May 27, 1969 J. C. HOBBS II, ET AL 3,446,400

PLURAL SOURCE FLUID DISPENSER WITH INTERCONNECTED DISCHARGE VOLUME VARYING MEANS

Filed Jan. 25, 1967

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FIG. 1

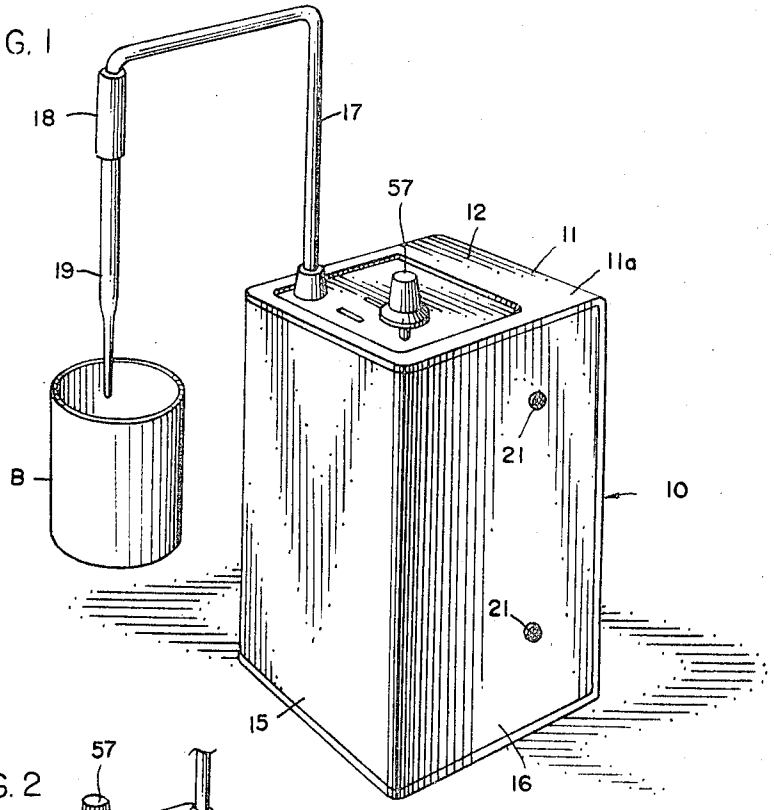
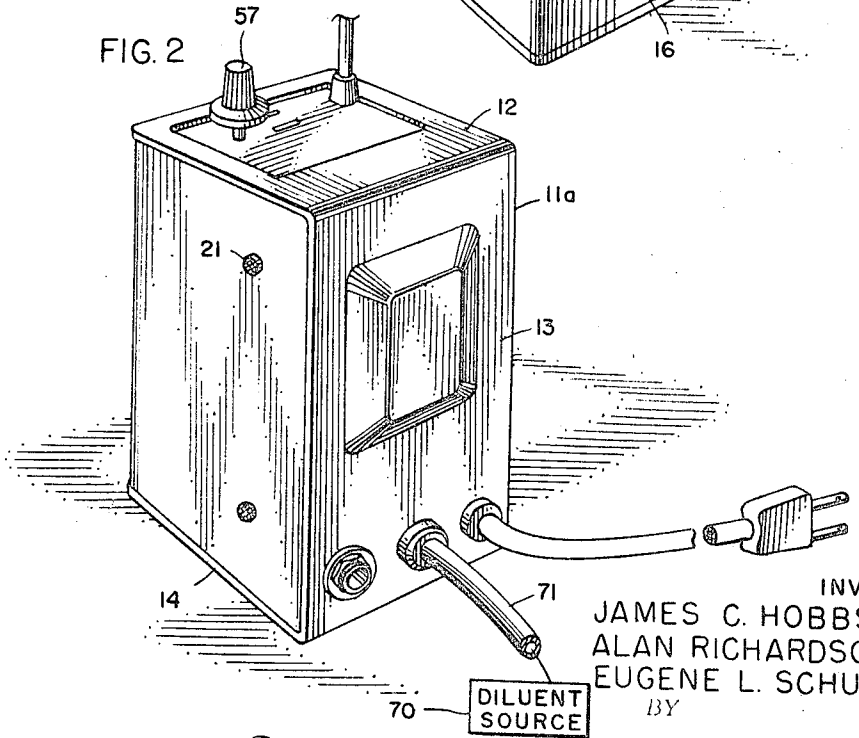


