March 26, 1957 M. SINGER ET AL 2,786,468

MOTOR DRIVEN INJECTION APPARATUS

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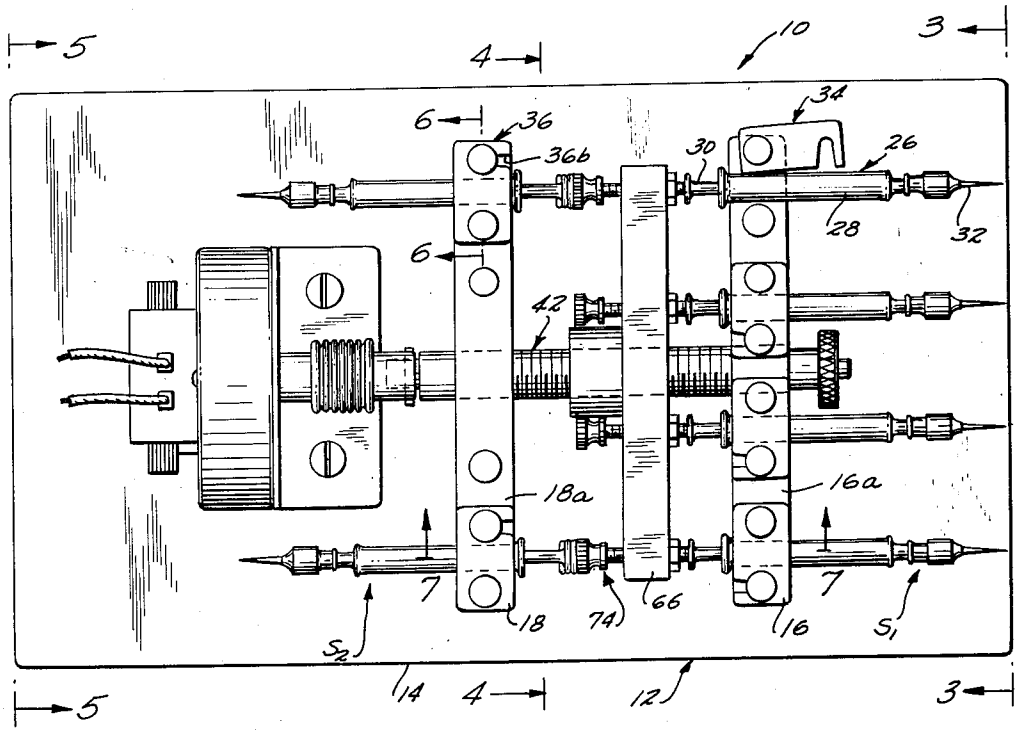
FIG. 1.



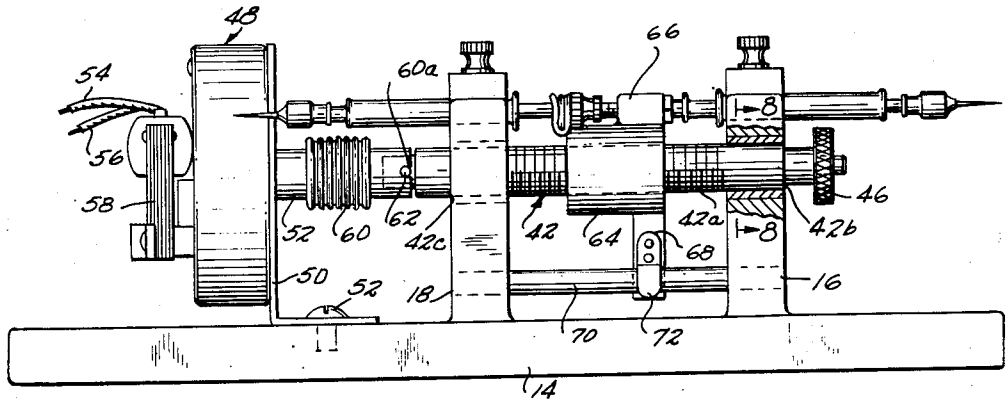


FIG. 2.

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FIG. 3.

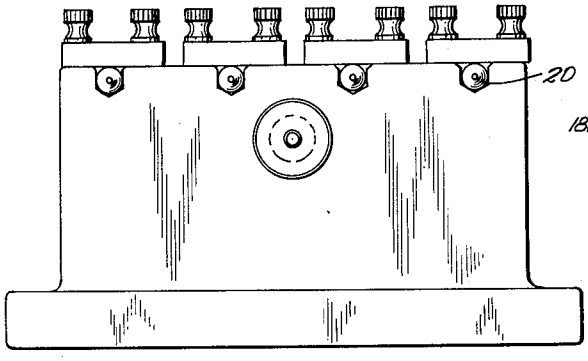


FIG. 6.

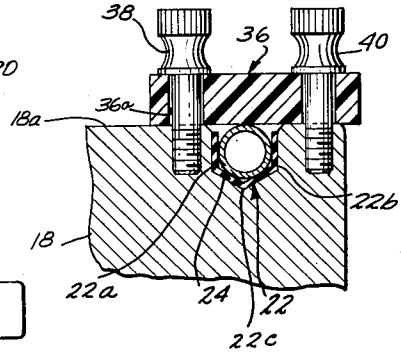
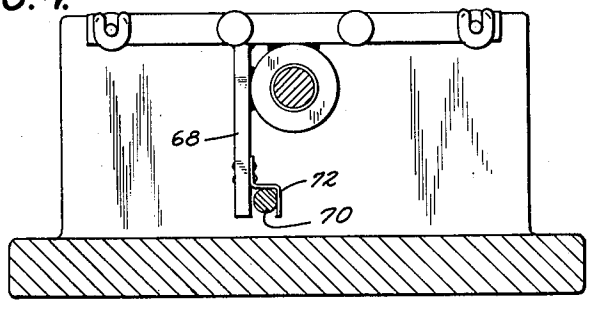


FIG. 4.



