Dec. 16, 1969 A. R. JONES ET AL 3,484,024

DILUTER WITH DROP RETRACTOR

Filed Sept. 6, 1968 3 Sheets-Sheet 1

FIG. 1

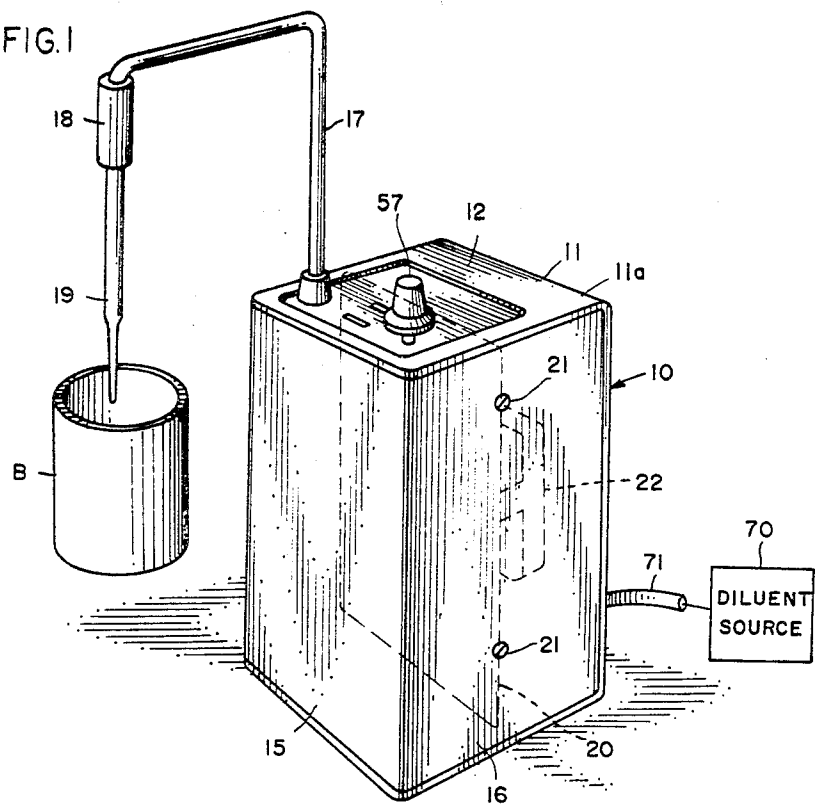


FIG. 7

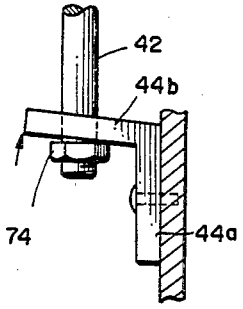


FIG. 8

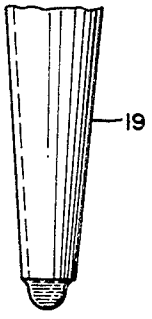
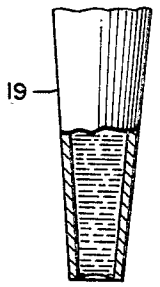


