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 [31] **33589/66**
 Continuation-in-part of application Ser. No. 654,737, July 20, 1967, now abandoned.

2,887,250	5/1959	Zilk	222/76
3,143,393	8/1964	Hons	73/425.4
3,263,554	8/1966	Pickels	73/425.6
Re26,180	4/1967	Frenzel et al.	222/390X
3,355,070	11/1967	Pethmers	222/529X
3,448,895	6/1969	Mesh	222/76X

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[54] **DISPENSING APPARATUS FOR RECEIVING AND DISCHARGING A PRECISELY PREDETERMINED VOLUME OF FLUID**
 12 Claims, 11 Drawing Figs.

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 222/76, 222/135, 222/144.5
 [51] Int. Cl. G01n 19/00
 [50] Field of Search 222/23, 76,
 146, 386, 390, 529, 533, 566, 144.5, 135;
 239/587, 588, 303—305; 248/68; 285/137;
 141/21; 78/425, 425.6

[56] **References Cited**
UNITED STATES PATENTS
 2,177,752 10/1939 Stern 222/390X
 2,183,727 12/1939 Stern 222/390X

ABSTRACT: A motorized syringe for receiving and dispensing and/or diluting very accurately controlled amounts of liquids in combination with a separate portable or remote, hollow-bodied control unit connected by a flexible conduit to one or more such motorized syringes. The operation of a plurality of the motorized syringes may be integrated by means of a programmed operating means whose operation cycle is initiated from the remote control unit connected therewith, with the attendant advantage that complex operations requiring the use of many such syringes in combination with one another may be carried out at a single location, with the operator merely exchanging vessels serving the liquid-conducting outlet/inlet tube or tubes provided in the remote control unit and connected with the flexible conduit, whereby the liquid is readily dispensed or picked up; and, if necessary, some further stage of the process can be initiated by actuation of one or more control buttons provided on the control unit. The outlet/inlet tubes are of relatively small diameters and have interchangeable probelike portions with a free end projecting a substantial distance beyond the body to facilitate picking up liquid from and/or dispensing liquid into vessels having relatively narrow, elongated necks.

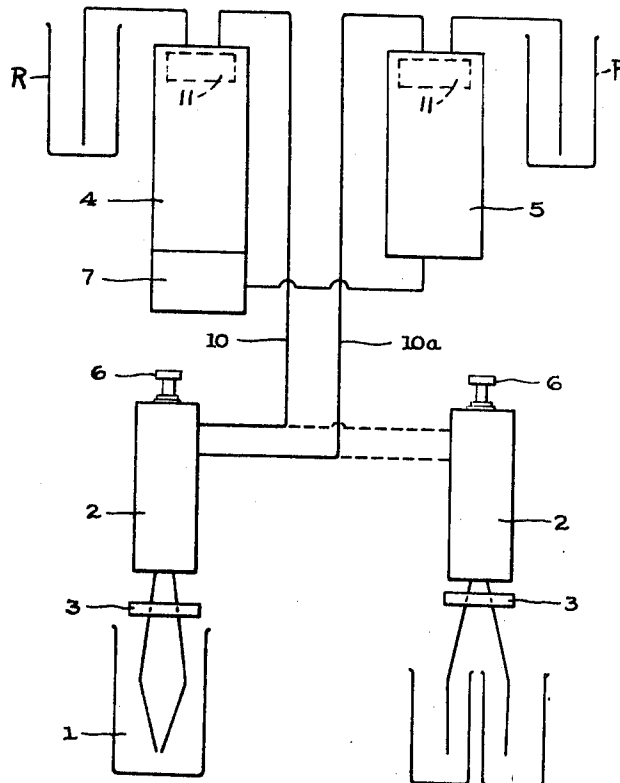
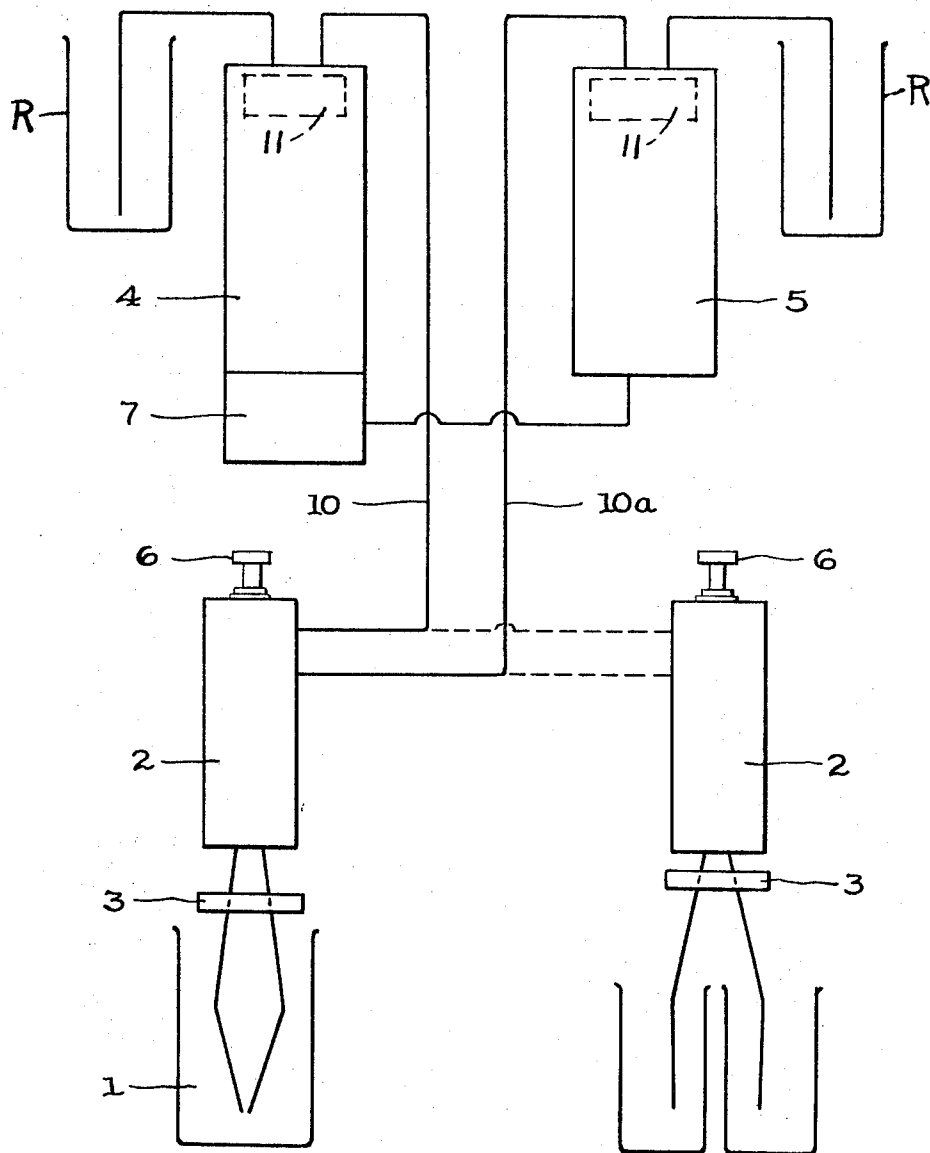


