Feb. 6, 1968 J. MAURUKAS 3,367,746

SELF-CLEANING SYRINGE AND PUMP SUITABLE THEREFOR

Filed Oct. 11, 1965 2 Sheets-Sheet 1

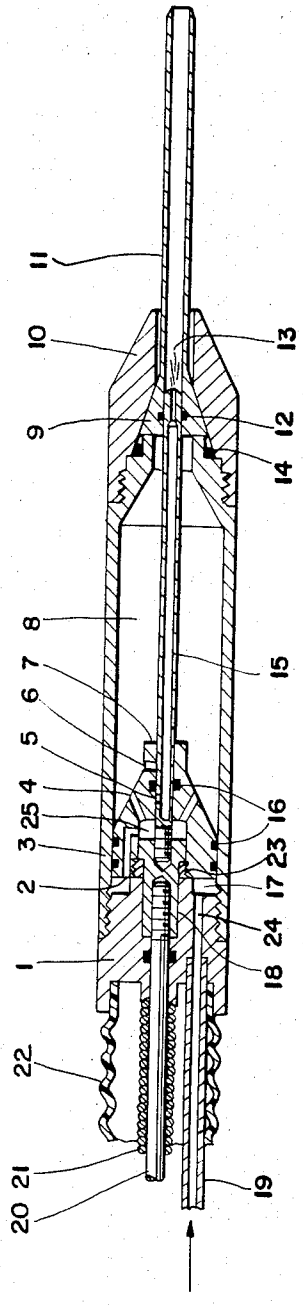


Fig. 1

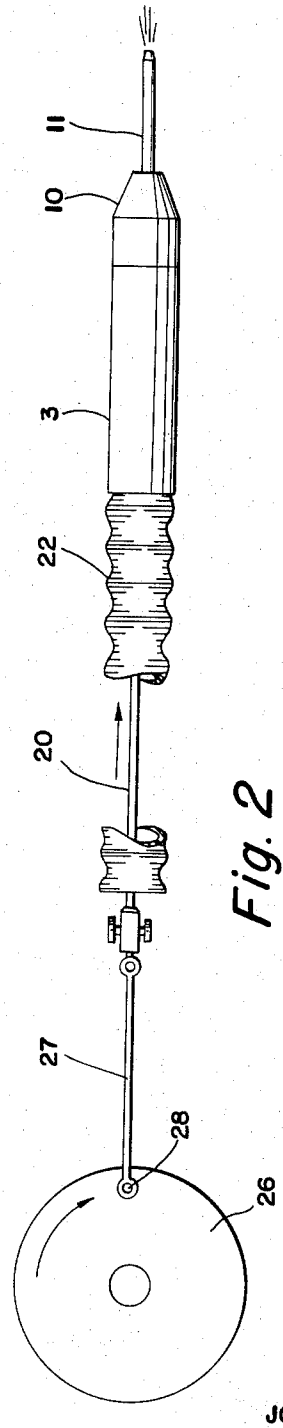


Fig. 2

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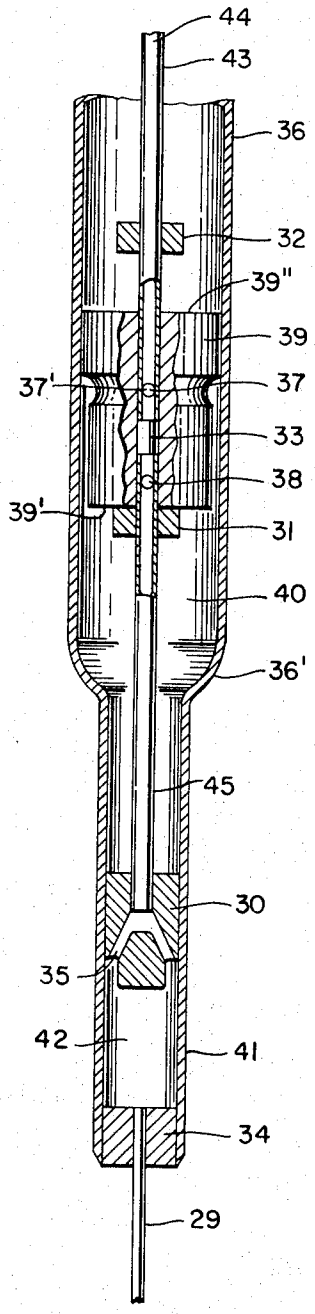


Fig.3

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SELF-CLEANING SYRINGE AND PUMP SUITABLE THEREFOR

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Continuation-in-part of application Ser. No. 394,955, Sept. 8, 1964. This application Oct. 11, 1965, Ser. No. 494,671

5 Claims. (Cl. 23—253)

This application is a continuation-in-part of copending application Serial No. 394,955, filed September 8, 1964, now abandoned.

