Sept. 17, 1968 T. CHRISTIE 3,401,839

LIQUID SAMPLING AND DISPENSING DEVICE

Filed May 29, 1967 3 Sheets-Sheet 1

FIG. 1

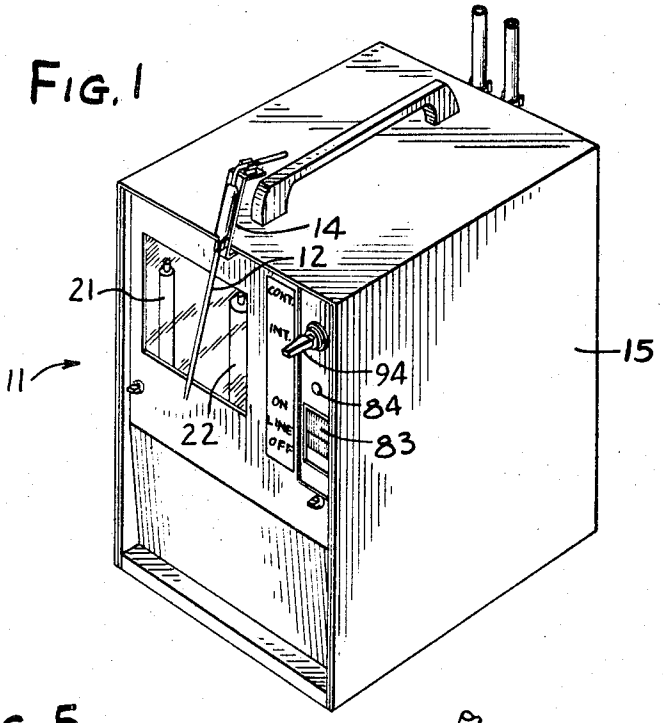
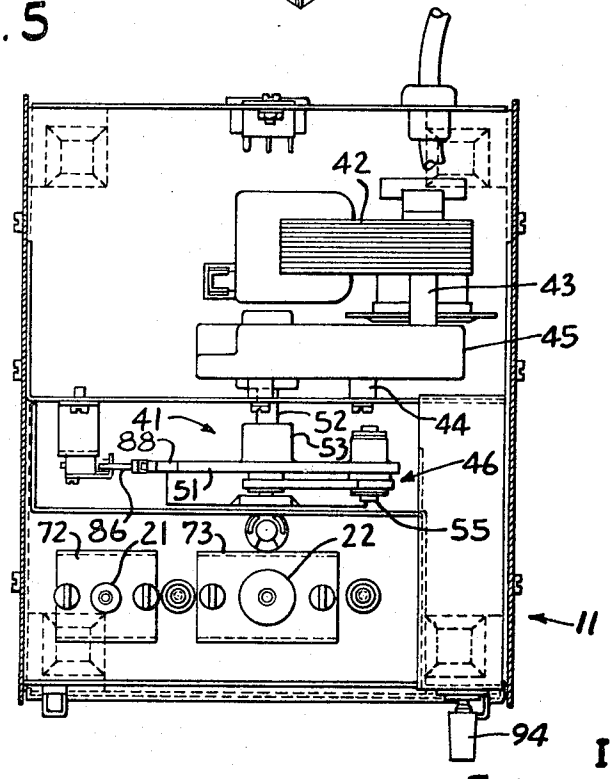


FIG. 5



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LIQUID SAMPLING AND DISPENSING DEVICE

