United States Patent [19]

Natelson

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[45] **Sept. 24, 1974**

[54] **COMPACT, FLEXIBLE, MULTIPLE FLUID DISPENSER**

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[73] Assignee: **Rohe Scientific Corporation,** Santa Ana, Calif.

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[21] Appl. No.: **297,797**

[52] **U.S. Cl.** **222/137,** 222/309, 222/387

[51] **Int. Cl.** **B67d 5/52**

[58] **Field of Search** ..... 222/133, 137, 386, 387, 222/132, 135, 134, 309, 405, 267, 385; 128/218 A, DIG. 1, 218 R; 73/425.6; 23/259

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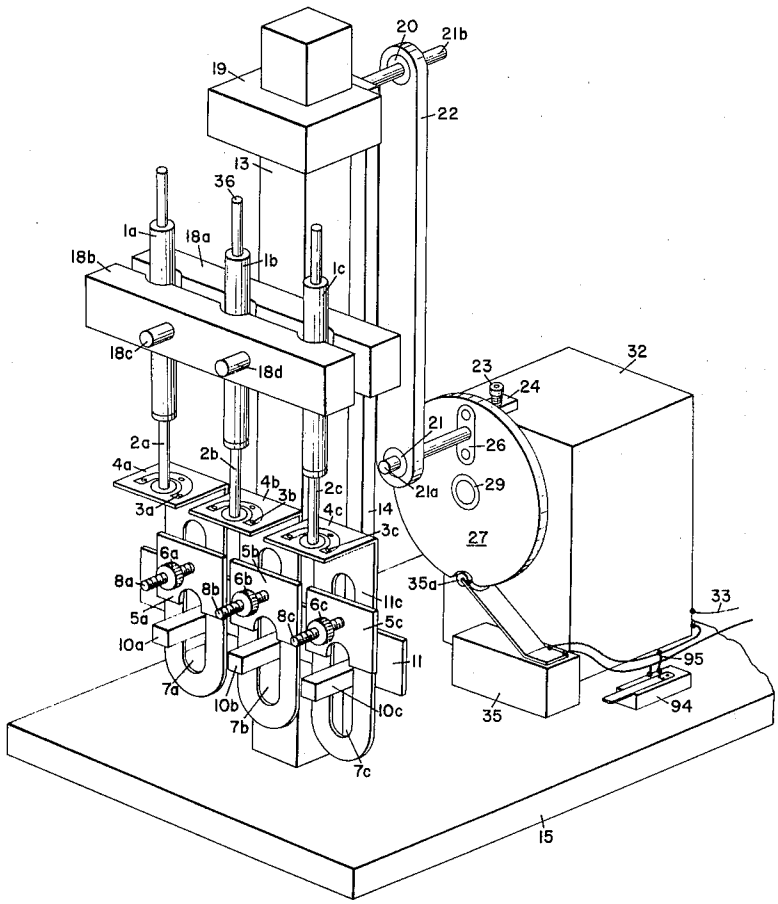
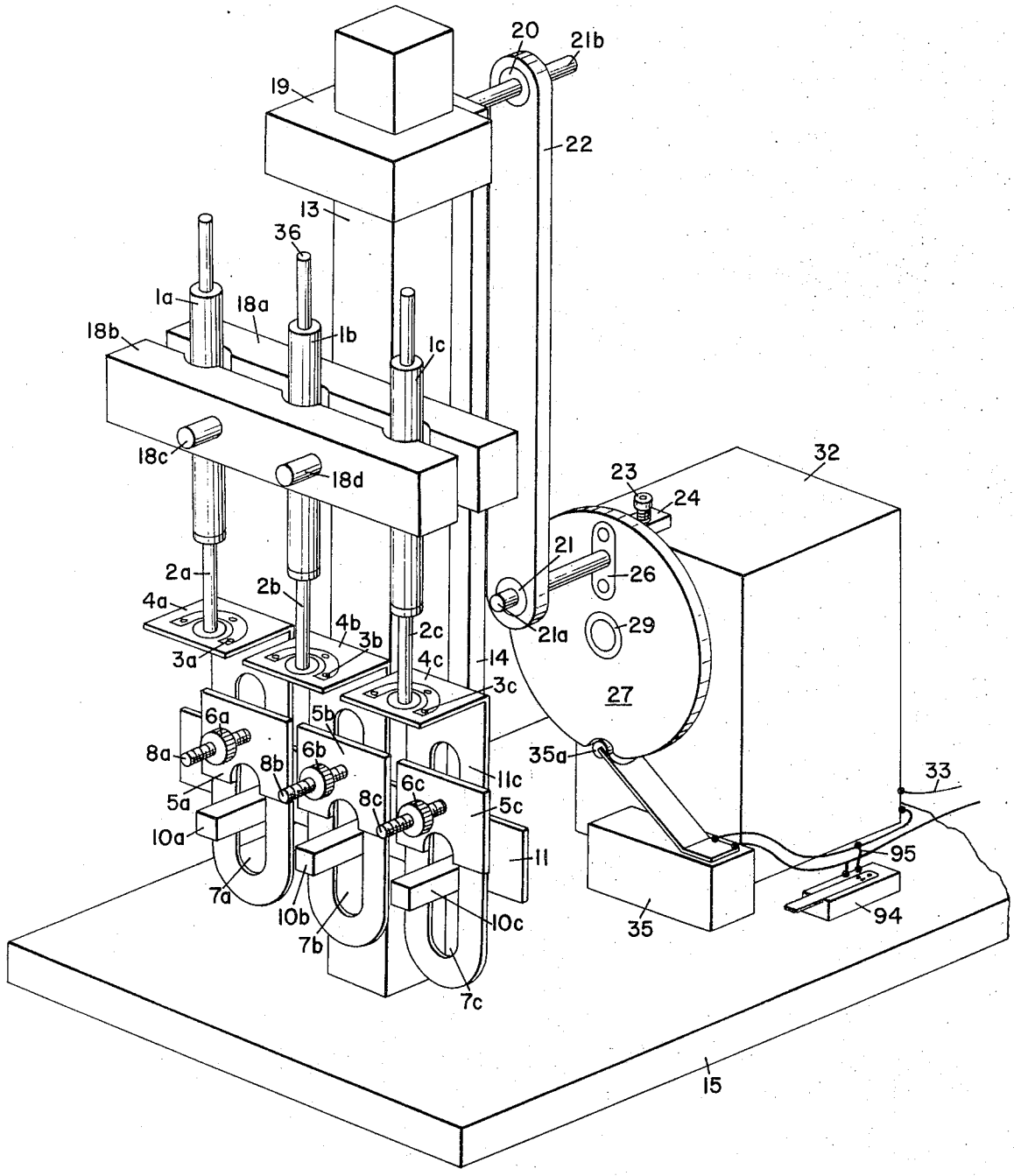
Primary Examiner—Stanley H. Tollberg
Assistant Examiner—James M. Slattery
Attorney, Agent, or Firm—George B. Oujevolk

[57] **ABSTRACT**

A simple compact fluid dispenser, capable of dispensing a plurality of fluids from separate containers, the volume dispensed from each container of the dispenser being independently adjustable over a wide range. In the instrument, a motor rotates a cam causing a slide to move up and then down along a slide post. Attached to the slide post is a fixed clamp capable of holding a plurality of containers in the form of syringes. The plungers of these syringes each rest on a separate movable support. Lift bars are attached to a slide in such a manner that free travel is allowed before they engage and lift the different supports. The extent of free travel can be zero, in which case the slide lifts and lowers the plunger its full traverse. On the other hand, it may be so large that as much as 99 percent of its travel distance is free and only 1 percent of the travel of the lift bar causes the plunger to be raised or lowered. Thus, one plunger may have no free travel and the other have 99 percent free travel, delivering only 1 percent of the volume delivered from the first plunger, on the same stroke of the slide. The movement of the slide is also adjustable. This is done by moving a pivot around, which a connecting bar from the cam to the slide rotates so that it is closer or further from the center of the cam, regulating the diameter of the circle that the bar travels, and thus the maximum thrust of the slide. By means of shims, syringes of different bore may be utilized giving further flexibility to the instrument. The instrument can be used in connection with several types of valve arrangements, including a preferred type of multiple rotary valve.

