June 3, 1969

D. ROSENBERG

3,447,479

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SYRINGE PUMP

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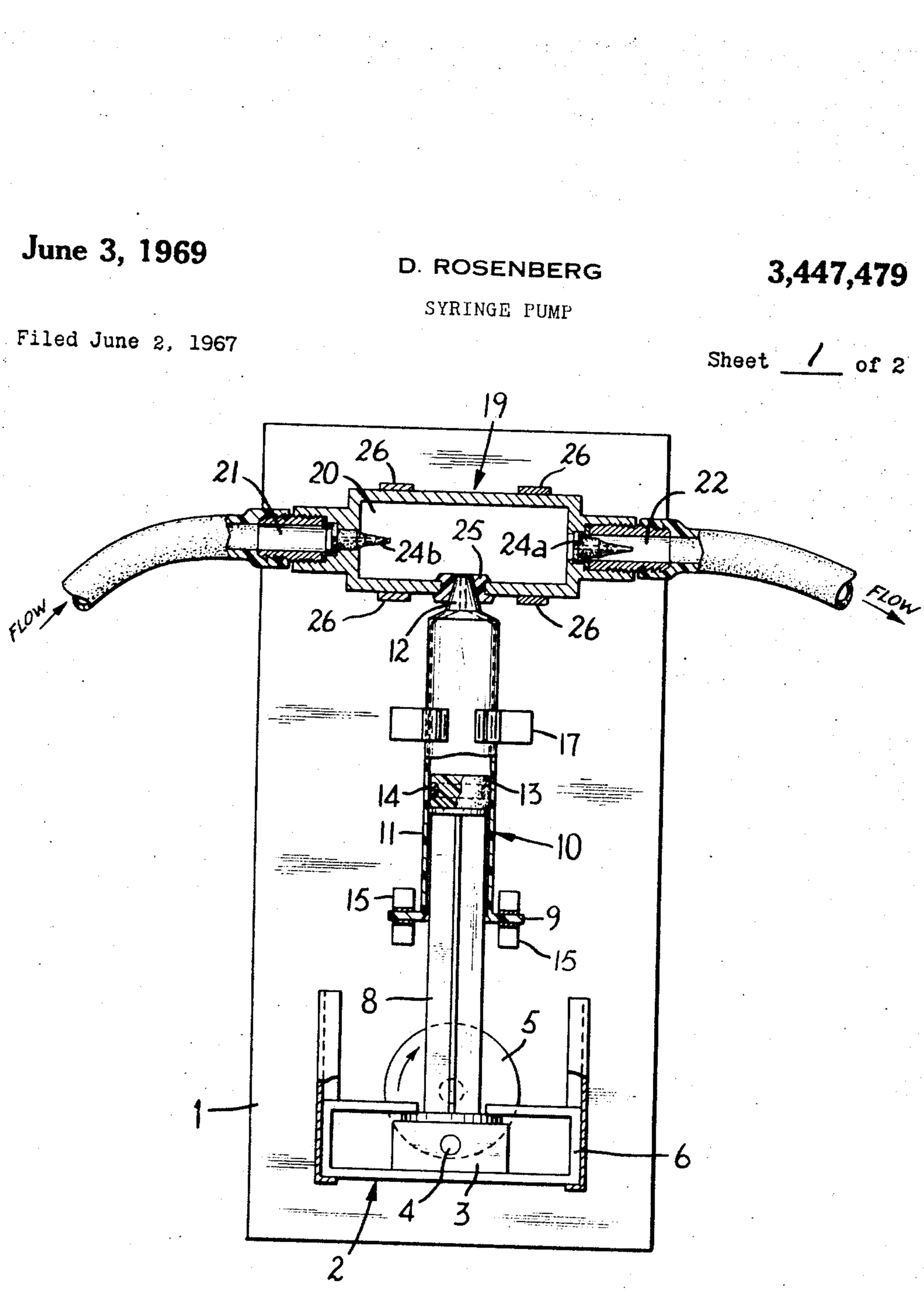


