United States Patent

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[54] **PRECISION FLUID DISPENSER**
10 Claims, 6 Drawing Figs.

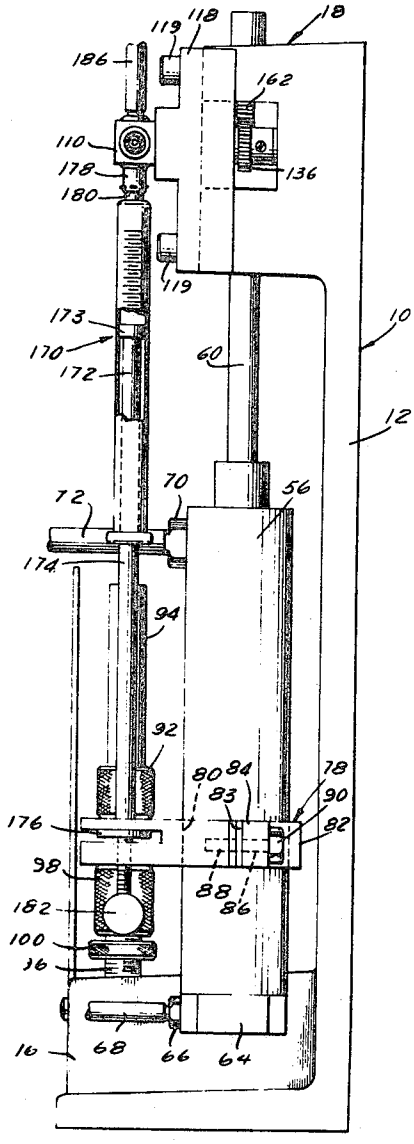
[52] **U.S. Cl.** **417/400,** 91/216
[51] **Int. Cl.** **F04b 17/00,** F01b 15/00
[50] **Field of Search** 103/227, 50; 91/216; 417/400

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ABSTRACT: An apparatus is described for repeatably dispensing precise quantities or amounts of liquid. An actuator operates a reciprocable syringe plunger for drawing liquid into the syringe and discharging same. A valve controls the inflow and outflow of the syringe and spaced permanent magnets hold the movable member of the valve in a position for connecting the syringe either with a source of liquid or in a position for connecting the syringe with a conduit for conveying discharged liquid, until the syringe plunger has been moved by the actuator to the respective ends of its stroke.



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SHEET 1 OF 3

Fig. 1.