11 Claims, 15 Drawing Figures

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22
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18b
1b
1c
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18d
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2b
4a
4b
3b
2c
21a
29
3a
4c
14
3c
27
6a
5b
8a
6b
35a
33
8b
11c
6c
5a
8c
5c
10a
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95
7a
10b
10c
35
94
7b
7c
15

FIG. 1

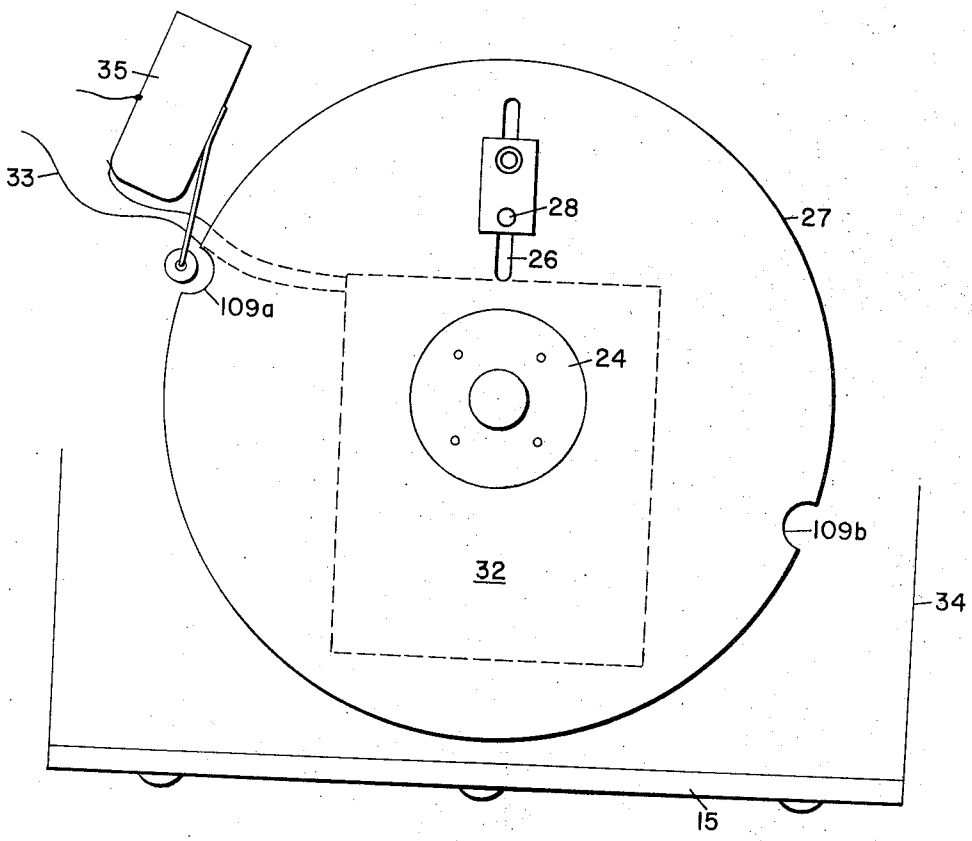
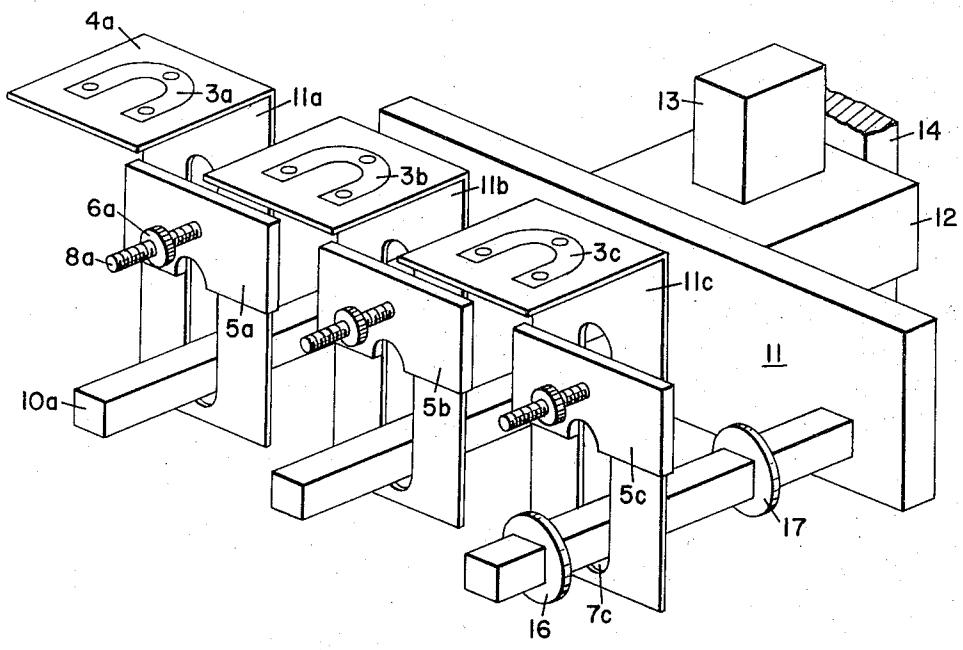


FIG. 2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3a
11a
3b
11b
3c
11c
13
14
12
6a
8a
5a
10a
5b
5c
11
17
16
7c

FIG. 3a

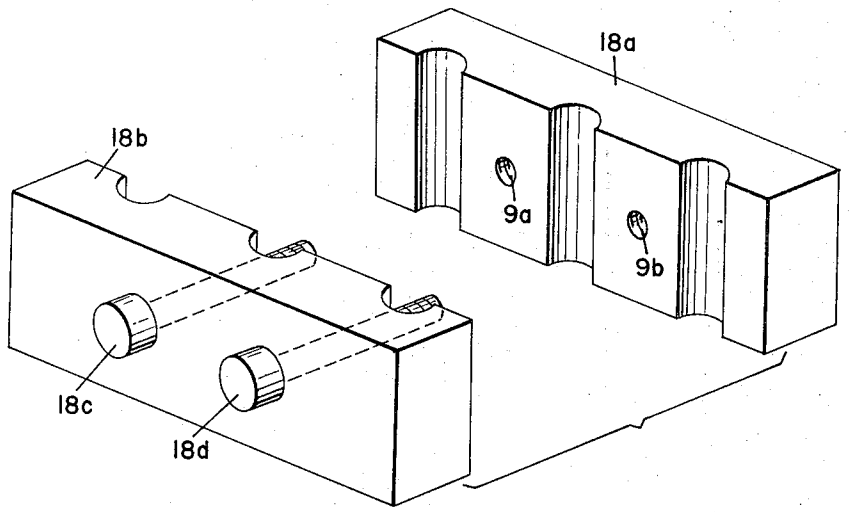
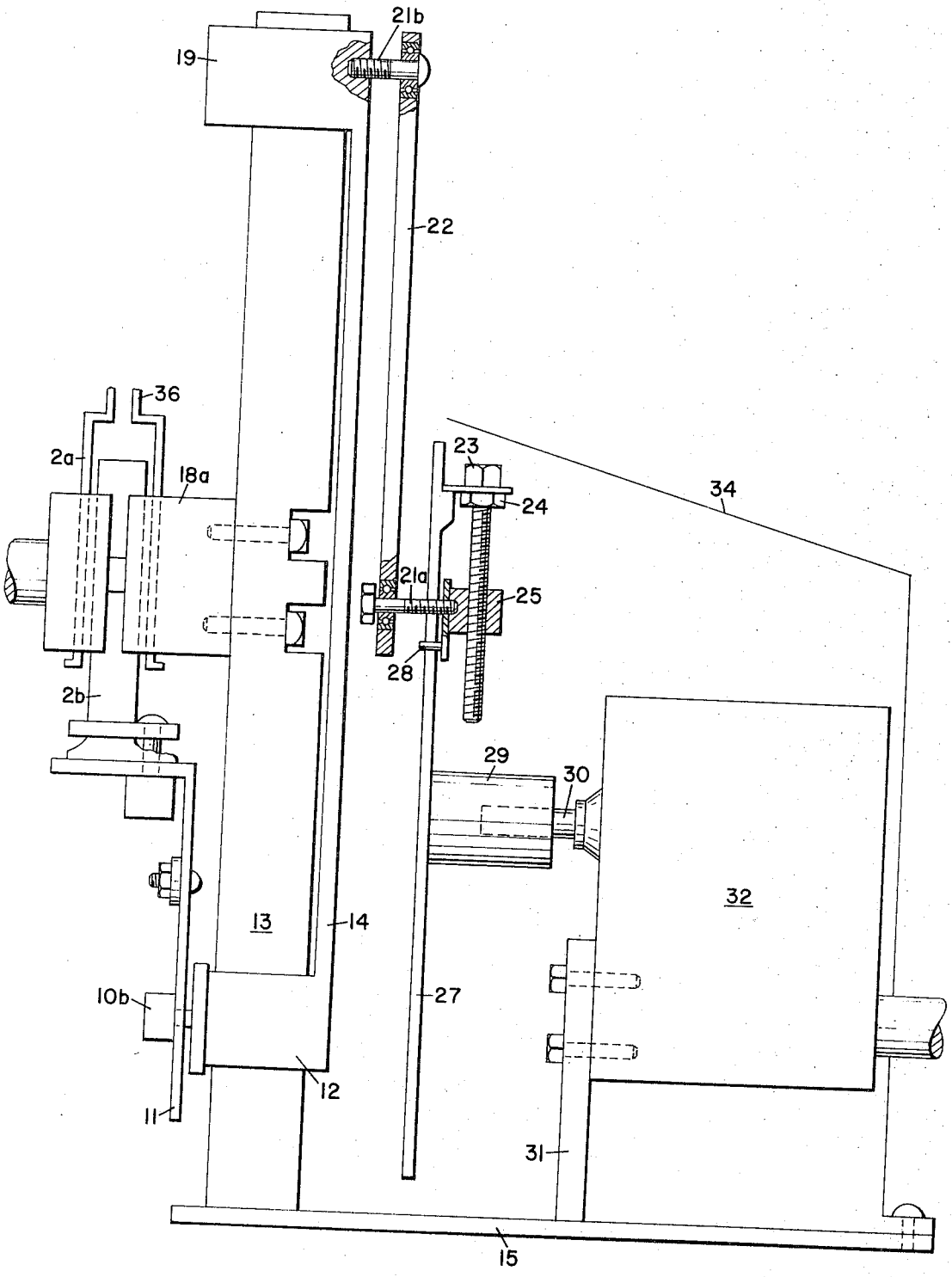