FIG. 9



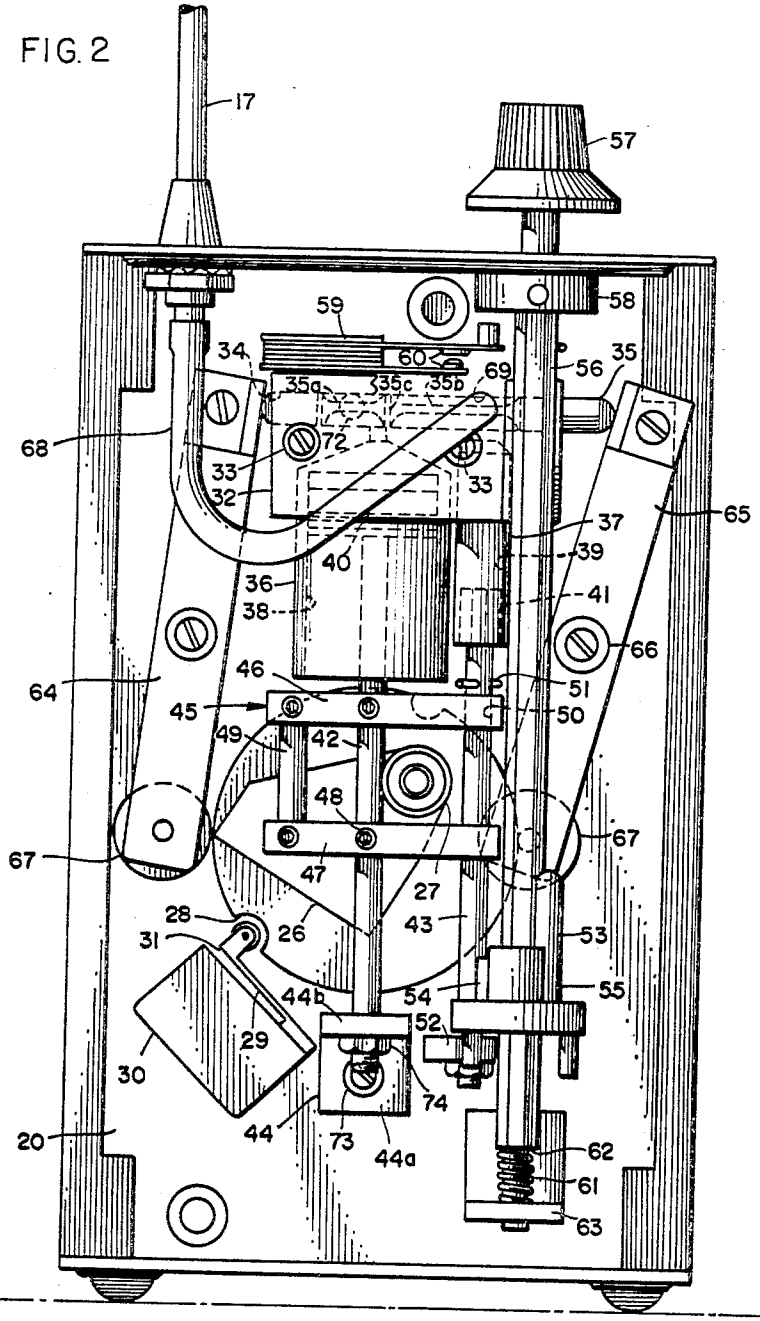
INVENTORS:
ALAN RICHARDSON JONES
EUGENE L. SCHULTZ
BY: Dawson, Tilton, Fallon & Lungmus
ATT'YS

