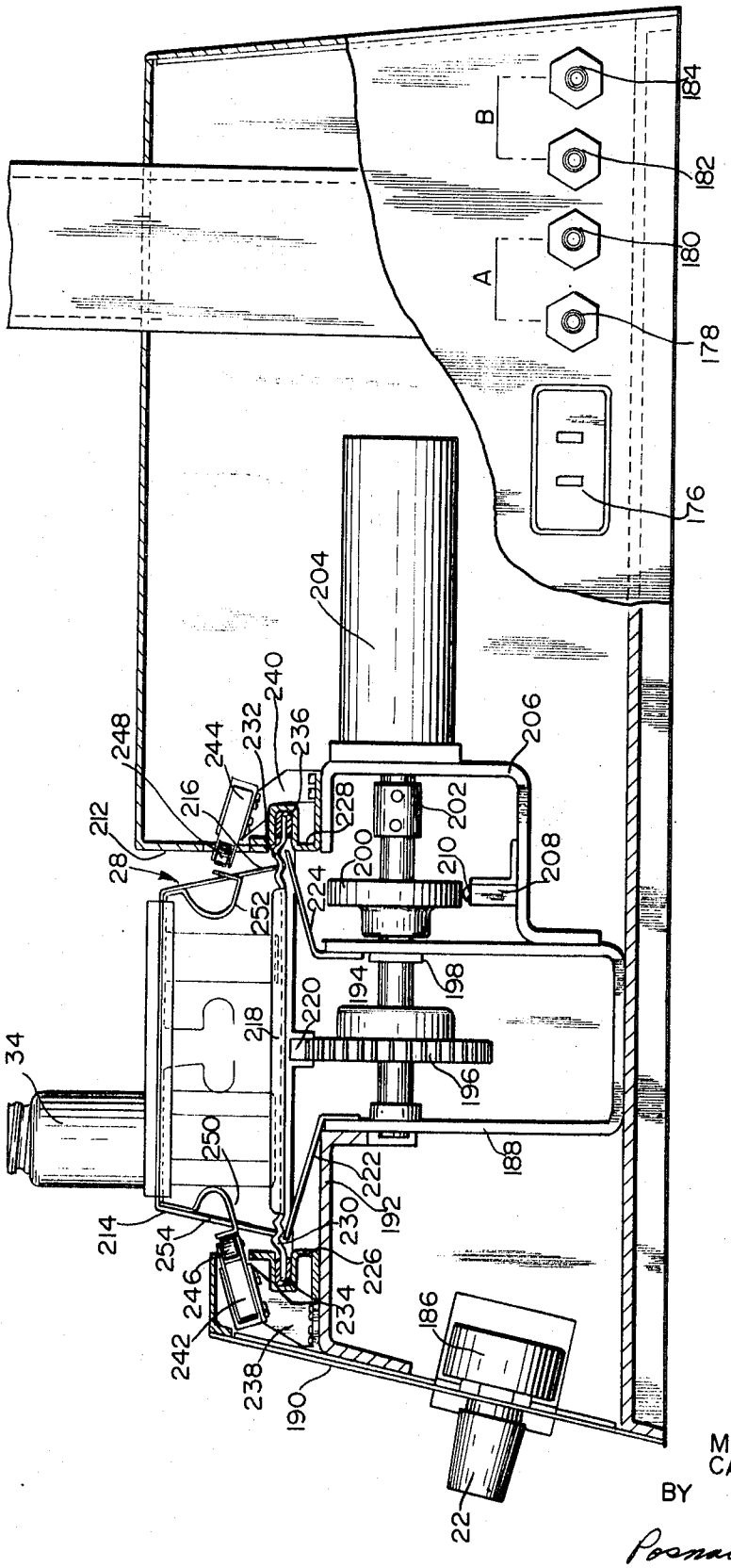



FIG. 3A

INVENTORS
MICHAEL E. CROSLIN
CARL R. BLACKMAN

BY

Posnack, Roberts & Cohen

ATTORNEYS