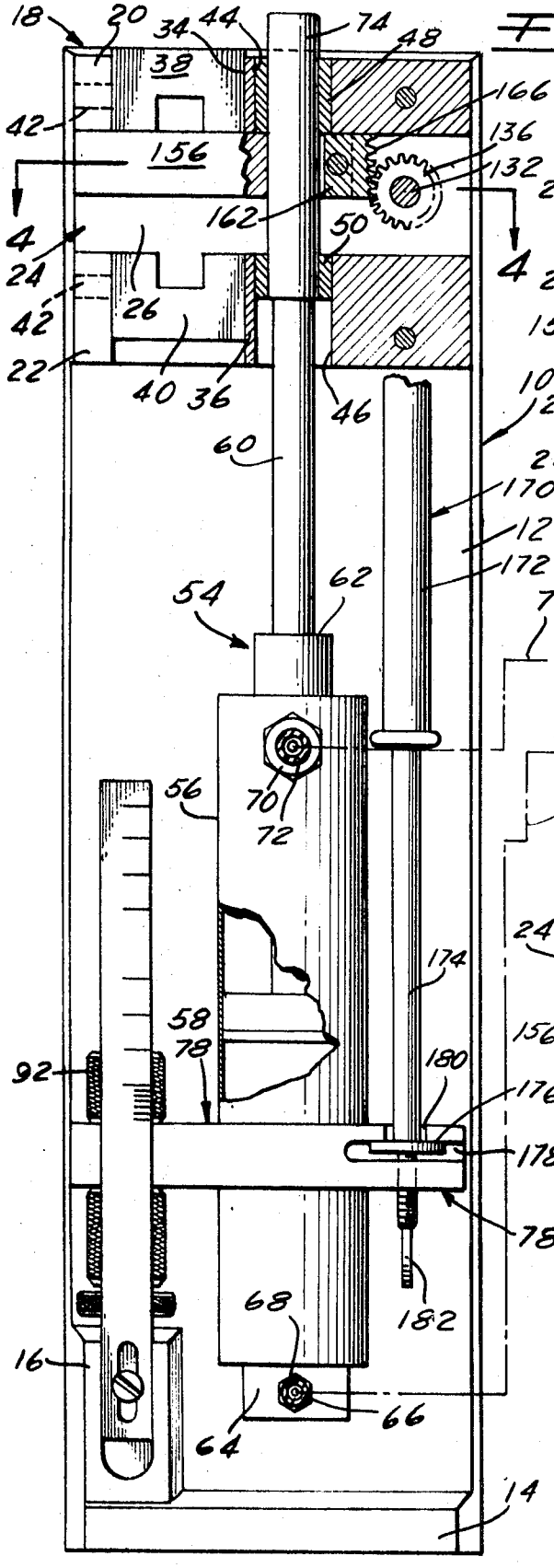


Fig. 3.

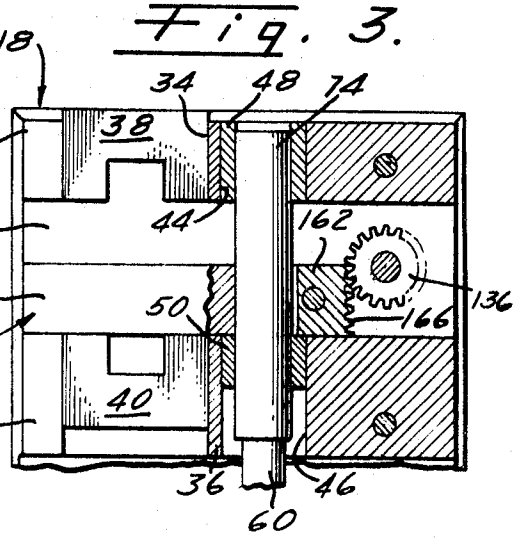
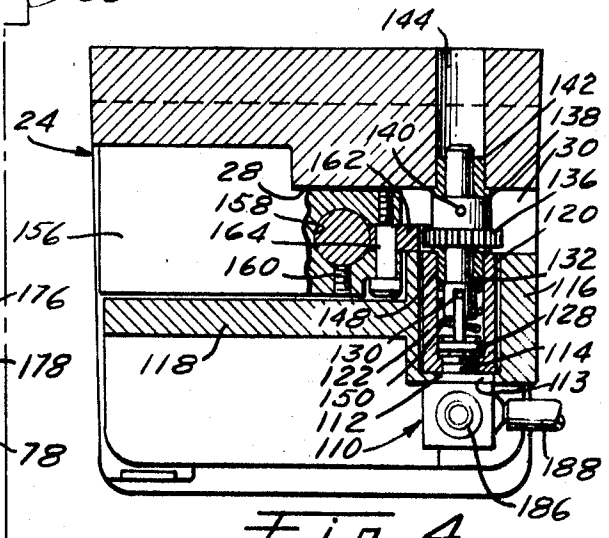
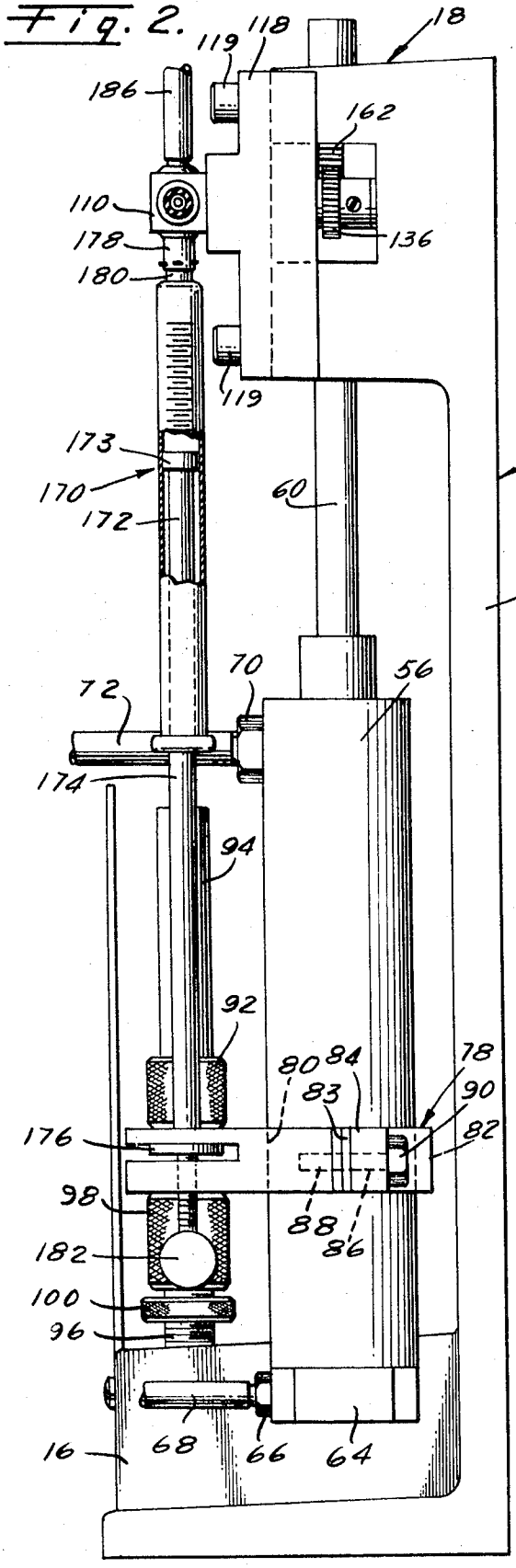