18a
18b
9a
9b
18c
18d

FIG. 3b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19
22
36
2a
18a
23
24
34
21a
25
28
2b
29
30
32
13
14
10b
27
12
11
31
15

FIG. 4

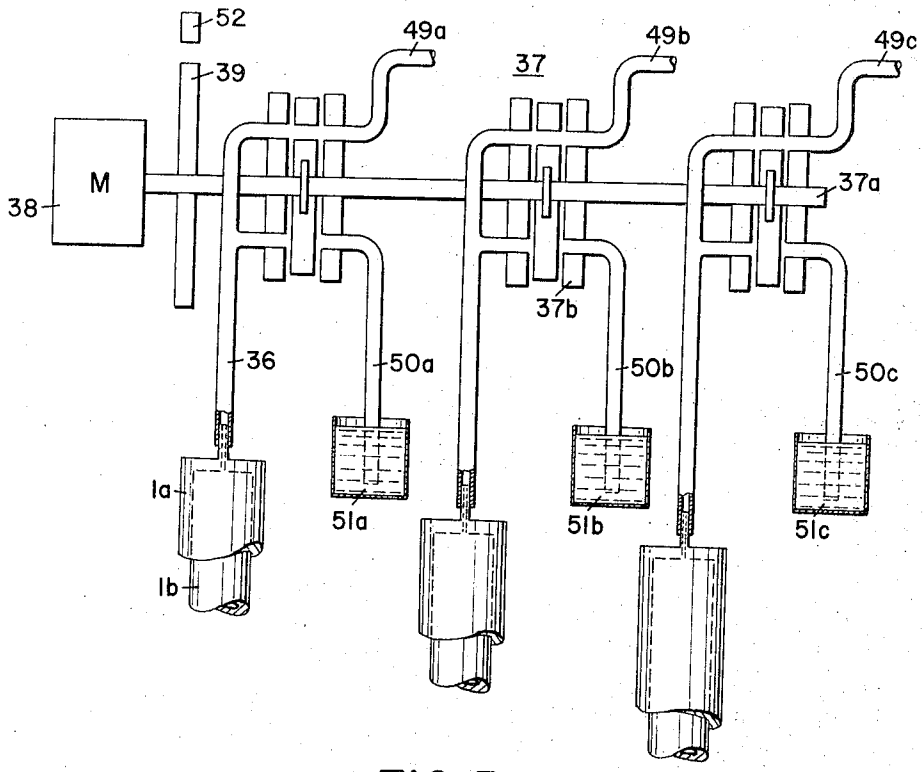
52
39
49a
37
49b
49c
M
38
37a
37b
36
50a
50b
50c
1a
51a
51b
51c
1b

FIG. 5a

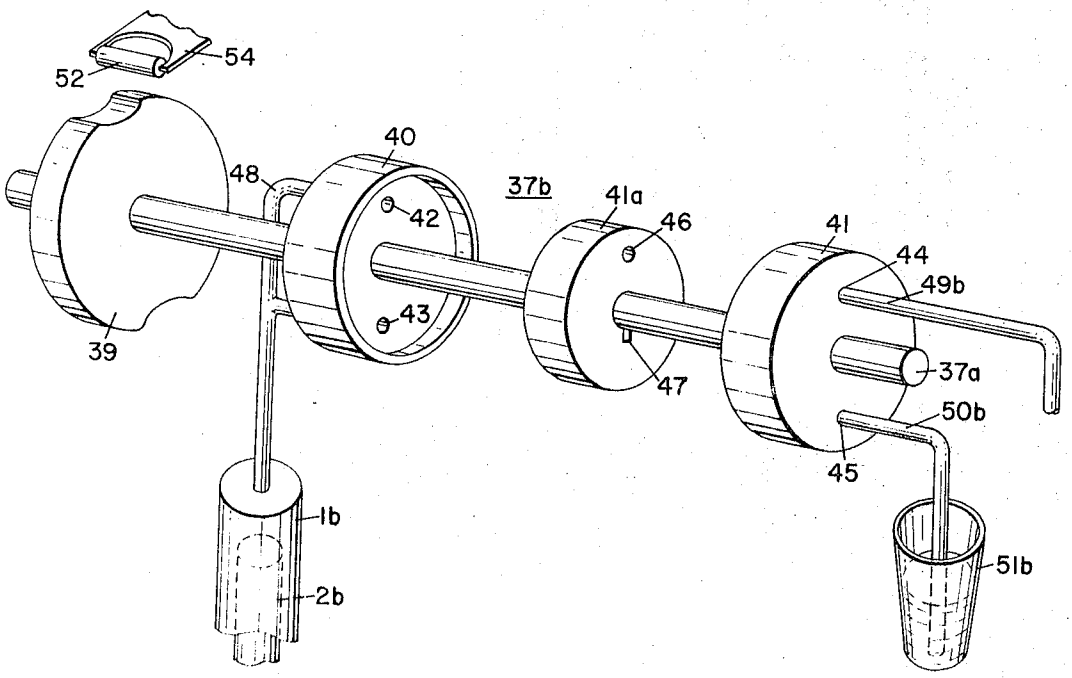
52
54
40
48
37b
41a
42
46
41
44
49b
43
37a
39
47
50b
45
1b
51b
2b