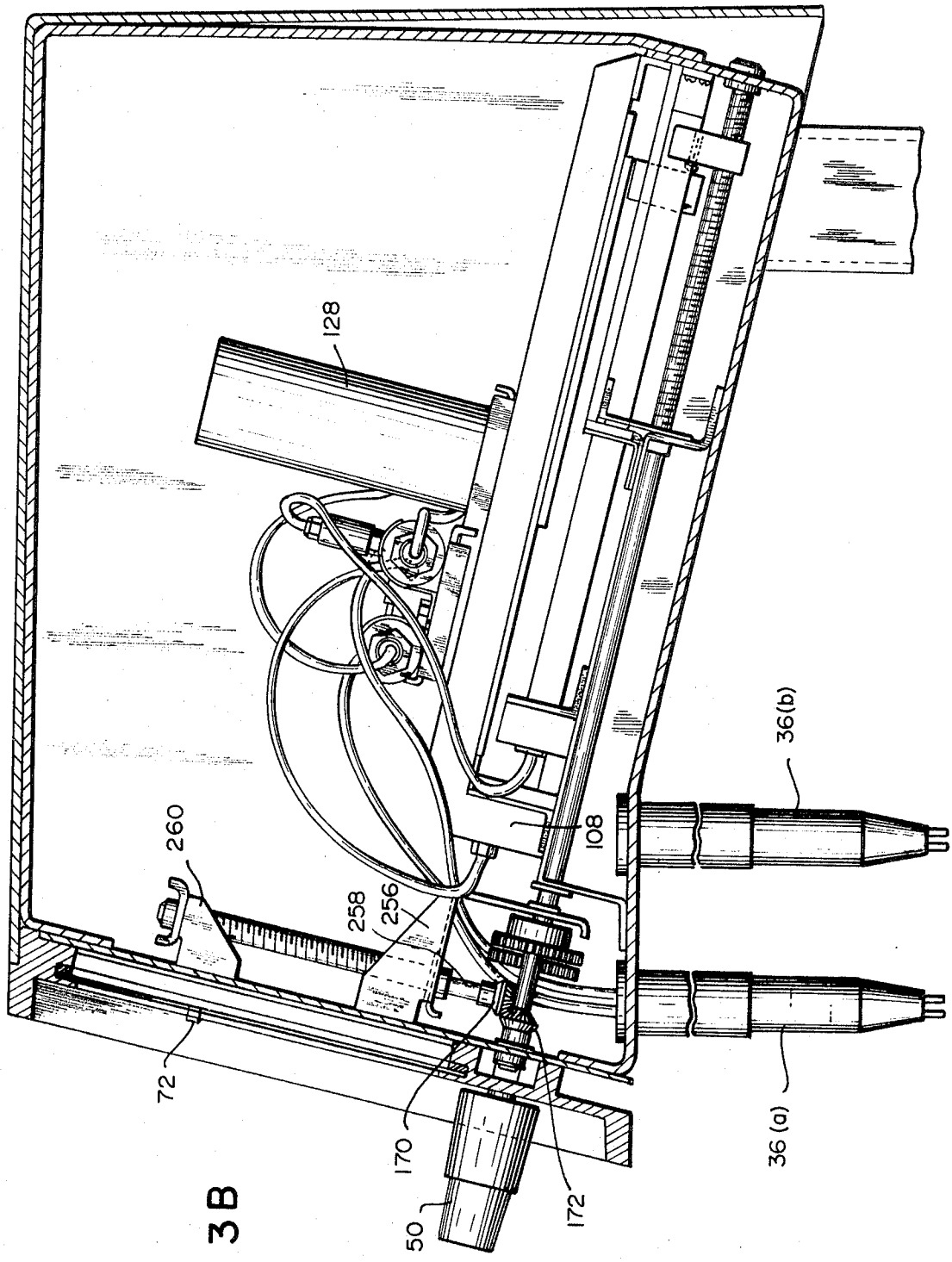



FIG. 3B

INVENTORS
MICHAEL E. CROSLIN
CARL R. BLACKMAN

BY

Cosnack, Roberts & Cohen
ATTORNEYS

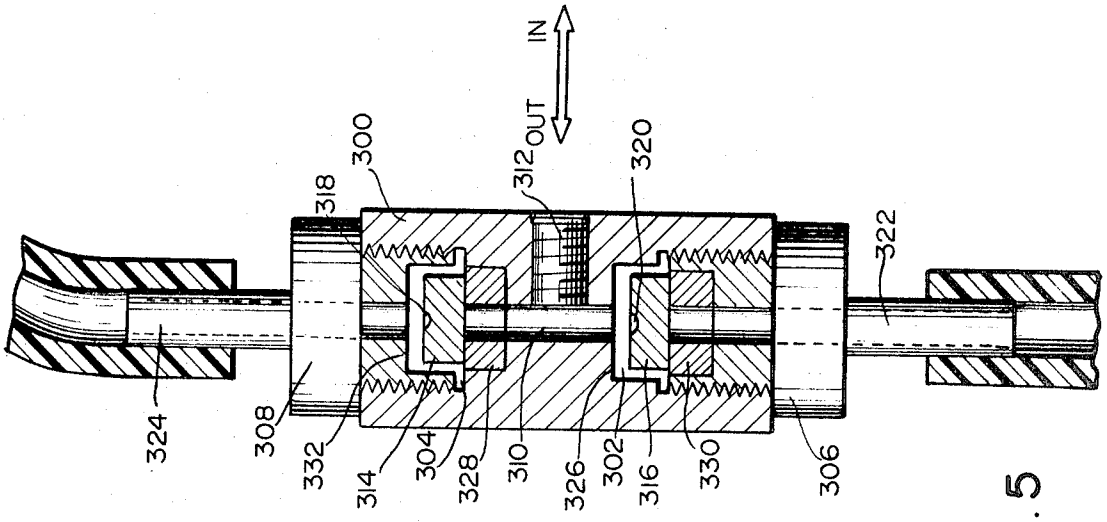