Fig. 4.



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Fig. 2.



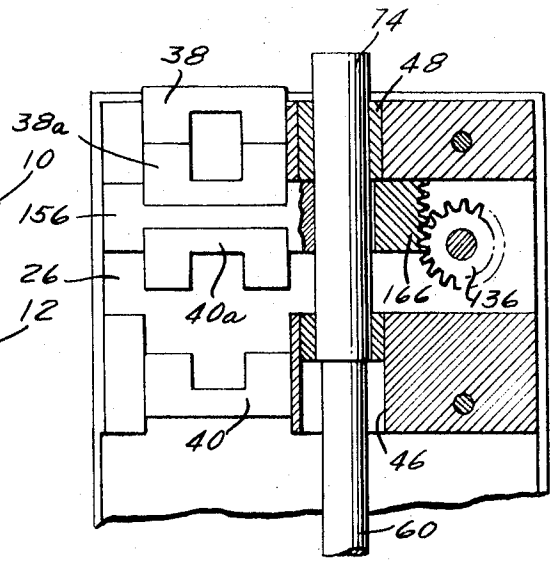


Fig. 6.

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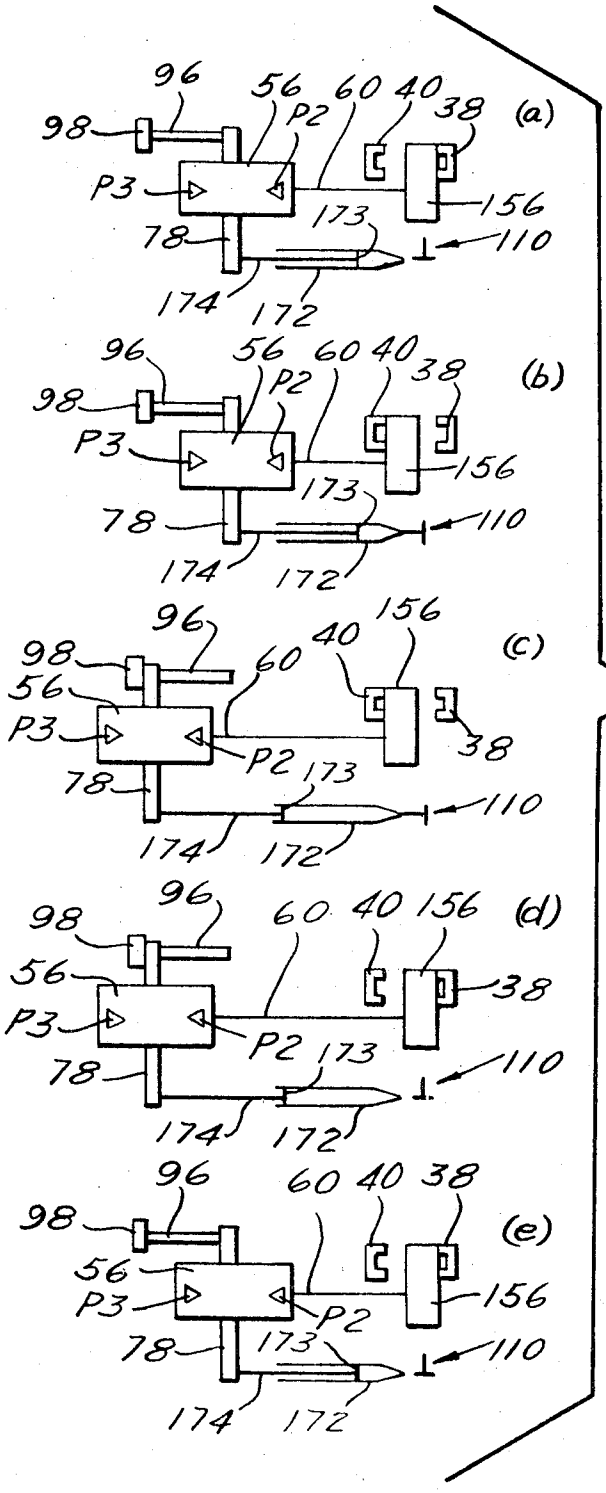


Fig. 5.