FIG. 5b

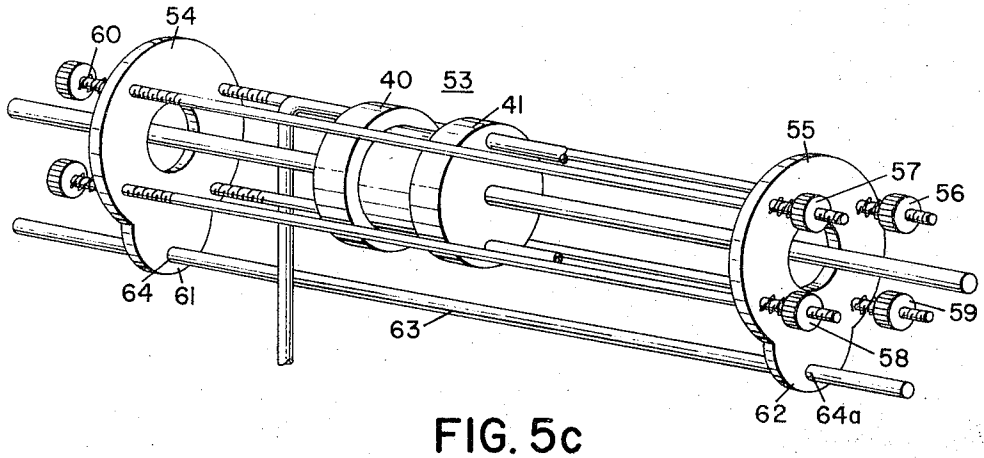

FIG. 5c

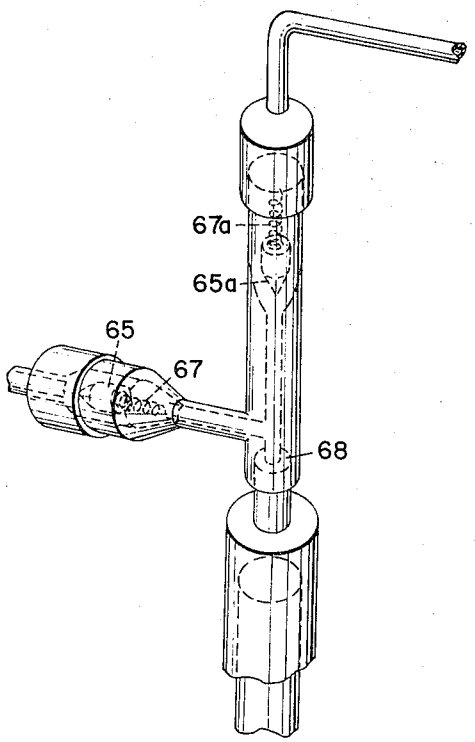

FIG. 6a

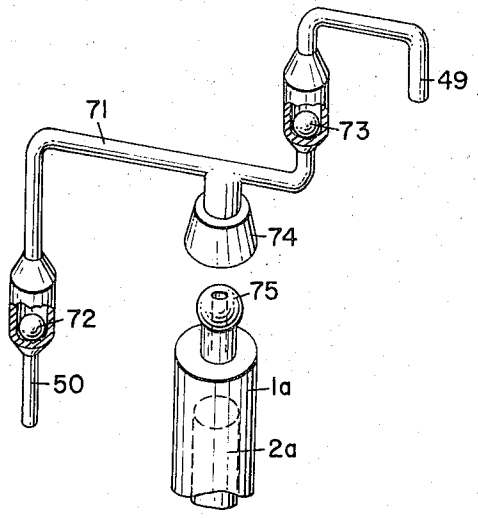

FIG. 6b

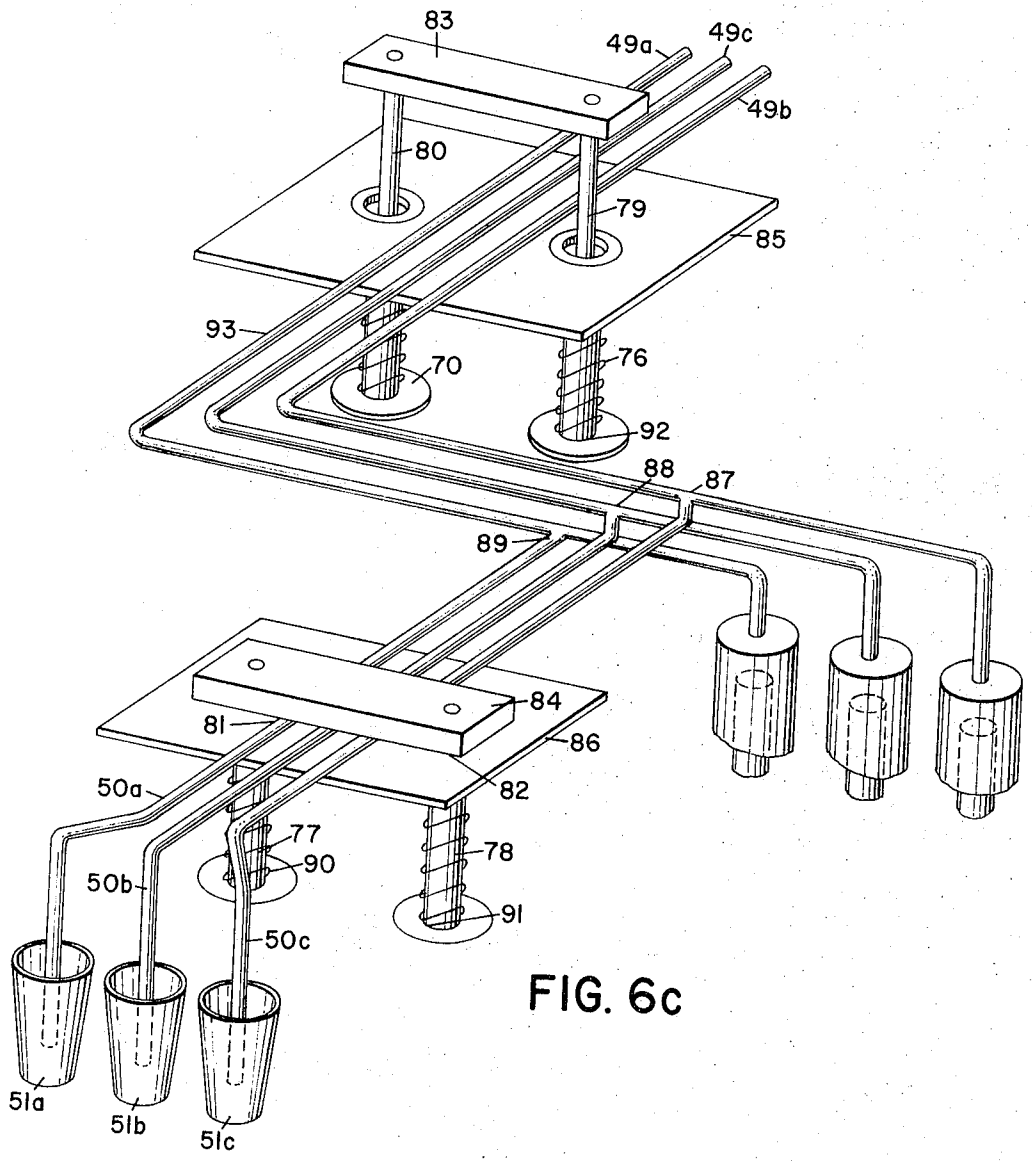
83
49a
49c
49b
80
79
85
93
70
76
92
88
87
89
84
81
86
50a
82
77
78
90
91
50b
50c
51a
51b
51c

FIG. 6c

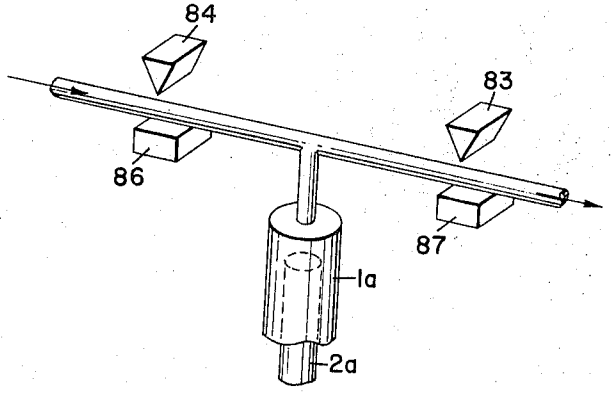
84
83
86
87
1a
2a

FIG. 6d

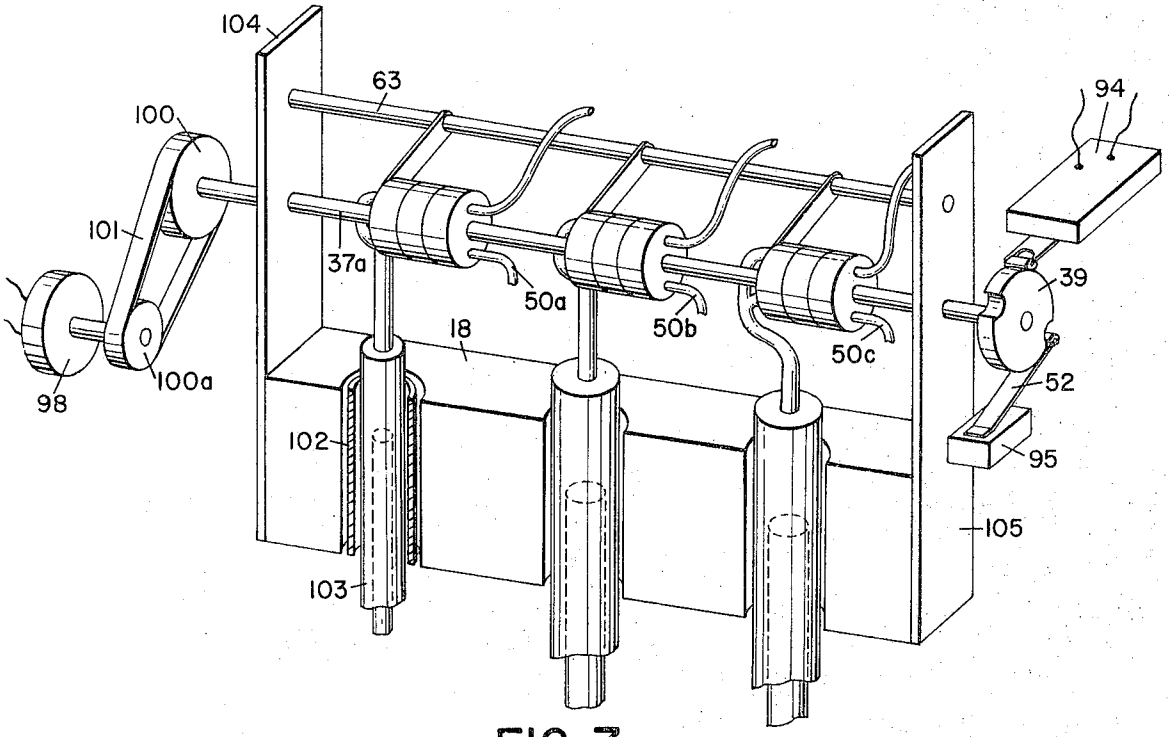

FIG. 7

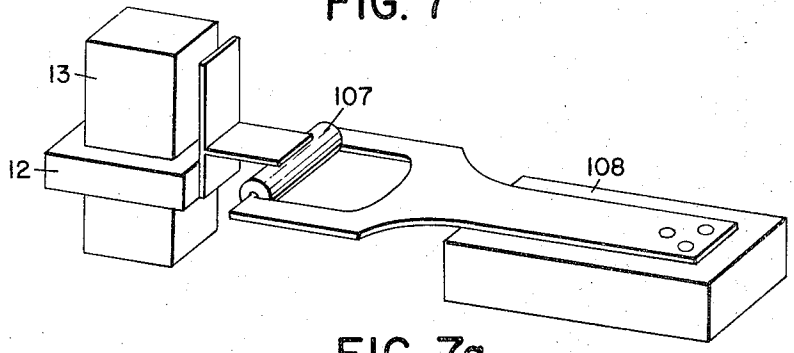

FIG. 7a

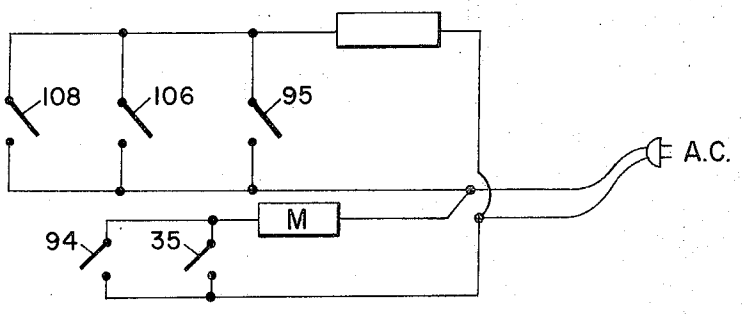

FIG. 7b

COMPACT, FLEXIBLE, MULTIPLE FLUID DISPENSER

BACKGROUND OF THE INVENTION

The present invention relates to a device for simultaneous delivery of different liquids from different sources in different quantities and more specifically, it relates to a dispenser of liquids which can simultaneously deliver different liquids from different sources at the momentary depression of a by-pass switch.

BRIEF REVIEW OF THE PRIOR ART

While dispensers based on a movement of the syringe barrel up and down in conjunction with a pair of valves to an inlet and an outlet are well known and in common use under the name of syringe dispensers, none of these instruments are capable of simultaneously delivering a plurality of specimens wherein each specimen can be delivered in a specified amount, using different syringes of different sizes or using the same sized syringe, each syringe moving a different distance of travel.