FIG. 1

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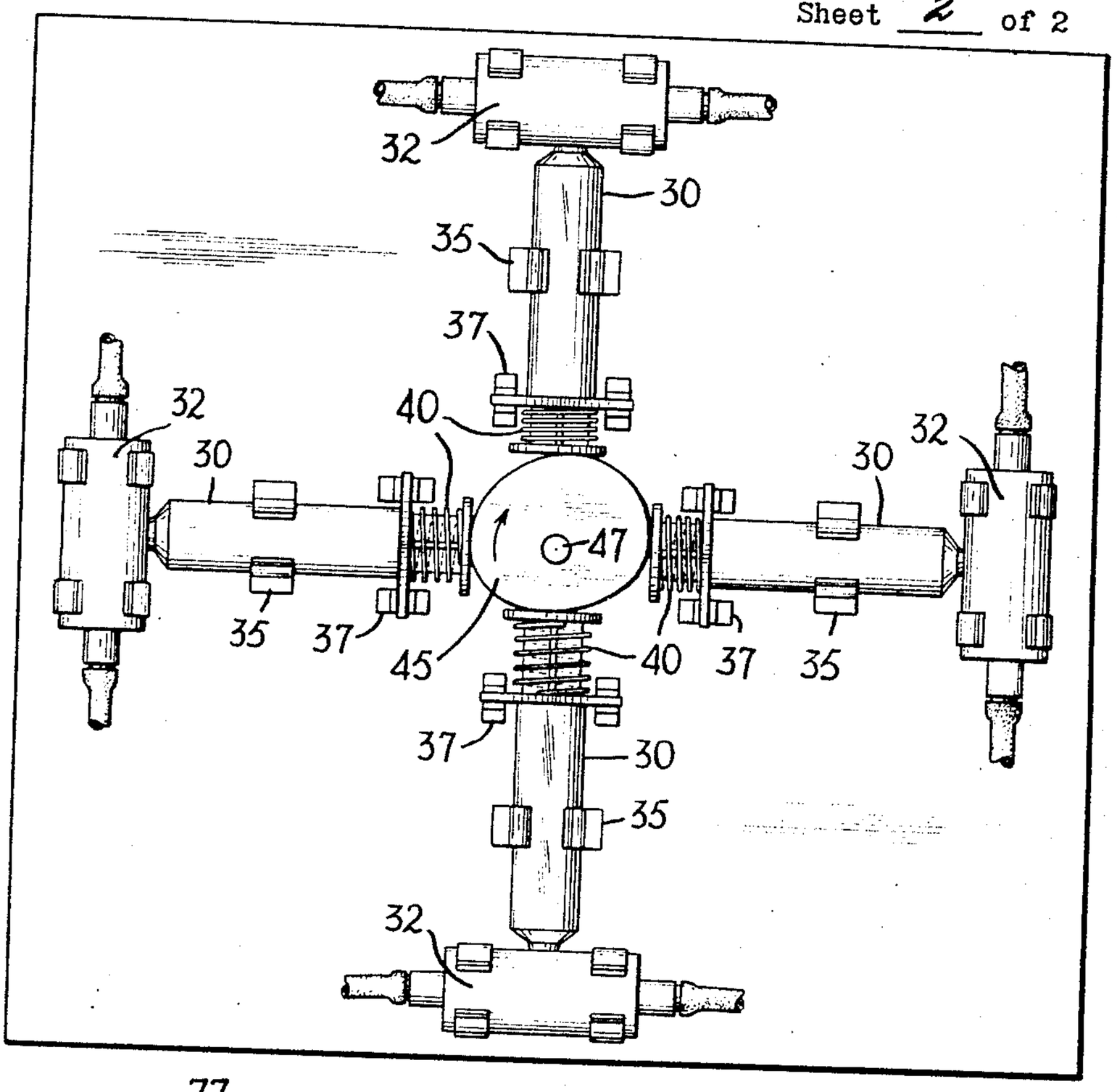
FIG. 2