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PRECISION FLUID DISPENSER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to liquid dispensing apparatus for use in medical and chemical research laboratories and industrial applications, and relates more particularly to apparatus of this character for repeated discharge or dispensing of precisely measured quantities of liquid.

2. Description of the Prior Art

There are various prior art devices aimed at repeated reproducible dispensing of predetermined quantities of fluids, including liquids. Various problems are encountered in providing suitable apparatus of this character that is satisfactory in meeting the very exacting requirements of scientific research laboratories and industrial applications.

SUMMARY OF THE INVENTION

The present invention comprises a syringe and actuating mechanism for reciprocating the plunger of the syringe. A valve having a movable valve member controls the flow of fluid to and from the syringe, said movable valve member having two positions. When in one position liquid is admitted to the syringe and when in the other position discharge liquid flows from the syringe.

The actuating mechanism is operated by fluid under pressure and has a longitudinally movable cylinder and a piston operable reciprocable therein, the piston being attached to a piston rod that extends outwardly of the cylinder and has a soft iron armature connected or attached thereto externally of the cylinder. The piston rod also has an operable connection with the movable valve member for moving it from one position to the other and vice versa.

The armature is movable between a pair of spaced permanent magnets.

There are stop means for limiting the longitudinal movement of the cylinder in both directions and when the cylinder is at one limit of movement the armature is held by one of the permanent magnets which holds the piston against movement in the cylinder. Pressurized fluid is then supplied to one end of the cylinder to cause it to move to the opposite limit of movement. When the cylinder reaches said opposite limit of movement and is brought to a stop thereat pressurized fluid still continues to exert pressure within the cylinder and effects sufficient pressure on the piston to pull the armature from the permanent magnet on which it has been held and move the piston rod and armature and bring the armature into engagement with the other permanent magnet. At the same time the piston rod moves the movable valve member to its other position. Pressurized fluid is then applied to the opposite end of the cylinder and reverse action occurs. Thus the valve is not operated from one position to the other until the plunger of the syringe has reached one end or the other of its range of movement.

OBJECTS AND ADVANTAGES OF THE INVENTION

It is an object of the invention to provide a precision liquid dispenser that is extremely accurate in reproducibility of precise quantities of liquid repeatedly discharged.

It is another object of the invention to provide a dispenser of this character that has means for controlling the admission of fluid to a syringe and the discharge of fluid therefrom by valve means that is held in respective operation positions until the plunger of the syringe has reached respective ends of its range of movement.

It is still another object of the invention to provide a liquid dispenser of this character having magnetic means for holding the movable valve member of the valve in one or the other of its operative positions until the plunger of the syringe has reached respective ends of its range of movement.

It is a further object of the invention to provide a liquid dispenser of this character that is relatively simple in construction and operation.

A further object is the dispensing of very small volumes of liquids.

The characteristics and advantages of the invention are further sufficiently referred to in connection with the following detailed description of the accompanying drawings which represent one embodiment. After considering this example, skilled persons will understand that many variations may be made without departing from the principles disclosed and I contemplate the employment of any structures, arrangements or modes of operation that are properly within the scope of the appended claims.

Referring to the drawings, which are for illustrative purpose only:

FIG. **1** is a front elevational view of a liquid dispenser embodying the invention, a portion of the upper end being shown in section to show the armature or valve operating block of the magnetic mechanism in its upper position;

FIG. **2** is a side elevational view of the same;

FIG. **3** is a view similar to the upper end portion as shown in FIG. **1** with the armature or valve operating block in its lower position;

FIG. **4** is a sectional view taken on line **4–4** of FIG. **1**;

FIG. **5**, (*a*), (*b*), (*c*) and (*d*), diagrammatically shows various stages of a cycle of operation. In these views the right hand side is to be considered as the top of the mechanism while the left hand side is to be considered its bottom thereof; and

FIG. **6** is a view similar to FIG. **3** showing an alternative arrangement.