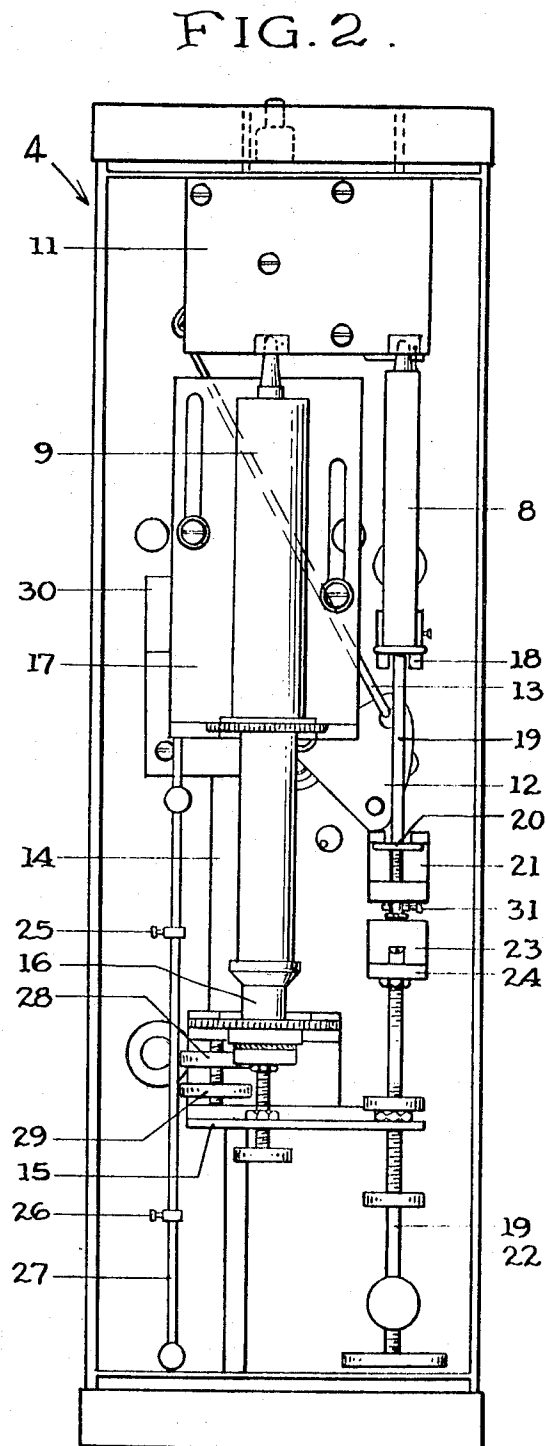
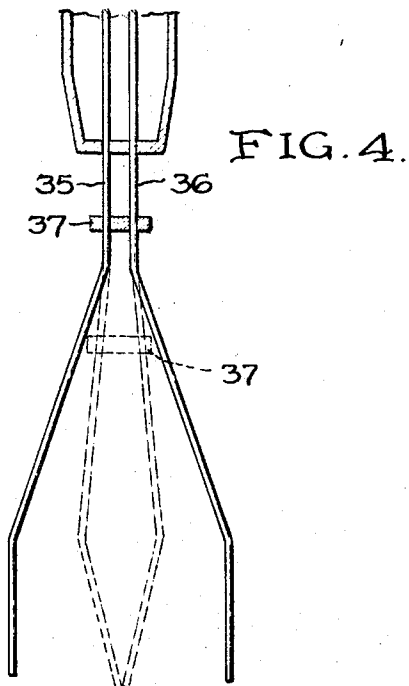
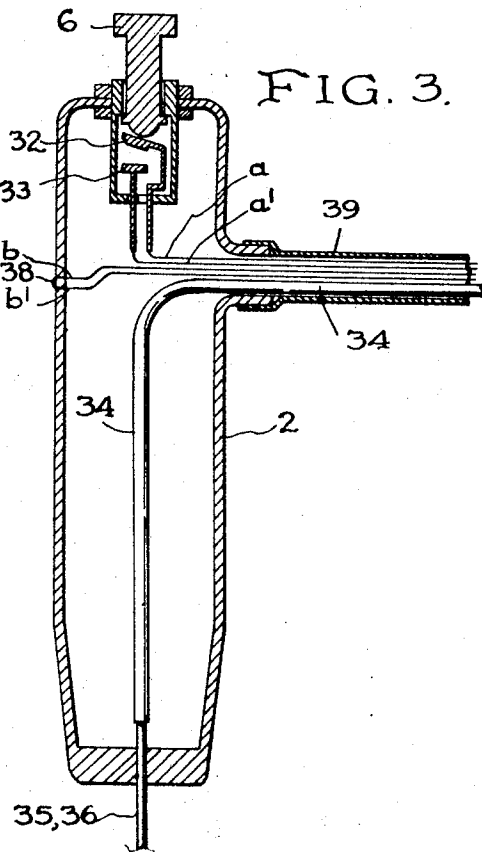
FIG. 1.