FIG. 5

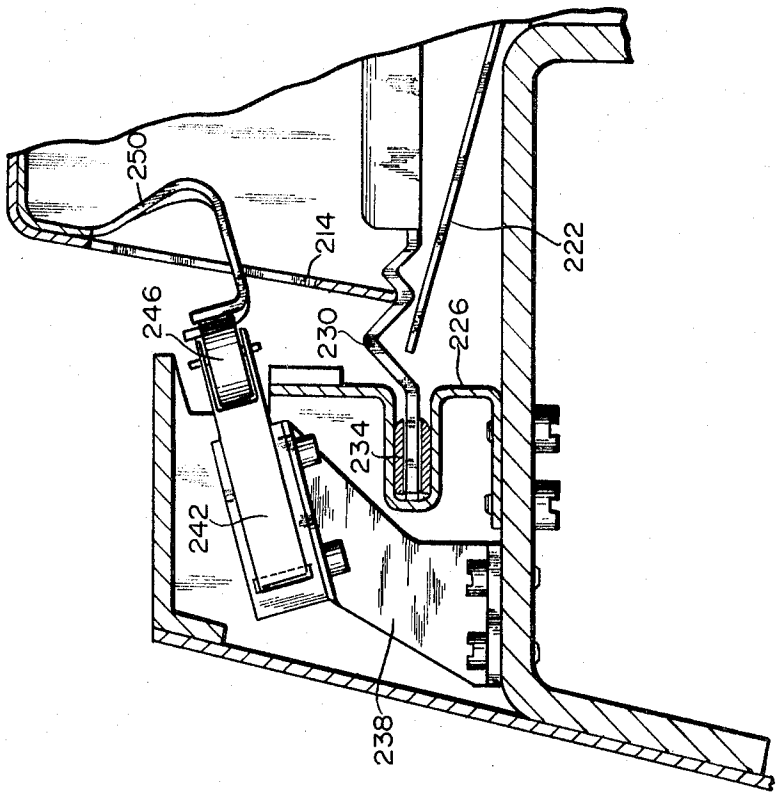



FIG. 4

INVENTORS
MICHAEL E. CROSLIN
CARL R. BLACKMAN
BY
Rosnack, Roberts & Cohen
ATTORNEYS