Dec. 16, 1969 A. R. JONES ET AL 3,484,024

DILUTER WITH DROP RETRACTOR

Filed Sept. 6, 1968 3 Sheets-Sheet 2

FIG. 2



INVENTORS:
ALAN RICHARDSON JONES
EUGENE L. SCHULTZ

BY: Dawson, Tilton, Fallon & Lungren
ATT'YS

Dec. 16, 1969 A. R. JONES ET AL 3,484,024

DILUTER WITH DROP RETRACTOR

Filed Sept. 6, 1968 3 Sheets-Sheet 3

FIG. 3

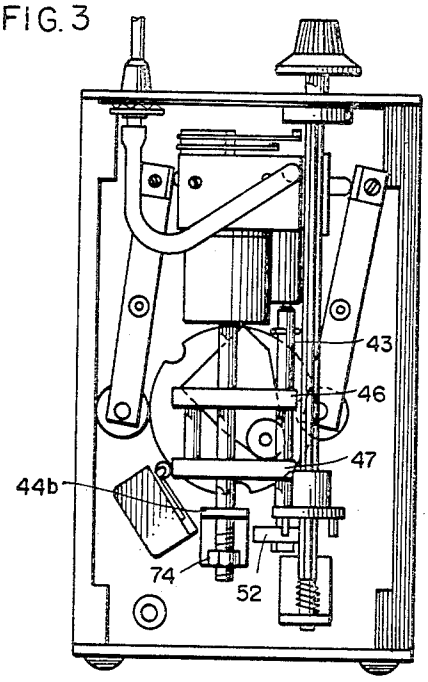


FIG. 4

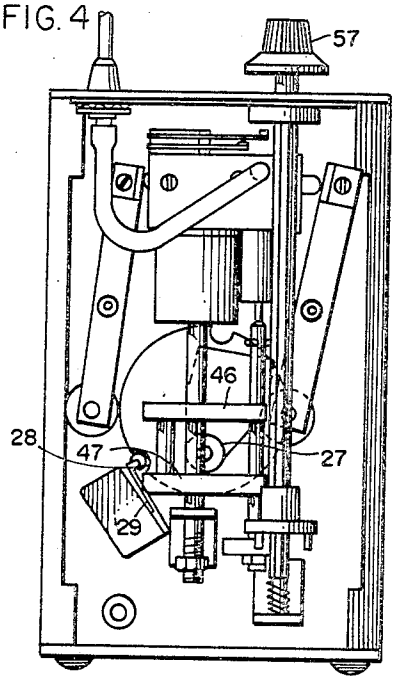


FIG. 5

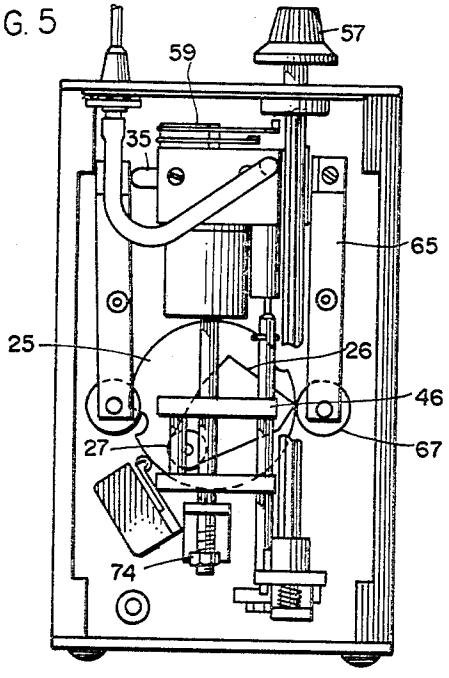
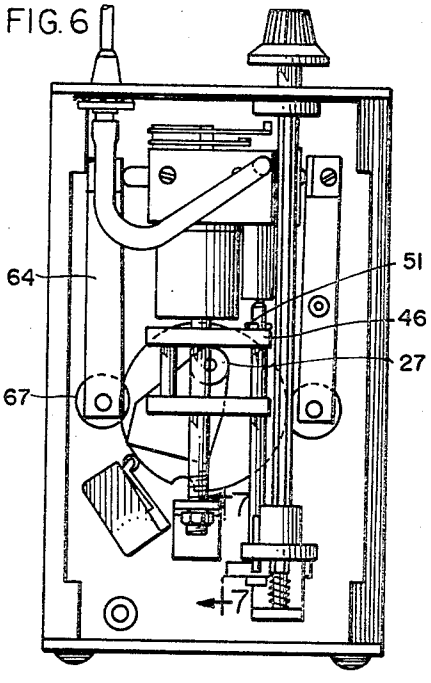


FIG. 6



INVENTORS:
ALAN RICHARDSON JONES
EUGENE L. SCHULTZ

BY: Dawson, Dilton, Ballou & Lungenus
ATT'YS

United States Patent Office 3,484,024 Patented Dec. 16, 1969

3,484,024

DILUTER WITH DROP RETRACTOR

Alan Richardson Jones, Miami, and Eugene L. Schultz, Hollywood, Fla., assignors, by mesne assignments, to American Hospital Supply Corporation, Evanston, Ill., a corporation of Illinois

Continuation-in-part of application Ser. No. 611,685, Jan. 25, 1967. This application Sept. 6, 1968, Ser. No. 758,006

Int. Cl. G01f *11/00;* B65d *25/52;* B67d *3/00*

U.S. Cl. 222—409 5 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. Immediately following such discharge, the diluent piston retracts slightly to retract into the pipette any liquid droplet that might otherwise cling to the outside of the pipette tip.

RELATED APPLICATION

This application is a continuation-in-part of co-pending application Ser. No. 611,685, filed Jan. 25, 1967, now Patent No. 3,446,400 of May 27, 1969.

BACKGROUND

The aforementioned co-pending application discloses 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 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.

Such 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, error-proof, and self-rinsing in operation.

While the self-rinsing feature greatly reduces any problems of cross-contamination in the diluting of successive samples, it is nevertheless important that the tip of the pipette be wiped following each discharge of sample and diluent therefrom. Otherwise a droplet of fluid will remain clinging to the tip of the pipette following such discharge. Since the tip of the pipette is immersed in sample fluid as the first step of a subsequent operation, it is apparent that the presence of a droplet at the end of the tip would dilute a subsequent sample in which the pipette tip is immersed and would thereby affect the accuracy of the measurement. Furthermore, if trace amounts of prior samples remain on the outer surface of the pipette tip and are dissolved or diluted by a droplet of diluent which remains clinging to the tip, then such droplet will tend to contaminate a subsequent specimen as the pipette tip is immersed therein. For these reasons, proper laboratory technique involves the manual wiping of the pipette tip following the delivery of each diluted sample to remove the depending droplet and thereby avoid errors

in measurement and possibilities of cross-contamination of samples.

SUMMARY

While the wiping of a pipette tip following the discharge of fluids therefrom is a conventional laboratory procedure, such a procedure is nevertheless time consuming and, at least in many cases, inconvenient. Such problems are particularly evident should the diluter of the aforementioned co-pending application be used as a component in automatic analysis equipment. In automated analysis, it cannot be assumed that a human operator would be present to wipe the pipette or that, if present, such an operator would have sufficient time and access to the pipette in order to perform the wiping operation in an adequate and consistent manner.

This invention is therefore concerned with an improvement over the structure of the aforementioned co-pending application which eliminates the need for wiping the pipette tip following the delivery of diluted samples therefrom. Such a result is achieved by providing means for retracting into the tip of the pipette the droplet which would otherwise hang downwardly from the tip following the discharge of fluids therefrom.

The droplet retraction means reverses the direction of the diluent piston a slight but precisely-controlled distance immediately following the discharge of sample and diluent from the pipette so that the droplet which would otherwise hang from the pipette tip is drawn back into the bore of the pipette. Such means includes a flexible guide member for the piston shaft, the spring-like member cooperating with an adjustable stop element on the shaft to reverse the direction of shaft movement a slight but measurable extent after the piston has reached the limit of its discharge stroke and the force causing the piston to execute such stroke has been relieved. At the end of the discharge stroke the stop element and the flexible member are brought into forcible engagement causing the latter to flex slightly in the direction of piston movement. Thereafter, when the piston driving force is relieved, the tension of the flexible member causes that member to return to its original position, which in turn causes the piston to retract slightly.

Adjustment of the stop element along the piston shaft permits percise control over the extent of flexure of the flexible member and, hence, gives accurate control over the extent of retraction of the droplet. By such adjustment, it has been found possible to retract the droplet only to the extent necessary to bring its undersurface flush with the tip of the pipette. Consequently, the liquid cutoff following delivery of fluid is adjustable to a point at the precise level, or at almost the precise level, of the pipette tip. The result is that no appreciable amount of air is drawn into the pipette during the subsequent intake of sample fluid.

THE DRAWINGS

FIGURE 1 is a perspective view illustrating a diluter when viewed from the front thereof, such view being partially schematic to illustrate a conventional source of diluent for such diluter;

FIGURE 2 is a front elevational view of the diluter with the outer cover thereof removed to illustrate the diluter's operating mechanism;

FIGURE 3 is a front elevational view similar to FIGURE 4 but in reduced scale and showing the diluter in a subsequent stage of operation;

FIGURE 4 is a front elevational view similar to FIGURE 5 but showing the diluter in a later operational stage;

FIGURE 5 is a front elevational view similar to FIG-

URES 3 and 4 but illustrating the diluter in a later stage of operation;

FIGURE 6 is a front elevational view similar to FIGURES 3–5 but illustrating the diluter in a still later stage of operation immediately prior to droplet retraction;

FIGURE 7 is a sectional view taken along line 7—7 of FIGURE 6;

FIGURE 8 is an enlarged view of the pipette tip and illustrating the condition of droplet formation when the diluter is in the operative stage illustrated in FIGURES 6 and 7;

FIGURE 9 is an enlarged sectional view of the pipette tip showing the location of fluid therein when the diluter is in the operative stage illustrated in FIGURE 2.

DESCRIPTION

In the embodiment 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 1 and 2, 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 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 connecting means **18** to a downwardly extending pipette **19**. As will be brought out more clearly hereafter, pipette **19** serves only as a delivery and intake conduit and need not be calibrated.

In the illustration given, the connecting means **18** simply constitutes a sleeve which communicates with tube **17** and pipette **19** and which maintains the parts in assembled relation. It is to be understood, however, that as long as a flow passage is defined by the connecting means and such flow passage communicates only with the tube **17** and pipette **19**, the connector may assume any suitable configuration and length. Thus, the pipette **19** may be part of an automatic analyzer, as indicated in co-pending application Ser. No. 854,968, filed Sept. 3, 1969, and the connector **18** may be of substantial length, extending from the pipette of such analyzer to the diluter apparatus which may, if desired, be spaced substantially from the analyzer.

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** secured in place by the same screws **21** which interconnect casing sections **11***a* and **11***b*.