The need of such an instrument arises in chemical analysis when it becomes necessary to add a plurality of reagents in different volumes to the same test tube or to different test tubes simultaneously. Thus, in an automated system, it is usually necessary to use as many dispensers as there are reagents to be added.

SUMMARY OF THE INVENTION

The present single instrument displaces any number of dispensers the number being limited merely by the desire of the operator to construct a machine suitable for his use. In a typical application, five plungers move simultaneously to deliver different amounts of five different liquids, with a single motor source driving the plungers. One can vary the size of the plungers and the distance of travel of each plunger independently and once the instrument is set, the instrument can perform its complete cycle by merely pressing a by-pass switch in a momentary fashion.

Generally speaking, the instrument has a motor which rotates a cam. This in turn causes a slide to move up and then down along a slide post. Attached to the slide post is a fixed clamp capable of holding a plurality of syringe barrels. The plungers of these syringes each rest on a separate movable support. Lift bars are attached to a slide in such a manner that free travel is allowed before these lift bars engage and lift the different supports. The extent of free travel can be zero, in which case the slide lifts and lowers the plunger its full traverse. On the other hand, it may be so large that as much as 99 percent of its travel distance is free and only 1 percent of the travel of the lift bar causes the plunger to be raised or lowered. Thus, one plunger may have no free travel and the other have 99 percent of free travel, thus delivering 1 percent of the volume delivered from the first plunger, on the same stroke of the slide. The movement of the slide is also adjustable. This is done by moving a pivot around which a connecting bar from the cam to the slide rotates so that it is closer or further from the center of the cam, thus regulating the diameter of the circle that the bar travels and thus the maximum thrust of the slide. By means of shims, syringes of different bore may be utilized giving further flexibility to the instrument.

The invention, as well as other objects and advantages thereof, will become more apparent from the following detailed description, when considered together with the accompanying drawing in which:

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** shows a perspective view of a multi-dispenser according to the inventive concept;

FIG. **2** illustrates a front view of a cam, different than the one shown in FIG. **1**, but also useful according to the inventive concept;

FIG. **3***a* is a perspective view of a portion of the bottom of the instrument depicted in FIG. **1** showing details of construction;

FIG. **3***b* shows a perspective explanation of another portion of the instrument depicted in FIG. **1**;

FIG. **4** presents a sectional view of the instrument of FIG. **1**;

FIG. **5***a* is a sectional view of a preferred valve arrangement used in the instrument of FIG. **1**;

FIG. **5***b* depicts a perspective exploded view of the valve arrangement;

FIG. **5***c* illustrates a clamping mechanism for the valve arrangement shown in FIG. **5***a*;

FIG. **6***a* is an alternate of valve arrangement which is very compact;

FIG. **6***b* presents a view similar to FIG. **6***a* and shows another type of valve arrangement;

FIG. **6***c* is an alternative press bar mechanism to control the inflow and outflow of solution;

FIG. **6***d* schematically explains the operation of the press bar mechanism of FIG. **6***a*;

FIG. **7** shows the preferred valve arrangement, mounted and in operation;

FIG. **7***a* illustrates a by-pass valve activated by a slide mechanism in connection with the embodiment of FIG. **7**; and,

FIG. **7***b* is an electrical schematic diagram of the circuit for FIG. **7**.

DETAILED DESCRIPTION

An overall view of the instrument is first shown (FIG. **1**) and then a sectional view is given (FIG. **4**). The instrument is designed to pump or eject liquids, e.g., solutions, reagents, test liquids, etc., in a plurality of containers in the form of syringe barrels **1***a*, **1***b*, **1***c* (only three barrels being shown for simplicity) by means of plungers **2***a*, **2***b*, **2***c* held fixed under the syringe barrels by plunger head fasteners **3***a*, **3***b*, **3***c*.

These plunger head fasteners **3***a*, **3***b*, **3***c* are fixed in place by a knurled screw. The plunger is pushed down and pulled up by means of plunger head supports **4***a*, **4***b*, **4***c*, formed by bending at right angles plunger supports **11***a*, **11***b* and **11***c*. At the bottom of the instrument and below the barrels are volume adjust slides **5***a*, **5***b*, **5***c* (see FIG. **3***a*) whose function will be hereinafter described in greater detail.

INDIVIDUAL VOLUME ADJUSTMENT

These slides **5***a*, **5***b* and **5***c* are held in place at particular locations by tightening nuts **6***a*, **6***b*, **6***c*. The vertical stroke of the slides will be determined by a guide slot **7***a*, **7***b*, **7***c* through which nuts **6***a*, **6***b*, **6***c* pass and, cooperating with these nuts are bolts **8***a*, **8***b*, **8***c*. Further cooperating with this combination is a clamp, hereinafter described, but likewise, having a screw arrangement, but this clamp has threaded holes **9***a*, **9***b* (see FIG. **3***b*) and is mentioned now only so that the clamp concept and the slide concept should not be confused. Part of

the slide concept consist of lift rods 10*a*, 10*b*, 10*c*, which move up and down and engage the lower end of volume adjust slides 5*a*, 5*b*, 5*c* to push plungers up and these engage the lower end of the slot to pull plungers down.

These lift rods 10*a*, 10*b*, 10*c* are held to a lift rod support 11 and the support in turn is attached to the instrument's lower slide also referred to herein as the second slide 12 (not to be confused with an upper or first slide described later).

VERTICAL MOVEMENT LOWER PORTION

Second slide 12 reciprocates vertically on a vertical slide post 13 and is connected to the bottom end of a tie rod 14. Slide post 13 is fixed on a table or metal base support 15. As shown in FIG. 3*a*, there may be a tendency for the lift rods 10*a*, 10*b*, 10*c* to sway in the guide slots 7*a*, 7*b*, 7*c*. To prevent such swaying, the lift rods have fixed washers 16, 17 which will insure correct vertical movement. To this point, most of the description has related to the lower part of the instrument under the syringe barrels 1*a*, 1*b*, 1*c*.

SUPPORTING THE SEPARTE LIQUIDS

The barrels 1*a*, 1*b*, 1*c* are tied to a barrel support 18*a* fixed to slide post 13. Barrel support 18*a* has vertical concave recesses to receive the barrels whcih are clamped to the barrel support by a barrel clamp 18*b* having corresponding recesses. The barrel clamp 18*b* holds the barrels to the barrel support 18*a* by means of screws fitted into threaded apertures, 9*a*, 9*b* and having knurled heads 18*c*.

VERTICAL MOVEMENT LOWER AND UPPER PORTION

Above the barrels 1*a*, 1*b*, 1*c* is the upper of first slide 19 on slide post 13. The second and first slides 12 and 19 are connected by the vertical tie rod 14, the first slide 19 being connected to the top of vertical tie rod 14, while the second slide 12 is connected to the bottom of the vertical rod.

Thus, the upper and lower slides 19 and 12 move up and down together, because both are connected by the tie rod 14, and vertical movement imparted to one slide, i.e., the upper slide 19, is imparted to the lower slide 12. To transmit vertical movement to the upper slide 19 along slide post 13, a crank arrangement using first and second ball bearings 20, 21 are mounted on axles 21*a* and 21*b*, connected by a connecting bar 22. Extending horizontally from the back of slide 19 is axle 21*b* and in a plane parallel to axle 21*b* but below it is axle 21*a*. The two axles are connected by connecting bar 22 and the two axles are connected to the bar by ball bearings 20, 21. The measure of the stroke of connecting rod 22 is determined by a cam arrangement with a radial slot and the radial position of axle 21*a* in the cam slot. The adjustment of this radial position is made by means of an adjusting screw 23 passing through a fixed clamp 24 which prevents the screw from advancing when turned and a nut 25 which does advance when the adjusting screw 22 is turned.

STROKE ADJUSTMENT

Axle 21 is disposed so as to move radially in a radial slot 26 in a cam 27. This arrangement is best understood by looking at FIG. 4. Clamp 24 is welded to cam 27. Screw 23 merely passes through and is not threaded to clamp 24. It is threaded to nut 25 tied to axle 21*a*.

As the screw 23 turns, nut 25 will move up or down causing axle 21*a* to move radially in slot 26. This in turn moves connecting bar 22 raising and lowering axle 21*b* connected to upper or first slide 19. Since upper or first slide 19 is connected to the second or lower slide 12 by tie rod 14 this in turn moves the lower slide vertically. To prevent nut 25 from turning horizontally, the nut is provided with a guide pin 28 which also enter slot 26 under axle 21*a*. The cam 27, with a cam axial support 29 is driven by a drive shaft 30 and, disposed under the drive shaft 30 is a motor support 31 for holdig an electric motor 32 connected to the drive shaft 30. At the rear of the motor is the a-c power supply line 33 to the motor. This portion of the instrument, i.e., the cam and motor, are preferably enclosed in a case 34, as will be subsequently explained, cam 27 is also used in connection with a by-pass switch 35 having a switch wheel 35*a* which will engage the cam.

VALVE STRUCTURE

At the top of each syringe barrel 1*a*, 1*b*, 1*c* is the syringe connection 36, for tubing leading to rotary valves 37, better illustrated in FIGS. 5*a*, 5*b*, 5*c*. The valves are operated by a valve axle 37*a* and one valve 37*b* is shown alone in FIG. 5*b*. The number of valves corresponds to the number of syringe barrels.