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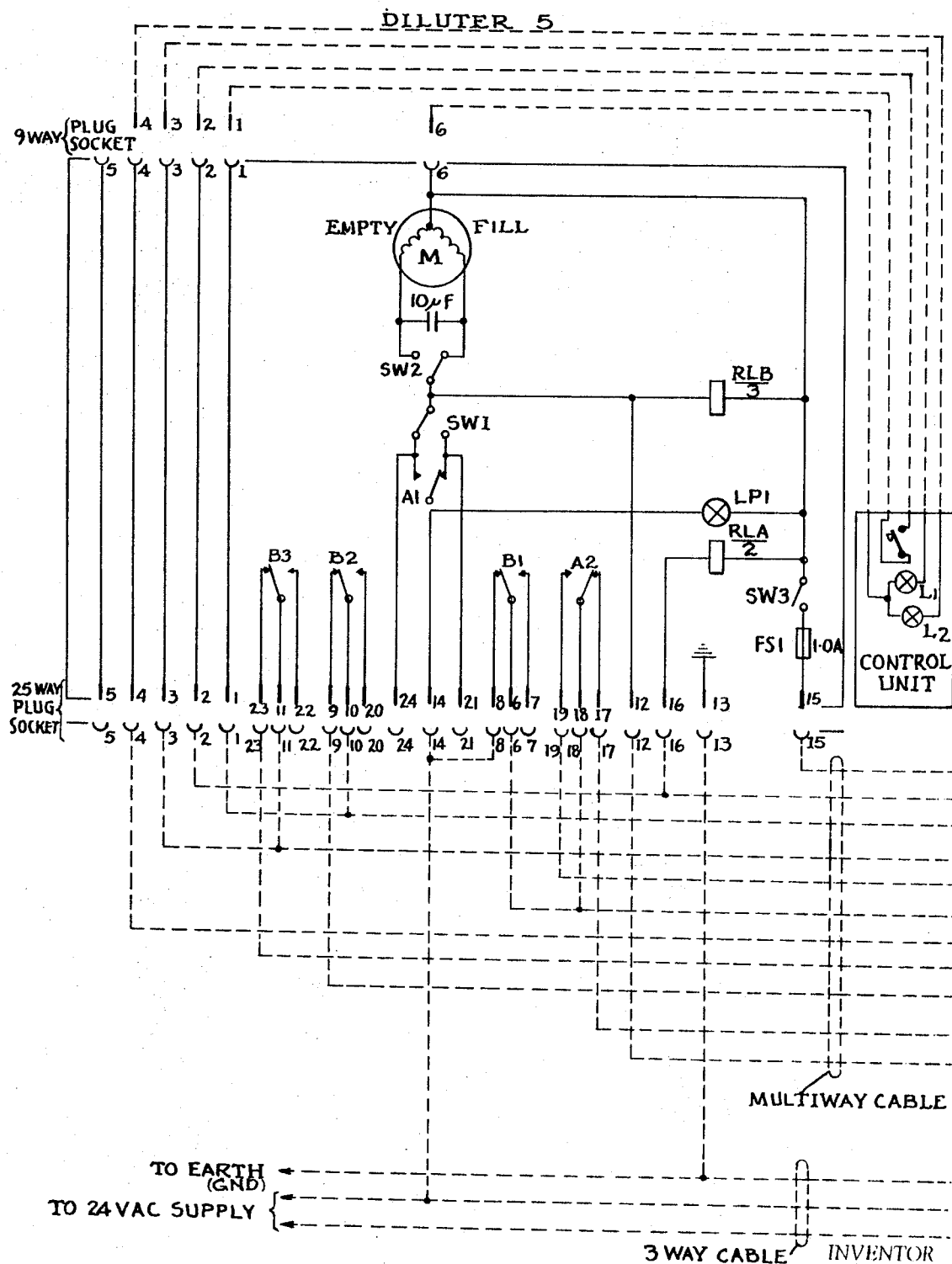


FIG. 5a.

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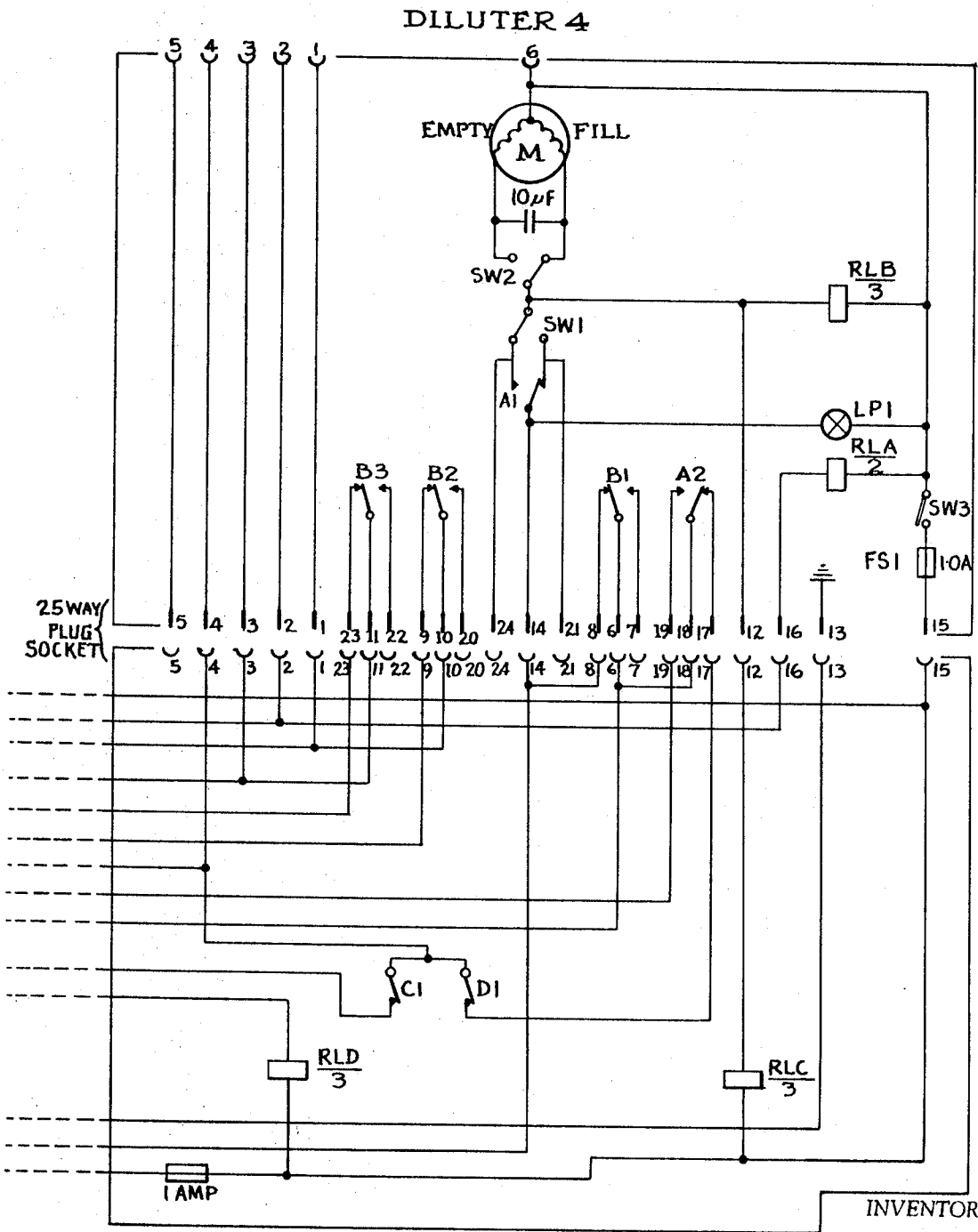


FIG. 5b.