An electric motor **22** is secured to the backside of mounting plate **20** and drives at a relatively slow rate a drive member or disk **25** disposed in front of the plate. 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 2, 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 the switch **30** is closed.

Referring to FIGURE 2, 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 2–4 and a second position illustrated in FIGURES 5 and 6.

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 **42** being slidably received and guided by an apertured member **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 FIGURE 2, 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 (a) 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, and (b) the distance that the diluent plunger and shaft will retract during the drop-retraction step hereinafter described.

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 2 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.

While specific means are shown and described for actuating override switch 59, it is to be understood that any suitable means may be provided for that purpose. Furthermore, the override switch may be part of automatic analysis equipment with which the diluter is used, such switch being operated in synchronization with the operation of the automated analyzer. In that event, the function of knob 57 and disk 58 in the operation of the override switch may of course be eliminated.

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 2, it will be seen that the levers 64 and 65 are roughly parallel and are coordinated in their operation to shaft 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 2, 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 2–4, 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 1) by means of tube 71 and valve port 72 (FIGURE 2).

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*.

Referring now to FIGURES 2 and 7, it will be observed that member 44 is of inverted L-shaped configuration, having a vertical portion or leg 44*a* secured by screw 73 or by any other suitable connecting means to mounting plate 20. The apertured horizontal leg or portion 44*b* slidably receives the piston shaft 42 of the diluent plunger, the shaft extending downwardly through the leg and having at its lower end a threaded adjustment nut or element 74. Member 44, particularly horizontal leg portion 44*b*, is formed of flexible spring-like material, so that leg portion 44*b* is capable of limited movement (in the direction of travel of shaft 42) between the normal or untensioned state illustrated in FIGURE 2 (and in broken lines in FIGURE 7) and the flexed or tensioned state illustrated in solid lines in FIGURES 6 and 7. The recovery force exerted by the member in its flexed condition is greater than the resistance to movement of piston 40 in cylinder 38 but is less than the motor-driven cam 26 when the roller of that cam engages the upper yoke member or plate 46 to shift the diluent plunger into its fully raised position. Preferably member 44 is formed of slightly flexible steel or other suitable metal; however, any material having the necessary requirements of flexibility and strength may be used. Furthermore, it will be understood that the spring action exerted by portion 44*b* might be achieved if the member were rigid and were pivotally mounted to mounting plate 20, the spring action of such a member being provided by a conventional spring element urging such member into its normal lowered position. Since the range of movement required of arm portion 44*b* is relatively slight (such range of movement being exaggerated considerably in FIGURES 6 and 7 for illustrative purposes), it has been found that sufficient spring action is achieved by forming member 44 of steel or other suitable metal and by rigidly mounting that member upon mounting plate 20.

When the diluter is in operative condition with its parts adjusted to achieve droplet retraction, the distance between the top surface of adjustment element or nut 74 and the undersurface of upper yoke plate 46 is slightly less than the distance between the undersurface of portion 44*b* in an untensioned state and the undersurface of the upper yoke plate in its fully raised position. Consequently, when cam 26 drives the diluent plunger into its fully raised position, the piston 40 therefore being at top dead center, adjustment nut or member 74 will be in forceable engagement with the undersurface of portion 44*b* of member 44 and will have flexed that portion a slight but definite extent upwardly as shown in exaggerated form in FIGURES 6 and 7. As soon as the roller 27 of the cam clears the undersurface of yoke plate 46 and begins to travel downwardly (by coasting action, since the motor is then de-energized) the upward force exerted by the cam roller upon the yoke assembly is released and portion 44*b* of member 44 flexes back into the normal untensioned condition illustrated in FIGURE 2. As it does so, arm 44*b* bears against adjustment member 74 to pull the diluent plunger shaft downwardly a slight extent, thereby tending to create a slight negative pressure in the diluent chamber 38. Since the downward flexure of the arm 44*b* occurs immediately before cam 26 engages roller 67 to shift lever 64 in a clockwise direction, the diluent chamber still remains in communication with the pipette and, therefore, a retraction of a droplet protruding from the pipette tip occurs.