Valves 37 are operated by a valve motor 38 which in turn rotates the valve axle 37*a* and the valve cam 39.

In the center of the valve moves axle 37*a*. This axle rotates as many valves as there are syringes. A close up view of this axle is shown in FIG. 5*b* which focuses down on one valve assembly. The valve assembly comprises three wafers, 40 and 41 are metal wafers, 41*a* is a plastic wafer, usually Teflon. Wafers 40 and 41 each have two holes 42, 43 and 44, 45 respectively perforating them while the central wafer has only one hole 46. The central wafer is cut out to form a keyway 47 or inset and connect rigidly thus to the central axle 37*a* while tube 48 from syringe connection 36 goes to holes 42 and 43 of wafer 40. When axle 37*a* rotates the central plastic wafer 41*a* will rotate. The other two wafers 40 and 41 do not rotate, since wafer 41 has the expel or exit tubing 49*a*, 49*b*, 49*c* and the entrance tubing 50*a*, 50*b*, 50*c* where liquid is sampled connected to its openings 44 and 45. The opening, within which the axle moves, is larger in diameter than the axle so that the axle can rotate readily without rotating these wafers. These wafers are also held from rotating by means of a clamp arrangement which holds the three syringes together and at the same time threads through a bar so as to prevent rotation of the outer wafers.

VALVE OPERATION

The cross-sectional view of FIG. 5*a* shows the operation of the arrangement valve. Focusing down on one of the valves 37*b*, one can see that two of the openings of the first metal wafer are joined by tube 48 which then goes to the syringe. The other metal wafer 41 also has two holes. One of them is connected to an exit tube, 49*b*, and the other to an entrance tube 50*b* and thus reagent 51*b*. In the position shown, which is that of exit, the plunger is moving up and expelling the solution through opening 42 and 44, allowing the solution to be moved out. Now on the downstroke, valve motor 39 ro-

tates the central wafer so that hole **46** now causes communication between holes **43** and **45** which have not moved. The plunger now moves down aspirating the solution. The valve motor on being activated again, will rotate the moving hole back into its original position as shown in FIG. **5***a*. Then, as the plunger moves up it will again expel the liquid going through holes **42, 46** and **41** and finally out through tube **49***a*, **49***b*, etc.

FIG. **5***b* shows the valve cam **39** in perspective so that one can see the two depressions and two elevations on the cam. A valve cam switch wheel **52** is also shown in a position where it should drop into one of the depressions on the cam. When the valve motor is given a bypass, the cam will rotate around until it again drops into a depression thus stopping the valve motor from moving. This action will be discussed later. FIG. **5***b* is then an exploded view of one of the valves to show its operation while FIG. **5***a* shows a cross sectional view to show how the valves are attached to the various plungers and solutions. FIG. **5***c* shows a clamping **53** which holds the three wafers together tightly. These are clamped together tightly by first holder of valve clamp **54** and second holder valve clamp **55** and four bolts **56, 57, 58, 59** which hold the assembly together, i.e., two holders **54** and **55** are tied together with the bolts **56, 57, 58, 59.** Springs and washers **60** are provided so that when the nuts are tightened down with the bolts the valves are spring loaded together, thus tension on the valves can be adjusted so that they will be tight enough so that they won't leak and not too tight so that the motor will not by able to rotate the central wafers. Extensions **61** and **62** are provided on the valve clamp holders so that as they clamp the valves, they also prevent them from rotating. The three valves (one for each barrel) are held in place by a rigid horizontal guide bar **63** (as can be seen from FIG. **7**). It prevents the rotation of the valve assembly while the axle **37***a* is rotating the central wafer. Extensions **61** and **62** have holes **64, 64***a* so that the rigid guide bar **63** can be threaded through them. The operation and positioning of these valves can be seen in FIG. **7.** One clamp holder for each valve is shown. This is done so as not to obscure the main functioning end of the valve where the liquids enter and exit.

ALTERNATE VALVE ARRANGEMENTS

An alternate valve arrangement is shown in FIG. **6***a*. The valve of FIG. **6***a* has two rubber valves, **65** and **65***a*, which are spring loaded in place by springs **67** and **67***a*. All held in a metal frame which twists into the Luer lock **68,** and the end of the syringe. The valve arrangement then fits on the syringe and needs no other support. Inlet tube **50** and outlet tube **49** are provided so that as the plunger moves down, the vacuum created unseats rubber valve **65** causing the liquid to flow into the syringe. The same vacuum simultaneously seats **65***a* held by spring **67***a*. On the upstroke, combination of the spring and the pressure, close valve **65** and open valve **65***a* pushing back spring number **67***a*, the liquid squirting out through tube **49.** This whole syringe assembly is held in one compact metal case which fits directly on the head of the syringe and needs no other additional support. This type of valve arrangement is available commercially.

A second alternate system, shown in FIG. **6***b*, uses a glass tube **71** with two ball valves **72** and **73** attached to the tube **71** which in turn is attached to the female of a ball valve **74** and the male of the ball valve **75.** As the plunger moves down, ball valve **72** is lifted and ball valve **73** is seated. The liquid then flowing into the syringe. Next, ball valve **73** is lifted, ball valve **72** is seated and the solution squirts out through exit tube **50.** The attachment of the ball joint to the syringe makes it very convenient to remove the valve system in case of breakage or in case of malfunction. A clamp is supplied and these are available commercially for clamping the ball valves in place; this is also a compact arrangement. In the system of FIG. **1,** where three syringes are shown, three separate sets of valves are required.

Another mechanism found very effective is the one shown in FIG. **6***c*. There are pairs of solenoids **75, 76,** and **77, 78** mounted on a plate. These solenoids will squeeze a plurality of tubes thus acting as valves when attached to press bars. The solenoids have armatures or soft metal cores **79, 80, 81, 82** connected to press bars **83, 84** which are pulled into the solenoids when they are activated. In this system the inlet tubes **50***a*, **50***b* and **50***c*, and the outlet tubes **49***a*, **49***b*, and **49***c*, are one continuous tube in one direction. These, by means of *y* connectors are connected to side tubes which go to the three syringes. Reagents **51***a*, **51***b*, and **51***c* are contained in beakers. As can be seen from FIG. **6***c*, when the plungers move down, solenoids **75** and **76** are activated, clamping the exit tube. The entrance tube being formed in the syringes, liquid moves from **15***a*, etc., through **50***a*, etc., and into the syringe. On the up stroke, solenoids **77** and **78** are activated and the entrance tubes are clamped. Solenoids **75** and **76** are deactivated so that the exit tube is released and liquid is squirted out through the exit tubes **49***a*, etc.

The mechanism by means of which this system works is shown schematically in FIG. **6***d*. It will be noted that a press bar number **83** and **84** are ground to a dull point to compress the tube sharply. These are shown as triangles in FIG. **6***d*. The base plate **85** and **86** on which these press bars press are actually one continous plate. This valve system, while it looks spread out in FIG. **6***c*, is actually very compact and small and conveniently operated. It is easily controlled and is effective in operating the dispenser. As previously mentioned, this is a continuous tubing system and the individual syringe units are connected to the main tube by y connectors **87, 88** and **89.**

The press bars **83** and **84** act on the main tube when activated by the solenoid pairs. The solenoids in turn are enabled by their lead wires **90, 91, 92, 93.**

OPERATION OF THE INVENTION

Operation of the instrument depends on the position of the cam motor by pass switch **94** and the valve motor bypass switch **95.** In the mode shown in FIG. **1,** the switch **94** when pressed will by-pass switch **35** and cause motor **32** to be activated. Cam **27** will rotate until switch **35** falls into the hole again, thus stopping the motor. In FIG. **1,** the cam then moves 360°. The instrument can be constructed so that the cam actually moves 180°. This is accomplished by having two depressions in the cam 180° apart as can be seen in FIG. **2.** The cam is attached to connecting bar **22.** This bar pivots on an axle **21***a* on a second ball bearing **21.** The position of this axle is variable, it being moved up or down in the slot on the cam by adjusting screw **23.** Adjusting screw **23** is pinned in place by a holder **24.** Thus, if rotated, screw **23** will not advance or retreat. How-

ever, if one looks at the side view in FIG. 4, one can see how the rotation of screw 24 will cause nut 25 to move up or down thus moving the axle which holds bearing 21 up or down. Axles 21*a* is movable and 21*b* is rigid. Both these axles hold the bar 22 thru ball bearings 21 and 20. In order for axle 21 to move up and down smoothly, it has a guide pin 28 which moves in the slot 26 and aligns and guides the nut so it does not wobble. In this manner, the radius of the circle, bar 22 rotates around on the cam, can vary. This in turn varies the length of travel up or down of the axle 21*b*, on which the other ball bearing 20 rotates. Axle 21*b* is rigidly attached to slide 19. Slide 19 and slide 12 are bound together by means of tie bar 14. The slide bars which are tied together slide up and down on slide bar 13. The movement of the cam in the circular motion is therefore translated into a motion where these two slide bars move up and down on a slide rod.

The purpose of the slide is to move the plungers of the syringes up or down depending on the position of the cam. For this purpose the multi-clamp is provided — 18*a* and 18*b* (see FIG. 2*b*). Although in the drawing this is shown as a clamp holding three syringes, usually five syringes are practicable on a routine basis. Three syringes are shown to simplify the structure. Any number of syringes, as many as ten, will operate in this system. The syringes are held by the barrel support 18*a* tied to the slide post. This does not move up or down. It is rigidly tied to the post. The syringes are held tightly to the barrel support by a barrel clamp 18*b* and by the two knurled head screws 18*c* and 18*d* which screw into threaded holes 9 and 9*a*. The barrel support 18*a* and the barrel clamp 18*b* are both graved so that the syringe barrels will fit in place.