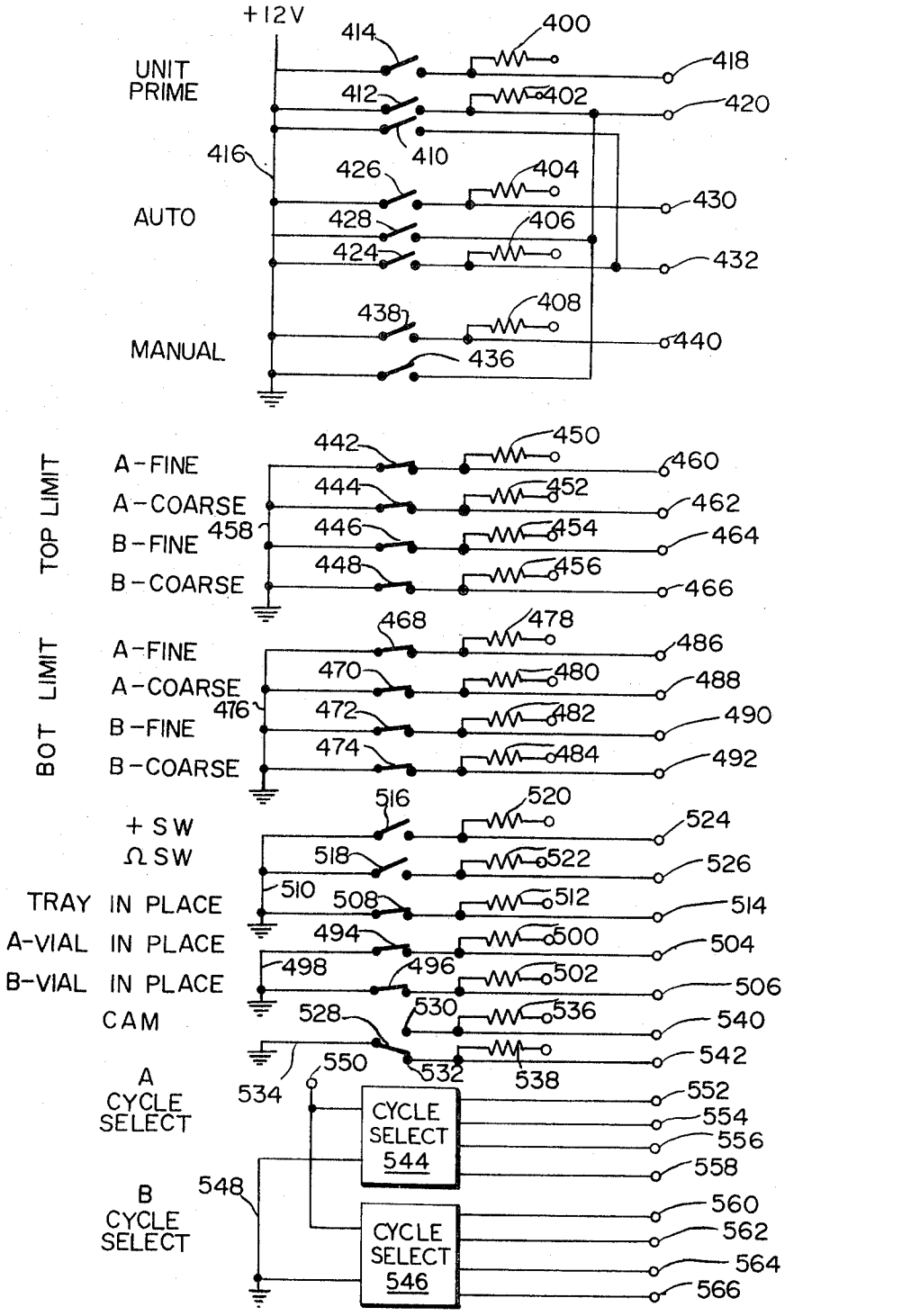



FIG. 6

INVENTORS
MICHAEL E. CROSLIN
CARL R. BLACKMAN

BY

Poonack, Roberts & Cohen
ATTORNEYS