Filed May 29, 1967 3 Sheets-Sheet 2

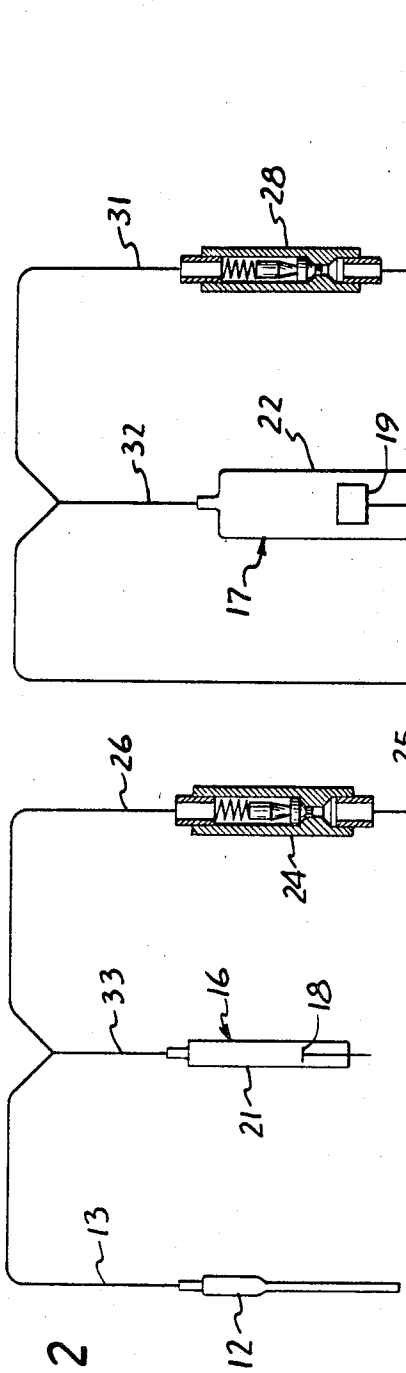

FIG. 2

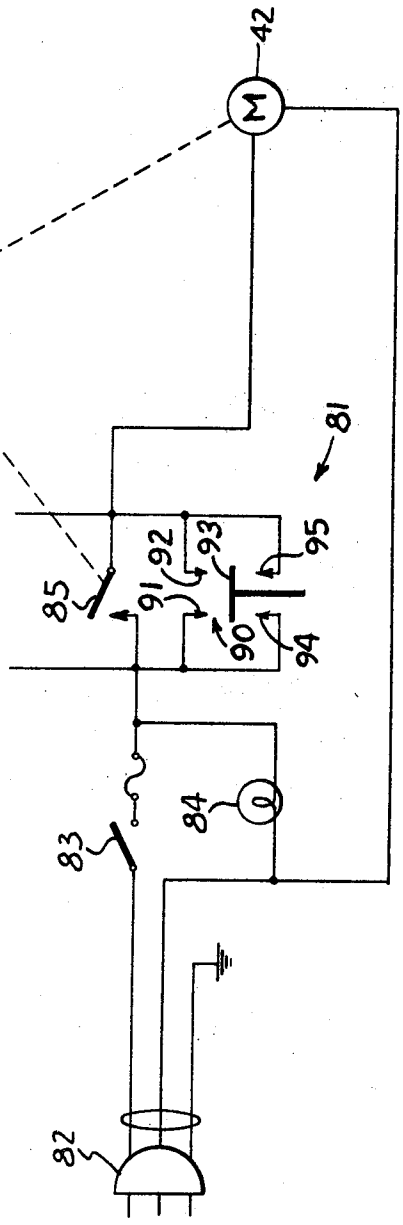

FIG. 6

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Sept. 17, 1968 T. CHRISTIE 3,401,839