The barrels numbered 1*a*, 1*b*, and 1*c*, for convenience, correspond to plungers 2*a*, 2*b* and 2*c*. The plungers rest on plunger supports 11*a*, 11*b*, and 11*c*. These plunger heads are held in place by plunger fasteners 3*a*, 3*b* and 3*c*. These fasteners are made of plastic and are tightened down by means of knurled head screws 3*d*, one being shown in FIG. 4. These fasteners hold the plunger tight to the support numbers 11*a*, 11*b* and 11*c*.

These plunger supports 11*a*, 11*b* and 11*c*, are bent at right angles and contain vertical elongated slots, 7*a*, 7*b* and 7*c*. The lift rods 10*a*, 10*b* and 10*c* penetrate these slots so that when the lift rods rise they will move along the slot and eventually reach the adjust slide 5*a*, 5*b*, and 5*c* and then lift the plunger. As the lift rod moves down it will move along the open slot until it reaches the bottom of the slot and then it will pull the plunger down. Thus, in order to adjust the travel, the plunger is going to take, three volume adjust slides are provided, 5*a*, 5*b* and 5*c*, these move up and down along the slot and may be fixed in place by a nut and bolt arrangement numbers 6*a*, 6*b* and 6*c* which permit the volume adjust slides 5*a*, 5*b* and 5*c* to be locked in place. Thus it is possible to loosen the nut of the nut and bolt arrangement, slide the adjust slide up and down, and in this way control the length of the slot, i.e., the bolts 8*a*, 8*b*, 8*c* are threaded and the nut is tightened by screwing the nut on the bolt. Once the volume adjust slide has been tightened in place, the distance rods 10*a*, 10*b* and 10*c* will travel will depend on the position of the slide. Thus in FIG. 3 it will be noticed that rod 10*b* will start lifting the support of the plunger immediately upon activation of the motor. However, rod 10*c* will travel a space in the slot until it reaches the volume adjust slide before it begins to lift a plunger. In this way, as shown in FIG. 3, plunger 2*b* will move a longer distance than plunger 2*c* even though the lift bars are both moving the same distance up and down.

Examination of FIG. 3 will show that the lift rods are rectangular in shape. This is for smoother motion and less waddle when lifting the syringe supports. These lift bars are fastened to lift rod support 11 which is attached to the second slide on the slide post. When the slide moves up and down on the slide post, the lift bar will then be lifted up or down.

MECHANICAL AND ELECTRICAL FEATURES

Preferably, the mechanism is activated by a foot switch which is shown as by-pass switch 94 in FIGS. 1*a* and 7*b*. This serves to by pass the cam switch 35 and thus start the motor rotating. The motor will go one rotation and the switch will then drop into the slot, opening the circuit and stopping the motor. Thus, each stroke of the foot switch will cause a complete cycle to occur in the instrument as shown in FIG. 1. The motor is attached to the cam as can be best seen in FIG. 4 by the cam axial support 20. Into this cam support is inserted the motor drive shaft 30. Slide bar 13 is also supported on this same supporting base. In order for the instrument to operate, one needs to supply a pair of valves, namely an inlet and outlet valve, attached to the nozzle of the syringes, FIGS. 5*a*, 5*b*, 5*c*, 6*a*, 6*b*, 6*c* and 7 show valve arrangements which have been used successfully and which have been herein described.

FIG. 7 shows also in a perspective how the valves and extensions are mounted, and supported on the syringe barrel holder 18. The axle, 37*a*, is rotated by means of a belt 99 and first pulley 100, which connects to the valve motor 98 through a second pulley 100*a*. As the valve motor 98 rotates, the central wafer in the three valves is being rotated. At the same time, one can see that the valve cam 39 is also being rotated so as to activate or de-activate the valve motor by-pass switch 95 and by-pass switch 94 to the main motor. The relative position of these two switches is adjusted so that the valve rotates into the correct position just before the main motor starts. It is very important that the valve be rotated and the holes be aligned before the plunger moves down to aspirate the specimen.

The valve drive is also driven by a pulley arrangement 101 and shims 102 are used so that plungers of varying bore can be held by the same clamp, i.e., a tuberculin 1 ml. syringe 103. The valve assemblies are held by support posts 104 and 105.

As previously mentioned, the cam 27 need not move 360°, and, the arrangement shown in FIG. 2 wherein the cam moves only 180° is often advantageous. Also, as shown in FIG. 2, the position of switch 35 may vary. However, what is important is that the valve be rotated and holes be aligned in the 180° position so that the plunger can then move up and expel the material. If the holes are not lined up when the plungers are moving up or down, then, of course, excessive pressure will be developed, and cause problems. This is avoided by activating the valve motor switch first. Examination of FIG. 7 shown that when by-pass switch 94 is placed on valve cam wheel 39, it can activate the main motor when pressed by passing switch 35 (see FIG. 1). A foot switch 106 is supplied which is the valve by-pass switch and when pressed momentarily will supply a by-pass to

switches 95 and 108, as can be seen in FIG. 7. This will start the valve motor. The motor switch 95 will now climb up on the valve cam, thus maintaining its activation even though switch 106 has been released. It will continue to be activated until the cam rotates 180°, and switch wheel 52 of switch 95 falls into the second hole of the cam. In the mean time, main motor by pass switch 94 is pressed by the hump on the same cam, at a time later than the activation time of switch 95. The valve motor runs at 25 rpm while the main motor runs at only 12 rpm. Thus, because of location of the depression and because of differences in speed, the valve motor rotates 180° and comes to rest before the main motor has moved significantly. The bypass switch 94 shorts switch 35 starting the main motor. This causes switch wheel of 35 to climb the cam. This can best be seen in FIG. 2 which applies where the valve of FIG. 7 is used. This main cam will rotate when by-passed momentarily, and come to rest at a position of 180° distant since this cam for this particular purpose has two depressions, 109*a* and 109*b*, instead of one depression 109 shown in FIG. 1.

The plunger will now have reached its lowest point and normally stop. However, the other by-pass switch 108 is supplied which is shown in FIG. 7*a*. When the lower slide drops to its lowest position, pressure on switch 108 gives a new by pass to valve motor so that the slide moves up and away from switch 108 inactivating it. The main cam will go 180° and come to rest until the valve motor is given a by-pass by the foot switch. The circuits are shown in FIG. 7*b*.

IMPORTANT OPERATIONAL FEATURES

In summary, the three valves are held on an axle. This axle is turned in such a way that a by-pass from a foot switch causes a 180° turn and aligns the valve perforations which then permits the plunger to retreat to aspirate the solution. As the plunger moves back to its lowest point, a by-pass switch is touched which starts the valve motor again. This lines up the central wafer and activates the main motor a second time so that the plunger moves up and the solution is expelled, and the system stops. It will not start again until the by pass motor (foot switch) to the valve motor is pressed again. If switch 108 is omitted, the instrument can be operated in such a way that with one press of the foot switch, the plunger moves down and with the second press of the foot switch, the plunger moves up.

It can thus be seen that this instrument performs a useful function in a system for chemical analysis wherein a plurality of reagents have to be added simultaneously and in different quantities using valves which can function for all purposes and which can take all kinds of materials including acids, alkalis and solvents. A plurality of syringes are used, these syringes being tightly clamped around the barrel. A separate clamp is supplied engaging each of the plungers. This second clamp is attached to a base support which is a right angle piece of metal which has on the vertical position a slot which is adjustable in the plunger so as to move the plungers up and down. The amount of free movement in each slot defines a time period when the plunger is not being lifted and thus each plunger movement may be varied by these lift bars. A cam operates a pair of slide bars which serve to guide the movement up and down of the lift bars of the plunger. Slide bars are tied together by a tie rod and in turn are activated by means of a large cam to which they are connected by a connecting rod. There is a slot and screw assembly in the large cam so that the circular movement of the axle on which the connecting rod rotates may be varied in diameter. This permits the further adjustment of the traverse of the syringes. In addition, further flexibility is made available in that the clamps which hold the syringes permit the use of narrow or wide syringes. Thus, even with the same traverse, a side range of different volumes of liquid can be ejected.

The preferred valve arrangement comprises three discs or wafers with the outer wafers having two holes and the inner wafers having one hole so that alternatively the single hole will line up with a pair of holes on one side or a pair of holes 180° away in the outer wafers. This permits the valve to serve as an inlet and outlet valve to permit the solution to be pumped in and out of the syringe as the syringe moves up and down. A separate valve motor rotates the inner core or the central wafer of these valves alternately placing the perforation in one direction and in a direction 180° away. A valve cam rotates along the same axis which permits the adjustment and synchronization of the valve movement with a main motor which operates the main cam. Thus, an opening is presented and the plunger retreats, bringing the liquid into the system and then as the central wafer rotates, another pathway is presented which permits the upper movement of the plunger to expel the liquid. These valves may be ganged on one axle and for this reason are readily mounted as a compact and integral part of the instrument. A typical example is shown in FIG. 7. In this arrangement, a tuberculin syringe 103 is held with the aid of a shim. This has only a 1 ml capacity. The other syringes have a 10 ml capacity. By having the other two syringes go at full throw, they will deliver 10cc. The tuberculin syringe can be made to go one tenth of the throw so as to deliver 0.1 ml. This is a situation where a ratio of solution volume to 1000 to 1 can be delivered in a practical manner, simultaneously, with the lift bars moving the same distance. It is to be noted that the adjustment on the large cam (the slot on the major cam) which is adjusted by the set screw is necessary in order to locate approximately the bottom part of the syringes since syringes have different lengths. Particular sets of syringes nay not align in the proper position. By having this additional adjustment, it is possible to take the syringe which is to move the largest traverse and adjust the maximum lift for that syringe. Others, of course, will then be adjusted to run at a shorter distance. Both volume adjustments, namely, at the cam and at the base of the syringes, are essential and desirable.