The device of this invention comprises a constant-volume self-cleaning syringe or pump comprising

(a) a cylindrical shell having a reservoir therein;

(b) a plunger arm and base;

(c) a plunger fitting closely into the reservoir and adapted to move axially in the reservoir with such close contact as to provide sealing and wiping contact therewith, the plunger having an axial opening extending therethrough to provide flow communication between a supply source of solvent and said reservoir and openings in said plunger adapted to permit and to cut off said communication;

(d) a reagent tube extending from said reservoir and in flow communication therewith; and

(e) an extension of said plunger arm extending into said reagent tube and adapted to fit slidably and snugly against the inside wall of said reagent tube and adapted to draw reagent into said tube through an opening at the opposite end of said tube by linear movement of said extension and to force reagent and solvent from said tube upon movement in the opposite direction.

This invention relates to a syringe designed to deliver a specific volume of solution. More specifically, this invention relates to a syringe which is self-cleaning in character and thereby adapted to deliver in successive operations identical or other solutions. Still more specifically, this invention relates to a syringe which is capable of mixing a desired volume of liquid solute in a desired volume of solvent and total specific volume of solution to be delivered. Still more specifically, it relates to a syringe which by simple replacement of parts can be altered to modify the specific volume to be delivered. Moreover, this invention relates to the pumping unit in said syringe which is adaptable to other uses. More specifically, this pump comprises a differential friction valve-plunger combination.

For various analytical purposes, it is desirable to measure and deliver particular volumes of reagent solutions. In many operations, the volume to be delivered in a number of successive operations is identical or can be made so. Making the volume of successive operations identical, permits the use of a single syringe for all steps in the procedure. In such cases, it is time consuming to measure such a standard volume in a measuring pipette and deliver the same. Such operation in addition to requiring time for measuring also requires a cleaning operation to remove last traces of solution remaining from prior operations.

Although a number of pipettes or syringes have been designed for the purpose of diluting to a specific volume a premeasured volume of reagent, or merely to deliver a specific volume of solution, these devices are unsatisfactory. The autodilutors presently on the market are instruments for pipetting and diluting micro-quantities of fluid semi-automatically in a ratio of 1:5 and higher. In such pipetting devices no cross-contamination will take place as long as the diluent syringe has ten times the capacity of the pipetting syringe. Cross-contamination of reagents, however, will unavoidably occur, if the ratio of reagent to diluent is reduced to 1:5 respectively.

For many operations this limited ratio of 1:5 or 1:10 is unsatisfactory since there are many chemical reactions requiring involved ratios lower than 1:10, and even as low as 1:2. This is very often due to the fact that chemical reactions at high dilutions of reagents produce little or no measurable color or precipitate.

Therefore, there is a need for a new reliable instrument capable of delivering a specific volume of reagent and diluent in the ratio of 1:2 to 1:5 and even lower with mixing and self-cleaning features to avoid waste of time in the measuring and cleaning operations presently necessary.

In accordance with the present invention, it has now been found that the disadvantages of the prior art methods for the purposes described above are overcome by the device of this invention and that a specific volume of solution having fixed concentrations of reagent and diluent can be repeatedly and successively delivered in a very simple operation with the self-cleaning syringe described herein.

The device of this invention is more simply described by referring to the drawings.

FIG. 1 is a cross-sectional side view of one modification of the syringe of this invention showing the various details of the assembled device.

FIG. 2 is a side view of the syringe of this invention connected with a drive wheel for mechanical operation.

FIG. 3 is a cross-sectional side view of a modification of the syringe of this invention.

In FIG. 1, sleeve 1 is in threaded relationship with outer shell 3. Sleeve 1 has an inner axial opening extending through its length which is adapted to accommodate rod 20 and plunger base 18. Plunger base 18 is affixed to and movable by linear axial movement of rod or cable 20. Plunger base 18 has its linear axis coinciding with that of sleeve 1 and also has affixed thereto plunger arm 15. Consequently linear axial movement of cable 20 effects corresponding linear axial movement of plunger base 18 and plunger arm 15, along the linear axis of shell 3 and in reservoir 8 in the interior of shell 3.