LIQUID SAMPLING AND DISPENSING DEVICE

Filed May 29, 1967 3 Sheets-Sheet 3

FIG. 4

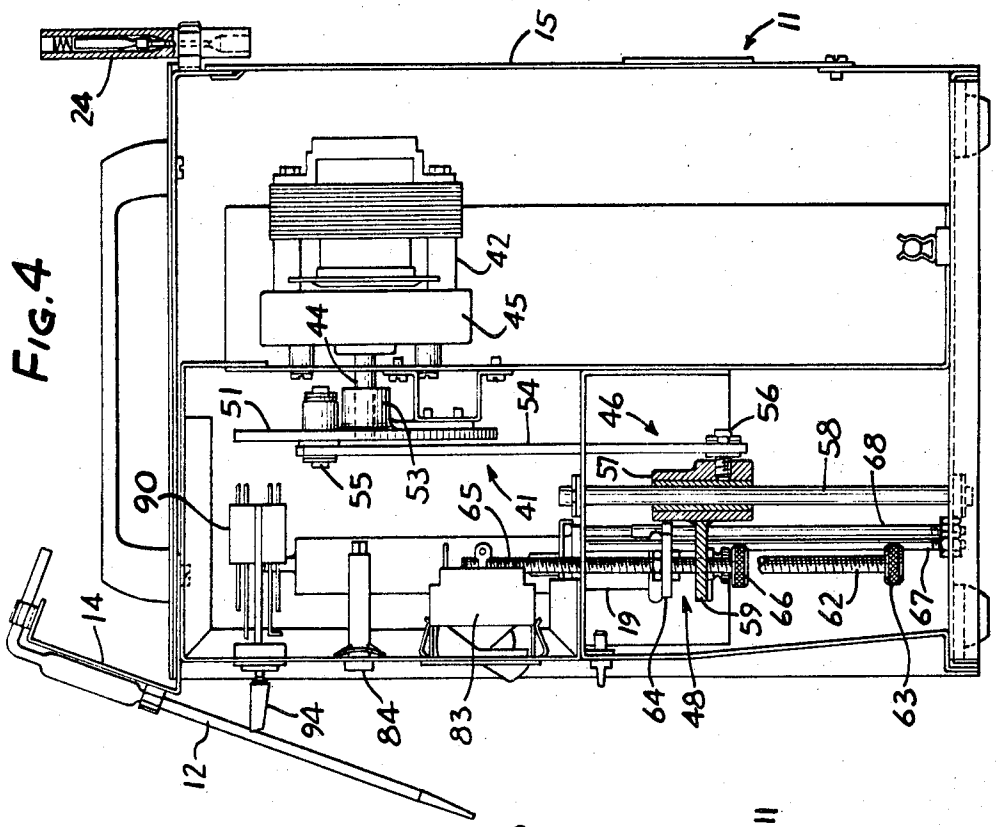
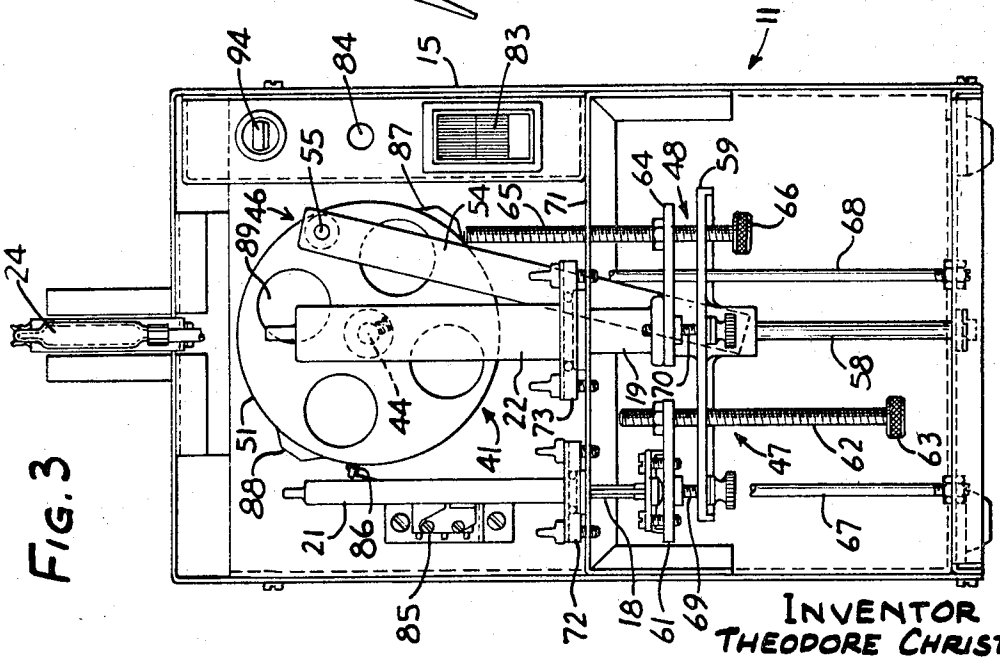


FIG. 3



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3,401,839

LIQUID SAMPLING AND DISPENSING DEVICE

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Filed May 29, 1967, Ser. No. 641,760
8 Claims. (Cl. 222—137)

ABSTRACT OF THE DISCLOSURE

An automatic diluter having a pair of motor driven plunger-type syringes for picking up precisely predetermined quantities of sample and diluent from separate supplies and for dispensing these quantities in common to form a diluted sample. Both plungers are driven by a single unidirectional electrical motor which is coupled to the plungers through a motion converting mechanism which changes the rotary output of the motor to the reciprocating motion necessary for plunger operation. Respective adjustable lost motion connections are provided between the motor and each of the plungers so that the stroke length of each of the plungers may be selected according to the respective portions of sample and diluent desired in the diluted sample. A control switch is provided in the motor supply circuit and is operated by a pair of camming surfaces which are rotated by the motor to interrupt motor operation when the plungers are at each limit of their respective reciprocations in order to automatically provide a hiatus between the pick-up and dispensing operations. A manually operable mode selector switch is connected in parallel with the control switch and has one position for interrupted operation in which it momentarily closes the motor supply circuit to permit the control switch to reclose and another position for continuous operation in which it maintains the motor supply circuit closed to override the operation of the control switch.