FIG. 2



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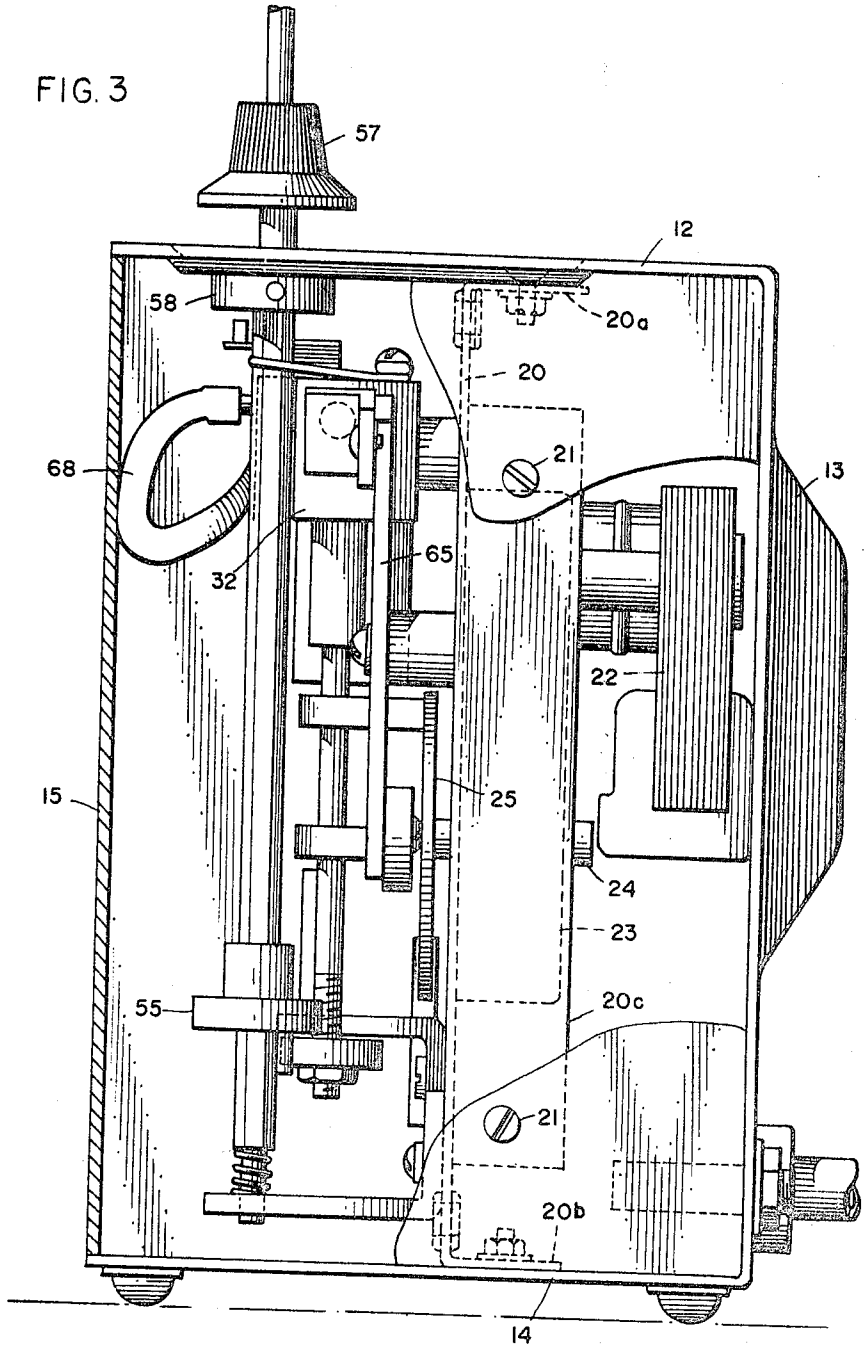
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FIG. 3