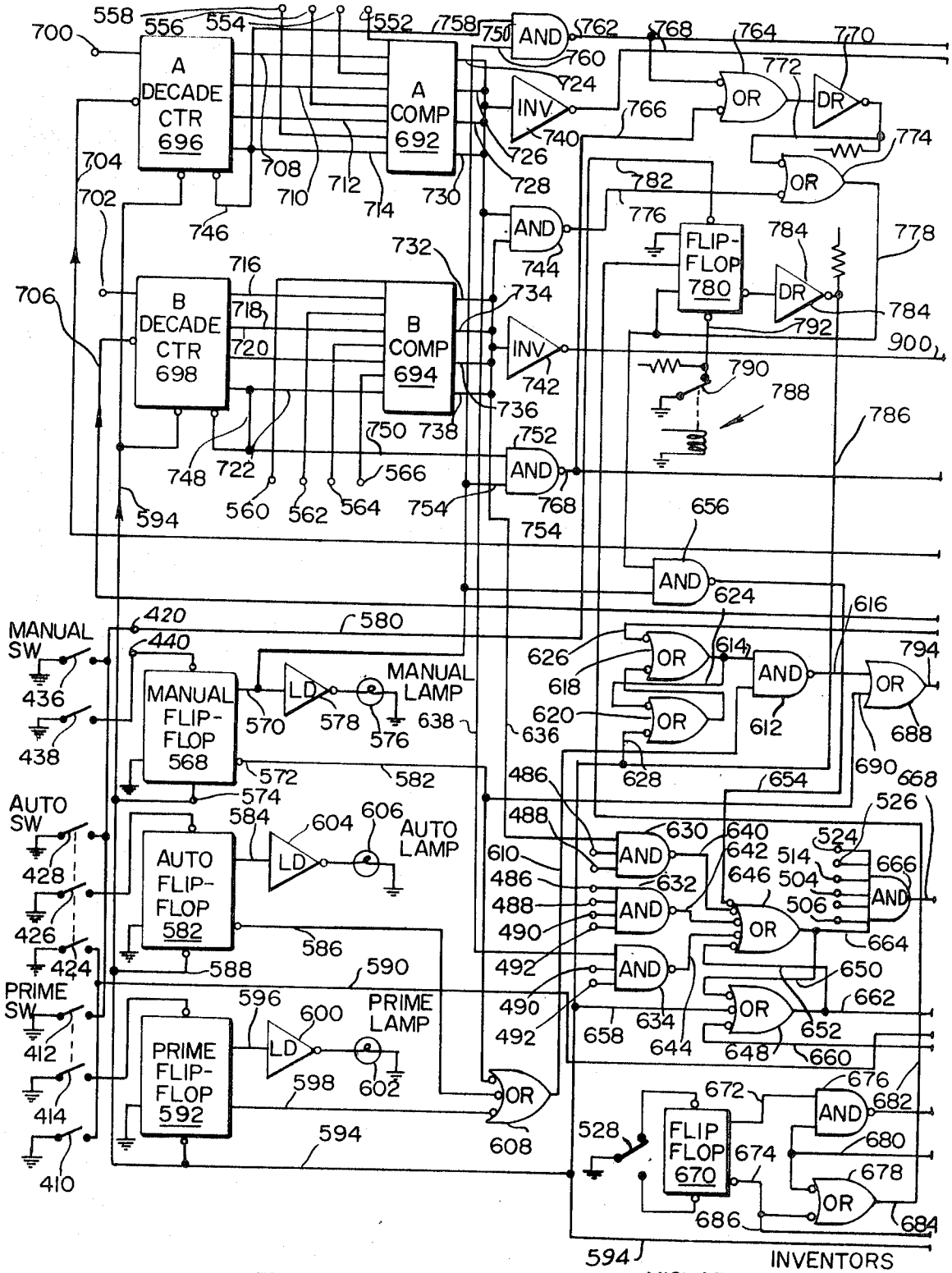



FIG. 7

INVENTORS
MICHAEL E. CROSLIN
CARL R. BLACKMAN
BY
Rosnach, Roberts & Cohen
ATTORNEYS