Summary of the invention

This invention relates to automatic diluters and, more particularly, to diluters of the type to automatically form diluted samples containing precisely predetermined portions of sample and diluent.

It is an object of this invention to provide an automatic diluter wherein the drive is provided by a single unidirectional motor. A more specific related object is to provide an automatic diluter employing a single unidirectional motor wherein respective plunger-type syringes are employed to pick up and dispense sample and diluent. Another object is to provide an automatic diluter of the foregoing type wherein the stroke length of the respective plungers may be readily and accurately independently adjusted so that the respective portions of sample and diluent constituting the diluted sample may be precisely controlled.

A further object is to provide an automatic diluter with a single unidirectional motor with the diluter capable of operation in either a continuous or an interrupted mode and where, when the diluter is operated in the interrupted mode, a hiatus is automatically provided between the pick-up and dispensing operations. Finally, it is an object of this invention to provide an automatic diluter which is relatively economical and reliable, and yet which is entirely suitable even for the most demanding operation.

Brief description of the drawings

Other objects and advantages of the present invention will be apparent upon reading the following detailed description with reference to the attached drawings, in which:

FIG. 1 is a perspective view of an automatic diluter constructed in accordance with the present invention;

FIG. 2 is a flow diagram illustrating the operation of the automatic diluter shown in FIG. 1;

FIG. 3 is a front view of the automatic diluter with the front panel removed to expose the motion converting and lost motion portions of the drive mechanism;

FIG. 4 is a side view partly in section with the side panel removed to illustrate the single unidirectional motor and its connection to the motion converting portion of the drive mechanism;

FIG. 5 is a top view of the automatic diluter with the top of the diluter removed to show the motor and control switch for interrupting the operation of the motor; and

FIG. 6 is a schematic of the electrical supply circuit for the motor.

Detailed description of the illustrated embodiment

Turning now to the drawings and particularly to FIG. 1 there is illustrated an automatic diluter, indicated generally by **11**, constructed in accordance with the present invention. The diluter **11** includes a conventional delivery means, in this instance a pipette **12**, which is connected at one end of a length of flexible tubing **13** (FIG. 2). In keeping with the normal practice, the tubing **13** is of sufficient length that the operator may immerse the tip of the pipette **12** in a sample supply to pick up a quantity of sample and then remove the pipette **12** to a dispensing position, typically over a clean vessel for receiving the diluted sample. For convenient storage of the pipette **12** a clamp bracket **14** may be fixed to the diluter housing **15**.

Referring to FIG. 2, the automatic diluter **11** includes first and second reversible fluid actuators, as illustrated the plunger-type syringes **16** and **17**, respectively, which are drivable in one direction to pick up respective predetermined quantities of sample and diluent from separate supplies and in the other direction to dispense these quantities in common to form the desired diluted sample. More specifically, with the plungers **18** and **19** at the top of their associated syringe bodies, **21** and **22**, respectively, in a prepick-up position the complete system from the outer tip of the pipette **12** to the outer tip of the diluent intake line **23** is filled with diluent. To pick up a predetermined sample quantity, the tip of the pipette **12** is immersed in a sample supply (not shown) and the plunger **18** is driven downwardly a predetermined distance. A spring biased check valve **24** prevents additional diluent from flowing through the hydraulic lines **25** and **26** to fill this increased volume and consequently a quantity of sample equal to the volume of the syringe body **21** above the plunger **18** is drawn into the pipette **12**. To prevent contamination of the sample and collection of the sample within the system, the volume of the pipette **12** is preferably larger than the quantity of sample picked up which, for example, in a typical clinical type diluter, may be 0–100 microliters. To pick up the desired quantity of diluent at the same time, the plunger **19** is driven downwardly a predetermined distance causing the desired diluent quantity to flow from the diluent supply **27** through the intake means **23**, a spring biased check valve **28**, and the hydraulic lines **31** and **32** into the portion of the syringe body **22** which is above the plunger **19**. As an example, in a typical diluter, the syringe **17** should be capable of picking up 0–10 milliliters of diluent.