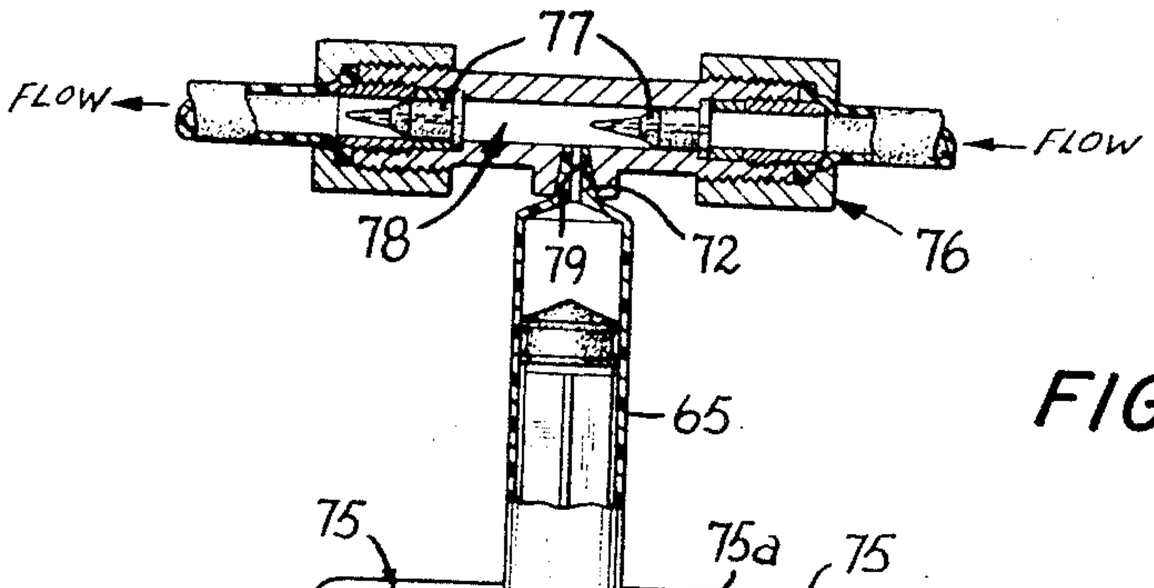
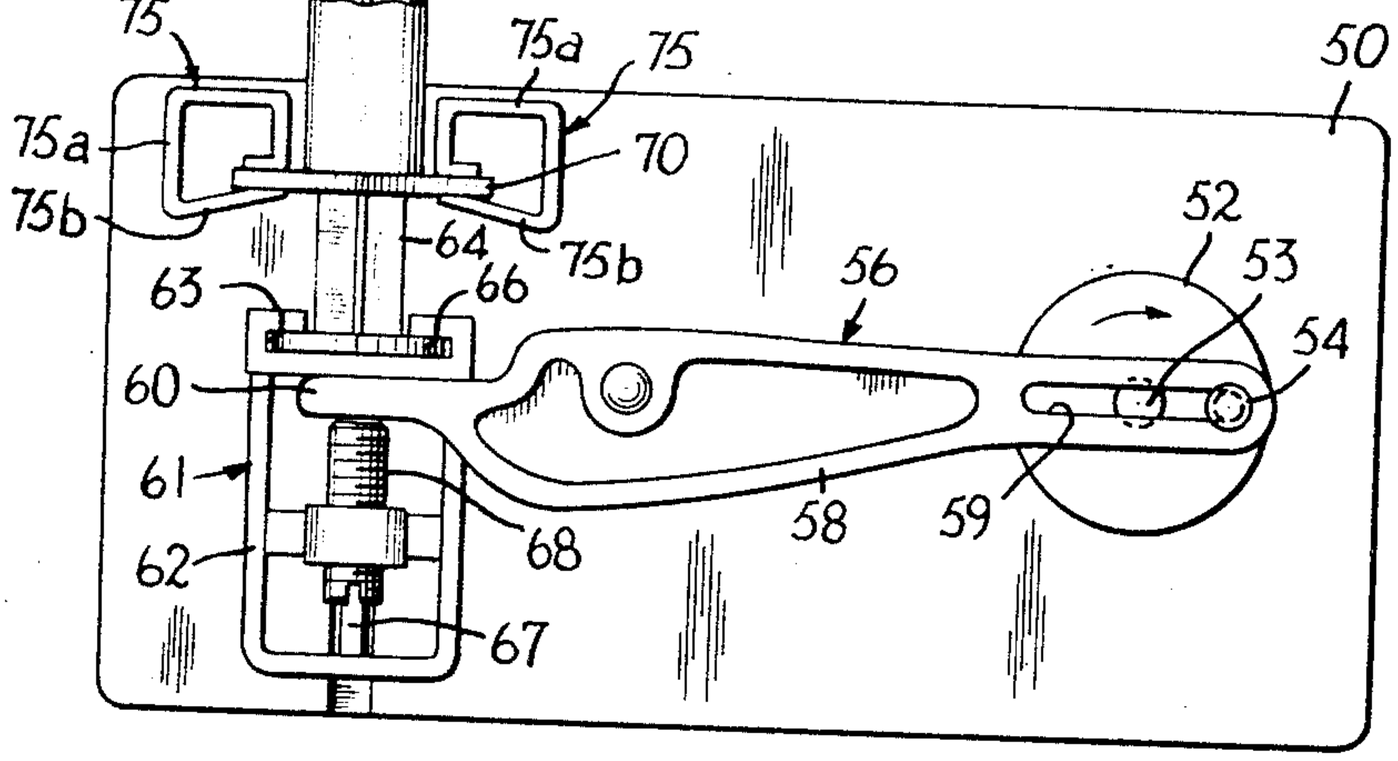




FIG. 3



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# SYRINGE PUMP

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12 Claims

## ABSTRACT OF THE DISCLOSURE

A syringe pump is provided in which the syringe is easily detachable from the assembly and replaceable with a syringe of the same or of a different size.