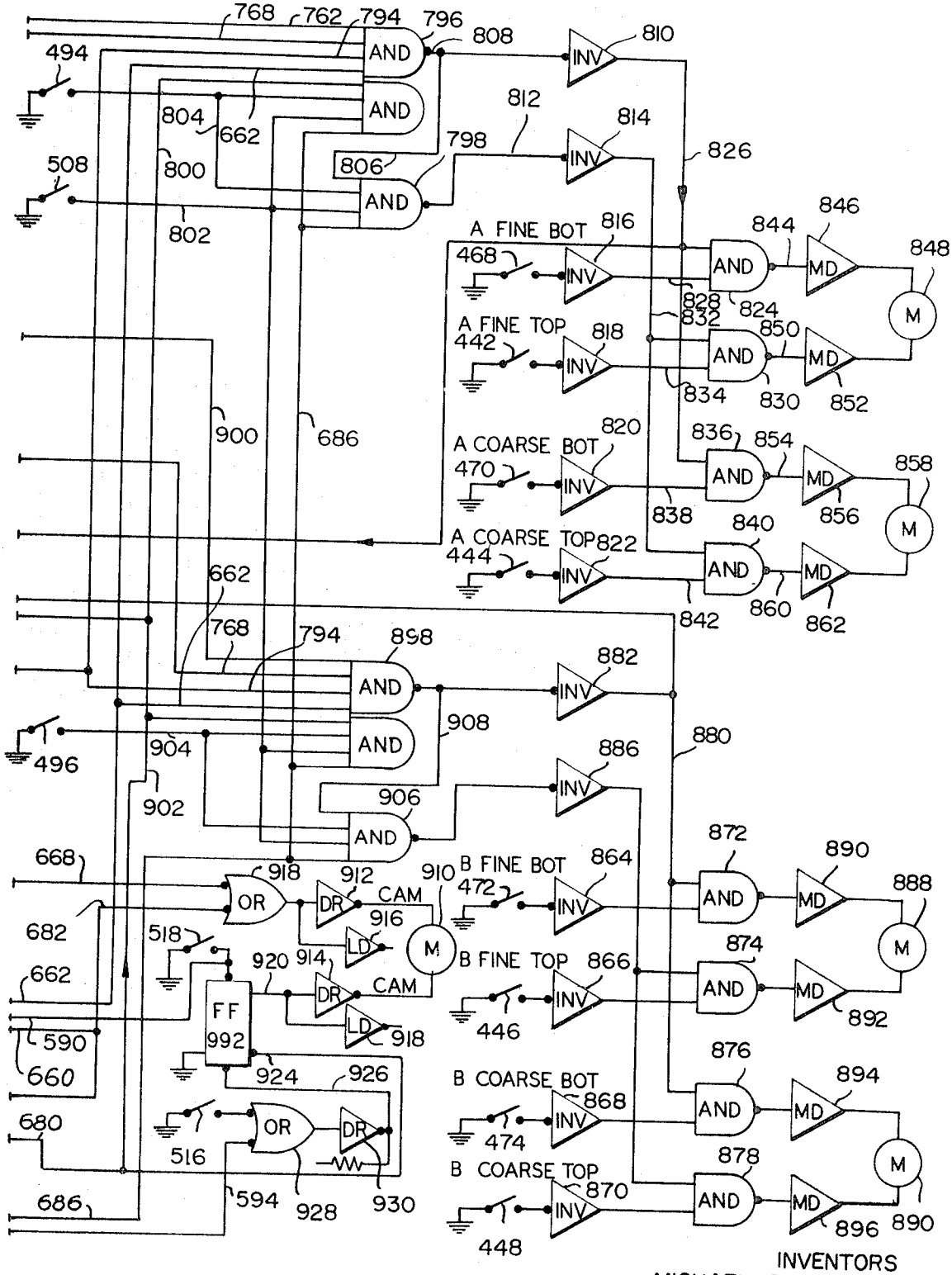



FIG. 8

INVENTORS
MICHAEL E. CROSLIN
CARL R. BLACKMAN
BY
Rosnick Selecter & Cohen
ATTORNEYS