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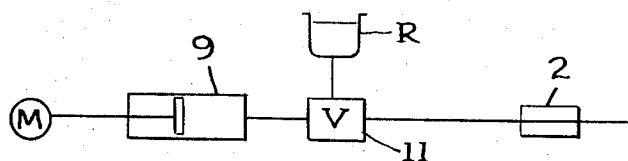


FIG. 6.

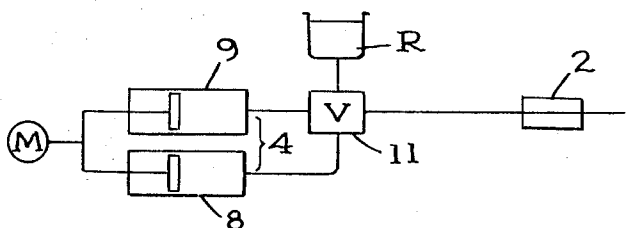


FIG. 7.

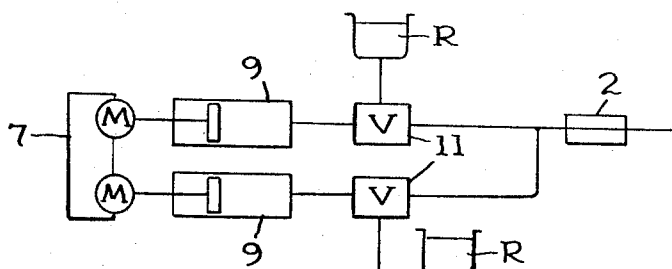


FIG. 8.

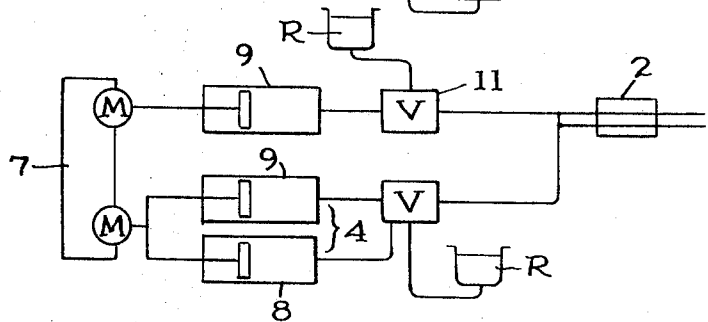


FIG. 9.

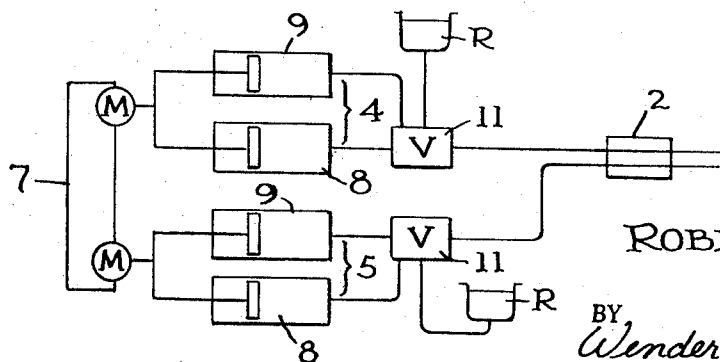


FIG. 10.

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DISPENSING APPARATUS FOR RECEIVING AND DISCHARGING A PRECISELY PREDETERMINED VOLUME OF FLUID

The present invention relates to a motorized syringe for dispensing or diluting liquids in combination with a separate portable control unit and is a continuation-in-part of my copending application Ser. No. 657,737, filed July 20, 1967, abandoned.

Motor driven syringes, which comprise a hollow cylinder having a plunger reciprocated therein so as to pick up and discharge liquid, find use in such laboratory operations as the dispensing of accurately controlled amounts of liquid and the picking up and dispensing of samples of liquid for test purposes. Motorized syringes have the advantages over pipettes and manually operated syringes whereby consistently reproducible accurate results may be obtained and that the operator is freed from the need to use one or both hands to operate the pipette or syringe. However, it has been necessary to actuate the electrical or like control mechanism for the motorized syringe and this has hitherto formed an integral part of the housing within which the motorized syringe has been mounted. This, coupled with the fact that the motorized syringe and associated mechanism are comparatively bulky objects, has meant that an operator has had to bring the vessel whose liquid is to be sampled or which is to receive liquid to the motorized syringe. This results in excessive movement around a work area. Furthermore, where liquid in a vessel was to be subjected to a series of samplings, additions or dilutions, it has been necessary to transfer the vessel from one place to another in order that the vessel could be located at each of the motorized syringes required to carry out the overall operation. Where the overall operation was complex in nature this would require a considerable bank of syringes each one of which had to be visited and actuated in the correct sequence, often with exchange of liquid receptacle during the operation. Thus such an arrangement was cumbersome in structure and operation, and also lent itself readily to human errors in view of the complexity of its operation.

We have now devised a remote control unit for use with one or more motorized syringes which overcomes the need to take vessels to the motorized syringe and which, because the control of the syringes is located at one place (and not upon each syringe as before) makes it possible to integrate the operation of a plurality of syringes by means of a programmed operating means whose operation cycle is initiated from the remote control unit. This has the advantage that complex operations requiring the use of many syringes in combination with one another may be carried out at a single location, the operator merely exchanging vessels serving the liquid inlet/outlet pipe or pipes in the control unit whereby the liquid is dispensed or picked up and, if necessary, initiating some further stage in the process by actuation of a button of the control unit.

Accordingly, the present invention provides the combination of a control mechanism and one or more motorized syringes each adapted to receive and discharge accurately controlled amounts of liquid and provided with one or more inlet/outlet pipes, which syringes are adapted to be operated by the actuation of one or more electrical switches, characterized in that the control mechanism is a remote control unit comprising a housing adapted to be held in the hand and to be moved about a work area independently of the motorized syringe or syringes, which housing is provided with one or more electric switches adapted to actuate the motorized syringe or syringes and with one or more conduits adapted to permit the flow of liquid through the housing and which are adapted to be connected to the motorized syringe or syringes by flexible conduits.

From a preferred aspect, the invention provides a combination as described above wherein two or more motorized syringes are caused to act in combination by a programmed operating means whose cycle of operations is initiated by actuation of a switch in the control unit.