At its end opposite from that at which plunger base 18 is attached, shell 3 has affixed thereto in threaded relationship housing 10 which in turn embraces and retains in close relationship with the adjacent end of housing 3, the reagent tube 11. Reagent tube 11 is replaceable by corresponding tubes of identical inner diameter, but of varying length so as to allow variations in the volume of reagent to be drawn into the interior thereof in accordance with desired volumes of reagents as described hereinafter. Where desired, the units 9, 10 and 11 can be one integral piece attached to shell 3. In some cases, it may also be desirable to have shell 3 and units 9, 10 and 11 as one integral piece.

Plunger arm 15 has a passageway opening extending through its length and also has an outer diameter adapted to permit entry of the plunger arm 15 into the interior of reagent tube 11 and provide close intimate contact therewith.

Sleeve 1 also has an opening or aperture 24 therein communicating with the interior of tube 19 and adapted to permit the flow of fluid into an annular space 17 provided between sleeve 1, shell 3 and plunger 7. Plunger 7 also has apertures or openings 2 and 4 in communication with each other and with annular space 17 so that, in the position of the device shown in FIG. 1, solvent can flow from a supply connected to tube 19, through tube 19 into annular opening 17, through aperture 2 into annular opening 25, and through aperture 4 into the reservoir 8 in shell 3.

A portion of plunger base 18 fits into the axial opening in plunger 7 and is retained therein by threaded ring 23 which fits in threaded relationship into a threaded portion of said axial opening in plunger arm 7. Plunger base 18 is adapted to move on its linear axis when corre-

sponding movement is made by cable 20 so that when cable 20 is moved toward the right as the device is shown in FIG. 1, the plunger base 18 moves into annular space 25 so as to block flow of liquid through aperture 2 and also to cut off flow of liquid into apertures 4. Also when plunger base 18 has been moved to completely occupy the annular space 25, this causes a movement of plunger arm 15 so that the opening 5 is placed in flow communication with opening 6 in plunger 7. This communicating relationship of openings 5 and 6 permits flow of liquid from reservoir 8 through the interior passageway in plunger arm 15 and subsequently into the interior of reagent tube 11 and eventually out the opposite end of reagent tube 11. Consequently, as plunger 7 moves from one end to the other end of the inner space of the shell 3, the liquid originally in reservoir 8 is forced out the exit end of reagent tube 11.

As the cable continues its movement toward the right after plunger base 18 has completely filled the annular space 25, plunger base 18 engages the adjacent inner wall of plunger 7 so as to cause plunger 7 and plunger arm 15 also to move to the right. When this movement has continued to the extreme right of reservoir 8, plunger arm 15 has moved completely into the inner space of reagent tube 11 and plunger 7 has moved into close contact with the end wall surface of reservoir 8, plunger arm 15 has moved completely into the inner space of reagent tube 11 and plunger 7 has moved into close contact with the end wall surface of reservoir 8 which end wall surface corresponds in exact detail to the shape and dimensions of the outer surface of plunger 7 so that there is no space for liquid to remain between the contacting surfaces of plunger 7 and the end wall section of reservoir 8.

Thus by movement of the cable 20 to the extreme right, the various plungers effect removal of the solution from the interior space 8 and simultaneously the reagent from the interior of reagent tube 11. O-rings 16 provide close contact to effect sealing against leakage. Likewise O-rings 12 and 14 provide similar sealing.

The syringe is loaded with reagent and solvent by movement of cable 20 from the extreme right position as just described to the extreme left position shown in the drawing. This movement of the cable can be done manually or by mechanical means as shown in FIG. 2. In preparation for loading of the syringe, the end of the reagent tube 11 is advantageously wiped clean and then inserted into a supply of liquid reagent. As plunger base 18 is moved from the extreme right position towards the left, it moves out of the close contact with the interior wall of plunger 7 so that annular space 25 becomes unoccupied and liquid can flow through aperture 2 into annular space 25 and then through aperture 4 into interior space 8 which is being vacated for flow of liquid thereinto as the plunger 7 moves to the left. This movement of plunger 7 to the left creates a vacuum in reservoir 8 which increases the rate of flow of liquid thereinto. In the initial movement of plunger base 18 from the extreme right position toward the left, it effects a corresponding movement of plunger arm 15 so as to remove opening 5 from communicating relationship with opening 6 thereby cutting off any flow of liquid from reservoir 8 into the interior of plunger arm 15.

In the modification shown in FIG. 1, cable 20 is provided with protective armor 21 and is housed in flexible hose 22. While an armored cable of this type is preferred so as to prevent as much as possible any shock resulting from the parts coming into close contact with each other to effect the complete removal of liquid, it is also possible to have a rigid rod in place of cable 20 with the equipment carefully adjusted so as to avoid any shock of the plunger when it comes into contact with the interior end wall surface of reservoir 8.