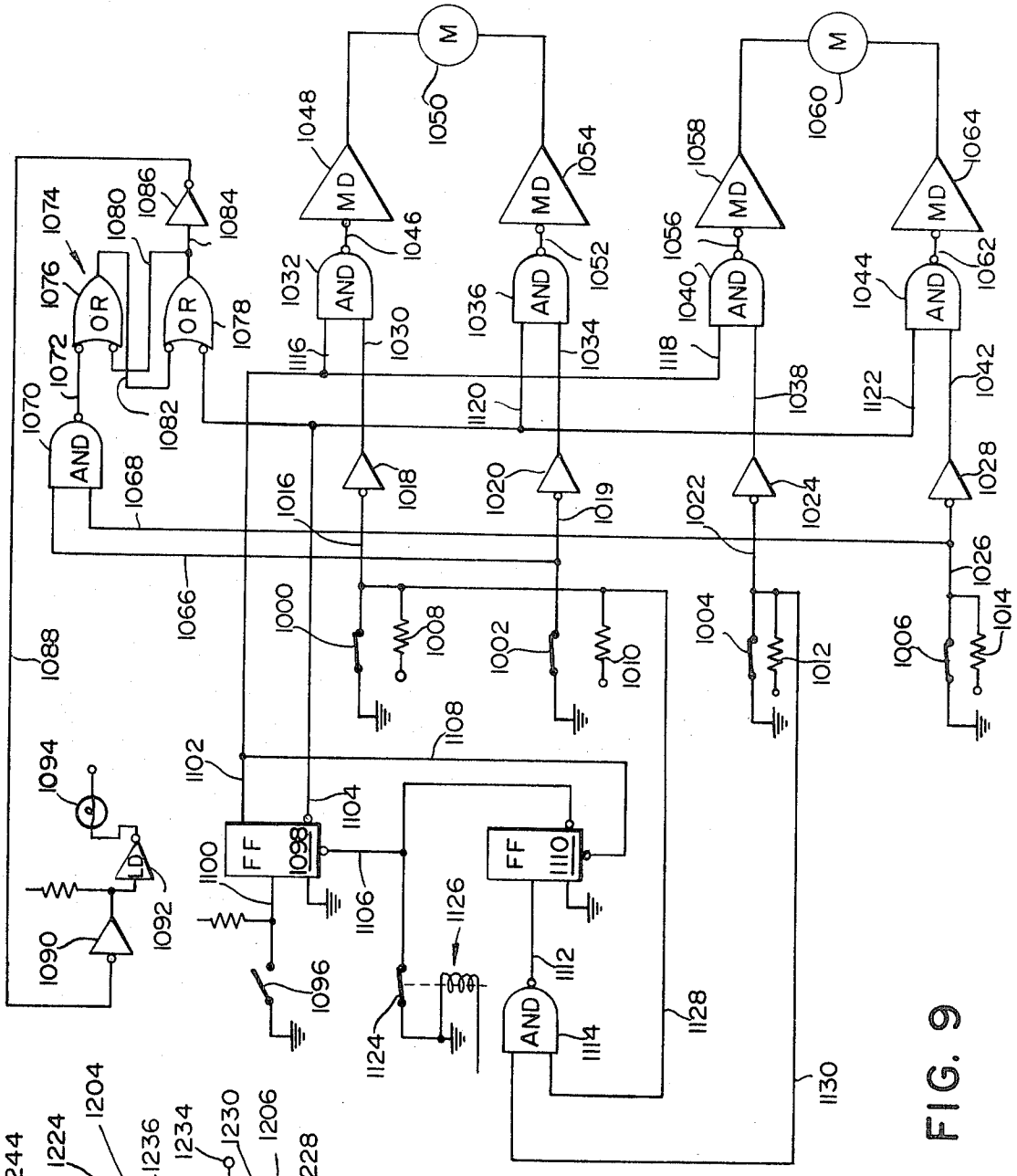



FIG. 9

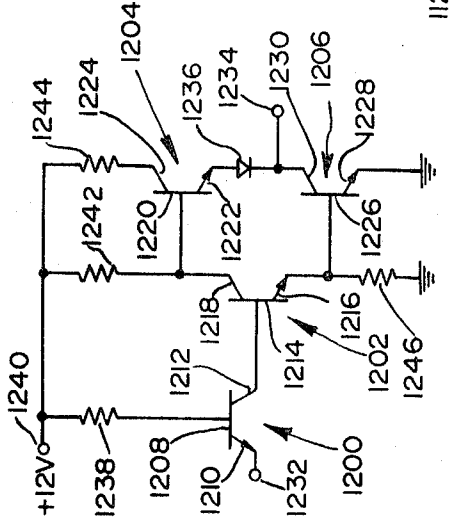



FIG. 10

INVENTORS
MICHAEL E. CROSLIN
CARL R. BLACKMAN

BY

Bonnack, Roberts & Cohen
ATTORNEYS

# DISPENSING APPARATUS AND ASSOCIATED ELECTRONIC CONTROL FOR SELECTING DIFFERENT MODES OF OPERATION

## 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. Still further, the invention relates to valves of the type useful in permitting the withdrawal of fluids from a source or reservoir and the dispensing of such withdrawn fluids via a dispensing nozzle.

## 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 ultramicroliter 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 ultramicroliter 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 device 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.

Another feature of the invention relates to the provision of a bi-directional valve having three ports, two of which are respectively coupled to the source of fluid and to the dispensing means and the other of which is connected to a pump which withdraws fluid from the source and discharges it through the same valve to the dispensing means.

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 at **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 can also 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 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 fluids 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 36*a* and 36*b*, 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 10 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 ten 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 position. 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 **308**.

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 seal 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 aforenoted 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. 3A 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. 3A. 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 15 vials inasmuch as the 16 combination will be used for zero.

The aforenoted 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. More 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 a 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 input 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 line **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** to 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 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 switch **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 gate **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. 3A. 