Upon the completion of the above described pick-up operation, the pipette **12** is removed from the sample supply and placed over a diluted sample receiving vessel (not shown). To dispense the quantities of diluent and sample previously picked up, the plungers **18** and **19** are driven upwardly. As the plunger **18** is driven upwardly,

diluent flows through the hydraulic lines **33** and **13** into the pipette **12** forcing the sample quantity out. Likewise, as the plunger **19** is driven upwardly, the check valve **28** prevents return flow to the diluent supply **27** thereby causing the diluent to flow through the hydraulic lines **32**, **25**, the check valve **24**, and the hydraulic lines **26**, **13** to force the predetermined quantity of diluent from the pipette **12**. The velocity of the diluent as it exits from the pipette **12** is generally sufficient to obtain adequate mixing of the diluted sample.

From the foregoing, it will be understood that the plungers **18** and **19** are reciprocated relative to their associated syringe bodies **21** and **22**, respectively, to pick up and dispense the desired quantities of sample and diluent. It will also be readily apparent that by maintaining an equality between the downward and upward stroke lengths for each of the plungers **18** and **19**, the amounts of sample and diluent dispensed are equal to the amounts picked up.

Turning now to FIGS. 3–5, the reciprocating drive for the plungers **18** and **19** is provided by a drive mechanism indicated generally at **41**. In accordance with an important aspect of this invention, the drive power is provided by a single unidirectional motor **42**, in this instance a conventional electrical motor. In this manner, significant savings in terms of cost and complexity are realized with no loss in precision as will become apparent hereinafter.

To provide a drive speed appropriate for the diluter, typically 6 r.p.m., the motor shaft **43** may be coupled to the diluter drive shaft **44** through a conventional speed change mechanism **45**. To convert the rotary motion of the drive shaft **44** to the reciprocal motion required for operation of the plungers **18** and **19**, the drive mechanism **41** also includes a motion converting mechanism indicated generally by **46**. Moreover, in carrying out this feature of the invention, to provide the desired stroke lengths for each of the plungers **18** and **19**, the drive mechanism **41** further includes respective lost motion connections **47** and **48** between the motion converting mechanism **46** and the plungers **18** and **19**.

The motion converting mechanism **46** includes a drive member **51**, as illustrated a disk, which is mounted for rotation with the drive shaft **44** by a hub **53**. One end of a drive link **54** is pivotally connected at **55** to the disk **51** eccentrically of the drive shaft **44**. The other end of the drive link **54** is pivotally connected at **56** to a collar **57** which is mounted for reciprocation along a guide shaft **58**. The collar **57** carries a platform **59** and thus as the disk **51** is rotated, the platform **59** is reciprocated along the guide rod **58** with a fixed stroke equal to twice the distance between the drive shaft **44** and the pivot **55**.

For most applications of the automatic diluter, the length of the stroke of the platform **59** is considerably greater than the desired length of the stroke of either plunger **18** or **19**. For this reason, to couple the reciprocating motion of the platform **59** to the plungers **18** and **19** with respective desired reductions in the stroke lengths for each of the plungers, the lost motion connections **47** and **48** are provided. To adapt the diluter for use where different portions of sample and diluent are desired, the amount of motion lost by each of the connections **47** and **48** is preferably independently adjustable. To this end in the illustrated embodiment, the lost motion connection **47** includes a plate **61** to which the plunger **18** is fixed and through which a bolt **62** is threaded. The shank of the bolt **62** freely passes through an aperture in the plate **59** and terminates below the plate **59** in a head **63** which is large relative to the aperture. Similarly, the lost motion connection **48** includes a plate **64** to which the plunger **19** is fixed and through which a bolt **65** is threaded. The shank of the bolt **65** passes freely through an aperture in the plate **59** and terminates below the plate in a head **66** which is large relative to the aperture

in the plate **59** through which the shank of the bolt **65** passes. Guide rods **67** and **68** are passed through the plates **61** and **64**, respectively, to prevent any tendency of the plates to pivot in a horizontal plane. Thus, it will be appreciated that the lengths of the respective strokes of plungers **18** and **19** may be readily selected by simply turning the bolts **62** and **65**. For most purposes, sufficient adjustment sensitivity is available if the bolts **62** and **65** have approximately 32 threads/inch.