As shown in FIG. 2, the linear axial movement of cable 20 can be actuated by mechanical means. In this case, driving wheel 25 is rotated by an actuating means, now shown, so that when the driving wheel is in the position shown in the drawing, plunger 7 is at its extreme right position and has delivered all the liquid from reservoir 8 and from the inner space of reagent tube 11. As the wheel continues its rotation from this position, the connecting point, at which wheel 26 is connected to arm 27, is moved to a position 180°, removed from the position shown in the drawing. At this new point, the connecting arm 27 has moved cable 20 and thereby plunger 7, plunger base 18 and plunger arm 15 to the extreme left positions shown in FIG. 1. In this movement of the plunger 7, plunger base 18 and plunger arm 15 from the extreme right to the extreme left position, the reagent tube 11 has been filled with reagent and the reservoir 8 has been filled with solvent.

When the diluent from reservoir 8 is exhausted through the narrowed opening at the end of plunger arm 15, it produces a spray jet effect 13 for dilution with the reagent in reagent tube 11 and also a self-cleaning action. The close fit of the exterior of plunger arm 15 and interior of reaction tube 11 augments the self-cleaning action. Practically 100% volumetric efficiency is effected in filling reservoir 8 with a new supply of diluent by way of ports 2 and 4 as cable 20 pulls plunger 7 toward the left. The volume of reservoir 8 can be modified by replacement with substitute shells 3 in which the inner diameter of shell 3 is constant so as to provide a close contact with the external diameter of plunger 7. However, correspondingly greater lengths of shell 3 replacement units provide correspondingly increasing volumes for reservoir 8.

Obviously, however, with such substitute shells of greater length, the distance of movement of plunger 7 from the extreme left to the extreme right positions must be modified accordingly. If the operation is performed mechanically, then corresponding adjustments must be made for the distance between the center of the connecting pivot pin 28 in its position as shown in FIG. 2 and its position in the extreme left position described above as being 180° removed from the position shown in FIG. 2. The distance between these two points should be identical to the distance to which plunger 7 must move from its extreme right end to its extreme left end position. Also, as described above, the volume of reagent collected in and discharged from reagent tube 11 can be modified by replacement of the reagent tube 11. The replacement tubes have identical interior diameters so as to assure intimate and wiping contact of the exterior surface of plunger tube 15 and the interior surface of reagent tube 11. The change in volume is effected by the correspondingly greater length of the replacement tube and the interior space therein. In such case, the longer plunger arm 15 is also substituted so as to assure complete occupation of the interior of reagent tube 11 and effective evacuation of the liquid therein.

It can be seen, therefore, that the effective volume of diluent and reagent to be collected and delivered is determined by the reservoir spaces in the interior of sleeve 3 and plunger arm 15 and the volume of reagent collected and delivered is determined by the reservoir in reagent tube 11. Generally, however, while it is possible to use interchangeable units as described above, so that these various modifications in volume of reagent and volume of diluent can be modified in various ways, it is generally desirable to have various sizes of these devices more or less permanently assembled to give the various volumes of diluent and reagent.

The use of an annular space 17 is preferred as the means for flow communication between solvent feed tube 19 and port 2. However, where means are provided to prevent rotation or movement of plunger 7 on its axis, then the opening in tube 19 can be positioned opposite port 2 so as to feed directly thereinto.

While only one means is shown for mechanically actuating movement of cable 20 from one extreme position to the other, it is possible to use various other actuat-

ing means such as electrical solenoid, hydraulic piston, etc. in place of the mechanical eccentric shown in FIG. 2. A floor switch or other actuating means can be used to leave the hands free for various hand manipulations. Reagent tube 11 is preferably of a transparent material for visual inspection during the various operating steps of the device. The O-rings 12 and 14 and 16 can be made of Teflon, nylon or rubber and are easily accessible for replacement should this be required.

The operation of the device of this invention is illustrated by the following example which is offered merely for illustrative purposes. It is not intended that the design of the syringe of this invention nor its method or scope of operation be restricted in any way by this illustration.

The device shown in FIG. 1 and FIG. 2 and as described above is assembled in a vertical position with the driving means located at the top and the reagent tube 11 at the lowest extremity. A diluent supply is connected with tube 19 and the cable driving means 26 is positioned at its lowest point, or as shown as described above the extreme right in the FIG. 2. Diluent has filled the reservoir 8 behind plunger 7 which is at that point closed to any flow of diluent through its interior.