Referring more particularly to FIGS. **1** to **4** of the drawings, there is shown a body, indicated generally at **10**, of any suitable material, preferably a nonmagnetic material such as aluminum for example. Body **10** has a back part **12** upstanding at right angles from the rear of a base **14** which has a lug **16** upstanding therefrom at one side and integral with said base and the back part **12**.

At the upper end of the back part **12** is a forwardly projecting block, indicated generally at **18**, having horizontal upper and lower parts **20** and **22** spaced vertically apart to provide a space, indicated generally at **24**. Space **24** has a part **26** at one side, from the inner end of which is a portion **28** of reduced width and from which extends a further reduced width part **30**.

Horizontal upper and lower parts **20** and **22** of the block **18** have aligned vertical holes **34** and **36** in which respective permanent magnets **38** and **40** are disposed and secured in place by respective set screws **42**. The inner faces of the magnets **38** and **40** are flush with the top and bottom surfaces of the space **26**, except when additional magnetic force is required as in the use of large volume syringes or pumps. FIG. **6** illustrates the application of two additional magnets **38***a* and **40***a* cemented to the armature and aligned to meet magnets **38** and **40** now recessed into upper and lower parts **20** and **22**. These magnets may be of any suitable type but those used are alnico magnets.

There are also axially aligned vertical openings **44** and **46** in the respective upper and lower parts **20** and **22** of the block **18**. In each of the openings **44** and **46** is a bearing or bushing **48** and **50** respectively.

An actuator means, indicated generally at **54**, is provided and comprises a cylinder **56** in which is disposed a piston **58** carried by an actuator shaft **60** which extends outwardly of the upper end of the cylinder through a bushing or seal **62** of an end wall, not shown, thereby preventing actuating pressurized fluid from escaping from the upper end of the cylinder, the opposite end of the cylinder being closed by a wall, also not shown, which includes a lug **64** having a fluid passage therein but not shown, a fitting **66** being provided for said fluid passage to which a pressurized fluid conduit **68** is attached to supply pressurized fluid to the lower end of the cylinder through said fluid passage. Adjacent the upper end of the cylinder is a fitting **70** to which a conduit **72** is attached to

supply pressurized fluid to the upper end of the cylinder. Shaft **60** has an enlarged upper end portion **74** slidable in the bearings **48** and **50** of the block **18**.

A relatively flat cylinder bracket, indicated generally at **78**, is attached to the cylinder **56**. There is an opening **80** in said bracket in which the cylinder **56** is disposed, one side of the opening **80** being defined by a strap **82**. From the hole **80** there is a slot **83** to the adjacent edge of the bracket thus providing a somewhat resilient tongue **84** at the end of the strap **82**. Tongue **84** has a hole **86** therethrough in alignment with a tapped bore **88** in that portion of the bracket opposite the tongue, there being a screw **90** disposed in said hole and screwed into the tapped bore **88** to tighten the strap **84** on the cylinder and secure the cylinder in its opening **80**.

The bracket **78** also has a vertical tapped bore, not shown, which is provided with screw threads, not shown, and in which is screwed a bushing **92** of suitable friction reducing material such as Teflon, for example, Teflon being the trademark of the Du Pont Company for their fluorocarbon resins. The bushing may be externally knurled to facilitate screwing into the tapped bore in the bracket. Bushing **92** has a longitudinally extending bore therethrough for reception of adjustment nut **94** on which said bushing is slidable so that the cylinder bracket is movable upwardly and downwardly and is guided by said nut **94** which has an enlarged knurled part **95**. Nut **94** has a tapped bore extending longitudinally there through and said nut is screwed onto an externally threaded adjustment shaft **96** which has a lower end portion screwed into a tapped bore, not shown, provided therefor in the lug **16**. Rotation of the part **95** of the adjustment nut effects upward or downward movement of the nut **94** and there is a lock nut **100** on the adjustment shaft below the part **95** for securing the adjustment nut in adjusted positions. The part **95** of the adjustment nut provides a stop for downward movement of the cylinder bracket and hence for the cylinder **56**. Shaft **94** is upstanding from lug **16** and its axis is parallel to the axis of the actuator means **54**.

A three port, two position valve, indicated generally at **110** has a part **112** from which an externally threaded part **114** extends. The part **112** is received in an opening **113** provided therefor in a housing portion **116** of a valve mounting plate **118** secured to the front side of the block **18** by screws **119**. Housing portion has a bore **120** extending from the inner end and axially aligned with the opening **113**. Within the bore **120** is a valve adapter **122** having a bore therein with an annular inturned flange having threads for threaded reception of the threaded part **114** of the valve **110**. Thus the valve is held in position by the adapter **122**. Valve **110** may be of any suitable well known character but as shown by way of example is of the type disclosed in the application of Clark H. Hamilton, for a VALVE, Ser. No. 403,223, filed Oct. 12, 1964, the valve **110** however being of such character as to have two operative positions as will be described hereinafter.