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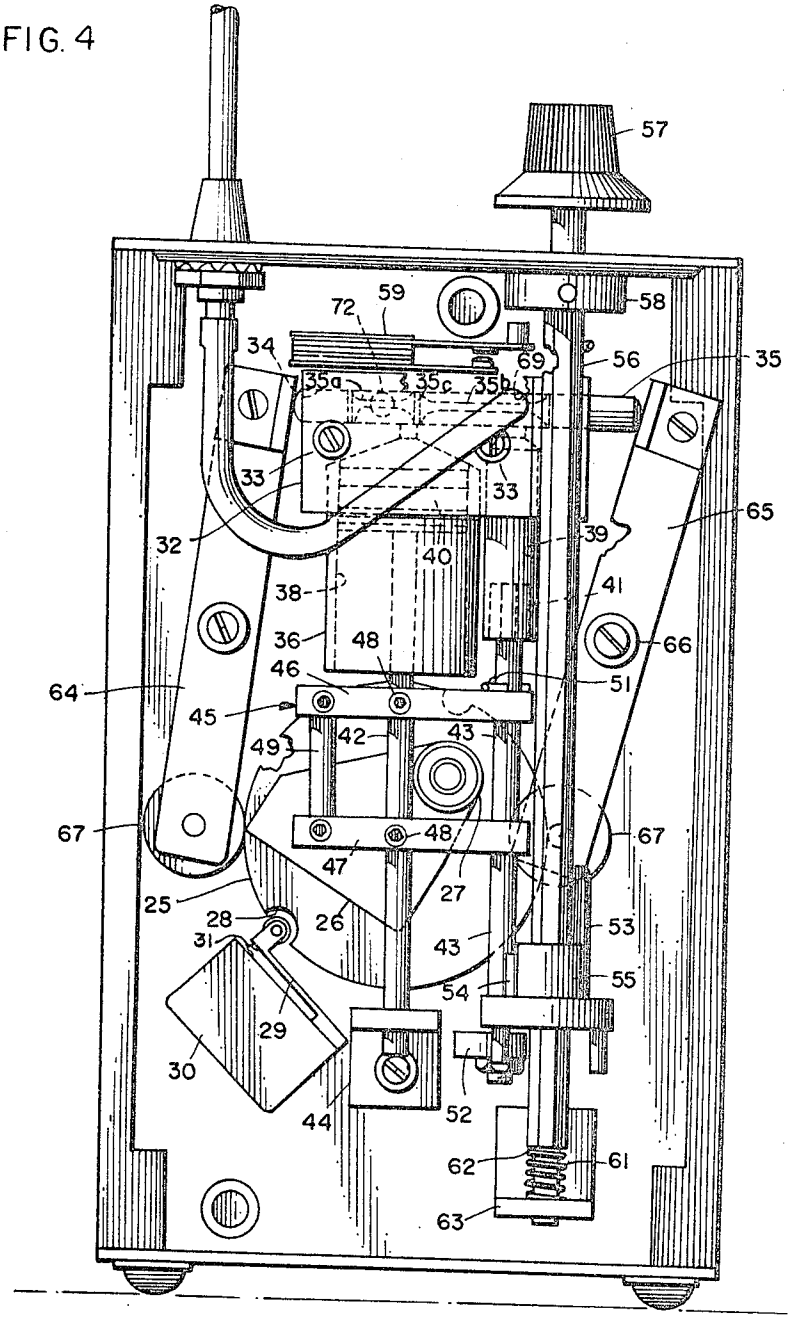
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FIG. 4



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PLURAL SOURCE FLUID DISPENSER WITH INTERCONNECTED DISCHARGE VOLUME VARYING MEANS