At this point it should be noted that the automatic diluter of the present invention may be employed where it is desired to simply dispense constant amounts of diluent such as for purposes of diluting a series of premeasured samples. For this form of operation the lost motion connection **47** is adjustable to a position where the plunger **18** remains at the top of the syringe body **21** as the platform **59** reciprocates.

Also, provision may be made for instance where the plungers **18** and **19** are of different lengths. To this end adjustable stops **69** and **70** are fixed to the platform **59** and project therefrom to engage the plungers **18** and **19**, respectively, during the upward stroke of the platform **59**. The heights of the stops **69** and **70** are adjusted so that the plungers **18** and **19** both reach the tops of their associated syringe bodies **21** and **22**, respectively, just as the platform **59** reaches the upper limit of its reciprocation.

To maintain the syringe bodies **21** and **22** stationary during reciprocation of the plungers **18** and **19**, the syringe bodies are fixed to a mounting plate **71** by clamp plates **72** and **73**, respectively. The mounting plate **71** is fixed to the diluter housing **15**.

Referring now to FIG. 6 in addition to FIGS. 3–5 and particularly to the supply circuit **81** for the motor **42**, the supply circuit may be connected to a wall receptacle through a conventional male connector plug **82** and may also include an on-off switch **83**, illustrated as a conventional rocker-type switch, and a power-on indicating pilot light **84**.

To prevent any loss of sample from the pipette **12** upon the completion of a pick-up operation and during the movement of the pipette **12** from the sample supply to the diluted sample receiving vessel, and to prevent the introduction of air into the pipette **12** upon completion of a dispensing operation, provision is preferably made to automatically interrupt the operation of the motor **42** when the plungers **18** and **19** are at either of the limits of their respective reciprocations. To this end in the illustrated embodiment, a normally closed control switch **85** is connected in series with the motor **42**. To provide the desired interruption in the operation of the motor **42**, the switch **85**, in this instance a microswitch, is provided with an operating arm **86** which is biased into the path of a pair of diametrically opposed camming surfaces **87** and **88**. The camming surfaces **87** and **88** are carried by the disk **51** and their positions thereon are related to the point at which the drive link **54** is connected to the disk so that the surface **87** engages the operating arm **86** to open the supply circuit **81** when the plungers **18** and **19** are at the bottoms of their respective strokes while the surface **88** engages the operating arm **86** when the plungers **18** and **19** are at the tops of their respective strokes.

To prevent fluid accumulation beyond the tip of the pipette **12**, such as the formation of droplets, the camming surfaces **87** and **88** are preferably positioned on the disk **51** so that motor interruption occurs after the platform **59** has completed its stroke in one direction and started its stroke in the other direction. In this manner, all drive force is removed from the plungers during motor interruption.

In order to provide effective interruption, the travel of the disk **51** after the motor supply circuit **81** has been opened must be limited to a distance less than the circumferential length of the camming surfaces **87** and **88**.

To this end, the motor **42** is preferably provided with a brake (not shown), such as a friction brake. For the same reason, the inertia in the system is minimized as by removing unnecessary material from the disk **51**, conveniently done by forming the apertures **89** therein.

To enable the operator to select the mode of operation for the diluter, the motor supply circuit **81** may be provided with a mode selector switch **90**. As shown the selector switch **90** is a two position, double throw switch connected in parallel with the control switch **85**. For an interrupted mode of operation, the switch **90** has one contact set, say the upper set **91, 92**, from which the contactor **93** is returned to an open position by bias means (not shown), such as a spring. In this position, the contactor **93** momentarily engages the contacts **91, 92** to restart the motor **42** thereby causing the switch **85** to reclose. For a continuous mode of operation, the contactor **93** "locks-in" when brought into engagement with the lower contact set **94, 95** and thereby overrides the operation of the control switch **85**. For convenience of operation, the contactor **93** may be carried by a lever arm **96** projecting from the diluter housing **15**. For an alternative method of mode selection, a treadle switch (not shown) may also be coupled in parallel with the control switch. The provision of a treadle switch enables the operator to select interrupted or continuous operation simply by tapping the treadle for interrupted operation or by maintaining the treadle depressed for continuous operation.