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 aforenoted 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 flop 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 provide 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 **880 890** 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 B 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 beneath the dispensing nozzles according to the number 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 **110**, 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 **1120** 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** an **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 provide 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 or receptacles past the dispensing nozzles, the pump being arranged and controlled to dispense selected and equal quantities of fluid into the receptacles or vials in sequence.

Further in accordance with the invention there is provided 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 aforenoted 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 aforenoted 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 adjusting the magnitude of said quantity, said apparatus further 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; and electronic control means comprising automatic mode, manual mode and prime mode select means and flip flops coupled to and set by said select means to generate signals for controlling said first and supply means, said prime mode select means controlling said first means and dispensing means to flush air and foreign substances from the same.

2. Apparatus as claimed in claim 1 comprising mode selection means coupled to said first means to enable said receptacles to be moved past said dispensing means automatically or under manual control.

3. Apparatus as claimed in claim 1 comprising control means coupled to said first means to control the rate of dispensing of said quantity through said dispensing means.

4. Apparatus as claimed in claim 1 wherein said first means includes a coarse fluid withdrawal means and a fine fluid withdrawal means collectively operable with at least one said source of fluid.

5. Apparatus as claimed in claim 4 wherein said dispensing means includes a dispensing nozzle coupled to both said withdrawal means.

6. Apparatus as claimed in claim 4 wherein said control means includes coarse and fine adjustment means respectively coupled to said coarse and fine fluid withdrawal means.

7. Apparatus as claimed in claim 1 wherein said means for moving a plurality of receptacles comprises means for the automatic indexing of vials past said dispensing means.

8. Apparatus as claimed in claim 7 wherein said control means includes coarse and fine adjustments.

9. Apparatus as claimed in claim 7 comprising electronic means for counting the number of vials into which fluid has been dispensed, means for selecting a number of vials into which fluid is to be dispensed, and comparison means to compare the selected and counted numbers.

* * * * *