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FIG. 5

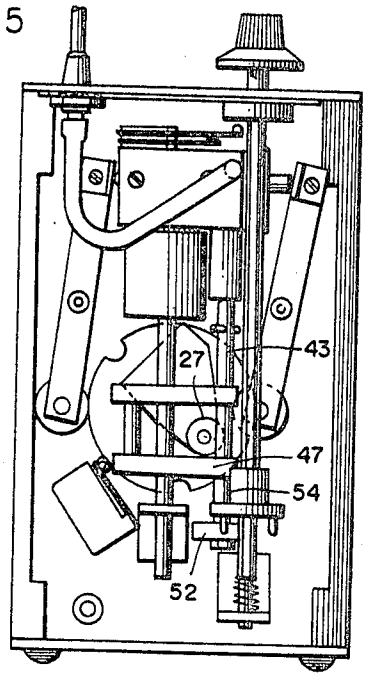


FIG. 6

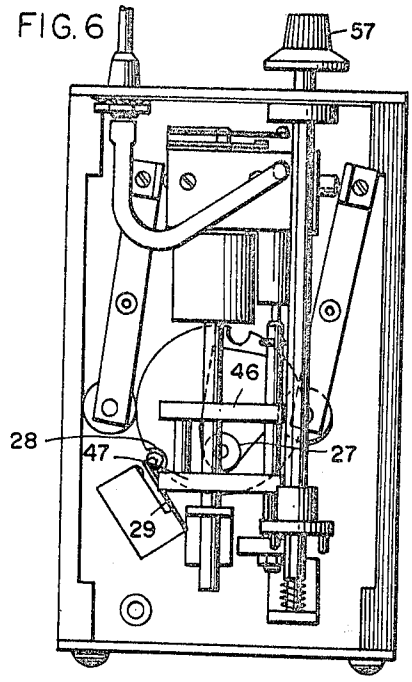


FIG. 7

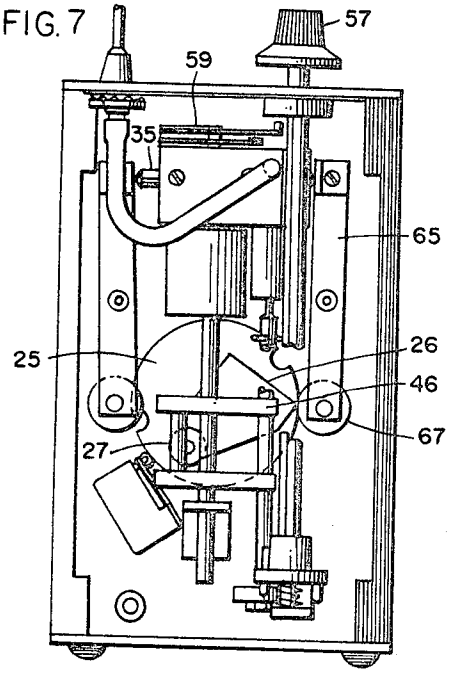
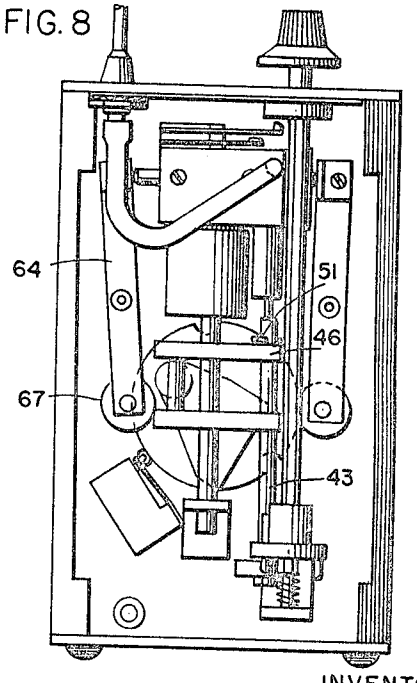


FIG. 8



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3,446,400

PLURAL SOURCE FLUID DISPENSER WITH INTERCONNECTED DISCHARGE VOLUME VARYING MEANS

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Int. Cl. B67d 5/60
U.S. Cl. 222—134 12 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for diluting a liquid sample with a suitable diluent. A motor-driven eccentric and yoke assembly are arranged to shift downwardly and upwardly the piston of a fixed-volume diluent chamber for drawing and discharging a measured amount of diluent. As the yoke assembly approaches its lower position, it engages and drives downwardly the piston assembly of a sample chamber communicating with an uncalibrated pipette, and as the yoke assembly is then moved upwardly, the sample and diluent are discharged through the pipette. A valve, driven by the same motor which operates the pistons, controls the flow of diluent and sample in positive synchronization with piston operation.

Background of the invention

It is a common practice in clinical laboratories to prepare dilutions of small specimens of body fluids so that analytical procedures may be carried out on the diluted samples. Ordinarily, the diluting operation is performed manually, using a standard calibrated pipette. Such a procedure is not only time consuming and tedious, but also presents an opportunity for error, especially where a high degree of skill has not been attained by the technician and where a high speed of operation is necessary or desirable.

Efforts have been made to develop devices for performing diluting operations mechanically but such devices tend to be cumbersome, complicated, and subject to frequent breakdown. Frequent adjustment of such devices is required in order to maintain a reasonable level of accuracy. In general, prior efforts have been unsuccessful in developing a diluter which may be operated to mix a sample with a precise amount of diluent by a relatively inexperienced laboratory technician.

Summary of the invention

The diluter of the present invention constitutes a simple and reliable device for automatically diluting samples with selected diluents in predetermined sample-diluent ratios. Specifically, the diluter is capable of discharging a precise fixed amount of any selected diluent along with a predetermined amount of a selected sample, thereby discharging the sample and diluent in a precisely controlled and predetermined ratio.

The diluter is of simple and reliable construction, having a motor-driven intake and delivery means which draws and discharges precisely-controlled amounts of diluent and sample despite the normal "run-on" or coasting of such a motor following de-energization thereof. In addition, the device is substantially jam-proof and error-proof in operation and, since it is self-rinsing, it is capable of successively diluting different samples without danger of cross-contamination.

Brief description of the drawing

FIGURE 1 is a perspective view illustrating a diluter of the present invention when viewed from the front thereof;

FIGURE 2 is a broken perspective view of the same diluter viewed from the rear thereof;

FIGURE 3 is a broken side elevational view illustrating the operative mechanism of the diluter;

FIGURE 4 is a front elevational view of the diluter with the outer cover thereof removed to illustrate the diluter's operating mechanism;

FIGURE 5 is a front elevtaional view similar to FIGURE 4 but in reduced scale and showing the diluter in a subsequent stage of its operation;

FIGURE 6 is a front elevational view similar to FIGURE 5 but showing the diluter in a later operational stage;

FIGURE 7 is a front elevational view similar to FIGURES 5 and 6 but illustrating the diluter in a later stage of operation;

FIGURE 8 is a front elevational view similar to FIGURES 5–7 but illustrating the diluter in a still later stage of operation.

Description of illustrated embodiment

In the embodiment of the invention illustrated in the drawings, the numeral **10** generally designates a diluter having a casing **11** composed of two interfitting casing sections **11***a* and **11***b*. As shown most clearly in FIGURES 2 and 3, casing section **11***a* is generally C-shaped and defines the top, rear, and bottom walls **12–14** of the casing. Section **11***b* is also of C-shaped configuration (when viewed in horizontal section) and defines integral front and side walls **15** and **16**, respectively. A rigid tube **17** extends upwardly from top wall **12** and then turns forwardly and downwardly, the tube's downwardly projecting end being coupled by connector sleeve **18** to a downwardly extending pipette **19**. Preferably the pipette **19** is formed of glass or other transparent material which can be easily rinsed and wiped free of traces of samples diluted or to be diluted by the device. As will be brought out more clearly hereafter, pipette **19** serves only as a delivery and intake conduit and need not be calibrated.

Casing section **11***a* also constitutes part of the main frame upon which the operating mechanism of the diluter is mounted. Another frame element takes the form of a vertical partition or mounting plate **20** (FIGURE 3) which has rearwardly turned portions **20***a* and **20***b* at its upper and lower ends secured to the upper and lower walls **12** and **14** of casing section **11***a*. The mounting plate also has rearwardly turned side portions **20***c* with threaded apertures for receiving screws **21** for interconnecting casing sections **11***a* and **11***b*.

An electric motor **22** is secured to the backside of mounting plate **20** and, in combination with gear reduction assembly **23**, drives horizontal shaft **24** at a relatively slow rate. FIGURE 3 reveals that shaft **24** extends forwardly through mounting plate **20** and has affixed to its forward end a rotatable drive member or disk **25**. The front face of the disk carries an irregularly-shaped cam member **26** which in turn supports an eccentric roller **27**. The periphery of the drive disk **25** is provided with circumferentially-spaced recesses **28** to receive the roller-equipped free end portion of arm **29** of microswitch **30**. As evident from FIGURE 4, when the arm **29** is in an outwardly extending unflexed state, contacts **31** are spaced apart and the microswitch is open. On the other hand, when disk **25** has rotated into a position wherein the roller-equipped free end portion of the switch arm is no longer received within a recess **28**, then switch **30** is closed.

Referring to FIGURES 3 and 4, it will be seen that a valve block **32** is secured by screws **33** to the front of

mounting plate **20** above drive disk **25**. The upper portion of the block has a horizontally and transversely extending bore **34** which slidably receives an elongated spool valve member **35**. The ends of the valve member project outwardly from the through bore of the valve block and are engaged by lever means for the shifting of the valve member between a first position illustrated in FIGURES 4–6 and a second position illustrated in FIGURES 7 and 8.

The valve block is also bored from the underside to receive open ended sleeves **36** and **37** which extend downwardly from the valve block in side-by-side parallel relation and which define diluent and sample chambers **38** and **39** respectively. Both of the chambers communicate at their upper ends with bore **34**. As indicated in the drawings, diluent chamber **38** is substantially larger in diameter than the sample chamber and slidably receives a piston or plunger **40** extending upwardly through the open lower end thereof. Sample chamber **39** similarly receives a plunger or piston **41**. The plunger of the sample chamber may slidably engage the inner wall surface of that chamber or, if desired, may be of substantially smaller diameter than the sample chamber with the lower end of the sample chamber being partially closed to provide an opening of a size sufficient only for slidably receiving the plunger. Both of the plungers **40** and **41** are provided with downwardly extending rods or shafts **42** and **43**, the lower end of the diluent plunger shaft being slidably received and guided by an apertured guide element **44** secured to mounting plate **20** below drive disk **25**.

Rotary movement of the drive member **25** is translated into reciprocatory movement of the plungers **40** and **41** by means of eccentric **27** and a cooperating yoke assembly **45**. The yoke assembly, illustrated most clearly in FIGURES 3 and 4, comprises a pair of vertically-spaced and horizontally-extending upper and lower yoke members or plates **46** and **47** rigidly secured to diluent plunger shaft **42**. In the illustration given, the plates are apertured to receive the shaft and are thereafter fixed securely to that shaft by set screws **48**. It is to be understood, however, that any other means for permanently fixing the plates to the shaft may be used. To insure a rigid interconnection between the parts and to precisely space plates **46** and **47**, a spacer element **49** may span the space between the plates and be permanently secured to such plates by any suitable means.