The motorized syringes for present use comprise an accurately machined cylinder within which a close-fitting plunger

is journaled. The cylinder and plunger may be made from any suitable materials such as glass, nylon, stainless steel and the like and suitable cylinders and plungers are commercially available. The plunger may be provided with a sealing member, such as an O-ring, to ensure sealing contact between the plunger and the cylinder walls. The plunger is reciprocated within the cylinder by means of a motor-driven ram or the like. For example the free end of the plunger may be carried by a motor-driven carriage, the cylinder being held stationary or vice versa. While the cylinder and plunger may be exchanged with others in order to provide variation in the amount of liquid picked up and discharged during a full stroke of the plunger within the cylinder, it is usually more convenient to provide the syringe-driving mechanism with adjustable stops which may be used to alter the length of the stroke of the plunger in the cylinder. These stops may take the form of buffers which prevent further movement of the plunger where the linkage between the plunger and its driving means is provided with a clutch, such as a slipping spring clutch, which permits slip or relative movement. Alternatively, the stops may actuate switches which stop and may reverse the motion of the plunger.

The outlet from the syringe may be connected directly with the control unit where the syringe is to pick up and discharge liquid only through the control unit. However it will usually be preferred to provide the syringe with a valving means, for example a twist valve, which operates in harmony with the stroke of the plunger to ensure that, where the plunger has drawn liquid into the cylinder, the cylinder may be sealed to prevent drainage of liquid therefrom or from the liquid source. Where the syringe is to pick up liquid from a separate supply and to discharge it through the control unit, as is the case where the syringe is to dispense a reagent or diluent, the valve means may be provided with the requisite number of inlets and outlets to which the source of liquid supply and the control unit may be connected. The use of a twist valve is particularly preferred for the valving means since the residual liquid held in a twist valve after operation is small, minimizing the risk of contamination of successive liquids which pass therethrough. Furthermore a twist valve suffers less than other forms of valve from jamming.

The plunger and valving means may be driven by any suitable motor and linkage system and the one motor may drive both the plunger and the valve. It is preferred to use a synchronous reverse-phase electric motor. The necessary circuitry to ensure the correct sequence of operations of the plunger and valve may be varied to suit any particular operational sequence and are conventional in nature.

As indicated, a single motorized syringe may pick up liquid from some source and this may not be via the control unit, and then discharge the liquid via the control unit. Such a syringe may therefore be used to dispense a given amount of diluent or reagent into a vessel or to transfer a given amount of sample liquid from one vessel to another. For convenience, such a form of motorized syringe and its associated mechanism will be denoted herein as a dispenser. However, where it is desired to pick up a sample of liquid and then to discharge it with a diluent, it will be appreciated that two syringes may be required. These syringes may be operated separately or, more preferably, may be operated in unison by a single motor. In the latter case, one motorized syringe may be of the form described above for a diluter, the other may be of the same construction but of different capacity and provided with valving means whereby it picks up and discharges liquid only via the control unit. Where the second syringe has a different length of stroke from the other, its plunger may be driven by means of a magnetic clutch from the driving means of the other syringe which permits relative movement between the two plungers once one has completed its stroke. Such a two-syringe apparatus will be denoted herein as a diluter. Motorized syringes of the described type as used in dispensing and diluting systems are commercially available, for example, through Fisons Scientific Apparatus, Ltd., Loughborough Leicestershire, England.

It will be appreciated that where a syringe is to pick up and discharge a series of samples of different liquids, it is undesirable that contamination of one sample by another should occur. It is therefore preferred that sample liquid should not be drawn up into the cylinder of the syringe since this is difficult to clean effectively between each sampling. It is especially preferred that liquids to be sampled should be accommodated in the conduit in the control unit which they serve. The samples may be picked up and ejected without contaminating the syringe, whose cylinder is full of air or a liquid, such as a diluent, which does not contaminate successive samples or other liquids which are to pass through the conduit. The conduit may be washed clean by passing diluent through it, which also discharges the sample, or by some other means. The air or liquid in the cylinder of the syringe serves as a piston to transmit the suction or expulsion forces generated in the syringe to the liquid to be sampled.

The control unit for present use comprises a housing which is to be held in the hand and which is provided with one or more tubes or like conduits through which liquid may flow to and from the appropriate motorized syringe or syringes and with one or more electrical switches whose actuation initiates the operation of a given syringe or series of syringes. The housing may be of a pistol grip type or may be an elongated cylindrical or cigar shape. It may be made from any suitable material such as a chemically resistant synthetic resin, e.g. nylon, polyethylene, polystyrene, or the like.

The tubes or like conduits with which the housing is provided may be mounted externally, or more preferably, are encased within the housing. These tubes are provided at one end with means for connecting them to a flexible conduit or tube which permits the flow of liquid between the control unit and the dispenser and/or diluter mechanisms which it serves. Such connections may be by means of a screw union, a bayonet or push fit. The other ends of the tubes of the control unit protrude sufficiently far from the housing to enable liquid to be picked up from and dispensed with directional accuracy into the comparatively elongated and narrow-necked vessels such as test tubes used in laboratories. For a tube which is to be used solely for dispensing liquids, the extent of protrusion need only be sufficient to ensure that accurate directional control is achieved and the protruding portion or probe may be from, say, 3 to 6 inches long. However, the bore of a discharge tube may be related to the capacity of the syringe which it serves. Thus for a 20-ml.-capacity syringe the protruding portion of the tube in the control unit is preferably about 1.5 mm. in internal diameter and for 10 ml. and 5 ml. syringes the internal diameters are about 1.0 mm. and 0.5 mm. respectively. For a tube which is to be used for the sampling of liquids it is usually preferred that the capacity of the tube be such that little or none of the sample enters the motorized syringe which the tube serves. It is also preferred that, where a control unit is provided with both discharge and a sampling tube, the sampling tube protrude from about one-half an inch to 1 inch further than the discharge tube. The appropriate dimension of the protruding portions or probes for each tube or like conduit in the control unit may be readily assessed for any given case.

The probes or protruding portions of the tubes in the control unit are preferably made detachable, for example by a screw, bayonet or push fit, to permit interchange for different syringes and different operations. The probes and associated tube in the control unit may be made from any suitable chemically resistant material such as polyethylene or stainless steel.