It is also possible to operate the machine in another manner without adjusting the slides under each syringe at a different position. In this case, the syringes will all move the same traverse. This will then be adjusted by screw 23 so as to adjust the volume. If 4 ml is to be delivered with 5 ml syringes, it is not necessary to adjust each one separately. They may all be adjusted simultaneously by screw 23, and all may move the same distance. Alternatively, if one uses two syringes of different volume, one can deliver two different volumes without resorting to the slide adjust. The slide adjust permits greater flexibility. The instrument can be used in a less flexible mode if one desires.

RECAPITULATION

It is to be observed therefore that in the foregoing description, an over all view of the multidispenser is given in FIG. 1 showing the cam rotating 360° each time it receives a by pass and shows three syringes, but does not show the valve arrangement. Then, FIG. 2 is a view facing the cam. In this case, the cam is designed to rotate 180° at each by pass since two depressions are shown. FIG. 3*a* is a view of the support for the barrels of the syringes, and FIG. 3*b* is a view of the supports for the plungers of the syringes and the mechanism for adjusting the throw of the plungers, and also shows the support of the slides. A cross sectional view of the instrument showing the syringe in place, but not the valves, is given in FIG. 4 and a sectional view of a preferred valve arrangement for the syringes is given in FIG. 5*a* while FIG. 5*b* is an exploded view of one of the valve arrangements in three dimension and FIG. 5*c* shows the clamping mechanism for the valves.

An alternative valve arrangement is shown in FIG. 6*a*, using rubber plugs which fit into seats. The whole mechanism being a compact piece of metal which fits directly on the syringe. FIG. 6*b* is similar to FIG. 6*a* except that it is made of all glass and a ball joint is used to connect to the syringes. Another alternative mechanism is shown in FIG. 6*c* which uses a press bar on a multiplicity of tubes to control the inflow and the outflow of the solution as the plungers move up and down. The movement of solenoids in the instrument are synchronized with the movement of the syringes. This operation is schematically illustrated in FIG. 6*d*. A preferred valve mounted on a bracket and attached to centrifuges is shown in FIG. 7. It also shows the drive mechanism for synchronizing its motion for the syringes. FIG. 7*a* shows a by-pass valve activated by a slide mechanism on the downward movement when it reaches the bottom, used in connection with FIG. 7. The circuit for FIG. 7, when the dispenser is used in connection with this valve arrangement, is shown in FIG. 7*b*.

These drawings illustrate a compact, flexible fluid dispenser arrangement for dispensing measured amounts of a plurality of fluids. The dispenser arrangement has a frame post (13) including clamp means thereon (FIG. 3*b*) for holding the container barrels 1*a*, 1*b*, with vertical plungers 2*a*, 2*b* therein. The plungers have a plunger head fasteners 3*a*, 3*b* and separate moveable supports 4*a*, 4*b* for each plunger disposed to engage said plunger head fasteners. The moveable supports are engaged in turn by lift rods 10*a*, 10*b*. Associated with each moveable support are vertical slots 7*a*, 7*b* with each lift rod being in one slot, the position of said slot with respect to the lift rod serving to regulate the vertical movement of the lift rod before it engages the corresponding moveable support. The lift rods are connected to vertical slide means 12, 14, 19 which raise and lower the lift rods. The vertical slide means are in turn connected to crank means, 20, 21, 21*a*, 21*b*, 22 attached to a cam 27. Cam 27 has a radial cam slot 26 therein for adjusting the position of the crank means, the position of the crank means in the cam slot determines the stroke of the vertical slide means.

I claim:

1. In a compact, flexible fluid dispenser for dispensing measured amounts of a plurality of fluids from container barrel (1*a*, 1*b*) said fluids being ejected by pushing on a plunger head (3*a*, 3*b*) of a plunger, said plunger penetrating said barrel, said plunger head (3*a*, 3*b*) protruding out from one end of the barrel, the amount of liquid dispensed being determined by the longitudinal stroke of said plunger reciprocating in said barrel, in combination:

a. a post (13) including clamp means thereon for holding at least two container barrels (1*a*, 1*b*) in substantially parallel relationship so that plunger heads protruding from barrels held by said clamp means are substantially side by side;

b. separate moveable supports (4*a*, 4*b*) disposed to engage separate protruding plunger heads;

c. separate vertical lift rods (102, 10*b*) disposed to engage corresponding moveable supports and adjustable longitudinal slots (7*a*, 7*b*) associated with each moveable support, said longitudinal slots being in a plane substantially parallel to the plane of said longitudinal plungers, each lift rod being in one slot, said longitudinal slots serving to regulate the vertical movement of the lift rod before the lift rod engages said moveable support;

d. slide means (12, 14, 19) connected to said lift rods to raise the lower said lift rods; and,

e. a rotating cam (27) and crank means (20, 21, 21*a*, 21*b*, 22), said cam having a cam slot (26) therein for adjusting the position of said crank means, said crank means being coupled to said slide means, the position of said crank means in said cam slot determining the stroke of said vertical slide means.

2. A dispenser, as claimed in claim 1, wherein said cam slot is substantially radial, an outer axle connected to said slide means, and, an inner axle disposed for radial movement in said slot, a connecting bar connecting said inner and outer axles, and means to fix the radial position of said inner axle in said cam slot.

3. A dispenser, as claimed in claim 1, said post having upper and lower slides (19, 12), a tie rod connecting said slides, said outer axle being connected to one of said slides.

4. A dispenser, as claimed in claim 2, said post having upper and lower slides (19, 12), a tie rod connecting said slides, said outer axle being connected to one of said slides.

5. A dispenser, as claimed in claim 4, said post being a substantially vertical post, said adjustable longitudinal slots being substantially vertical.

6. A dispenser, as claimed in claim 5, including valve arrangements connected to each barrel other end.

7. A dispenser, as claimed in claim 6, said valve arrangements being a non-corrosive material for pumping strong corrosive liquids and includes first and second ball valves.

8. A dispenser, as claimed in claim 6, said valve arrangements including a pair of spring loaded rubber valves.

9. A dispenser as claimed in claim 6, said valve arrangement including three y-shaped aperture tubes having an aspirating aperture connected to the source of the dispensing fluid, an expelling aperture to dispense said fluid and a third aperture disposed for connection to said barrel other end so that a continuous connection exists between aspirating and expelling aperture to dispense said fluid and a third aperture disposed for connection to said barrel other end so that a continuous connection exists between aspirating and expelling apertures of said tubes and said barrels other

end, means for causing sequential pressure along said tubes synchronized with the plunger movements so as to cause a continuous unidirectional pumping action of fluids in said barrels.

10. A dispenser as claimed in claim **6**, said valve arrangements including

a. a valve axle rotated by drive means;

b. a plurality of cylindrical valves disposed on said valve axle each comprising two outer discs and an inner disc held tightly together by clamp means, the two outer discs being prevented from rotating, a keyway in said center layer to be rotated when said valve axle rotates, and openings in the two outer discs, alignment being maintained between corresponding openings in the two outer discs, the center disc containing only one opening so that on rotation it can form communication between corresponding openings in the outer discs thus resulting in the alternating formation of two fluid passageways;

c. connecting means to connect the barrel other end simultaneously with the two openings on the first of the outer discs, separate connecting means for one of the openings of the second outer disc to a receptacle to accept liquid dispensed, and program means for synchronizing the rotation of the valves with that of the plungers so that on the downstroke of the plunger there is communication from the plunger to a dispensing connecting tube.

11. In a compact, flexible fluid dispenser for dispensing measured amounts of a plurality of fluids from container barrels (**1***a*, **1***b*) said fluids being ejected by pushing on a plunger head (**3***a*, **3***b*) of a plunger, said plunger penetrating said barrel, said plunger head (**3***a*, **3***b*) protruding out from one end of the barrel, the amount of liquid dispensed being determined by the longitudinal stroke of said plunger reciprocating in said barrel, in combination:

a. a post (**13**) including clamp means thereon for holding at least two container barrels (**1***a*, **1***b*) in substantially parallel relationship so that plunger heads protruding from barrels held by said clamp means are substantially side by side;

b. separate moveable supports (**4***a*, **4***b*) disposed to engage separate protruding plunger heads;

c. separate traveling means (**10***a*, **10***b*) disposed to engage corresponding moveable supports and adjustable travel limit means (**7***a*, **7***b*) associated with each moveable support, said travel limit means serving to regulate the movement of the traveling means before the traveling means engages said moveable support;

d. a rotating cam (**27**) and crank means coupled to said traveling means, said cam having a cam slot (**26**) therein for adjusting the position of said crank means, the position of said crank means in said cam slot determining the travel distance of said traveling means.

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