Within the valve adapter **122** is a valve actuator **126** operably connected to the movable valve member, not shown, of the valve **110**. Valve actuator **126** has a flange **128** thereon and at its inner end said valve actuator has a flattened part with a notch therein, said flattened part being received in a notch **130** of a valve shaft **132**. There is a gear **136** with an integral collar **138** secured to the valve shaft **132** by means of a pin **140**. Gear **136** is disposed in the space **30** and on said valve shaft **132** is a bushing **142** disposed in a bore **144** extending from the rear of the body **10**. Bushing **142** is retained in position by an external flange at its inner end which engages the area of the rear wall of space **30** about the bore **144**. The end of the collar **138** opposite the gear abuts against the inner end of said bushing or bearing **142**.

There is also a bearing **148** similar to bearing **142** disposed on valve shaft **132** at the opposite side of the gear **136**, said bearing extending into the bore of the valve adapter and having its flange engaging the adjacent end of the valve adapter and being engaged by the adjacent side of the gear **136**. A spring **150** is disposed within the bore of the valve adapter **122** and reacts between the bearing **148** and the flange **128** of the valve actuator, and urge these parts apart. There is a sufficient clearance between the valve actuator and the valve shaft so that there will be no binding and the valve readily actuated with rotative movements of the gear.

Within the spaces **26** and **28** is a traveling block or armature **156** having a vertical bore **158** therethrough for reception of the upper end portion **74** of the actuator shaft **60**, said traveling block being secured to said shaft portion **74** by means of a set screw **160** disposed in a tapped bore provided therefor. The bore **158** is disposed in a part of the traveling block that is of reduced width and disposed in the space portion **28**. The traveling block or armature is of any suitable magnetic material such as low carbon steel and is illustrated in FIG. **6** and described on line **25** pages **5** and **6**.

Means for actuating the gear **138** comprises a rack **162** disposed in a notch provided therefor at the free end of the reduced width part of the traveling block, said rack being secured in said notch by a screw **164**. Rack **162** has teeth **166** operably engaging the teeth of the gear **136** and adapted to rotate said gear with vertical movements of said traveling block **156** which in turn is actuated upwardly and downwardly with corresponding movements of the actuator shaft **60**. The traveling block **156** moves between the magnets **38** and **40**.

A syringe, indicated generally at **170**, has a transparent barrel **172** and a plunger **173** on a plunger rod **174** having a flange **176** at its outer, free end. The syringe may be of any well known type for handling liquids or gases and is removably attached to the valve **110** by any well known means. For example, a luer lock is used and includes a female part **178** on the valve **110** and a male part **180** on the forward end of the syringe barrel. Thus the forward or upper end of the syringe is securely held in position.

The plunger rod is secured to the cylinder bracket by placing the pressure member or flange **176** in a recess **178** in the cylinder bracket. There is also a notch **180** to accommodate the adjacent part of the plunger rod so that there is proper alignment of the parts of the syringe, said flange being held in position by a thumb screw **182** disposed in a tapped opening provided therefor in the portion of the cylinder bracket below the recess **178**. The syringe may, of course, be installed in the mechanism or removed therefrom and various types and sizes of syringes may be used.

A conduit **186** connects the valve **110** with a source of fluid to be measured and there is a conduit **188** connected to said valve for discharged fluid.

Actuator cylinder may be operated by any suitable fluid under pressure but air under pressure is a convenient and satisfactory fluid. Conduits **68** and **72** connect the lower and upper ends of the cylinder **56** with a valve mechanism, indicated generally at **190**, which receives air under pressure by means of a conduit **192** connected to a source of air under pressure, not shown. Valve **190** is shown as being manually operated and may be of any suitable two position type. Pressurized fluid is supplied to the valve **190** from a suitable source of such pressure by way of conduit **192**. This fluid is directed to the upper end and the lower end respectively of the cylinder **56** by proper positioning of the valve **190**. When fluid pressure is supplied to one end of the cylinder the fluid at the other end is returned to the valve and vented therefrom by means of an atmospheric vent port, not shown. This arrangement is well known and need not be further described.

It is to be understood that while the valve **190** is manually operated it may be automatically operated by suitable mechanism of any well known type.