The syringe pump has a drive mechanism, a coupling means to hold the plunger of the syringe and the drive means in operative engagement, engaging the end of the plunger in an easily detachable manner, and adapted to accommodate syringe plungers of different sizes, and a mounting means holding the syringe body in a fixed position relative to the drive means, engaging the syringe body in an easily detachable manner, and adapted to accommodate syringe bodies of different sizes.

This invention relates to a syringe pump, and more particularly, it relates to a syringe pump in which the syringe is readily detachable and replaceable.

Surgical syringes are readily available and can accurately meter fluid. Moreover, since they employ a piston and cylinder, they have proved suitable for accurately pumping measured small amounts of fluid for laboratory use.

One such laboratory syringe pump is shown by Wiley et al. in U.S. Patent No. 3,259,077. Wiley et al. disclosed a pump assembly which employs a surgical syringe at the means for pumping measured amounts of fluid. However, the valve assembly that is associated with the system is rather complicated and the pump itself relatively expensive to manufacture. Moreover, the syringe is not readily detachable from the assembly and the assembly is not adapted to readily employ a syringe of another size.

In a laboratory, it is often necessary to have several pumps of different sizes for different pumping operations. However, most often only one pump is in use at a time. It is therefore advantageous to provide a syringe pump which can employ syringes of different sizes and in which the syringe can be readily detached and replaced with another for quick conversion. The instant assembly provides such a syringe pump assembly. Moreover, this syringe pump needs only one drive mechanism, one valve assembly, and several syringes to provide a versatile pump which can perform the functions of several pumps at lower cost.

The instant pump comprises a base; a fluid line; a syringe having a body portion, a pumping plunger reciprocably movable between limits in the body portion, and an aperture in the body portion communicating with the fluid line for receiving fluid from and discharging fluid to the fluid line upon reciprocation of the plunger; means holding the syringe on the base in an easily-detachable manner, and adapted to accommodate syringes of different sizes; a check valve assembly in the fluid line communicating with the syringe such that fluid can proceed through the fluid line in only one direction, whereby fluid is pumped through the fluid line upon reciprocation of the plunger; and drive means operatively connected to the plunger for reciprocably moving the plunger within the syringe body to pump the fluid in the fluid line.

The syringe used in this syringe pump assembly is preferably an ordinary surgical syringe. Such syringes comprise a hollow sylinder having an apertured tip formed at one end and a laterally extending flange at the other end. The flange is normally provided as a convenient place for gripping the syringe when it is held in one hand. A plunger is provided for reciprocable movement within the cylindrical body. The plunger has an end which extends from the flanged end of the syringe. The plunger is fitted in a substantially fluid-tight seal against the walls of the cylindrical body of the syringe and forms with the body a piston and cylindrical pump. The seal on the plunger is normally maintained by an "O" ring or the like. On the pressure stroke the plunger pump forces fluid from the syringe body through the tip, and on the vacuum stroke the plunger draws fluid into the body through the tip, for the next pumping or pressure stroke.

Surgical syringes are normally made from plastic material such as polyethylene or polypropylene; however, syringes made of any material that is inert to the fluid being pumped, such as glass, nylon, and Teflon, are suitable for use in this invention. The material is preferably transparent or translucent, but it need not be.

The syringe can be of generally any size, length and diameter, and of any capacity. Capacities from about one cc to about ten cc are preferred for use in pumps of this invention.

The syringe is supported on a base which can normally also serve to house or support the drive means for the assembly. The case can be made from any material, such as wood, plastic, or metal. Plastic materials, such as nylon and polycarbonates, are preferred. The base can be formed in any desired or convenient shape, such as a cube.

The base can hold or otherwise support one or more syringes. If a plurality of syringes are used, they can be positioned in any location, or grouped in any manner on the base. It is to be noted, however, that if a plurality of syringes are provided they can all be driven by the same drive mechanism by proper positioning of the syringes on the base. This can be accomplished by arranging the syringes with their plungers all adjacent to the drive mechanism. One way of doing this is to arrange them in a star-like configuration about the drive member.

If only one syringe is supported on the base, it normally will be positioned tip-end up, in a generally vertical position. The syringe should be supported on the base by mounting members that permit easy detachment of the syringe from the base. The mounting members should also be adjustable to accommodate syringes of different sizes.

One preferred mounting member is a clamp of the snap clip type. The snap clips can be provided on the base in position to grasp the flanged portion of the syringe and, additionally, if desired, the cylindrical body of the syringe also.

The snap clips which engage the flanged portion of the syringe prevent any longitudinal displacement of the syringe which might occur when the plunger is reciprocated. Moreover, by providing clips which grap the flanged portion guide firmly, it is possible to prevent any motion of the syringe at all. This makes it possible to employ only one set of clips which engage the flanged portion of the syringe to secure the syringe in position on the base.