The number of tubes or like conduits with which the control unit is provided may be dependent upon the number and the natures of the syringes which it is to control. While a liquid sample may be picked up and discharged through the same tube and probe and while a diluent for the sample may also be discharged through the same tube and probe, it will usually be necessary to provide a separate tube and probe in the control unit for each liquid to be passed through the handset, especially where successive liquids might interact. For convenience it is preferred to provide a standard type of control

unit having, say two tubes which may be provided with a range of interchangeable probes. Where an operation makes use of more liquids than can be handled by one control unit without contamination, additional control units may be used. It is also usually preferred that each tube and probe in the control unit serve only one dispenser and/or diluter; although where mixing of liquids in the one tube and probe is not deleterious, several diluters and/or dispensers may be served by the one tube and probe via a manifold.

While the probes which may be fitted to control unit are usually straight stainless steel tubes of varying dimensions, we have found it convenient to provide a control unit, wherein two tubes are to be used for the simultaneous pickup of samples from a common source, with a pair of probes of flexible construction which is provided with means for altering the relative positions of the free ends of the probes. For example the probes may be a pair of diverging tubes having a slideable collar encircling them both which may be slid down the probes to bring their tips together for simultaneous sampling from one vessel then be slid up the probes to permit them to splay and discharge the samples into two separate vessels.

As indicated above, the housing of the control unit is also provided with one or more electrical switches, which are preferably of the push button type, for initiating the operation of the syringe or syringes which the control unit serves. The switch may be connected to the syringe mechanism or to the programmed operating means therefor in the conventional manner. While the control unit may be provided with an individual switch to actuate each syringe which it serves, it is preferred to provide the control unit with only one switch. Where one syringe or a diluter mechanism is served by the control unit, the switch on the control unit may be connected directly to the syringe mechanism. However, where a plurality of syringes are served which operate in cooperation with one another, the switch on the control unit may be connected to a programmed operating means which operates the syringes in the desired sequence and which is itself actuated by the switch on the control unit. The programmed control means may take the form of a rotating disc adapted to trip switches operating the syringes or may take the form of a series of relays. While the programmed operating means may be one which will carry out the whole of the intended test operation upon a single actuation of the switch on the control unit, it is usually preferred that the program be designed to carry out the overall operation in a number of stages, each of which requires initiation from the control unit. Such interrupted process enables the operator to identify with the ease the stage of the process which has been reached and to change vessels or to incubate a sample during one of the interruptions if required. If desired, the programmed operating means may be so designed that, once any particular stage is initiated, actuation of the switch on the control unit will have no effect until the stage has been completed.

The circuitry required for a programmed operating means may be readily devised for any given operation.

In addition to the switches and the conduits, the control unit may also be provided with one or more indicator lamps which serve to show an operator which stage of an overall operation has been reached. The number of lamps required may be varied from operation to operation but will rarely exceed three. The lamps and their circuitry are conventional in nature.

The control unit is connected to dispensers and/or diluters it serves or the programmed operating means therefor by flexible electrical leads and liquid conduits. The flexible conduits may take the form of tubes made from a synthetic resin such as polyethylene or tetrafluoroethylene. The conduits and leads may be housed together in a common covering or sheath.

While the use of a remote control unit provides many advantages where a single dispenser or diluter is used, it is of especial benefit when combined with the use of a programmed operating means to control a plurality of dispensers and diluters. The devices of the invention may find use for example in

testing for blood glucose or urea, in preparing double samples of different concentrations for the testing of the sodium and potassium content of the sample in a flamephotometer and in preparing samples for hemoglobin or leucocyte counts.

By way of example the invention will be illustrated by a double-dilution device in which samples of different concentrations are prepared from a single source and with respect to the accompanying drawings in which:

FIG. 1 is a schematic representation of the apparatus employed;

FIG. 2 is a plan view of a diluter mechanism;

FIG. 3 is a vertical section of the control unit;

FIG. 4 is an enlarge vertical section showing the probes for the control unit of FIG. 3,

FIG. 5 (identified as FIG. 5a and FIG. 5b on two pages) is the circuit diagram of the apparatus in which the component parts are denoted by the standard form of symbol and identification;

FIGS. 6 and 7 are schematic representations of the most simplified form of a dispenser and diluter mechanism, respectively, with other basic components comprising the basic inventive combinations defined in respectively the first two claims;

FIG. 8 is a similar simplified schematic diagram of the combination systems utilizing two dispenser mechanisms, and as defined in the third claim;

FIG. 9 is a further simplified schematic representative of a combination embodying one dispenser mechanism and one diluter mechanism feeding one or two probes; and

FIG. 10 is still another schematic representation of two diluter mechanisms with two probes, which is an even more simplified representation of FIG. 1.

The apparatus for the double dilution comprises a sample in a beaker or like vessel 1, a control unit 2 having a double flexible probe 3, one probe being connected by flexible polythene tubing 10 to a diluter mechanism 4, the other probe to another diluter 5 by tubing 10a. The control unit is provided with a pushbutton electrical switch 6 which is connected to the interlink or programmed operating means 7 which causes the two diluters to operate in unison upon actuation of switch 6. Each diluter is connected to a reservoir or supply of water which is used as the diluent. The power for the interlink and the diluters is supplied by a 24-volt transformer (not shown).

Diluter 4 shown in FIG. 2 contains two motorized syringes 8 and 9, syringe 8 picks up the sample to be diluted by suction via line 10 and syringe 9 picks up water from the supply or reservoir R, both syringes discharge their contents down line 10 to the control unit and out via one arm of the double probe 3. Both syringes are fitted into a P.T.F.E./stainless steel twist valve 11 which is operated through the crank 12 and the connecting rod 13 by a synchronous reverse-phase motor (not shown in FIG. 2, but shown schematically at M in FIGS. 6-10). This valve connects syringe 8 with control unit and syringe 9 in turn with the supply of water and then with the control unit for the pickup and discharge stroke of the plunger in syringe 9 respectively. The motor which drives valve 11 also drives a rack 14 on which is mounted a bracket 15 which engages with the free end 16 of the plunger in syringe 9. The barrel of syringe 9 is held firmly against valve 11 by means of an L-shaped clamp 17. The barrel of syringe 8 is held against the valve 11 by a plastic clamp 18 which can be tightened by moving it along a support rod 19. The free end 20 of the plunger of syringe 8 is held in a second plastic clamp 21 which also slides along support rod 19 with additional support from the guide rod 22 which is mounted under support rod 19. The clamp 21 carries a magnet 23 which makes contact with an adjustable catchplate 24 mounted on bracket 15.