A container of reagent is raised so that the lower extremity of reagent tube 11 is immersed below the surface of the liquid reagent. The driving means for rotating wheel 26 is then actuated, advantageously by foot operation of a floor switch, so that the wheel 26 is rotated 180° and as the cable 20 is moved upwardly and with it the various attachments described above, the reagent is drawn into the interior of reagent tube 11. At the same time, diluent flows through port opening 2 into annular opening 25 and through apertures 4 to reach that part of reservoir 8 being evacuated by plunger 7. When plunger 7 has reached its uppermost position, the desired volume of diluent has been forced into reservoir 8 and the desired volume of reagent has been drawn into reservoir 13 in the interior of reagent tube 11.

Not only does the very narrow opening at the delivery end of plunger arm 15 cause a spray effect in delivery of diluent into the interior of reagent tube 11, it also retards the flow of reagent from tube 11 into the interior of plunger arm 15. Plunger arm 15 retains a small volume of diluent from the preceding delivery and is retained therein during its upward movement by virtue of the movement of plunger arm 15 which shifts the opening 5 out of flow communication with opening 6 in plunger 7. This traps a constant volume of diluent in the interior of plunger arm 15 which is eventually replaced by the last corresponding volume of diluent in reservoir 8. In this way, the amount of diluent delivered in each cycle of operation is the effective volume of reservoir 8, that is the total volume of reservoir 8 minus the volume occupied by plunger arm 15.

An important feature of this invention is the self-cleaning action of plunger arm 15 in passing in close contact with the interior surface of reagent tube 11 while the spray effect of diluent passing through the narrow opening at the delivery end of plunger arm 15 simultaneously rinses the interior of reagent tube 11. This combination effects a self-cleaning action with small quantities of diluent and with an efficiency not previously attainable. Generally in order to effect such spraying the diameter of the restricted opening is no more than ⅓ the diameter of the reservoir or interior of reagent tube 11.

The various components of this syringe can be made of various materials depending somewhat on the type of solutions and reagents to be used in the device. Generally stainless steel is preferred where it is desirable to provide corrosion resistance to a variety of solutions. Various plastics can also be used, particularly where aqueous solutions are to be used.

FIG. 3 shows a simplified modification of the self-cleaning syringe of this invention. The top of the reservoir 40 can be open and is contained only by the position of plunger 39 having rear end 39'' and front end 39'. Solvent is introduced through opening 44 in tube 43 which also serves in this case as the plunger base arm. In this modification, reagent tube 41 is larger and has plunger arm portion 30 fitting closely against the inner wall of the reagent tube 41. As plunger arm portion 30 is moved upward, reagent from a supply positioned below aspirating needle 29 draws a quantity of reagent or sample into the reservoir 42 in the interior of reagent tube 41. In this upward motion, plunger base arm 43 is positioned so that lower shaft collar 31 moves plunger 39 upward and locates port opening 37 so that solvent being fed into opening 44 can flow through port opening 37 through port opening 37' (shown in FIG. 3 as coinciding with port opening 37) and extending from the axial opening in plunger 39 to the grooved exterior of plunger 39 and into the reservoir 40. As arm portion 30 reaches the top of reagent tube 41, reservoir 42 has become filled with reagent and reservoir 40 has become filled with solvent. The bottom of reservoir 40 is blocked by plunger arm portion 30 so that the reagent and solvent do not intermingle during the upward stroke of the plunger base arm 43. When the direction of plunger arm 43 is reversed and moved downwardly, plunger base 32 presses against plunger 39 and pushes it downwardly. At the same time, port opening 37 is moved downwardly and sealed off from communication with reservoir 40. At the same time, port opening 38 is now positioned below plunger 39 and in communication with the interior of reservoir 40. This permits the solvent from reservoir 40 to flow downwardly through the interior of plunger arm 45, through the openings in plunger arm portion 30 and into the reagent tube reservoir 42. At this point the solvent and the reagent intermingle and the resultant solution is pushed downward and out through aspirating needle 29 as plunger 30 passes downwardly to the bottom of reservoir 42. By close contact of plunger arm portion 30 with the inner wall of reagent tube 41, the solution is wiped clean from the interior wall of the reservoir 42. If it is desired that there be complete delivery of liquid from reservoir 42, plunger 30 can be made to conform exactly to the configuration of the end wall 34 at the bottom of reagent tube 41.

As indicated above, certain elements of this syringe which comprise the pumping element can be used for delivery of measured volumes of liquid for various other purposes. In such cases the liquid to be pumped is fed into opening 44 and out the opening in plunger arm 45 as described below.

Thus, the pumping unit comprises outer shell 36, reservoir 40, which in this case is narrowed at the bottom with an opening extending into the reservoir 42 of reagent tube 41 to permit exit of the liquid being pumped therefrom. The length of plunger arm 45 is sufficient to pass through and beyond the end wall 36' of reservoir 40 regardless of its position and has a widened portion 30 adapted to fit snugly but slidably against the inside wall of the reagent tube 11.

Also included in the pumping element are collars 31 and 32, plunger 39, port openings 37 and 38 and plug 33 which prevents communication between port openings 37 and 38.

In this pumping unit, liquid is fed into opening 24 as plunger 39 moves in an upward path so that with port opening 37 in communication with the interior of reservoir 40, liquid flows into reservoir 40. Then when the reservoir is filled and the direction of plunger 39 is reversed to a downward path, port opening 37 is moved downwardly and sealed from communication with reservoir 40 and port opening 38 is also moved downwardly and is placed in communication with the interior of reservoir 40. Plunger arm 45 is extended beyond the opening in the bottom of reservoir 40, so that plunger arm 45 extends beyond the bottom of reservoir 40 regardless of the position of plunger 39 and to deliver liquid therefrom

by virtue of communication of the interior of reservoir 40 through port opening 38 and out the interior of plunger arm 45.

The pumping unit used in the design of the self-cleaning syringe described herein is adaptable to many other uses and is described and claimed herein as a new pumping unit. This pump comprises a differential friction valve-plunger combination. This pump comprises sleeve 1 and outer shell 3. Sleeve 1 has an inner axial opening extending through its length adapted to accommodate rod 20 and plunger base 18. Plunger base 18 is affixed to rod 20 and is movable by linear axial movement of rod 20. Plunger base 18 has its linear axis coinciding with that of sleeve 1 and also has affixed thereto plunger arm 15. When used for purposes other than the self-cleaning syringe shown herein, plunger arm 15 can have a wider opening at the delivery end thereof than shown for the restricted opening in FIG. 1.

Linear axial movement of rod 20 effects corresponding linear axial movement of plunger base 18 and plunger arm 15 along the linear axis of shell 3 and in reservoir 8. In the pump design being described, housing 10 and reagent tube 11 can be replaced with any type of fitting which will connect to the receiving line or receptacle for the fluid being pumped, or such fittings can be omitted and the fluid being delivered through plunger arm 15 can be delivered into an open receptacle.

In the pump design the function of unit 9 which permits passage of plunger arm 15 therethrough and also completes enclosure of reservoir 8, can be performed by having a similar piece welded to or integrally formed as part of the end wall of reservoir 8. As an alternate, the end wall of reservoir 8 can be designed with an opening therein adapted to receive and permit passage of plunger arm 15 with a tight fit so that there is no leakage of fluid between plunger arm 15 and the opening at the wall end of this wall closing off reservoir 8.

Plunger arm 15 has a passageway opening extending through its length and also has an outer diameter adapted to permit entry of the plunger arm 15 into the opening of end wall sealing means 9 and to provide close intimate contact with the wall of this opening.

Sleeve 1 also has an opening or aperture 24 therein adapted to permit the flow of fluid from a supply source into an annular space 17 provided between sleeve 1, shell 3 and plunger 7. If desired, sleeve 1 can be omitted and tube 19 connected directly to open space 17 to supply fluid thereto. Plunger 7 also has apertures or openings 2 and 4 communicating with each other and with annual space 17, so that in the position of the device shown in FIG. 1, fluid can flow from a supply connected to opening 24 through opening 24 into annual opening 17, through aperture 2 into annular opening 25, and through aperture 4 into the reservoir 8 in shell 3.

A portion of plunger base 18 fits into the axial opening in plunger 7 and is retained therein by threaded ring 23 which fits in threaded relationship into the threaded portion of said axial opening in plunger 7. Plunger base 18 is adapted to move on its linear axis when corresponding movement is made by rod 20 so that when rod 20 is moved towards the right as the device is shown in FIG. 1, the plunger base 18 moves into annular space 25 so as to block flow of fluid through aperture 2 and also to cut off flow of fluid into aperture 4. Also when plunger base 18 has been moved to completely occupy the annular space 25, this causes the movement of plunger arm 15 so that the opening 5 is placed in flow communication with opening 6 and plunger 7. This permits flow of fluid from reservoir 8 through the interior passageway in plunger arm 15 and thereby delivery of fluid from the pump.

Consequently as plunger 7 moves from one end to the other of the inner space of the shell 3, the liquid originally in reservoir 8 is forced out the exit end of plunger arm 15. As the rod 20 continues its movement toward the right after plunger base 18 has completely filled the annular space 25, plunger base 18 engages the adjacent inner wall of plunger 7 so as to cause plunger 7 and plunger arm 15 also to move to the right. When this movement has continued to the extreme right of reservoir 8, plunger 7 has moved into close contact with the end wall surface of reservoir 8 which end wall surface corresponds in exact detail to the shape and dimensions of the outer surface of plunger 7 so that there is no space for liquid to remain between the contacting surfaces of plunger 7 and the end wall section of reservoir 8. This close contact is not imperative but if the close contact is not so provided, a small amount of liquid or fluid will remain in the reservoir each time that the plunger 7 reaches the end of its travel in reservoir 8.

O rings 16 provide close contact to effect sealing against leakage between plunger 7 and outer shell 3. Likewise O rings 12 provide similar sealing against leakage between plunger arm 15 and the opening through the end wall of reservoir 8 or end wall unit 9.

While certain features of this invention have been described in detail with respect to various embodiments thereof, it will, of course, be apparent that other modifications can be made within the spirit and scope of this invention and it is not intended to limit the invention to the exact details shown above except insofar as they are defined in the following claims:

The invention claimed is:

1. A constant-volume self-cleaning syringe comprising:

(a) a sleeve 1 having an axial opening extending therethrough;

(b) a cylindrical shell 3 adapted to be sealably attached to said sleeve and having a reservoir therein of uniform diameter extending from the end attached to said sleeve through a substantial portion of the length of said shell, and terminating in an end wall;

(c) a plunger base 18 adapted to fit partially in said axial opening of said sleeve and also adapted to receive and retain the end of a cable rod 20;

(d) a plunger 7 adapted to fit within said reservoir and having an outer diameter corresponding to the inner diameter of said reservoir and adapted to move axially and linearly in said reservoir with such close contact between the exterior surface of said plunger and the wall surface of said reservoir as to provide a sealing and wiping contact between said surfaces; said plunger having a rear end facing toward said sleeve and a front end extending into said reservoir and said plunger having an axial opening extending therethrough, a port opening in the said rear end of said plunger extending to and communicating with said axial opening in said plunger at a point spaced from said rear end of said plunger, at least one aperture extending from said axial opening in said plunger to the front end of said plunger, said port opening, said axial opening and said aperture of said plunger being in flow communication with each other, said plunger also having a front opening located in the approximate region of said front end of said plunger spaced from said aperture and connecting with said axial opening of said plunger at a point closer to said front end and spaced from the point where said aperture connects with said axial opening, said axial opening of said plunger being adapted to receive said plunger base and adapted to permit only limited movement of said plunger base within said axial opening of said plunger, and said plunger also being adapted to receive a plunger arm in the axial opening thereof;

(e) a plunger arm 15 adapted to slidably fit the axial opening of said plunger and also to be attached to said plunger base, said plunger arm having a linear axial opening extending through a substantial portion of the length thereof and connecting with a more restricted opening at that end of said plunger arm opposite to the end affixed to said plunger base, said

plunger arm also having a side opening extending through a side wall thereof adapted to be positioned in flow communication with said front opening of said plunger so as to provide flow communication between the interior of said plunger arm and the exterior of said plunger when said two openings are positioned opposite each other;

(f) a reagent tube **11** affixed to the end of said shell opposite from the end affixed to said sleeve and having an opening extending throughout the length of the tube, said reagent tube opening conforming in shape and size to the exterior of said plunger arm and adapted to receive said plunger with close wiping contact of the surface thereof when said plunger arm is moved into the interior of said reagent tube;

(g) said end wall of said reservoir conforming identically in shape and size with the exterior of said plunger, whereby when said plunger is moved to said end of said reservoir there is close intimate contact between the exterior surface of said plunger and said end wall; and

(h) a means for moving said cable rod, and with it the plunger, plunger base and plunger arm attached thereto, so that said plunger is moved from a position at one end of said reservoir to the opposite extreme position at the other end of said reservoir and also thereby moving said plunger arm into and out of the interior space of said reagent tube, whereby a self-cleaning action is effected on the interior of said reagent tube by the wiping action of the exterior surface of said plunger arm on the interior surface of said reagent tube and the simultaneous spraying of fluid on said interior surface effected by passage of said fluid through said restricted opening.

2. A syringe of claim **1** in which said cable rod is an armored flexible cable.

3. A syringe of claim **1** in which said means for moving said cable rod and the plunger, plunger base and plunger arm comprises a driving wheel, said cable being pivotally attached to said wheel at a point spaced from the center of rotation of said wheel equal to one-half the distance said plunger travels in said reservoir.

4. A pump comprising:

(a) a cylindrical shell having a reservoir therein of uniform diameter, extending through a greater portion of the length of said shell and terminating in an end wall;

(b) a plunger adapted to fit within said reservoir and having an outer diameter corresponding to the inner diameter of said reservoir and adapted to move axially and linearly in said reservoir with such close contact between the exterior surface of said plunger and the wall surface of said reservoir as to provide sealing and wiping contact between said surfaces; said plunger having an axial opening extending therethrough, a port opening extending from said axial opening extending to the exterior of said plunger and adapted to provide communication between said axial opening and that portion of said reservoir between said plunger and said end wall of said reservoir;

(c) a plunger arm adapted to slidably fit the axial opening of said plunger and also to be restricted in its movement in both directions the plunger arm slides through said plunger first in one direction and then in the opposite direction so that after limited movement of said plunger arm, said plunger is advanced in the same direction of movement of said plunger arm, said plunger arm having a first port opening positioned and adapted to provide communication between the interior of said plunger arm and the opening in said plunger providing communication between said axial opening and the interior of said reservoir when said plunger arm is moving in a direction away from the end wall of said reservoir, said plunger arm also having a second port opening spaced from said first port opening adapted to provide communication between the interior of said plunger arm and the interior of said reservoir when said plunger arm is moving in a direction toward the said end wall of said reservoir;

(d) a sealing means adapted to prevent communication between said first and second port openings in said interior of said plunger arm;

(e) said plunger arm extending to and beyond said end wall of said reservoir and extending through an opening in said end wall, said opening and the exterior of said plunger arm being of such size and shape as to provide sealing contact and thereby prevent flow of liquid therebetween.

5. A pump camprising:

(a) a cylindrical shell having a reservoir therein of uniform diameter extending through a substantial portion of the length of said shell and terminating in an end wall;

(b) a plunger base arm of long cylindrical shape having a plunger base affixed to the exterior thereof and extending for only a short portion of the length of said arm, said arm having a linear axial opening running a substantial portion of the length thereof and having a port opening adapted to provide communication between the linear axial opening and the exterior of said arm;

(c) a plunger adapted to fit within said reservoir and having at least a portion of its outer diameter corresponding to the inner diameter of said reservoir and adapted to move axially and linearly in said reservoir with such close contact between the exterior surface of said plunger and the wall surface of said reservoir as to provide a sealing and wiping contact between said surfaces; said plunger having a rear end adjacent to said plunger base and a front end at the opposite end of said plunger; said plunger having an axial opening extending therethrough, a port opening extending from said axial opening in said plunger to a point on the exterior of said plunger spaced from the rear end of said plunger and having between said point and the rear end of said plunger a portion of the plunger which is in close contact with the interior wall surface of said reservoir, said port opening in said plunger and in said plunger base arm being adapted to provide flow communication between said axial opening in said plunger base arm and said reservoir, said axial opening of said plunger being adapted to receive said plunger base arm and adapted to permit only limited movement of said plunger base arm within said axial opening of said plunger, and said plunger also being adapted to receive a plunger arm in the axial opening thereof;

(d) a plunger arm adapted to slidably fit the axial opening of said plunger and comprising an extension of said plunger base arm, said plunger arm having a linear axial opening extending through at least a substantial portion of the length thereof but cut off from communication with the axial opening in said plunger base arm, said plunger arm having a side opening extending through a side wall thereof adapted to be positioned in flow communication with said reservoir so as to provide flow communication between said reservoir and the interior of said plunger arm when said side opening is uncovered by said plunger;

(e) a collar mounted on said plunger arm forward of said side opening which cooperates with said plunger to limit the relative movement of said plunger arm with respect to said plunger whereby the plunger blocks the side opening in said plunger arm when said plunger abuts said collar;

(f) said end wall of said cylindrical shell having an opening therein conforming identically in shape and size with the widest portion of the exterior of said plunger arm, whereby said plunger arm portion is adapted to move therethrough in such close contact with the wall of said opening that there is no leakage therethrough;

(g) a means for moving said plunger, and with it said plunger base and plunger base arm attached thereto, so that said plunger is moved from a position at one end of said reservoir to the opposite extreme position at the other end of said reservoir and also thereby moving said plunger arm through and beyond said reservoir, and through said opening in the end wall of said reservoir, said plunger arm being of sufficient length to extend in all of its positions beyond the said opening in said end wall.

References Cited

UNITED STATES PATENTS

32,658	6/1861	Thomas	103—227
287,053	10/1883	Powers	103—188
1,241,196	9/1917	Cogswell	141—130
1,909,454	5/1933	Brunner	103—188 X
2,031,826	2/1936	Ekstromer	103—189
2,821,330	1/1958	Meylan	222—321 X

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