It will be noted that eccentric roller **27** projects forwardly into the space between yoke plates **46** and **47** and is engageable with one or the other of the plates as drive member **25** rotates. Of particular importance is the fact that the diameter of eccentric roller **27** is substantially less than the distance between the spaced yoke plates. In the embodiment illustrated, the distance between the plates is nearly twice the diameter of the roller; however, it is important only that the spacing be greater than the roller's diameter plus the distance measured vertically that the roller will continue to move from its extreme uppermost and lowermost positions because of the momentum or inertia of the driving mechanism after electric power to motor **22** has been interrupted.

The plates of the yoke assembly are apertured at **50** for slidably receiving the shaft **43** of sample displacement plunger **41**. The extent of the sliding movement between the parts is limited by an upper stop pin or element **51** secured to the upper end portion of shaft **43** and by a lower stop disk or element **52** secured to the shaft's lower end. It is believed apparent that where only a single volume of sample is to be deliverable by the diluter, stop **52** should be permanently located in a position where it will be engaged by the undersurface of yoke plate **47** as the yoke assembly approaches the lower limits of its range of movement. In the illustration given, the diluter is adapted to deliver either of two preselected volume samples depending upon whether a relatively large spacer element **53** or a relatively small spacer element **54** is interposed between stop **52** and yoke plate **47**. The spacer elements **53** and **54** are carried by a sleeve member **55** which is vertically bored to receive vertical hexagonal shaft **56**. The sleeve is readily slidable along the hexagonal shaft and normally rests upon the lower stop disk **52**, contact with the stop disk being made by one of the spacer elements which are part of the sleeve-spacer assembly.

The hexagonal shaft **56** projects upwardly through top wall **12** of the diluter casing and is provided at its upper end with a control knob **57** for rotating the shaft and sleeve-spacer assembly into either a first position wherein the smaller spacer **54** is disposed between stop **52** and yoke plate **47**, or into a second position wherein the larger spacer **53** is disposed between the stop and lower yoke plate.

Besides being rotatable into either the first and second positions of adjustment, shaft **56** and knob **57** are movable vertically between the normally raised position illustrated in FIGURE 4 and a lowered position wherein a disk **58** secured to the shaft engages the arm of override switch **59** to close the contacts **60** of that switch. Disk **58** also serves to limit the extent of upward movement of the shaft and knob, by engagement with the undersurface of top wall **12**, in response to the upward force exerted by compression spring **61**. The compression spring is interposed between a shoulder **62** near the lower end of the shaft and the upper surface of a bracket arm **63** secured to mounting plate **20**.

Referring again to the diluter's valve assembly, spool valve member **35** is shifted between its first and second positions by levers **64** and **65** disposed on opposite sides of valve block **32**. The levers have their upper ends in engagement with opposite ends of the spool valve member and are pivotally supported intermediate their ends by mounting screws **66** attached to vertical mounting plate **20**. At their lower ends, the levers are provided with rollers **67** engageable by the outer limits of cam **26** as drive member **25** rotates.

Referring to FIGURE 4, it will be seen that the levers **64** and **65** are roughly parallel and are coordinated in their operation to shift valve member **35** in either one direction or the other. Specifically, when the roller **67** of one lever is engaged by cam **26** and urged thereby into its outermost position, the roller of the other lever is pivoted by valve member **35** into an inwardly disposed position in the path of the cam member when the cam has rotated approximately 180 degrees. Thus, as viewed in FIGURE 4, the valve member is urged to the right into its first position upon contact between the cam member and roller **67**, and the valve will remain in that position until the cam has rotated approximately 180 degrees and engages the roller of the right-hand lever to shift the valve member to the left into its second position of adjustment.

The spool valve **35** has a pair of reduced spool portions **35***a* and **35***b* separated by an intermediate enlargement **35***c*. When the valve is in the first position illustrated in FIGURES 4–6, pipette **19** and tube **17** directly communicate with sample chamber **39** through connecting tube **68** and port **69**. At the same time, diluent chamber **38** is in communication with a suitable diluent source **70** (illustrated diagrammatically in FIGURE 2) by means of tube **71** and valve port **72** (FIGURE 4).

When the spool valve is in its second position, both the diluent chamber and the sample chamber communicate with the space of bore **34** defined by constriction **35***b* of the valve member, and port **72** is blocked from communicating with the sample and diluent chambers by valve enlargement **35***c*.

Operation

FIGURE 4 illustrates the diluter in a condition ready for operation, it being assumed that tube **71** is in communication with a source of water or other suitable diluent and that all of the passages of tubes **71**, **68**, **17**, **18**, and **19**, and the chambers of cylinders **38** and **39** are filled

with diluent as a result of prior operation of the device.