If desired, an additional snap clip can be provided to engage and support the cylindrical body against any lateral displacement of the syringe which might otherwise occur.

Snap clips are preferred, since they are readily available and easily fabricated for special application. Moreover, they are long wearing and simple to use. They permit easy removal and replacement of the syringe on the assembly and can readily accommodate a wide range of syringes of different sizes without any special adjustment.

A preferred snap clip for the flanged portion of the syringe comprises a pincer-shaped clip employing a rigid

support member and a resilient pincer arm which bears against the support. The flange is inserted between the pincer arm and the support and is held in position therebetween by the spring force of the arm. This type of clip is preferred, since it has been found to provide firm support for the syringe on the base without any additional support members. It is adapted to readily accommodate syringes of different sizes since the size of the flanged portion of the syringe does not vary greatly for different syringes. A clip of the type described above also permits easy removal of a syringe from the assembly.

Snap clips are normally made at least in part of a highly resilient material, such as spring steel, or hard long-wearing resilient plastics, such as nylon or polypropylene.

Other suitable snap clips can be preferably C- or U-shaped, depending upon the portion of the syringe they are to hold. For example, a snap clip that is positioned to hold the cylindrical body should be C shaped and be oriented such that the body of the syringe is inserted into the open mouth of the C.

Another snap clip which can be used to engage the flanged portion of the plunger should be normally shaped as a narrow U and be oriented such that the flange is inserted into the narrow open slot between the arms of the U.

It is also possible to provide snap clips which are of adjustable tension to ensure a tight grip on any size syringe used. Other mounting members for holding the syringe in place, such as clamps of all types can be used. It is to be noted, however, that any mounting members provided should be readily adjustable and should be adapted to hold the syringe in a manner such that removal of the syringe from the assembly is readily accomplished.

The mounting members can be fixed in position on the base, and need not be movably mounted in order to hold different capacity syringes. This is due to the fact that the bodies of syringes of different capacities normally vary most in body diameter. This, however, does not affect the positioning of the mounting members, and thus they need not be movable on the base. However, if desired, the mounting members can be made adjustable on the base to occupy the same relative position for each different syringe.

The tip of the syringe communicates with a check valve assembly through which the fluid is pumped. The check valve of the instant invention can comprise a check valve chamber having an inlet and an outlet, check valves at the inlet and the outlet, and an aperture adapted to receive the tip of the syringe. The check valves ensure that fluid can flow only in one direction as the plunger reciprocates. Duckbill valves are preferred as the check valves. However, poppet valves, flap valves, or the like can also be used.

The aperture in the chamber should be provided with means to ensure a fluid tight fit about the tip of the syringe. However, it should also be adapted for the easy removal of the syringe therefrom, since the syringe is normally removed from the check valve assembly when it is dismounted from the base. The fit should also be such that it accommodates different syringes. It is to be noted, however, that the tip of different syringes is a generally frustoconical member which is the same size, regardless of the syringe body size. Therefore, normally the fit need not be one that is adjustable.

It is preferred that the fit is accomplished by merely forming the aperture of the chamber as a frustoconical passage which matches the taper of the frustoconical tip of the syringe. When the tip of the syringe is placed into this passage, the exterior of the tip engages and forms a seal against the walls of the passage due to the close fit. This provides a tight seal which can withstand high fluid pressure without leaking. However, to remove the syringe, it is merely necessary to twist the syringe and thereby break the seal. The syringe can then be easily removed from the check valve chamber.



The fit of the syringe tip in the check valve chamber can also be accomplished by providing a resilient sealing ring at the aperture of the check valve assembly through which the tip is inserted. A sealing ring can grip the tip of the syringe and maintain a fluid tight seal thereagainst when the tip is in position but also permits easy removal of the syringe. It is also possible to make the entire check valve assembly housing of resilient material, such as rubber and thus avoid the necessity of providing a separate sealing ring to seal against the syringe tip.

Another method of fitting the syringe to the check valve chamber is by providing a threaded engagement or bayonet coupling of the syringe and check valve assembly. It is necessary however in these embodiments to specially modify the syringe tip for the coupling. Therefore, these means for coupling are less preferable than those described above.

The check valve assembly can, if desired, be permanently affixed to the syringe as a part thereof. Since it is a simple and inexpensive mechanism, it can be replaced when the syringe is replaced. This eliminates the necessity of cleaning the check valve assembly to remove residual fluid after each fluid is pumped through it.

The check valve assembly need not be supported on the base, since it is mounted on the syringe tip and supported thereby. However, it desired, snap clips or other similar mounting members can be provided on the base to hold the check valve assembly in position. The mounting members, in such a case, can be adjustably positioned on the housing so that they can support the check valve assembly regardless of the length of the syringe.

The drive mechanism that is used in the instant pump assembly to reciprocate the plunger of the syringe is preferably an eccentric drive means that is powered by an electric motor. The motor can be housed in the base and be operatively connected to the eccentric drive member by a motor shaft. The eccentric drive member can be a cam, a Scotch yoke assembly, or the like. The drive mechanism, however, need not be an eccentric drive apparatus. Any mechanism adapted to convert the rotational motion of the motor to translational movement of the plunger of the syringe is suitable.

The drive mechanism should be disposed in a position such that rotation of the motor causes the drive mechanism to bear against the plunger of the syringe and cause reciprocal movement thereof.

If a cam drive is used, a spring can be employed as part of the drive mechanism to return the plunger to its original position, after the cam has formed the plunger to move inwardly. A comperssion spring disposed between the flanged portion of the cylindrical body and the end of the plunger is preferred.

If a Scotch yoke is used, no additional means need be provided to withdraw the plunger from the cylinder since the yoke both forces the plunger inwardly and withdraws it from the cylindrical body. It is to be noted that both of the above drive mechanisms can be adapted to actuate a plurality of syringes mounted at a plurality of different positions on the base.

The extent of the movement of the plunger determines the amount of fluid pumped on any one stroke. Means, such as stops, set screws, and lost motion linkages can be provided to precisely control the extent of the plunger movement.

In operation, the rotation of the motor shaft rotates the drive mechanism to cause reciprocal motion of the plunger in the syringe body. When the plunger moves inwardly into the body, fluid in the syringe body and in the check valve chamber is pumped from the outlet thereof. As the plunger is withdrawn from the body, fluid is drawn from the inlet into the check valve as-

sembly and into the syringe body for transfer from the outlet of the assembly on the next stroke.

The syringe can be readily detached from the assembly by merely withdrawing it from the snap clips and removing the check valve chamber from the syringe tip. A syringe of a different size can be easily substituted in the assembly merely by inserting it into the snap clips, and placing the check valve chamber on the tip.

The instant assembly is simple, versatile, and convenient to use. It can be fabricated quite inexpensively since nearly every portion of the assembly with the exception of portions of the motor can be made of inexpensive materials, such as plastic. Thus, this invention provides with a minimal expense a pump which can perform the functions of several pumps.

Preferred embodiments of this invention will now be described in connection with the following drawings, in which:

FIGURE 1 is a plan view of a syringe pump of this invention with the check valve assembly shown in cross-section;

FIGURE 2 is a plan view of a syringe pump in accordance with this invention employing a plurality of syringes.

FIGURE 3 is a plain view of another embodiment of a syringe of this invention with the check valve assembly shown in cross-section.

In FIGURE 1, a syringe pump in accordance with this invention is shown. It comprises a base **1**, housing a motor (not shown). The motor is operatively connected to Scotch yoke assembly **2** by a drive wheel **5** mounted to a motor shaft (not shown). The Scotch yoke assembly is composed of a rectangular bar **3** rotatably mounted on a pin **4**. The pin **4** is eccentrically mounted relative to the drive wheel **5**. A C-shaped clamp **6** surrounds rectangular bar **3** and operatively engages an end **7** of a plunger **8** of a syringe **10**. The C-shaped clamp **6**, the drive wheel **5** and the rectangular bar **3** are all formed of plastic.

The syringe **10** has a tip portion **12** and a cylindrical body portion **11** which terminates in a flange **9** at the end thereof. The plunger **8** is mounted for reciprocal movement within the cylindrical body **11**. The plunger **8** has a piston **13** thereon, having an O-ring sealing member **14** thereabout to ensure a leak-proof seal between the piston **13** and the cylindrical body **11** of the syringe.

The syringe **10** is vertically positioned tip end up, and is supported on the base by snap clips **15** which engage the flange **9**, and a snap clip **17** which engages the cylindrical body. These snap clips are made of spring steel and are quite resilient. The syringe **10** can be readily removed from their grasp and replaced with a syringe of the same or of a different size. The clips can accommodate syringes of one cc. to about ten cc. capacities. The check valve assembly **19** is located on the syringe tip **12** and communicates therewith. It is supported on the base by snap clips **26**. The check valve assembly comprises a check valve chamber **20** having an inlet **21**, and an outlet **22**. Duckbill valves **24***a* and **24***b* are provided at the inlet to ensure fluid flow only from the inlet to the outlet in one direction. The tip of the syringe is held in a fluid tight fit in the check valve assembly by a resilient sealing ring **25** which is adapted to permit easy detachment of the syringe tip from the check valve assembly.