The volume picked up and delivered by syringe 9 is controlled by two adjustable stops 25 and 26 which can be moved to and fro along actuating rod 27 which is mounted along side the rack 14. Fitted to the bracket 15 are two knurled wheels 28 and 29 which act as trip levers for the stops. When one of the knurled wheels strikes a stop, the actuating rod is moved

thus actuating microswitch 30 to which it is connected and causing the motor to stop and reverse. The volume picked up by syringe 8 is controlled independently by another adjustable stop 31 mounted on the guide rod 22. When clamp 21 strikes the stop 31, the adjustable catchplate 24 parts from the magnet 23 and the plunger in syringe 8 is not longer driven.

In operation, both plungers are initially at the end of their forward strokes and syringes 8 and 9 are empty. Valve 11 connects syringe 8 with the control unit and syringe 9 with the supply of diluent. Upon initiation of the dilution operation, the motor in the diluter is energized and draws the bracket 15 away from the valve 11. This commences the suction stroke for the syringe 9 which continues until stop 26 is tripped by knurled wheel 29 which occurs at the point at which the syringe has picked up the desired quantity of diluent. During the movement of bracket 15, catchplate 24 carries magnet 23 with it and hence also draws the plunger for syringe 8 with it. When clamp 21 strikes the stop 31 further travel of the clamp is prevented, the contact between the catchplate 24 and the magnet is broken and the suction stroke of the plunger in syringe 8 is complete even though the suction stroke of syringe 9 may continue.

When stop 26 is tripped by knurled wheel 29 at the end of the suction stroke of syringe 9, the motor is stopped and reversed by microswitch 30 and valve 11 is turned to form a common discharge path from both syringes via line 10 to the control unit. If desired, the turning of the valve may take place with an intermediate closed position to minimize the risk of backflow. Where the valve turning is carried out in a series of steps with an intermediate closed position, further actuation of the button on the control unit may be required to turn the valve from its closed position to that at which it provides the common discharge path for syringes 8 and 9.

When the valve 11 is in the discharge position, the motor drives rack 14 towards the valve 11 on the discharge stroke of syringe 9. As the rack advances, catchplate 24 recontacts magnet 23 and the plunger of syringe 8 is caused to carry out its discharge stroke in unison with the rest of the discharge stroke of syringe 9. Discharge of the syringes continues until knurled wheel 28 strikes stop 25 at the end of the travel of the plunger in syringe 9. The motor drive is disconnected from rack 14 and valve 11 is turned to connect syringe 9 with the supply of diluent or to an intermediate closed position and the diluter is ready to repeat its operation upon further actuation of switch 6 in the control unit.

As indicated above, the plunger of syringe 8 does not actually draw the liquid to be sampled into the cylinder of the syringe but only into that arm of probe 3 which it serves by means of the suction generated in line 10.

The syringes 8 and 9 may be made from nylon, glass or other suitable noncorrodible materials and other parts may be made from for example, stainless steel.

The second diluter 5 is of similar construction as diluter 4 except that the capacities of syringe 8 and/or 9 may be different in order that a different proportion of sample and diluent is discharged from diluter 5.

The two diluters are caused to act in unison upon actuation of the single button in the control unit by means of the interlink 7 which comprises a series of relays the first of which is actuated by the switch 6 and itself actuates a series of further relays in the desired sequence. The function and construction of the interlink will be readily appreciated from the circuit diagram FIG. 5. It is preferred to construct the interlink 7 of a size suitable for mounting upon one end of either of the diluters 4 or 5 to form a single unit as shown in FIG. 1.

Controlling the operation of diluters 4 and 5 and interlink 7 is control unit 2 shown in FIG. 3. This comprises a hollow cigar-shaped housing made from nylon. This housing is provided with the pushbutton switch which closes contacts 32 and 33 between the electrical leads a and a' which are connected to the interlink 7 to energize the relays in interlink 7.

The housing is also provided with a pair of polyethylene tubes 34 encased within the housing. One tube is connected to

the valve 11 on one diluter, the other tube to the valve on the other, by means of the flexible lines 10 and 10a referred to above. The free ends of each of tubes 34 are provided with flexible stainless steel probes 35 and 36 in a push fit. As may be seen from FIG. 4, each probe is of stepped shape and both are encircled by a collar 37 which may be slid over the stepped portion of the probes to urge their tips together or slid off the stepped portion to permit the probes to splay apart. The splayed position (shown by full lines in FIG. 4) permits simultaneous discharge from diluters 4 and 5 to two different vessels, the closed position (shown in dotted lines) permits the simultaneous pickup of samples by diluters 4 and 5 from the one vessel.

The housing is also provided with two indicator lamps, one of which is shown diagrammatically as 38 in FIG. 3. This lamp is a conventional indicator lamp and is connected by leads b and b' to the interlink 7 and serves to show an operator the point in the overall position which has been reached.

The leads for the switch and the indicator lamps are housed with the flexible tubes connecting the control unit to the diluters in a common sheath 39.

In carrying out a double dilution using the above apparatus, the diluters initially have all syringes empty and ready to commence their suction strokes. The bottom of the two indicator lamps on the control unit is on. The operator slides collar 37 over the step of probes 35 and 36 to bring their tips together and inserts the probes into the liquid to be sampled. Button 6 is actuated which actuates the interlink 7 which energizes the motors on diluters 4 and 5 to drive the plungers for all syringes on their suction strokes. Liquid sample is drawn into probes 35 and 36 and diluent is picked up by syringes 9 in each diluter. During this operation neither indicator lamp 38 is on, but the top light goes on when both of syringes 9 have completed their suction stroke, stops 26 have been tripped by knurled wheels 29 and microswitches 30 have reversed the motors and turned the valves 11, in this case to an intermediate closed position. The diluters are now ready to discharge the diluent and samples. Interlink 7 is programmed so that further operation of the diluters requires further actuation of the button 6 at this point. The operator removes the probes from the sample vessel, slides collar 37 off the step of the probes to permit them to splay apart and inserts the probes into two separate fresh receiving vessels before actuating button 6. The diluters then discharge their contents into the two vessels to provide two samples of different concentration. During the discharge the top lamp 38 is on. At the end of the discharge, diluters 4 and 5 and interlink 7 automatically revert to their starting positions in readiness for another dilution operation and the bottom indicator light only is switched on.