I claim as my invention:

1. An automatic diluter for withdrawing a predetermined sample quantity from a sample supply and a predetermined dilute quantity from a diluent supply and for dispensing these quantities of sample and diluent to form a diluted sample, said diluter comprising the combination of delivery means immersible within the sample supply for withdrawing a sample and removable therefrom for discharging the sample and diluent, a first reversible fluid actuator connected to the delivery means and drivable in one direction for drawing the predetermined sample quantity into the delivery means and in the other direction for dispensing said sample quantity from the delivery means, diluent intake means immersible within the diluent supply, a second reversible fluid actuator coupled to the intake means and to the delivery means and drivable in one direction for drawing the predetermined diluent quantity into the intake means and in the other direction for dispensing said diluent quantity from the delivery means, and drive means including a single unidirectional motor coupled to drive both of the actuators alternately in said one and said other directions.

2. The automatic diluter of claim **1** wherein the first and second actuators each include a syringe of the type having a plunger movable within a body, said motor has a rotatably driven output shaft, and said drive means further includes motion converting means coupled between the output shaft of the motor and each of the syringes for converting the rotary motion of the motor output shaft into reciprocating motion of each of said plungers relative to its associated body.

3. The automatic diluter of claim **2** further including means connected to the motor for automatically interrupting motor operation upon the completion of the first actuator plunger stroke in both said one and said other directions whereby the delivery means may be removed from the sample supply without the loss of any of the sample from the delivery means and returned to the sample supply without the introduction of any air into the delivery means.

4. The automatic diluter of claim **2** wherein the motion converting means includes a drive member connected to the output shaft for rotation therewith, a guide shaft, a platform mounted for movement along the guide shaft, a drive link having one end pivotally connected to the platform and an opposite end pivotally connected to the drive member eccentrically of the motor shaft whereby the platform is reciprocated along the guide shaft with a constant stroke length, and respective lost motion connections between the platform and each of the plungers of the first and second actuators whereby the first actuator plunger is reciprocated with a stroke length corresponding to said predetermined quantity of sample and said second actuator plunger is reciprocated with a stroke length corresponding to said predetermined quantity of diluent.

5. The automatic diluter of claim **4** wherein each of lost motion connections includes adjusting means for setting the amount of motion lost thereby whereby the respective amounts of sample and diluent dispensed from the delivery means are independently selectable.

6. The automatic diluter of claim **4** wherein the drive member has a pair of diametrically opposed camming surfaces projecting therefrom, and the motor is an electric motor with a supply circuit which includes a control switch having an operating arm disposed for actuation by the camming surfaces to open the switch thereby interrupting operation of the motor, the camming surfaces bing positioned on the drive member relative to the connection of the drive link thereto so that one of the camming surfaces actuates the operating arm when the plungers of the first and second actuators are at one extreme limit of their respective reciprocations and so that the other of the camming surfaces actuates the operating arm when the plungers of the first and second actuators are at the other extreme limit of their respective reciprocations whereby the delivery means may be removed from the sample supply without the loss of any of the sample from the delivery means and returned to the sample supply without the introduction of any air into the delivery means.

7. The automatic diluter of claim **6** wherein the motor supply circuit further includes a mode selector switch connected in parallel with the control switch, the mode selector switch having at least two positions and being operable in one of the positions to momentarily close the supply circuit to restart the motor after its operation has been interrupted through actuation of the operating arm by one of the camming surfaces and in the other position to override the control switch by maintaining the supply circuit closed when the operating arm is actuated by either of the camming surfaces.

8. The automatic diluter of claim **6** wherein the camming surfaces are positioned on the drive member relative to the connection of the drive link thereto so that motor operation is interrupted while the plungers of the first and second actuators are at each of the extreme limits of their respective reciprocations but after the platform has moved from the extreme limits of its reciprocation whereby all drive force on the plungers is relieved during motor interruption.

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WALTER SOBIN, *Primary Examiner.*

U.S. DEPARTMENT OF COMMERCE

PATENT OFFICE

Washington, D.C. 20231

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,401,839 September 17, 1968

Theodore Christie

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

In the heading to the printed specification, lines 3 and 4 "Honeywell Inc., Minneapolis, Minn., a corporation of Delaware" should read -- Precision Scientific Company, Chicago, Ill., a corporation of Illinois --.

Signed and sealed this 10th day of February 1970.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents