May 7, 1957 G. GORHAM ET AL 2,791,180

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FIG. 1.

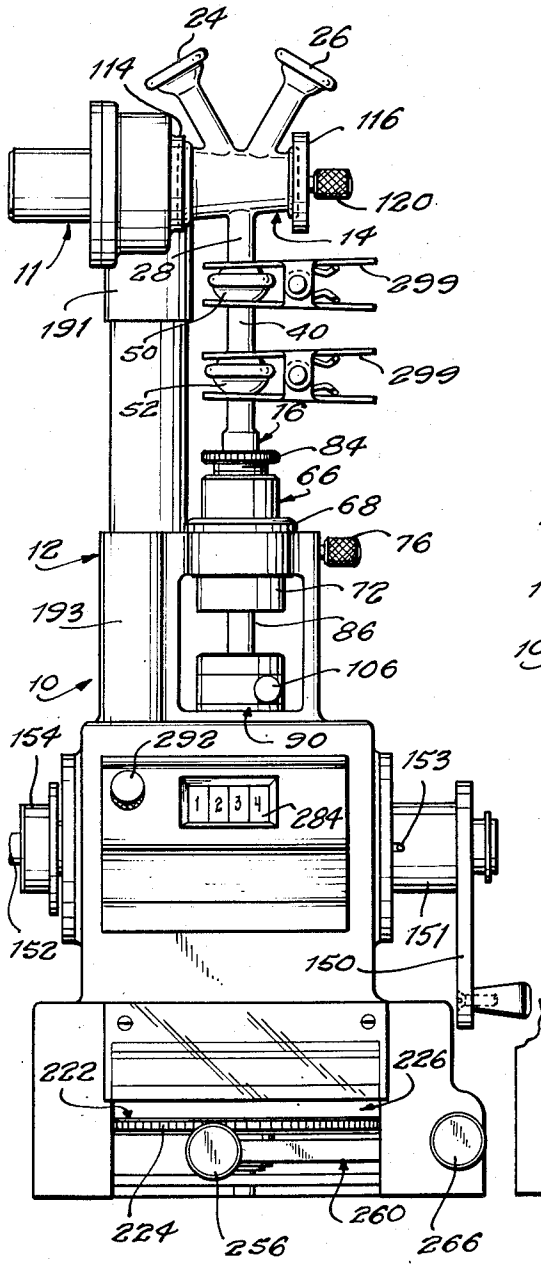
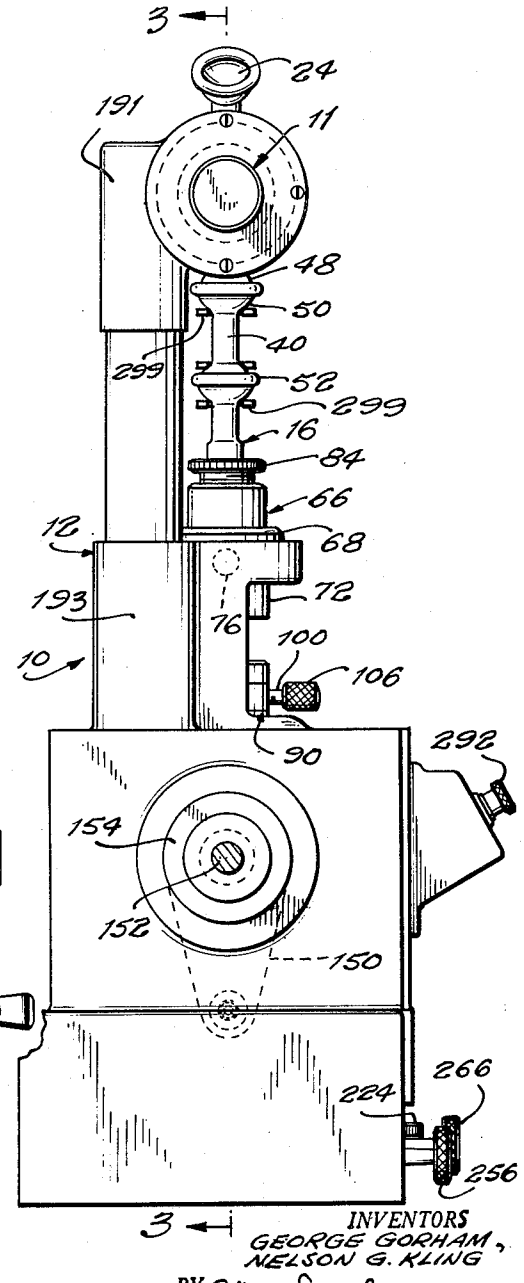


FIG. 2.



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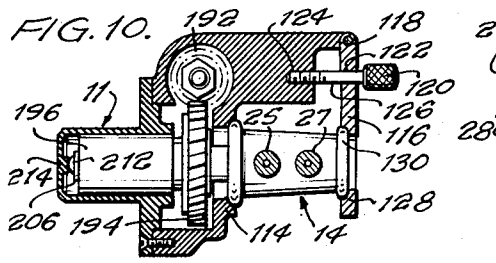


FIG. 10.

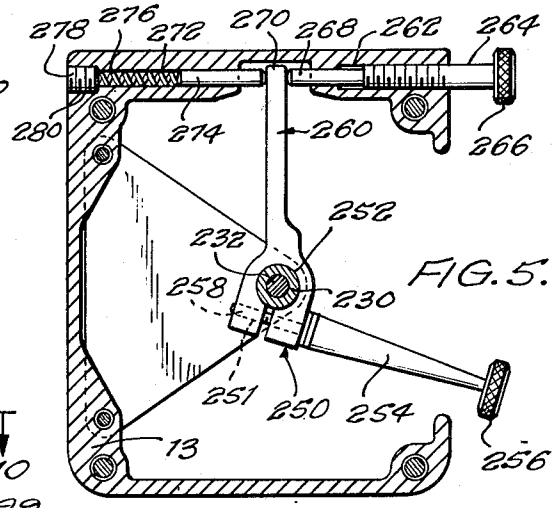


FIG. 5.

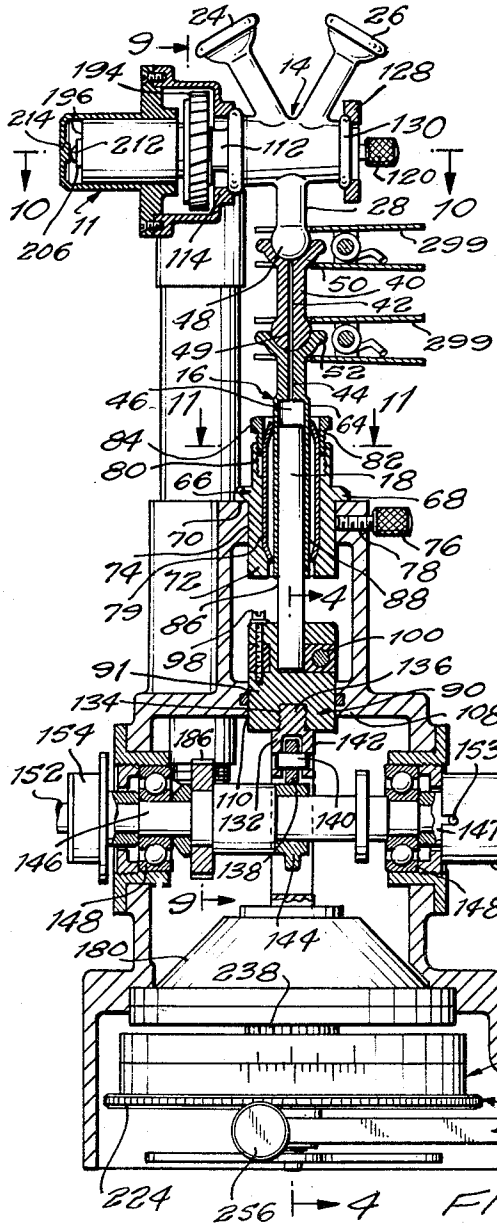


FIG. 3.

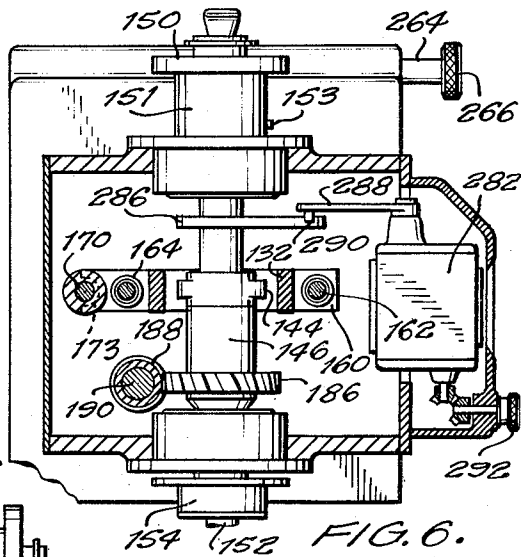


FIG. 6.

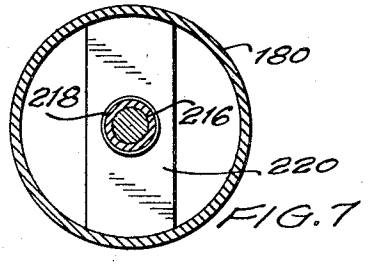


FIG. 7

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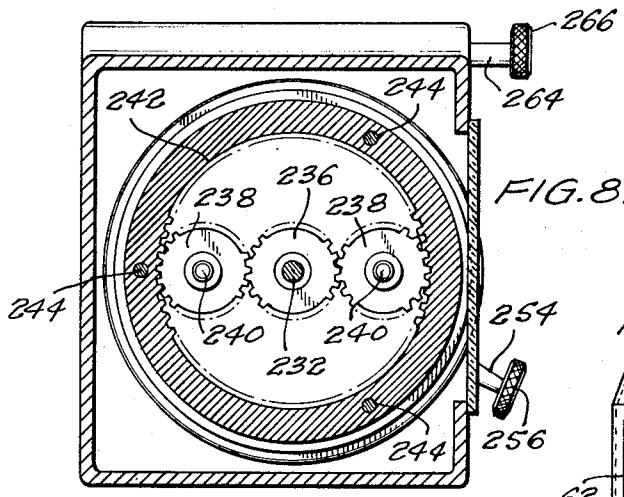


FIG. 8.

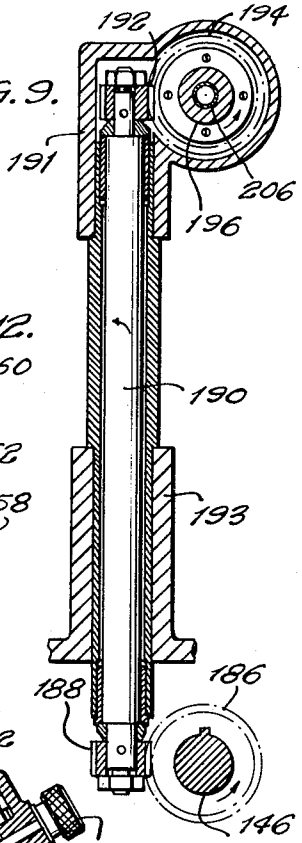


FIG. 9.

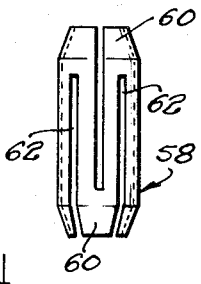


FIG. 12.

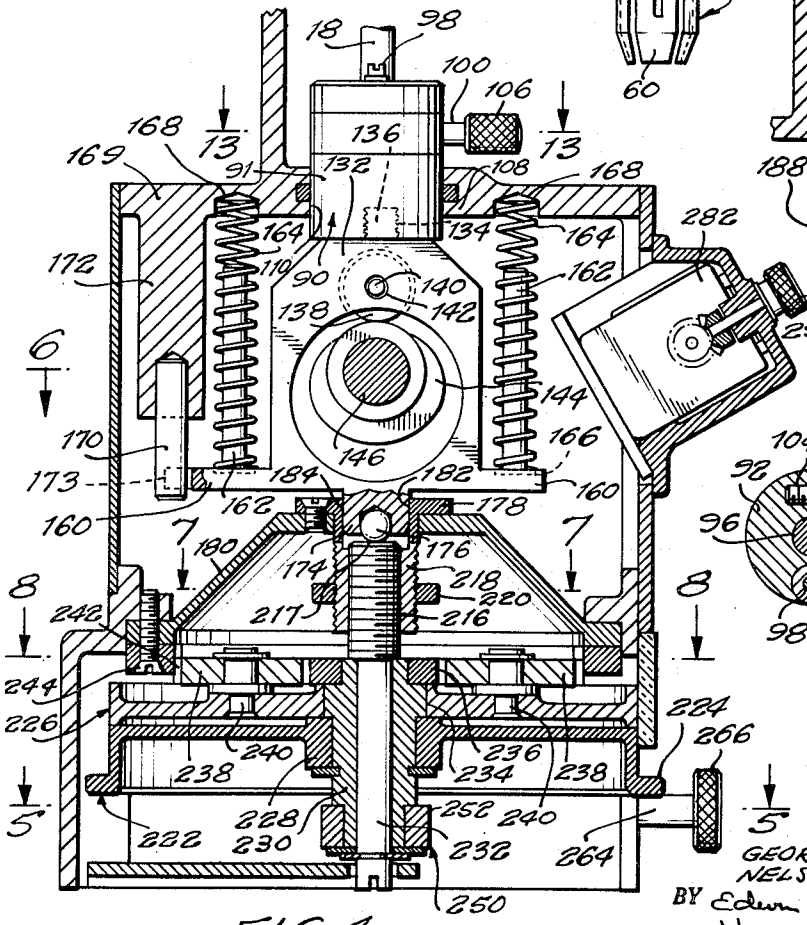


FIG. 4.

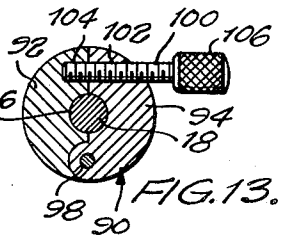


FIG. 13.

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FIG. 3A.

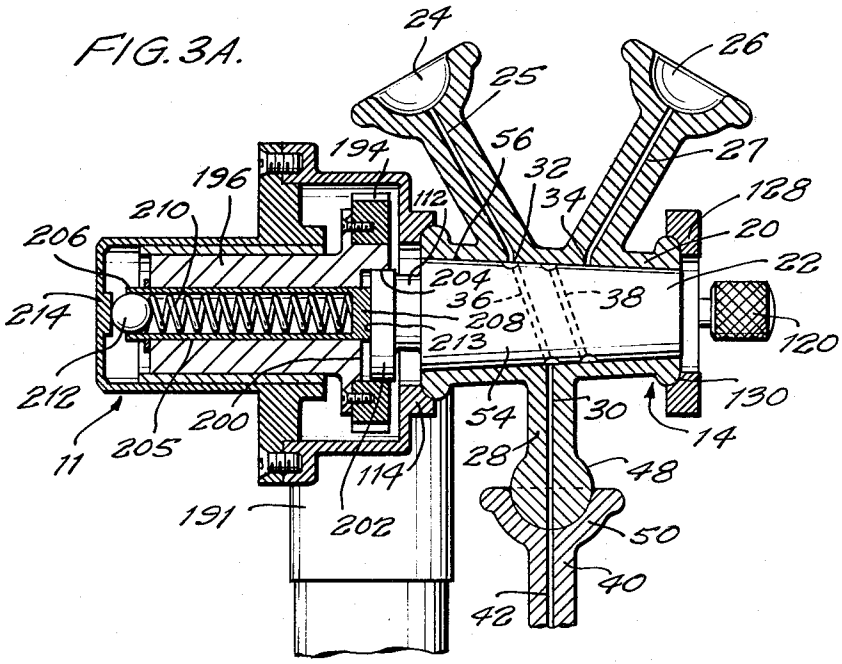


FIG. 14.

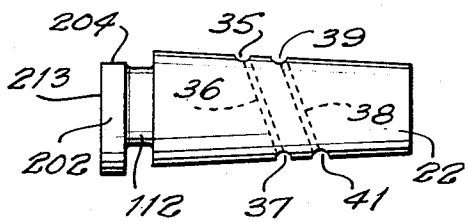


FIG. 11.

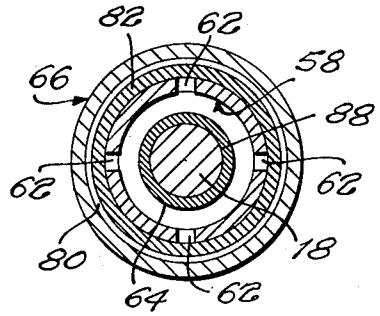
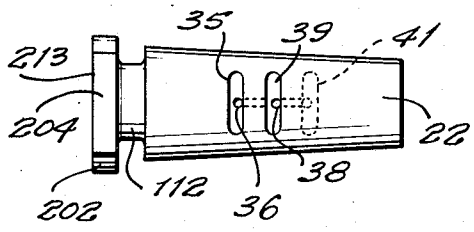


FIG. 15.



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United States Patent Office 2,791,180 Patented May 7, 1957

2,791,180

PUMP

George Gorham, New York, and Nelson G. Kling, Roslyn, N. Y., assignors, by mesne assignments, to Technicon International, Ltd., a corporation of New York

Application February 9, 1952, Serial No. 270,822

9 Claims. (Cl. 103—38)

This invention relates to improvements in pumps and more particularly to pumps adapted to dispense small quantities of fluid.

This invention is a continuation in part of our application Serial No. 146,956, filed March 1, 1950, now Patent No. 2,727,466, assigned to the assignee of the present application.

One object of the present invention is the provision of an improved pump for dispensing, with a high degree of accuracy, a predetermined quantity of fluid during each fluid dispensing cycle of the pump.

A further object is to provide a pump which is constructed so that the cylinder, piston and valve can all be made of glass as well as of metal or any other suitable material.

Another object of the present invention is the provision of a pump with improved means for the accurate measurement of the quantity of fluid dispensed by the pump, which quantity will be identical under identical conditions at the same setting.

Another object of the present invention is the provision of a pump of the aforenoted character with means for adjusting the output of the pump while the latter is in operation, as well as when the pump is idle, whereby to dispense variable predetermined quantities of fluid.

Another object of the present invention is the provision of an improved pump in which the fluid contact parts thereof are readily removable and replaceable for cleaning, sterilizing or repair or for altering the capacity of the pump.

Another object of the present invention is the provision of a pump having improved valve means and valve actuating means.

Another object of the present invention is the provision of improved means for releasably securing the pump cylinder in position on the pump.

Yet another object of the present invention is generally to provide an improved pump for dispensing accurately measured small quantities of fluids for various purposes, for example, for use in titration, for supplying liquids to chromophotographic columns, for use in micro-injections, for perfusions, etc.

The above and other objects, features and advantages of the present invention will be more fully understood from the following description considered in connection with the accompanying illustrative drawings.

In the drawings:

Fig. 1 is a front elevational view of a pump embodying the present invention;

Fig. 2 is a side elevational view thereof;

Fig. 3 is a sectional view taken on the line 3—3 of Fig. 2;

Fig. 3A is a front elevational view, partly in section, on an enlarged scale, of the upper part of Fig. 3;

Fig. 4 is a sectional view taken on the line 4—4 of Fig. 3;

Fig. 5 is a sectional view taken on the line 5—5 of Fig. 4;

Fig. 6 is a sectional view taken on the line 6—6 of Fig. 4;

Fig. 7 is a sectional view taken on the line 7—7 of Fig. 4;

Fig. 8 is a sectional view taken on the line 8—8 of Fig. 4;

Fig. 9 is a sectional view taken on the line 9—9 of Fig. 3;

Fig. 10 is a sectional view taken on the line 10—10 of Fig. 3;

Fig. 11 is a sectional view taken on the line 11—11 of Fig. 3;

Fig. 12 is a front elevational view, on an enlarged scale, of the cylinder-clamping element;

Fig. 13 is a sectional view taken on the line 13—13 of Fig. 4;

Fig. 14 is a plan view of the valve member; and

Fig. 15 is a view similar to Fig. 14 with the valve member shown rotated 90° from the position shown in Fig. 14.

Referring to the drawings, and more particularly to Figs. 1, 2 and 3 thereof, the pump 10 according to the present invention comprises a generally vertical main frame 12 having positioned relative thereto at its upper end a valve assembly 14, a cylinder 16 and a piston 18 which are operatively associated with the pump 10 in a manner to be described in detail hereinafter. The fluid to be dispensed by the pump 10 is under the control of the valve assembly 14, said valve assembly comprising a valve body or casing 20 and a tapered valve member 22 rotatably mounted in the valve body 20 in fluid sealing relation therewith. The valve body 20 is provided with a fluid inlet 24 and a fluid outlet 26, and laterally projecting from an intermediate point of the valve body is an elongated projection 28 having a passage 30 extending therethrough for a purpose which will be apparent from the description which follows. Inlet 24 is in communication with port 32 of the valve body by means of passage 25 and outlet 26 is in communication with the port 34 of the valve body, by means of passage 27, said ports 32 and 34 being longitudinally spaced for sequential registry with the fluid passages of the tapered valve member 22. The valve member 22 is provided with a pair of parallel diagonally extending passages 36 and 38 which are spaced apart a predetermined distance for registry with the ports 32 and 34 of valve body 20 and the passage 30 in a predetermined sequence. The passage 36 is provided at its inlet and outlet ends with transversely extending recesses 35 and 37, respectively, and similarly the passage 38 is provided at its inlet and outlet ends with transversely extending recesses 39 and 41, respectively. Each of said recesses 35, 37, 39 and 41 extends peripherally of the valve member 22 a short distance and said recesses provide for the passages 36 and 38 to be in communication with their associated ports 32 and 34 and passage 30 for a predetermined degree of rotation of the valve member whereby smooth and continuous flow characteristics through the valve are achieved on the rotation of said valve member. It will be understood that the fluid capacity of passages 36 and 38 and their associated recesses is such as to permit a maximum amount of fluid to be dispensed corresponding to the maximum setting of the operating length of the stroke of piston 18 and the maximum capacity of cylinder 16. The valve member 22 is adapted to be rotated by means to be described hereinafter and on the rotation of said valve member a predetermined quantity of fluid to be pumped or dispensed will enter the fluid passage 30 on the intake or suction stroke through the inlet 24 and fluid passages 25 and 36 which will be in fluid-communication during the intake stroke. The fluid entering the passage 30 will be drawn into the cylinder 16 and on the outlet or dispensing stroke the piston 18 will be effective to discharge the fluid in the cylinder 16 through the outlet 26 by way of the passages 30, 38 and 27 which will be in registry on the fluid expelling stroke. It will be understood from the above that on the fluid inlet stroke of piston 18 fluid will enter the interior 46 of cylinder 16 through the port 32 and passage 30 which will be in

registry with the passage 36 extending diagonally through the valve member 22 and on the fluid outlet stroke of the piston 18 the fluid drawn into the cylinder 16 will be discharged through the outlet 26 by means of the port 34 and passage 30 which will be in fluid communication with the passage 38 in the valve member 22. In order to connect the fluid passage 30 with the cylinder 16 there is provided a coupling element 40 having a fluid passage 42 extending therethrough, which latter fluid passage is in fluid communication with the passage 44 of cylinder 16 which is in communication with the interior 46 of said cylinder, as best shown in Fig. 3.

The lower portion 48 of projection 28 is spherically formed complementary to the socket portion 50 of the coupling element 40. Similarly, the lower portion 49 of coupling element 40 is also in the form of a sphere or ball and is formed complementary to the socket 52 formed integral with the upper part of cylinder 16. The spherical formations 48 and 49 and their complementary sockets 50 and 52 are ground and polished whereby a fluid-tight seal between the projection 28, coupling element 40 and cylinder 16 is obtained. It will be readily apparent that any misalignment between the projection 28 of valve body 20 and the cylinder 16 will have no adverse effect on the fluid communication between the passages 30, 42 and 44 since the coupling member 40 will effectively compensate for any such misalignment. Thus, due to the ball and socket joints above described, coupling the projection 28 to the upper portion of cylinder 16 requires no critical alignment. From the above it will be seen that the fluid passage 30 is in fluid communication with the interior 46 of the cylinder 16 at all times in the assembled condition of pump 10.

The peripherally extending surface 54 of valve member 22 and its complementary interior surface 56 of the valve body 20 are ground and polished whereby a fluid-tight seal is maintained between the valve member 22 and the valve body 20. It will also be evident from the above that on the fluid inlet stroke the port 32 is in registry with fluid passage 30, by means of fluid passage 36, and fluid passage 38 will be cut off from its associated fluid passages in the valve body while on the fluid expelling or dispensing stroke fluid passage 38 will be in registry with fluid passages 27 and 30 with the fluid passage 36 being out of registry with its associated passages in valve body 20. Thus on each revolution of the valve member 22 the instant apparatus will be effective to dispense a predetermined quantity of fluid through port 34 and its associated fluid outlet 26.

Cylinder 16 is adapted to be releasably secured in a vertical disposition relative to the main frame 12 by means about to be described. With reference to Fig. 12, there is shown a cylinder clamping element 58 which is of generally cylindrical contour having tapered end portions 60. There is provided a plurality of uniformly spaced longitudinally extending slots 62 with each slot opening into only one end 60 of the clamping element 58 in alternate fashion. Thus each longitudinal slot 62 opens into only one end of the clamping element 58 with adjacent slots opening into alternate ends of the clamping element whereby an extremely uniform clamping action is effected when the clamping element 58 is operatively associated with the cylinder 16 as shown in Fig. 3.

The clamping element 58 is adapted to surround the outer peripheral surface 64 of cylinder 16 and the clamping element and its associated cylinder extending therethrough are adapted to be releasably clamped relative to the main frame 12 in a manner about to be described. The clamping element 58 and cylinder 16 are adapted to be positioned in the support member 66, which support member is provided with an annular shoulder 68 which is adapted to rest on the surface 70 of the frame 12. The support member 66 has a body portion 72 which extends through the opening 74 of the frame 12 and is adapted to be releasably clamped in such position by means of the clamping screw 76 which has a threaded shaft portion 78, the end portion of which is adapted to bear against the body portion 72 of the support member 66 to thereby releasably clamp the latter in position relative to frame 12. The support member 66 has an opening 79 extending therethrough, one end of which is enlarged and internally threaded at 80 for the reception of the apertured clamping element 82. The clamping element 82 is provided with a serrated annular shoulder 84 for convenience in manually turning said element relative to the support member 66. The opening 79 of member 66 is formed complementary to clamping element 58. It will be apparent from the above that when the element 82 is tightened relative to the support member 66 said element will be effective to peripherally engage an exterior surface portion of the clamping element 58 to thereby secure the cylinder 16 in position. Thus the tightening of the element 82 relative to its associated portion of the clamping member 66 will be effective to force the clamping member 58 in a radially contracting direction, which force in turn will be effective to clamp the cylinder 16 in position and will be uniform over the surface area of said cylinder.

Positioned in the cylinder 16 is a piston 18 which is adapted to be longitudinally reciprocated relative to said cylinder and is releasably clamped in position by means about to be described. The peripheral surface 86 of piston 18 and its complementary interior surface 88 of cylinder 16 are ground and polished and have a sealing fit and are in fluid sealing relationship without the need of extrinsic means such as packing rings, piston-rings, and the like. The piston 18 is adapted to be releasably clamped in piston clamping member 90 which comprises a body portion 91 and complementary portions 92 and 94 (see Fig. 13) having an aperture 96 extending therebetween for the reception of the lower portion of piston 18. The complementary portions 92 and 94 are hingedly mounted to each other by means of pin 98 and clamping screw 100, which is associated with aligned apertures 102 and 104 extending through the complementary portions 92 and 94, respectively, is adapted to be manually tightened to secure the piston 18 in position. The clamping screw 100 is provided with a knurled handle 106 to facilitate the manual rotation of clamping screw 100. Thus the piston 18 is adapted to be releasably secured to the piston clamping member 90 and the latter member is adapted to be longitudinally reciprocated to thereby longitudinally reciprocate piston 18 relative to the cylinder 16. The piston-clamping member 90 is mounted in the frame 12 for longitudinal reciprocation and, more particularly, the frame 12 is provided with a bearing portion 108 which is formed complementary to the peripherally extending surface portion 110 of said piston clamping member.

The fluid contact portions of the pump 10, namely the valve assembly 14, the coupling member 40, the cylinder 16 and the piston 18, are all adapted to be readily removable and replaceable for cleaning, sterilizing or repair, or for altering the capacity of the pump. The coupling member 40 may be retained in assembled relation to the cylinder 16 and the protuberance 28 of the valve body 20 by means of any suitable clamps, such as clamps 299 shown in the drawings. These parts may be formed of any suitable material, for example, but without limitation, glass, stainless steel, and the like, and said parts may be disassembled from frame 12 by a quick and simple manual operation and without the need of tools of any kind. The valve assembly 14 is releasably mounted to the upper portion 11 of the frame 12 and the end portion 12 of valve 14 is adapted to be positioned in the complementary socket 114 which is an integral part of portion 11 of frame 12. In order to releasably maintain the valve assembly 14 so positioned, there is provided a valve mounting arm 116 which is pivotally mounted to the frame 12 by means of the pivot pin 118.

There is provided a valve clamping screw **120** which extends through aperture **122** in valve arm **116** and which is received in aperture **124** of frame **12** which is threaded complementary to the shaft portion **126** of valve clamping screw **120**. The valve mounting arm **116** has a socket portion **128** which is adapted to extend over the portion **130** of the valve body **20** and said valve arm **116** is clamped in such position against the valve body by means of clamping screw **120**. Thus to position the valve assembly **14** relative to the frame **12** it is merely necessary to insert the end portion **112** of the valve assembly in socket **114** of the frame and to rotate the valve mounting arm **116** into the position shown in Fig. 10, in which the portion **128** thereof extends over the portion **130** of valve body **20**, and to clamp the valve mounting arm in such position by means of the valve clamping screw **120**. It will be readily apparent from the above that in order to disassemble the fluid contact parts of the pump it is merely necessary to unscrew valve clamping screw **120** and swing the valve arm **116** away from the valve assembly **14** whereby the latter may be readily removed from the frame **12**. On removing the valve assembly **14** from the frame **12** the coupling member **40** will be free for removal and the cylinder and piston may in turn be removed by loosening clamping screws **76** and **106**, respectively. It will also be readily apparent from the above that to remove cylinder **16** from the cylinder clamping element **58** it will only be necessary to loosen the element **82**. Thus from the above it will be seen that the fluid contact parts of the pump **10** may be readily assembled and disassembled by a few simple manual operations wherefor the instant apparatus may be readily cleaned and sterilized.

Suitably secured to piston clamping member **90** is a part **132** which is adapted to vertically reciprocate piston **18**. More particularly, the lower portion of the clamping member **90** is apertured at **134**, which aperture is threaded complementary to the threaded projecting portion **136** of part **132**, whereby part **132** is securely assembled to the clamping member **90**. Rotatably mounted at the upper portion of part **132** is a roller **138** which has a shaft **140** extending therethrough, which shaft is mounted in the aligned apertures **142** of part **132** (see Figs. 3 and 4). The roller **138** is adapted to coact with eccentric **144** which is secured to the main drive shaft **146** in any suitable manner. Thus on the rotation of drive shaft **146** eccentric **144** will be effective to raise roller **138**, which roller in turn will be effective to raise piston **18**. Thus eccentric **144**, on rotation of shaft **146**, will be effective to vertically move piston **18** in an upward direction in the fluid dispensing stroke of the apparatus. The main shaft **146** is journaled for rotation in the bearings **148** which are secured in position relative to the main frame **12** in any conventional manner.

The drive shaft **146** may be manually rotated by means of operating handle **150** mounted on said shaft and may be selectively power rotated by any conventional motor drive (not shown) which is adapted to rotate shaft **152** which is connected to the main shaft **146** through clutch **154**. Clutch **154** may be of any conventional construction which is operable to disengage the motor drive shaft **152** from the motor shaft **146** so that the pump can be manually operated by handle **150**. Handle **150** is connected to collar **151** for turning the latter and thusly rotate shaft **146** when said collar is in engagement with the cross pin **153** fixed to external part **147** of said shaft. Said collar is slidable longitudinally of shaft part **147** to engage and disengage said pin **153** and thus be operatively connected to and disconnected from shaft **146**. It will be understood that when collar **151** is disconnected from pin **153**, said collar is not rotated by shaft **146** when the latter is power operated through clutch **154**. It will be readily apparent that when the operating crank **150** is rotated and is operatively associated with shaft **146**, or when the motor is drivingly clutched to shaft **146**, the rotation of the latter will be effective to vertically raise piston **18** to dispense a predetermined quantity of fluid through outlet **26**.

The part **132**, which constitutes the piston operating member of the instant apparatus, is provided with a pair of projecting flanges **160** each of which is provided with a fixed guide shaft **162** disposed, and operating, within compression spring **164**, with one end of said spring abutting against the face **166** of flange **160** and the opposite end of said spring being received in suitable recesses **168** in an intermediate portion **169** of the main frame **12**. The piston operating member **132** is further guided for reciprocatory motion by means of guide rod **170** which is suitably affixed to the projecting part **172** of an intermediate portion of main frame **12**. The piston operating member **132** is provided with an arcuate cut-out portion **173** which is formed complementary to rod **170** and which is adapted to ride up and down peripheral portions of rod **170** to thereby guide the piston operating member **132** in its vertical reciprocatory path of motion. It will be evident from the above, that eccentric **144** will be effective to raise or elevate the piston operating member **132**, the raising of the latter element being effective to compress the springs **164**, which surround shafts **162**, which compressed springs will be effective to return the piston operating member **132** to its lowermost position to complete a cycle of operation. Thus on the rotation of the main shaft **146** the eccentric **144** will raise the piston operating member **132** and its associated piston **18** and the springs **164**, operatively associated with the piston operating member, will return the latter member to its lowermost position to thereby return piston **18** to its lowermost position. Piston operating member **132** has at its lower portion a centrally positioned guide shaft **174**, which shaft has suitably positioned therein and projecting therefrom a hardened steel ball **176**, the latter ball coacting with adjustment means to be described below. Shaft **174** is positioned in the bearing part **178** which in turn is secured to the fixed part **180** of the instant apparatus. The inner peripheral surface **182** of bearing part **178** is adapted to coact with the outer peripheral surface **184** of shaft **174** whereby the bearing part **178** and shaft **174** will coact to guidingly support the piston operating member **132** for its range of reciprocatory motion.

The valve member **22**, which is adapted to be rotated relative to the valve body **20**, is driven from the main drive shaft **146** by gear **186** which is suitably fixed to said main drive shaft, gear **186** being permanently in mesh with gear **188** which is fixed to vertical drive shaft **190**. Shaft **190** is journaled for rotation in the frame **12** at the portions **191** and **193** thereof . At the opposite end of shaft **190** there is provided a gear **192** which is permanently in mesh with gear **194** fixed to the horizontal drive shaft **196**, the latter shaft being in turn journaled for rotation in the housing **11** at the upper part of the main frame **12**. The shaft **196** is provided with a recess **200** which is adapted to receive the end portion **202** formed integral with valve member **22**. The end portion **202** is of generally cylindrical contour having a flattened portion **204** and recess **200** is formed complementary to end portion **202** so that when the end portion **202** is positioned in recess **200** the rotation of shaft **196** will be effective to concomitantly rotate the valve element **22** to thereby effect the dispensing of fluid to be pumped. The rotation of the main shaft **146**, which is effective to rotate the eccentric **144**, will also be effective to rotate the shafts **190** and **196**, the rotation of the latter shaft being effective to rotate the valve member **22** relative to its associated valve body.

In order to insure a constant fluid-sealing relationship between valve member **22** and valve body **20** there is provided in the shaft **196** means to urge the valve member **22** to the right, as shown in Fig. 3, or in fluid-sealing relation with the valve body **20**. More particularly, the

shaft 196 is apertured at 205 for the reception of tubular element 206 which has a solid or closed face 208 at one end. Positioned in tubular element 206 is a coil spring 210 and a steel ball 212, said steel ball being positioned between one end of spring 210 and the centrally positioned protuberance 214 formed integral with housing 11. As best shown in Fig. 3A, the spring 210 and its associated steel ball 212 will be effective to urge said tubular element against the face 213 of portion 202 to spring urge element 22 in a fluid-sealing direction. Thus spring 210 will provide a constant force on the valve member 22 in a fluid-sealing direction to effect a fluid-sealing relation between valve member 22 and its associated valve body.

The capacity of the instant pump 10 may be altered by interchanging cylinder 16 and its associated piston 18 and further the amount of fluid to be dispensed by the instant mechanism is adjustable pursuant to one of the features of the present invention. To vary the quantity of fluid dispensed by pump 10, without varying the speed of rotation of shaft 146, the operating length of the stroke of the piston 18 is adjustable by means of an adjustable stop device which is provided to limit the intake stroke of piston 18. With reference to Fig. 4, the adjustable stop device includes a micrometer screw 216 which is threadedly received in its complementary support element 218, the latter element being threadedly received in support member 220 which is fixed to member 180 in any suitable manner (see also Fig. 7). Thus element 218 is threaded internally complementary to the threads on micrometer screw 216, which element is fixed relative to member 180 and therefore is fixed relative to the main frame 12. The ball 176, which is associated with piston-operating member 132, is operatively associated with the upper face 217 of micrometer screw 216, the micrometer screw being effective to limit the downward movement of the piston-operating member 132 to thereby thus limit the intake stroke of piston 18. Provision is made for turning screw 216 by accurately measurable amounts whereby to accurately predetermine the length of the intake stroke of piston 18. In order to rotate screw 216 and to thereby limit the length of the intake stroke of piston 18, there is provided adjusting mechanism which will now be described in detail.

The mechanism for rotating the micrometer screw 216 comprises the manually operable member 222 which as here shown is in the form of a drum having a suitable scale on its outer peripheral surface, as described in detail in the afore-referred to co-pending application. The lower edge of said drum is provided with a serrated circumferential flange 224 for convenience in manually turning said drum, said serrated portion being accessible externally of frame 12. A vernier member 226 is mounted for rotation co-axially with drum 222 and carries a vernier scale on its peripheral outer surface complementary to the scale on member 222. The drum 222 has its hub portion 228 fixed to sleeve 230, which sleeve is fixed to the shaft 232, the latter shaft being fixed to the micrometer screw 216 whereby the rotation of drum 222 will be effective to directly rotate micrometer screw 216. The hub 234 of the vernier member 226 is mounted for turning movement about the sleeve 230, which is fixed to and rotates with drum 222 coaxially with the screw 216. The drums 222 and 226 are connected by reducing gear mechanism, for example planetary gear mechanism, as a result of which drum 226 has a smaller circumferential movement than that of drum 222. The planetary gear mechanism about to be described is substantially the same as the planetary gear mechanism described and illustrated in the referred to co-pending application. The ring gear 236 is fixed to sleeve 230 and meshes with gears 238 journaled for rotation on the pins 240 which are carried by the vernier drum 226. The gears 238 mesh with the internal gear 242 carried by member 180, said internal ring gear being secured to member 180 in any conventional manner, as by means of screws 244. From the above it will be apparent that the micrometer screw 216, is rotatable relative to the member 218 and thus adjustable longitudinally of its axis by the rotation of manually operated drum 222, and the vernier drum 226 will also be rotated by the rotation of the screw 216 through the planetary gear mechanism constituted by the gears 236, 238 and 242.

The planetary gear mechanism, above described, provides for very accurate measurements and adjustments of the turning of the micrometer screw 216 of the stop device of the piston-operating member 132 to thus provide for accurate measurements of fluid dispensed during the operation of the pump. In order to secure an even more accurate measurement and adjustment of the rotation of the micrometer screw 216, and its consequent axial movement, there is provided means whereby the micrometer screw 216 may be rotated a very small accurately measured amount. This provision, which constitutes the fine adjustment for controlling the quantity of fluid dispensed during the dispensing stroke of the operation of the pump, comprises an adjusting clamp member 250 of the split type which is apertured at 252 for the reception of complementary portions of sleeve 230 which surrounds and is fixed to shaft 232. (See Figs. 4 and 5.) The clamp member 250 is adapted to be releasably clamped to shaft 232 and for this purpose there is provided a clamping arm 254 having a handle 256 secured at one end and a threaded shaft 258 fixed to its opposite end. It will be understood that the clamp member 250 is suitably apertured and threaded at 251 for the reception of the shaft 258 so that when clamping arm 254 is rotated in a tightening direction the clamping member 250 will be firmly clamped to its associated sleeve portion 230 whereby the rotation of the clamping member 250 will be effective to rotate the micrometer screw 216 for the axial adjustment thereof. Thus the clamping arm 254 may be rotated in one direction about its longitudinal axis for clamping the clamping member 250 to the shaft 232 and may be rotated in an opposite direction for releasing the clamping member 250 from clamping engagement with the shaft 232.

In order to rotate the clamping member 250 by accurately measured small amounts when in clamping engagement with the shaft 232, there is provided a control arm 260 which may be formed integral with the clamping member 250. The base 13 of the frame 12 is apertured at 262 for the reception of adjusting screw 264 which is threadedly received in the aperture 262. The adjusting screw 264 is provided with a knurled handle 266 to facilitate the manual actuation of screw 264, the latter screw being provided with an end portion 268 which is adapted to act as a stop member for the end portion 270 of the arm 260. The base 13 of the main frame 12 is also provided with an aperture 272 which is aligned longitudinally with the aperture 262. Positioned in aperture 272 is a pin 274 which is spring-loaded against the portion 270 of arm 260 by means of a spring 276 positioned in aperture 272 between one end of pin 274 and the retaining screw 278, the latter screw being received in the threaded aperture 280 which is coaxial with the aperture 272. As best shown in Fig. 5, it will be seen that the spring driven pin 274 will be effective to spring-urge the end 270 of arm 260 against the end portion 268 of the adjusting screw 264. Thus by rotating and consequently adjusting the handle 266 of screw 264 the latter screw will be rotated and axially displaced whereby the arm 260 will be rotated a corresponding amount about its associated shaft 232. It will be understood that the fine adjustment above described is effective only when the clamping member 250 is clamped to the sleeve 230 and conversely the fine adjustment will not be effective when the clamping member 250 is unclamped from the sleeve 230. The rotation of the adjusting screw 264 will be effective to rotate the shaft 232 a small amount relative

to the major adjustment above described. It will also be apparent that the adjusting screw **264** may be graduated in increments consistent with the graduations on the drums **222** and **226**. After the major adjustments of the micrometer screw **216** are made it is merely necessary to clamp the clamping member **250** relative to the shaft **232** and to rotate the screw **264** as desired in order to effect the requisite adjustment of the screw **216** whereby to provide for the accurate measurement of the fluid quantity being dispensed during the operation of the pump. It appears evident that the range of adjustment of rotation of the shaft **232** by means of the above described fine adjustment is relatively narrow whereby the screw **264** will be effective to render extremely small and accurate adjustments of the micrometer screw **216**. It will be noted that the above adjustments for the micrometer screw **216** can be effective in both the operative and inoperative conditions of the pump whereby accurate adjustments of the amount of fluid dispensed may be made efficiently and quickly.

In order to measure the number of revolutions of the shaft **146** and consequently the number of cycles of the instant pump there is provided a revolution counter **282** having a window **284** which is visible externally of the pump. The revolution counter **282** may be affixed to the main frame **12** in any desired manner and in the illustrative example the counter **282** is actuated by means disposed internally of the apparatus. The main shaft **146** has secured thereto a cam **286** which is adapted to actuate the counter-actuating arm **288** having a follower element **290** in operative engagement with the cam **286**. Thus on the rotation of the main shaft **146** the cam **286** will coact with the follower **290** to register the number of revolutions of the shaft **146** at the counter window **284**. The counter **282** is further provided with a reset knob **292** which is accessible externally of the apparatus and which may be manually rotated to reset the counter **282** as desired. It will be evident that the counter-actuating means of the instant apparatus, which is disposed internally of the frame **12**, minimizes the danger of manual actuation of the counter inadvertently or by accident.

The above pump **10**, having the adjustment features above described, provides for the dispensing of a predetermined quantity of fluid during each fluid dispensing cycle with a very high degree of accuracy. The above described means for achieving the accurate measurement of the fluid dispensed by the pump provides for such quantity to be identical under identical conditions at the same setting thereby imparting to the pump the quality of accurate reproducibility. The means for adjusting the pump stroke are operative both during the operative and inoperative condition of the pump to dispense variable predetermined quantities of fluid. All the fluid contact parts of the pump, as described in detail above, are readily removable and replaceable for cleaning and sterilizing. Thus by the mere manipulation of screws **76**, **106** and **120** all the fluid contact parts may be removed from the apparatus without the use of tools and in a very short time. The rotary valve means **14** and its associated mechanism for its actuation are simple and foolproof and in conjunction with its associated length of stroke adjusting mechanism provides for dispensing with a high degree of accuracy a variable predetermined quantity of fluid during each fluid dispensing cycle of the pump.

While there is shown and described herein certain specific steps for carrying out the inventive concept of this method it will be manifest to those skilled in the art that various modifications and embodiments of this inventive concept may be made without departing from the spirit and scope of the underlying inventive concept and the same is not limited to the specific method herein shown and described except insofar as indicated by the scope of the appended claims.

Having thus described our invention, what we claim and desire to secure by Letters Patent, is:

1. In a pump having a cylinder, a piston reciprocable therein, and means for reciprocating said piston comprising a member movable to a projected position for moving said piston in its fluid-expulsion stroke and to a retracted position in the movement of said piston in its fluid-intake stroke, a variable stop device for limiting the movement of said member to its retracted position comprising a stop member adjustably movable to various positions longitudinally of the path of said piston-operating member, manually operable means movable to various positions for moving said stop member to adjust the position thereof, means including a vernier device operatively connected to said manually operable means and operable thereby to indicate the adjusted position of said stop member, and additional fine adjustment means for adjustably moving said stop member a predetermined relatively small amount, said last mentioned means comprising a member adapted for releasable operative association with said stop member, said member having associated structure mounted for movement in response to the movement of an adjustment device, and an adjustment device adapted for manual operation, said device being operatively associated with said structure whereby the movement of said device is effective to move said structure and concomitantly said member to thereby move said stop member an amount corresponding to the amount of the movement of said device.

2. In a pump having a cylinder, a piston reciprocable therein, and means for reciprocating said piston comprising a member movable to a projected position for moving said piston in its fluid-expulsion stroke and to a retracted position in the movement of said piston in its fluid-intake stroke, a variable stop device for limiting the movement of said member to its retracted position comprising a stop member adjustably movable to various positions longitudinally of the path of said piston-operating member, manually operable means movable to various positions for moving said stop member to adjust the position thereof, and additional adjustment means for adjustably moving said stop member a predetermined relatively small amount, said last mentioned means comprising a member adapted for releasable operative association with said stop member, said member having associated structure mounted for movement in response to the movement of an adjustment device, and an adjustment device adapted for manual operation, said device being operatively associated with said structure whereby the movement of said device is effective to move said structure and concomitantly said member to thereby move said stop member an amount corresponding to the amount of movement of said device.

3. In a pump having a cylinder, a piston reciprocable therein, and means for reciprocating said piston comprising a member movable to a projected position for moving said piston in its fluid-expulsion stroke and to a retracted position in the movement of said piston in its fluid-intake stroke, a variable stop device for limiting the movement of said member to its retracted position comprising a stop member adjustably movable to various positions longitudinally of the path of said piston-operating member, manually operable means movable to various positions for moving said stop member to adjust the position thereof, and means including a vernier device operatively connected to said manually operable means and operable thereby to indicate the adjusted position of said stop member, said stop member comprising a screw and said vernier device including a rotary member and planetary gear mechanism actuated by said screw and connected to said rotary member for turning the latter pursuant to the operation of said manually operable means, the latter having a scale and said rotary member having a vernier scale complementary to said first mentioned scale, and additional adjustment means for adjustably moving said stop member a predetermined relatively small amount, said last mentioned means comprising a

member adapted for releasable operative association with said stop member, said member having associated structure mounted for movement in response to the movement of an adjustment device, and an adjustment device adapted for manual operation, said device operatively associated with said structure whereby the movement of said device is effective to move said structure and concomitantly said member to thereby move said stop member an amount corresponding to the amount of movement of said device.

4. In a pump having a cylinder, a piston reciprocable therein, and means for reciprocating said piston comprising a member movable to a projected position for moving said piston in its fluid-expulsion stroke and to a retracted position in the movement of said piston in its fluid-intake stroke, a variable stop device for limiting the movement of said member to its retracted position comprising a rotary screw longitudinally adjustable, by the turning thereof, to various positions longitudinally of the path of said operating member, a stationary member in which said screw is threaded for said movement thereof, a rotary member connected to said screw for turning and adjusting the latter, and additional adjustment means for adjustably moving said rotary screw a predetermined amount, said last mentioned means comprising a clamping member adjusted to be releasably clamped for operative association with said rotary screw, said clamping member having a projecting arm, and an adjustment screw adapted for axial movement on its rotation, said adjustment screw constituting a stop device for said arm whereby when said clamping member is operatively associated with said rotary screw the movement of said adjustment screw will be effective to move said arm to thereby move said clamping member, the movement of the latter member being effective to move said rotary screw an amount corresponding to the amount of movement of said adjustment screw.

5. In a pump having a cylinder, a piston reciprocable therein, and means for reciprocating said piston comprising a member movable to a projected position for moving said piston in its fluid-expulsion stroke and to a retracted position in the movement of said piston in its fluid-intake stroke, a variable stop device for limiting the movement of said member to its retracted position comprising a stop member adjustably movable to various positions longitudinally of the path of said piston-operating member, manually operable means movable to various positions for moving said stop member to adjust the position thereof, and additional fine adjustment means for adjustably moving said stop member a predetermined relatively small amount, said last mentioned means comprising a member adapted for releasable operative association with said stop member, said member having associated structure mounted for movement in response to the movement of an adjustment device, and an adjustment device adapted for manual operation, said device operatively associated with said structure whereby the movement of said device is effective to move said structure and concomitantly said member to thereby move said stop member an amount corresponding to the amount of movement of said device, and means for urging said structure against said adjustment device.

6. In a pump having a cylinder, a piston reciprocable therein, and means for reciprocating said piston comprising a member movable to a projected position for moving said piston in its fluid-expulsion stroke and to a retracted position in the movement of said piston in its fluid-intake stroke, a variable stop device for limiting the movement of said member to its retracted position comprising a rotary screw longitudinally adjustable, by the turning thereof, to various positions longitudinally of the path of said operating member, a stationary member in which said screw is threaded for said movement thereof, a rotary member connected to said screw for turning and adjusting the latter, and additional adjustment means for adjustably moving said rotary screw a predetermined amount, said last mentioned means comprising a clamping member adapted to be releasably clamped for operative association with said rotary screw, said clamping member having a projecting arm, and an adjustment screw adapted for axial movement on its rotation, said adjustment screw constituting a stop device for said arm whereby when said clamping member is operatively associated with said rotary screw the movement of said adjustment screw will be effective to move said arm to thereby move said clamping member, the movement of the latter member being effective to move said rotary screw an amount corresponding to the amount of movement of said adjustment screw, and a spring-driven pin for urging said arm in abutting relation with the end of said stop device.

7. In a pump having a cylinder, a piston reciprocable therein, and means for reciprocating said piston comprising a member movable to a projected position for moving said piston in its fluid-expulsion stroke and to a retracted position in the movement of said piston in its fluid-intake stroke, a variable stop device for limiting the movement of said member to its retracted position comprising a rotary screw longitudinally adjustable, by the turning thereof, to various positions longitudinally of the path of said operating member, a stationary member in which said screw is threaded for said movement thereof, a rotary member connected to said screw for turning and adjusting the latter, and additional adjustment means for adjustably moving said rotary screw a predetermined amount, said last mentioned means comprising a clamping member adapted to be releasably clamped for operative association with said rotary screw, said clamping member having a projecting arm, and an adjustment screw adapted for axial movement on its rotation, said adjustment screw constituting a stop device for said arm whereby when said clamping member is operatively associated with said rotary screw the movement of said adjustment screw will be effective to move said arm to thereby move said clamping member, the movement of the latter member being effective to move said rotary screw an amount corresponding to the amount of movement of said adjustment screw, a spring-driven pin for urging said arm in abutting relation with the end of said stop device, and means for releasably clamping said clamping member in operative association with said rotary screw.

8. In a pump, a supporting frame, a cylinder mounted in said frame, a piston reciprocable in said cylinder, a piston operating member for reciprocating said piston between a projected position and a retracted position, said projected position corresponding to the fluid-expulsion stroke and said retracted position corresponding to the fluid-intake stroke, a variable stop device for limiting the movement of said member to its retracted position comprising a rotary screw longitudinally adjustable, by the turning thereof, to various positions longitudinally of the path of movement of said operating member, a stationary member in which said screw is threadedly mounted for said movement thereof, means connected with said screw and turnable with the latter, and fine adjustment means for moving said rotary screw a predetermined amount, said last mentioned means comprising a clamping member adapted to be releasably clamped to said means turnable with said screw, said clamping member having a projecting arm, and an adjustment screw mounted in said frame for longitudinal adjustment by the turning thereof, one end of said adjustment screw being operatively associated with an end portion of said arm whereby the turning of the former will be effectual to move the latter and concomitantly said clamping member, the movement of the latter member being effective to turn said rotary screw an amount corresponding to the amount of turning of said adjustment screw, a spring driven pin for urging said arm in abutting relation with said one

end of said adjustment screw, and means accessible externally of said frame for releasably clamping said clamping member to said means turnable with said screw.

9. In a pump having a cylinder, a piston reciprocable therein, and means for reciprocating said piston from its fluid-expulsion stroke to its fluid-intake stroke, a variable stop device for adjustably limiting the fluid-intake stroke of said reciprocating means comprising a stop member adjustably movable to various positions longitudinally of the path of movement of said reciprocating means, manually operable means movable to various positions for moving said stop member to adjust the position thereof, and fine adjustment means for adjustably moving said stop member a predetermined relatively small amount, said last mentioned means comprising a member releasably operatively associated with said stop member, means for releasably clamping said last mentioned member in operative association with said stop member, and an adjustment device operatively connected to said last mentioned member whereby the adjustment of said device is effective to move said last mentioned member to thereby move said stop member an amount corresponding to the adjustment of said device, said last mentioned member having a projecting arm operatively associated with said adjustment device, and means for resiliently urging said arm against said adjustment device.

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