I claim:

1. The combination of a control mechanism and pump means for receiving and discharging a precisely predetermined volume of fluid from associated fluid reservoir means to a delivery site, which combination comprises:

- a. pump means including first variable-volume displacement-chamber pump means adapted for fluid flow communication with the reservoir means;
- b. an electrical motive power means operatively connected to and for driving said pump means;
- c. means including adjustable limit-stop means interconnected with said pump means and motive power means providing for selectively adjusting and effecting the precisely predetermined volumes of fluid;
- d. a hand-manipulatable housing of portable character capable of being moved about a work area independently of the pump means, the housing being provided with a fluid-conducting tubular probe having one end projecting from the housing and with a fluid flow communication line connecting the other end of the probe with the pump means, said housing having at least one electrical switch and related circuitry connecting it with the electrical motive means, said switch being operable to selectively actuate the electrical motive power means; and

e. a multiple-position valve means operatively connected with and driven by said motive power means in synchronization with said pump means and controlling the line of fluid flow communication to the pump means, whereby in a first position the pump means is in fluid flow communication with the fluid reservoir to provide intake of a predetermined volume of fluid into the pump means, and in another position to provide discharge of said fluid from the pump means via said probe in the housing to a delivery site.

2. A combination as defined in claim 9 wherein the pump means further includes a second variable-volume displacement-chamber pump means operatively connected with said power means, and having means providing fluid flow communication with said probe in the housing for picking up into and discharging from the probe an independently predetermined precise volume of fluid, said valve means including means to provide fluid flow communication in a sequence of positions not only between said first pump means and the associated reservoir, and between said first pump means and said probe in the housing, but also between said second pump means and said probe in the housing, whereby in a desired sequence a precise predetermined amount of first fluid is drawn into said first pump means, a precise predetermined amount of a second fluid is drawn into said probe by said second pump means, and subsequently the first and second fluids are discharged through said probe.

3. An association of a combination as claimed in claim 1 with another same combination also as claimed in claim 9, characterized in that the said pump means and the said valve means of said combinations serve one probe housing and in that there is further provided a programmed operation means operatively connected with said electrical motive power means and with said switch, said programmed operating means having a cycle of operations initiated by actuation of a switch in the housing, and which programmed operating means thereby actuates the motive power means driving each pump means and the valve means operatively serving the pump means in the desired sequence.

4. An association as claimed in claim 3 wherein said one housing is provided with a similar second probe and including fluid flow communication lines similarly and separately connecting it respectively with said pump means, reservoir means and said valve means to selectively serve each of the related associations in the combination

5. An association as claimed in claim 3 wherein the programmed operating means is provided with switch-activated means for effecting at least one interruption in the cycle of its operation and the housing is provided with a corresponding number of electrical switches operatively connected with said programmed operating means so that subsequent switch actuation initiates a further operation of the programmed operating means.

6. A combination as defined in claim 2 further including a subcombination comprising:

1. a third variable-volume displacement-chamber pump means adapted for fluid flow communication with a reservoir means;
2. an electrical motive power means operatively connected to and for driving said third pump means;
3. means including adjustable stop means interconnected with the said third pump means and the motive power means driving the third pump means providing for selectively adjusting and effecting the precisely determined volume of the displacement chamber of the third pump means;
4. a multiple-position valve means operatively connected with and driven by the motive power means driving the third pump means in synchronization with the third pump means and controlling the line of fluid flow communication to the third pump means, whereby in a first position the third pump means is in fluid flow communication with the reservoir means it serves to provide intake of a

predetermined volume of fluid into the third pump means, and in another position to provide discharge to a delivery site of said fluid from said third pump means via a probe in said housing to which the third pump is connected by a fluid flow communication line; and

further including a programmed operating means operatively connected with the said electrical motive power means serving all three pump means and said switch in the housing, said programmed operating means having a cycle of operations initiated by actuation of said switch in the housing and with programmed operating means thereby actuates the motive power means driving each pump means and the valve means operatively serving the pump means in desired sequence.

7. A combination and subcombination as claimed in claim 6 wherein the reservoir means connected to the third pump means is separate from the reservoir means connected to the first pump means; the electrical motive power means driving the third pump means is separate from that driving the first and second pump means; the fluid-conducting probe connected to the third pump means is separate from the probe serving the first and second pump means; and the multiple-position valve means serving the third pump means is separate from the multiple-position valve means serving the first and second pump means.

8. A combination as defined in claim 1 further including a subcombination comprising:

1. a third variable-volume displacement-chamber pump means adapted for fluid flow communication with a reservoir means;
2. a second fluid-conducting tubular probe in the said hand-manipulatable housing having one end projecting from the housing and with a fluid flow communication line connecting the other end of the probe with the third pump means;
3. a fourth variable-displacement-chamber pump means in fluid flow communication with said second probe in said housing for picking up into and discharging from the second probe an independently predetermined precise volume of fluid;
4. an electrical motive power means operatively connected to and for driving said third and fourth power means;
5. means including adjustable stop means interconnected with the said third and fourth pump means and the motive power means driving said third and fourth pump means providing for independently and selectively adjusting and effecting the precisely predetermined volumes of the displacement chambers of said third and fourth pump means;
6. a multiple-position valve means operatively connected with and driven by the motive power means driving the third and fourth pump means in synchronization with the

third and fourth pump means and controlling the lines of fluid flow communication to the third and fourth pump means to provide fluid flow communication in a sequence of positions between the third pump means and the reservoir means which it serves, between the third pump means and the second probe and between the fourth pump means and the second probe whereby in a desired sequence a precise predetermined amount of a fluid is drawn into the third pump means, a precise predetermined amount of another fluid is drawn into the second probe by the fourth pump means, and subsequently the two fluids are discharged through the second probe; and further including a programmed operating means operatively connected with the electrical motive power means serving the four pump means and a switch in the housing, said programmed operating means having a cycle of operations initiated by the actuation of the switch in the housing and which programmed operating means thereby actuates the motive power means driving each pump means and the valve means operatively serving the pump means in the desired sequence.

9. The combination and subcombination as claimed in claim 8 wherein the reservoir means connected to the third pump means is separate from the reservoir means connected to the first pump means; the electrical motive power means driving the third and fourth pump means is separate from that driving the first and second pump means; and the multiple-position valve means serving the third and fourth pump means is separate from the multiple-position valve means serving the first and second pump means.

10. The combination and subcombination as claimed in claim 9 wherein the first and second probes in the hand-manipulatable housing are moveable from a splayed-apart position to a closer adjacent position by means including a slidable member slidable along the probes to control the relative positions of the free ends of the probes.

11. An association as claimed in claim 6 wherein the programmed operating means is provided with switch-activated means for effecting at least one interruption in the cycle of its operation and the housing is provided with a corresponding number of electrical switches operatively connected with said programmed operating means so that subsequent switch actuation initiates a further operation of the programmed operating means.

12. An association as claimed in claim 8 wherein the programmed operating means is provided with switch-activated means for effecting at least one interruption in the cycle of its operation and the housing is provided with a corresponding number of electrical switches operatively connected with said programmed operating means so that subsequent switch actuation initiates a further operation of the programmed operating means.