In operation, when the motor shaft is rotated by the motor, the Scotch yoke reciprocates the plunger within the cylindrical body **11**. When the plunger is forced inwardly, a relatively high pressure is created in the cylindrical body, and fluid in the check valve chamber **19** and the body will be forced therefrom through the valve **24***a* which is forced upon by the high pressure created by the piston **13**. The duckbill valve **24***b* is held closed by the high pressure, and thus fluid can only flow to the outlet through valve **4***a*.



On the downstroke of the piston **13**, a partial vacuum is created in the cylindrical body **11** and fluid is drawn through the check valve **24***b* into the chamber **20** and into the cylindrical body **11** of the piston syringe **10**. The vacuum created causes the duckbill valve **24***a* to remain closed and prevents fluid from passing to the outlet **22**.

If a different capacity pump were required, or if the syringe became worn, the syringe **10** can be readily detached from the assembly by merely removing the check valve member from the snap clips **26** which hold it in position, and detaching it from the syringe **10**. The syringe can be removed by pulling it from the snap clips **15** and **17** and sliding it from the C-clamp **6** of the Scotch yoke assembly.

As can be seen by reference to FIGURE 1, this can all be readily accomplished without any difficulty. A syringe of the same size, or of a different size can be inserted in its place in a short time and without any substantial effort.

In FIGURE 2, a multiple syringe pump assembly is shown. It comprises four surgical syringes **30**, which are all similar to that described above in connection with the previous embodiment. Each of these syringes communicates with a check valve assembly **32**, also similar to that described above. Syringes are held in place by snap clips **35** and **37** which engage the body of the syringe, and the end flange of each syringe, respectively. Each of the syringes is provided with a compression spring **40** which normally holds the plunger in a withdrawn position. The syringes are mounted in a starlike configuration centering about the drive means. Four syringes are shown, however, and more than four syringes could be provided, if desired. The plungers of the syringes are all arranged to point inwardly and forced by the syringe toward a cam **45**, centrally located with regard to the plungers. This cam is mounted on a motor shaft **47**.

When the motor shaft is rotated, the cam rotates, sequentially depressing the plunger of the adjacent syringe as it rotates. The compression springs return the plungers to their withdrawn position as soon as the apex of the cam passes each plunger and permits such movement. As the plungers reciprocate due to the motion of the cam, fluid is pumped through the check valve assemblies in a manner similar to that described above.

It is to be noted that in this embodiment, the syringes can be of all the same size or of different sizes, and each of the syringes can be readily detached in a place independently of the others.

In FIGURE 3, another embodiment of the syringe pump in accordance with this invention is shown. It comprises a nylon base **50**, housing a motor (not shown). The motor is operatively connected to an eccentric drive mechanism by a drive wheel **52**, via a motor shaft **53**. An eccentric drive pin **54** is located on the drive wheel **52**. The drive pin is operatively connected to a pivoted yoke mechanism **56**. The yoke comprises a pivoted bar **58** having a slotted portion at one end **59**, for reception of the pin **54**, and a lever portion **60**, at the other end thereof. The drive pin **54** is located within the slotted portion **59** for pivotally moving the lever portion **60** upon rotation of the drive wheel **52**. The lever portion **60** engages a plunger drive mechanism **61** for reciprocally moving a syringe plunger **64** within a syringe body **65**. The plunger drive mechanism **61** comprises a carriage **62** having a slotted portion **63** which engages the end **66** of a plunger **64**. The carriage is movable in the same direction as is the plunger in a slot (not shown) via a key **67**. A set screw **68** is located adjacent to the lever portion **60** of the yoke drive **56** to limit the extent of the reciprocal motion of the plunger **64**, upon pivotal motion of the yoke drive **56**.

The syringe, which consists of a barrel portion **65**, a plunger portion **64**, a flanged end **70**, and an aperture tip **72**, is mounted on the housing with the plunger end

66 within the slotted portion of the plunger drive mechanism and the flanged portion 70 within a pair of pincer snap clips 75. The pincer snap clips are composed of a rigid section 75*a* and a resilient arm member 75*b*. The resilient arm is made of spring steel and tightly holds the flange of the syringe in position as the plunger of the syringe is reciprocated within the body portion 65. The syringe is easily demountable from the assembly by merely sliding it from the snap clips 75, and removing the plunger end 66 from the plunger drive mechanism 61.

The apertured tip of the plunger is inserted within a check valve assembly 76. The check valve assembly is provided with two duckbill valves 77, disposed within a check valve chamber 78 at the inlet and outlet of the chamber. The inlet and the outlet of the chamber are connected to a fluid line for flow through the assembly. The duckbill valves are arranged such that fluid can proceed only through the assembly in one direction.

A tapered passage 79 is formed in the check valve chamber between the inlet and outlet. This passage is formed to the same taper as the apertured tip of the syringe and seals thereagainst to prevent leakage of fluid from the assembly. The check valve chamber can be easily removed from the syringe by merely twisting it, thus breaking the seal and thereby loosening it, such that it can be easily removed from the assembly.

In operation, upon rotation of the motor shaft 53, the drive wheel 52 is rotated, thus causing eccentric motion of the pin 54. This pin moves the lever 60 of the yoke drive 56, thus causing reciprocal motion of the plunger within the body of the syringe. Fluid is pumped through the fluid line in measured amounts.

The plunger can be readily removed from the assembly by merely withdrawing it from the snap clips and the yoke and plunger drive mechanism in the manner described. The apertured tip can then be removed from the check valve chamber by merely twisting it to break the seal.

Thus, the instant invention has provided a simple and inexpensively constructed syringe pump adapted to serve many functions with a minimum of expense and with a maximum of versatility.

Having regard to the foregoing disclosure, the following is claimed as the inventive and patentable embodiments thereof:

1. A syringe pump adapted to interchangeably employ one or more of a series of similar syringes of the same or different sizes comprising, in combination, a syringe having a body portion including at least a barrel, a fluid-pumping plunger reciprocably movable in the barrel and having retaining means thereon, and an aperture in the body portion communicating with the barrel for entry of fluid to and exit of fluid from the barrel upon fluid-pumping reciprocation of the plunger; drive means including a motor operatively associated with the plunger for reciprocably moving the plunger within the barrel to draw fluid into the barrel and pump it out; coupling means holding in operative engagement in an easily detachable manner both the drive means and the retaining means on the fluid-pumping plunger, said coupling means being adapted to accommodate the retaining means on the plungers of any of a series of syringes of the same or different sizes; mounting means engaging the body portion in an easily detachable manner, and being adapted to hold the body portion of any of such series of syringes in a fixed position relative to the drive means, such that upon operation of the drive means the plunger is reciprocated in the barrel; and a check valve assembly in fluid connection with the aperture and barrel, such that fluid can be drawn into and pumped from the barrel of the syringe by the plunger, whereby upon operation of the drive means, the plunger is reciprocated and fluid is pumped through the check valve assembly in only one direction.



2. A syringe pump in accordance with claim 1 in which the body portion of the syringe has a flange, and in which the mounting means engages the flange on the body portion.

3. A syringe pump in accordance with claim 1 in which the drive means includes a cam.

4. A syringe pump in accordance with claim 1 in which the retaining means comprises a flange on the end of the plunger.

5. A syringe pump in accordance with claim 1, in which the coupling means is a yoke.

6. A syringe pump in accordance with claim 1 in which the coupling means includes a spring.

7. A syringe pump in accordance with claim 1 in which the mounting means comprises snap clips.

8. A syringe pump in accordance with claim 7, in which the snap clips include pincers.

9. A syringe pump in accordance with claim 1 in which the mounting means comprises clamps.

10. A syringe pump in accordance with claim 1 in which the aperture in the syringe is in a tapered tip on the end of the syringe barrel and in which the check valve assembly is mounted on the tip.

11. A syringe pump in accordance with claim 1 including means for controlling the length of the stroke of the fluid-pumping plunger in the barrel.

12. A syringe pump adapted to interchangeably employ one or more of a series of similar syringes, of the same or different sizes comprising, in combination, a base; drive means associated with the base, including a motor and an eccentric drive mechanism connected to the motor; at least one syringe detachably mounted on the base, said syringe comprising a cylindrical body having an apertured tip at one end thereof and a laterally extending flange at the opposite end thereof; a fluid pumping plunger reciprocably movable in the cylindrical body, said pumping plunger having a retaining means on the end thereof, and being adapted to upon reciprocation thereof draw fluid into the cylindrical body through the aperture in the tip; coupling means holding in operative engagement in an easily detachable manner, the drive means and the retaining means on the fluid pumping plunger, said coupling means being adapted to accommodate the retaining means on the plungers of a series of syringes of the same or different sizes; mounting means on the base engaging at least the flange on the cylindrical body of the syringe in an easily detachable manner and being adapted to hold flanges of such series of syringes in a fixed position on the base, such that upon operation of the drive means the plunger is reciprocated within the cylindrical body; a check valve assembly mounted on the tip of the syringe, said check valve assembly comprising a chamber having an inlet and an outlet; and check valves closing off the inlet and the outlet and permitting fluid flow through the assembly from the inlet to the outlet upon reciprocation of the plunger, such that fluid is drawn into and pumped from the cylindrical barrel of the syringe, whereby upon operation of the drive means, the plunger is reciprocated and fluid is pumped through the check valve assembly only in one direction.


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U.S. Cl. X.R.

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