In the operation of the apparatus or mechanism, it is to be understood that the cylinder moves upwardly and downwardly and is carried or supported by the shaft **60** which also moves upwardly and downwardly under certain conditions which are described hereinbelow. Movement of the cylinder is limited at the bottom by engagement of the cylinder bracket **78** with the adjustment nut part **94** and is limited in its upward movement by engagement of the bushing or seal **62** with the under side of the block **18**, it being noted that the diameter of the seal or

bushing **62** is greater than the diameter of the bore **46** so that said bushing or seal will not enter said bore but will engage the area of the bottom of said block **18** immediately about the lower end of said bore **46**. With the syringe installed as illustrated in FIG. **5***a*, the cylinder bracket **78**, cylinder **56**, and syringe plunger **174**, are adjusted to the zero point on the syringe scale **172**. With the cylinder bushing **62**, pressing the underside of block **18**, and the plunger at zero, the cylinder bracket **78**, is secured by clamping screw **90**.

With the syringe installed as shown in FIGS. **1** and **2** and the cylinder **56** in its lower position the cylinder bracket **78** is adjusted by means of the enlarged part **94** of the adjustment nut to bring the forward end of the syringe plunger to the quantity of discharge required and indicated on the syringe scale.

With this adjustment made, the operation of the mechanism or apparatus will be best understood by referring to FIG. **5**. As shown at (*b*) of FIG. **5** the traveling block **156** is in engagement with the lower magnet **40** which magnetically holds the block in its lower portion whereat the valve **110** is in the fill position. Cylinder **56** is in its upper position and ready to move downwardly when supplied with pressurized operating fluid by positioning the valve **190** to supply pressurized fluid to the lower end of said cylinder by way of the conduit **68**; that is, pressure is applied at P_3 while pressure above the piston **58** is relieved through the conduit **72** and the atmospheric vent port of the valve **190**.

Since the piston **58** in cylinder **56** is held stationary by magnet **40** pressurized fluid in the lower end of the cylinder **56** acts against the lower end wall of the cylinder to force said cylinder downwardly to the position shown in (*c*) of FIG. **5**. Since the valve **110** is at the fill position, downward movement of the plunger **173** in the syringe barred draws fluid into said barrel by way of the conduit **186**.

Downward movement of the cylinder **56** is halted when the cylinder bracket **78** contacts the adjustment nut. Continued supply of pressurized fluid to the lower end of the cylinder forces the piston **58** upwardly against the magnetic attraction of the magnet **40** causing the traveling block to move upwardly into engagement with the magnet **38**. The upward movement of the traveling block **56** causes the rack **162** to rotate the gear **136** and this in turn causes the valve **110** to be actuated to the discharge position. The parts are now in the position shown at (*d*) of FIG. **5**. Because the piston **58** and hence the traveling block **156** do not move until the cylinder has reached one or the other end of its stroke as limited by engagement of the bearing **62** with the block **18** or by engagement with the adjustment nut part **98** and there is a pressure build up sufficient to overcome the magnetic attraction of one or the other of the magnets **38** and **40** the valve **110** is not actuated from one operative position to the other until there has been a complete filling of the syringe or a complete discharge thereof. Consequently the amount of liquid repeatedly discharged by the syringe is consistently the same. The apparatus or mechanism is extremely accurate as required in scientific research.

After the traveling block **156** has been moved to the position shown in (*d*) of FIG. **5**, the valve mechanism **190** is operated to cut off the pressure to the lower end of the cylinder, that is P_3, and supply pressurized fluid to the upper end of the cylinder, as at P_2. The cylinder **56** then moves upwardly to its upper limit of movement, as shown at (*e*) of FIG. **5**, which is identical to (*a*) of FIG. **5**. As the cylinder moves upwardly, with the valve **110** in the discharge position, fluid is discharged from the syringe.

With the air pressure still applied to the upper end of the cylinder **56** and the piston **58** is forced downwardly to cause the traveling block **156** to move from engagement with magnet **38** to engagement with the magnet **40**.

The foregoing is a description of the cycling of the apparatus and after the discharge movement of the cylinder while the traveling block is held by magnet **38**, the operating of the mechanism or apparatus starts over at (*a*) of FIG. **5**. It should be noted that the valve mechanism **190** may be the simplest manual valve control or any automatic mechanism defined by the use requirements for automatic liquid dispensing.

A scale **198** may be provided for convenient resetting of the mechanism, said scale having a longitudinal slot **200** in its lower end for reception of a screw **202** screwed into a tapped opening provided therefor in front end of the lug **16**. Thus the scale may be adjusted longitudinally. The scale is positioned adjacent the cylinder bracket so that one edge of the latter is operably positioned as an indicator with respect to said scale.

Relative to the magnet arrangement it will be apparent that in a broad sense the magnets function as a detent. There may be, of course, other detent arrangements to releasably restrain movements of the piston rod and hence actuation of the valve **110** between the fill and discharge positions. By using a detent mechanism the valve **110** is not actuated from one position to the other until the syringe has been completely filled or completely discharged.

I claim:

1. A precision fluid dispenser, comprising:

A. an actuator mechanism including:

a. a cylinder part mounted for reciprocal longitudinal movements,

b. a piston operably disposed in said cylinder, said cylinder having means for connection at opposite sides of the piston with a source of pressure fluid,

c. a piston rod part to which said piston is secured,

d. a pair of magnetic detent means mounted in spaced relation to each other,

e. a traveling member secured to one of said actuator mechanism part, said traveling member being disposed and movable between said detent means and engageable therewith respectively, said detent means each restraining said traveling member with a limited force when said traveling member is engaged therewith;

f. and means for limiting reciprocating movements of one of said parts in both directions, the other part moving from one detent to the other when movement of said one part is stopped by said means for limiting reciprocal movement at a respective end of movement of said one part.

2. A precision fluid dispenser, comprising:

A. an actuator mechanism including:

a. a cylinder part mounted for reciprocal longitudinal movements.

b. a piston operably disposed in said cylinder, said cylinder having means for connection at opposite sides of the piston with a source of pressure fluid.

c. a piston rod part to which said piston is secured.

d. a pair of detent means mounted in spaced relation to each other.

e. a traveling member secured to one of said actuator mechanism parts, said traveling member being disposed and movable between said detent means and engageable therewith respectively, said detent means each restraining said traveling member with a limited force when said traveling member is engaged therewith;

f. and means for limiting reciprocating movements of one of said parts in both directions, the other part moving from one detent to the other when movement of said one part is stopped by said means for limiting reciprocal movement at a respective and of movement of said one part; and

B. a syringe operably connected to said other of actuator parts, movement of said one of said parts effecting filling and discharging of said syringe according to the direction of reciprocal movement of said one part; a valve; fluid connecting means for connecting the valve to said syringe, said valve having syringe filling and syringe discharging positions, said valve being operably connected to said other part and actuated thereby from one of said positions to the other when the respective detent

means releases said other part and the latter moves the traveling member to the other detent means.

3. The invention defined by claim 2, wherein the cylinder is the one part and the piston rod comprises the other part; the detent means each comprises a magnet, said magnets being spaced apart; and the traveling member comprises a traveling armature block being of less thickness than the space between the magnets and being adapted to be magnetically held by either of said magnets depending upon the position of the traveling armature block, operative movements of the piston rod moving said armature block from one magnet to the other when cylinder movement is stopped by the means for limiting reciprocating movements of said cylinder and moving said valve from one position to the other.

4. The invention defined by claim 3, wherein the syringe comprises a barrel, a piston in said barrel, and a plunger to which said piston is attached, and wherein the valve is fixedly mounted, means for connecting the valve to the forward end of the syringe barrel for holding said forward end in position; and a cylinder bracket to which the cylinder is secured for effecting movements of said cylinder bracket with respective movements of said cylinder, the free end of the syringe plunger being secured to said cylinder bracket for effecting longitudinal movements of the syringe plunger with respective movements of the cylinder bracket.

5. The invention defined by claim 4, wherein the means for connecting together the valve and the forward end of the syringe barrel comprises a pair of luer parts attached respectively to the valve and the syringe barrel, said parts being removably connected together.

6. The invention defined by claim 3, wherein the valve has a valve actuator and the connection between the traveling armature block and the valve includes a gear connected to said valve actuator and a rack connected to said traveling armature block, said rack having teeth engaging the teeth of the gear for effecting rotative movement of the gear with movements of the traveling armature block from one magnet to the other.

7. The invention defined by claim 4, including means for adjusting the cylinder relative to the cylinder bracket.

8. The invention defined by claim 3, wherein at least one of the means for limiting reciprocal movements of the cylinder is adjustable.

9. The invention defined by claim 1, including means for controlling the supply of pressure fluid to the respective ends of the cylinder and relieving pressure at the respective ends of the cylinder opposite the end to which pressure fluid is supplied.

10. The invention defined by claim 9, wherein the means for controlling the supply of pressurized fluid to the cylinder comprises a valve.