The electrical circuit for motor **22** is open because, as shown in FIGURE 4, the rider of switch arm **29** is received within the peripheral recess **28** of the drive member **25**, thereby allowing separation of contacts **31**. Prior to commencement of operation of the device, the operator rotates control knob **57** into either of its two positions to select the particular volume of sample to be diluted by a fixed volume of diluent. Thereafter, a suitable beaker B (FIGURE 1) containing the liquid sample to be diluted is raised until the tip of the pipette is immersed in the sample. Knob **57** is then depressed to close the contacts of override switch **59**. Motor **22** commences operation rotating drive member **25** in a clockwise direction, as viewed in FIGURE 4, to bring eccentric **27** into contact with the upper surface of yoke plate **47**. Continued rotation of the drive member and eccentric causes downward movement of the yoke assembly which in turn causes retraction or lowering of diluent plunger **40**. Diluent is thereby drawn into the diluent chamber through tube **71** and port **72**.

During the initial downward travel of the yoke assembly, sample plunger **43** remains stationary because the shaft of that plunger is freely slidable through the aligned openings of the yoke plates. However, at an intermediate point in the yoke assembly's downward path of travel, the undersurface of lower yoke plate **47** engages one of the spacer elements **53**, **54** which in turn rests upon the upper surface of stop **52**. Continued downward movement of the yoke assembly thereby causes stop **52**, shaft **43**, and sample displacement piston **41**, into a lowered position. Since the sample chamber is in communication with beaker B through the valveblock and through tubes **68**, **17**, **18**, and **19**, a small preselected amount of sample is drawn into the pipette as the sample displacement plunger completes its descent. At no time does the sample displacement piston descend far enough to draw sample into the valve assembly. Preferably, the parts are proportioned so that the increase in volume of the sample chamber **39** as the plunger descends does not exceed the volume of pipette **19**.

FIGURE 5 illustrates the unit just as the undersurface of yoke plate **47** engages spacer **54** and the shaft **43** of the sample displacement plunger commences its downward movement. FIGURE 6 illustrates the relationship of the parts as eccentric **27** has swung just slightly past its lowermost point and, as a result, both the diluent plunger and the sample displacement plunger have been shifted into their lowermost positions. Switch **30** is automatically opened to de-energize the motor because the rider of switch arm **29** has been received in a second peripheral recess **28** of drive member **25**. While the motor tends to run on slightly after de-energization, such run-on in no way effects the positions of the sample and diluent plungers because, as previously described, the space between upper and lower yoke plates **46** and **47** is substantially greater than the diameter of the eccentric roller. Therefore, the slight run-on of the motor simply lifts the eccentric roller slightly above the surface of lower yoke plate **47** without moving it upwardly a sufficient distance to bring it into contact with the undersurface of upper yoke plate **46**.

Since operation of the device has now automatically stopped, the operator withdraws the beaker from the pipette tip and preferably wipes the pipette tip to remove any liquid clinging to the outer surface and the lower end thereof. Thereafter, a receptacle (not shown) suitable for receiving the diluted sample is placed beneath the pipette and knob **57** is again depressed to close the contacts of the manually operated override switch **59**. Motor **22** again rotates drive member **25** and eccentric **27** in a clockwise direction. Well before the upper surface of the eccentric roller reaches the undersurface of upper yoke plate **46**, cam **26** swings into contact with the roller **67** of lever **65** to shift the valve member **35** into the second position illustrated in FIGURE 7. Only after the valve is fully shifted does the eccentric engage the upper yoke plate and cause the yoke assembly and the diluent plunger to commence their upward strokes. It is to be noted that the sample displacement plunger remains stationary until the yoke has nearly reached its uppermost position, at which time the upper surface of the upper plate **46** engages stop **51** on shaft **43** to drive that shaft and the sample displacement plunger upwardly.

During upward movement of the yoke assembly, the sample previously drawn into the pipette tip **19** is discharged therefrom followed by a volume of diluent equal to the displacement volume of the diluent plunger. The discharge of diluent ceases when eccentric **27** reaches its uppermost point, at which time upward movement of the yoke assembly and the diluent and sample pistons stops. The drive member **25** nevertheless continues to rotate momentarily until after cam **26** has engaged the roller **67** of lever arm **64** and has thereby driven valve member **35** back into the first position illustrated in FIGURE 4. Only after the valve member has been returned to such a position does a recess **28** of the drive member **25** reach the rider of switch **30** and permit automatic interruption of the motor's operation. The diluter has thus performed a full cycle of operation and again assumes the operative condition illustrated in FIGURE 4.