OPERATION

FIGURE 2 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 2, the rider of switch arm 29 is received within the peripheral recess 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 container B (FIGURE 1) containing the liquid sample to be diluted is raised until the tip of the pipette is immersed in the sample. The contacts of the override switch **59** are then closed (by depression of knob **57** in the form illustrated) and motor **22** commences operation to rotate drive member **25** in a clockwise direction, as viewed in FIGURE 2, to bring eccentric **27** into contact with the upper surface of lower 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 the 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 lowered positions. Since the sample chamber is in communication with the contents of container B through the valve block 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 3 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 4 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 affects the positions of the sample and diluent plungers because, as previously described, the space between the 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 the lower yoke plate **47** without moving it upwardly a sufficient distance to bring it into contact with the undersurface of upper yoke plate **46**.

During the interval that the device's operation has been automatically stopped, container B is manually or automatically withdrawn from the pipette tip and a second receptacle or container (not shown) suitable for receiving a diluted sample is placed beneath the pipette. The override switch is again closed to rotate 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 5. 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 the extreme upward limit of movement of the yoke assembly and the diluent and sample pistons is achieved. As such upward limit of movement is approached, adjustment member **74** contacts the undersurface of flexible arm **44***b* to flex that arm upwardly as shown in exaggerated form in FIGURES 6 and 7. When the eccentric has reached its uppermost or top dead center position, that is, when the parts assume the positions indicated in FIGURES 6 and 7, discharge of liquid from the pipette ceases and a droplet is momentarily formed at the pipette tip, as illustrated in FIGURE 8. Thereafter, as the eccentric passes its top dead center position, the downward force exerted by tensioned arm **44***b* shifts the diluent plunger downwardly until the tension of that arm is relieved, and such downward movement of the diluent plunger draws liquid back into the pipette to retract the droplet as indicated in FIGURE 8. Continued rotation of the drive member causes cam **26** to engage roller **67** of lever arm **64** and drive valve member **35** back into the first position illustrated in FIGURE 2. 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** to 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 2.

Droplet retraction therefore occurs immediately after the discharge of fluid from the pipette and an instant before the valve member is shifted to interrupt communication between the diluent chamber and the pipette. By careful adjustment of threaded adjustment member **74**, the extent of flexure of arm **44***b* may be precisely controlled so that when such arm flexes downwardly into an untensioned state the diluent piston is shifted just enough to retract liquid to the point where the liquid-air interface at the end of the pipette is almost precisely flush with the bottom surface of the pipette tip (FIGURE 8). Since no droplet hangs from the end of the pipette, wiping of the pipette tip to avoid problems of sample cross-contamination and to prevent dilution of a subsequent sample by such a droplet is eliminated.

It is believed from the foregoing that the elimination of the wiping step as a requirement of diluter operation renders the diluter of the present invention particularly suitable for use in conjunction with automated chemical analysis equipment.

While in the foregoing an embodiment of the invention has been disclosed 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.

What we claim is:

1. An automatic diluting device for diluting a sample with a fixed volume of diluent, said device including a diluent chamber having a reciprocable plunger therein, said plunger having a shaft extending from said chamber, 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 discharge passage means terminating in a depending pipette tip, 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 discharge passage means, means for reciprocating said plunger and for interrupting movement of the same for selected intervals following execution of each of the plunger's discharge and intake strokes, and means synchronized with the reciprocation of said plunger for positioning said valve member in said first position when said plunger exe-

cutes an intake stroke and in said second position when said plunger executes a discharge stroke, wherein the improvement comprises

a stop member mounted upon said plunger shaft, and a fixed abutment member mounted upon said device in the path of movement of said stop member, said stop member and said abutment member being engageable immediately prior to the completion of the discharge stroke of said plunger, at least one of said members being flexible and yielding slightly as said plunger completes its discharge stroke, said one of said members returning to an untensioned and unflexed condition immediately following completion of said discharge stroke to reverse the direction of movement of said plunger to a slight extent for retracting into said pipette a droplet formed at said tip following completion of said discharge stroke.

2. The structure of claim 1 in which said abutment member comprises the flexible one of said members.

3. The structure of claim 2 in which said stop member is threadedly and adjustably mounted upon said plunger shaft.

4. The structure of claim 2 in which said abutment member includes a flexible portion which in an untensioned state extends normal to the axis of said plunger shaft.

5. The structure of claim 4 in which said flexible portion of said abutment member is apertured for slidably receiving and guiding said plunger shaft.

References Cited

UNITED STATES PATENTS

2,619,116	11/1952	Ralston	222—571 X
2,721,008	10/1955	Morgan	222—571 X

FOREIGN PATENTS

574,925	1/1945	Great Britain.

ROBERT B. REEVES, Primary Examiner

H. S. LANE, Assistant Examiner

U.S. Cl. X.R.

141—117; 222—571