It is believed from the foregoing that the structure of the present invention constitutes a highly effective automatic diluting device which is simple and substantially foolproof in operation. Since sample is drawn into the pipette or probe at the end of the intake stroke and is discharged at the commencement of the delivery stroke, the pipette is thoroughly rinsed with diluent following the delivery of a sample and the danger of such a sample contaminating the next dilution is thereby avoided.

While in the foregoing, we have disclosed an embodiment of the invention in considerable detail for purposes of illustration, it will be understood by those skilled in the art that many of these details may be varied without departing from the spirit and scope of the invention.

We claim:

1. In an automatic diluting device for diluting a sample with a fixed volume of diluent, a diluent chamber having a reciprocable plunger therein, said plunger having a shaft extending from said chamber, a yoke assembly comprising a pair of yoke plates secured to said shaft and extending transversely with respect thereto, a valve assembly having a valve chamber communicating with said diluent chamber, diluent intake passage means and fluid discharge passage means communicating with said valve assembly, said valve assembly including a valve member shiftable between a first position wherein said valve chamber communicates with said diluent intake passage means and a second position wherein said valve chamber communicates with said fluid discharge passage means, a power driven rotatable drive member having an eccentric element disposed between said yoke plates for reciprocating said plunger as said drive member rotates, said yoke plates being spaced apart a distance substantially greater than the diameter of said eccentric element, and means for shifting said valve member between said first and second positions only when said eccentric is in an intermediate position spaced from both of said cam plates.

2. The structure of claim **1** in which said last-mentioned means includes a cam member mounted upon said drive means, and lever means operatively associated with said cam member for shifting said valve member between said first and second positions.

3. The structure of claim **1** in which said device includes a sample displacement chamber having a reciprocable plunger therein, said plunger having a shaft extending from said chamber and being slidably received in openings in said cam plates, and stop means provided by the shaft of said sample plunger for engaging said yoke

assembly and for urging said sample shaft and plunger upwardly and downwardly limited distances as said yoke assembly approaches the upper and lower limits of its range of movement.

4. The structure of claim 3 in which one of said stop means provided by the shaft of said sample plunger is adjustable.

5. The structure of claim 1 in which an electric motor is operatively associated with said drive member for rotating the same, and switch means are provided for de-energizing said motor when said eccentric element is near its uppermost and lowermost positions.

6. The structure of claim 5 in which said motor, drive member, eccentric, yoke assembly, and switch means are operatively associated to de-energize said motor at points near the uppermost and lowermost positions of said eccentric so that the coasting of said motor will carry said eccentric into positions intermediate said yoke plates following motor de-energization.

7. In a diluting device for diluting a sample with a fixed volume of diluent, a sample chamber and a diluent chamber having reciprocable sample and diluent plungers therein, said plungers having parallel operating shafts extending therefrom, a yoke assembly comprising a pair of transversely extending plates, said assembly being fixed to one of said shafts and slidably receiving the other of said shafts, means for reciprocating said yoke and said one shaft fixed thereto, and stop means provided by the other of said shafts engageable with said yoke assembly for urging said other shaft axially as said yoke approaches the limits of range of reciprocation, said means for reciprocating said yoke and said one shaft comprising an electric motor, a rotatable drive member operatively connected to said motor for rotation thereby, and an eccentric element mounted upon said drive member and disposed between the plates of said yoke assembly for reciprocating said yoke assembly when said drive member is rotated.

8. The structure of claim 7 in which said one shaft is fixed to said diluent plunger and said other shaft is fixed to said sample plunger.

9. The structure of claim 7 in which said stop means

is adjustable to vary the extent of upward and downward movement of said other shaft.

10. The structure of claim 7 in which said eccentric has its maximum dimension measured normal to said plates substantially less than the distance between said plates.

11. The structure of claim 7 in which said eccentric element comprises a roller having a diameter substantially less than the distance between said plates of said yoke assembly.

12. In a diluting device for diluting a sample with a fixed volume of diluent, a sample chamber and a diluent chamber having reciprocable sample and diluent plungers therein, said plungers having parallel operating shafts extending therefrom, a yoke assembly comprising a pair of transversely extending plates, said assembly being fixed to one of said shafts and slidably receiving the others of said shafts, means for reciprocating said yoke and said one shaft fixed thereto, and stop means provided by the other of said shafts engageable with said yoke assembly for urging the other shaft axially as said yoke approaches the limits of its range of reciprocation, said stop means being adjustable to vary the extent of upward and downward movement of said other shaft and including a pair of stop elements secured to said other shaft aidjacent the upper and lower ends thereof, and a plurality of spacers of different size adapted to be interposed between said yoke assembly and one of said stop elements for varying the extent of movement of said second shaft.

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U.S. Cl. X.R.

222—145