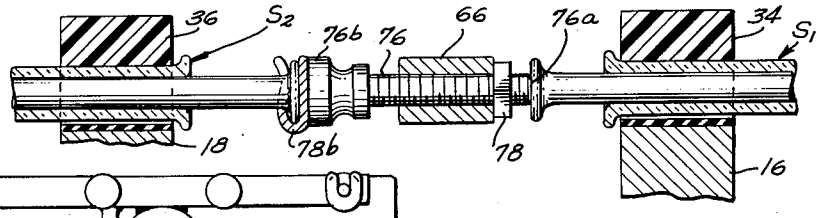
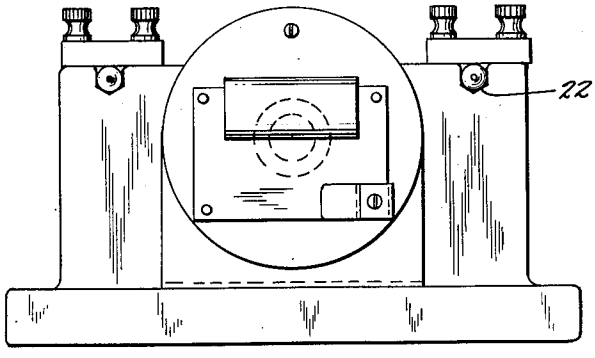


FIG. 7.

FIG. 5.



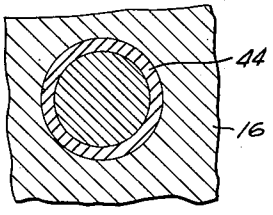


FIG. 8.

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2,786,468

MOTOR DRIVEN INJECTION APPARATUS

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Application June 29, 1955, Serial No. 518,748

5 Claims. (Cl. 128—218)

The present invention relates to motor driven fluid-metering apparatus, and in particular to a device for simultaneous perfusion and extraction of precise amounts of fluids over predetermined periods. To advantage, the invention finds application in the continuous infusion and extraction of microvolumes of solutions directly into and from organs and tissues.

Numerous devices are known for the injection of fluid solutions over relatively extended periods of time and at fairly well regulated rates. Characteristically, such devices comprise one or more hypodermic syringes of the type including a syringe barrel or cylinder containing the fluid solution to be injected and a plunger or piston operable in the barrel or cylinder for injecting the fluid through a needle into the object or person.

Broadly, it is an object of the present invention to provide an improved fluid-metering apparatus of the aforesaid character. Specifically, it is within the contemplation of the present invention to provide a syringe-type apparatus for continuous infusion and extraction of fluid solutions at microvolume levels which facilitates the maintainence of a constant volume within an object, system or person under observation or treatment.

It is a further object of the present invention to provide automatic perfusion and extraction means which permits controlled feed and delivery of microvolumes of fluid to a system over extended periods of time, substantially automatically and without regulation or supervision.

In accordance with an illustrative embodiment demonstrating features of the present invention, there is provided apparatus which includes a stationary support having a pair of spaced apart standards upon which are mounted plunger-operated hypodermic syringes each of standard construction. The syringes are mounted to extend in opposite directions with their plungers accessible in the space intermediate the standards. An actuating system is disposed between the standards and connected to the respective syringes and means are provided to displace the actuating member away from one of the standards and toward the other of the standards. By this action, the one or more syringes on one of the standards have their plungers depressed to achieve infusion of the liquid solution at a rate determined by the feed rate of the actuating member; and the plungers of the syringes on the other standard are pulled outwardly, providing vacuum in the associated syringes which effectuates fluid withdrawal at a rate determined by the feed rate of the actuating member.

The above brief description, as well as further objects, features advantages and applications of the present apparatus will be best appreciated by reference to the following detailed description of a presently preferred embodiment, when taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a plan view of a combined infusion and extraction apparatus embodying features of the present invention;

Fig. 2 is a front elevational view of the apparatus illustrated in Fig. 1;

Fig. 3 is an end elevational view of the apparatus illustrated in Fig. 1 taken along the line 3—3 of Fig. 1 and looking in the direction of the arrows;

Fig. 4 is a sectional view taken substantially along the line 4—4 of Fig. 1 and looking in the direction of the arrows;

Fig. 5 is an end elevational view of the apparatus shown in Fig. 1 taken along the line 5—5 and looking in the direction of the arrows;

Fig. 6 is an enlarged fragmentary detail taken substantially along the line 6—6 of Fig. 1 and looking in the direction of the arrows;

Fig. 7 is an enlarged fragmentary sectional view taken substantially along the line 7—7 of Fig. 1 and looking in the direction of the arrows; and

Fig. 8 is a fragmentary sectional view on an enlarged scale taken substantially along the line 8—8 of Fig. 2 and looking in the direction of the arrows.

Referring now specifically to the drawings, and in particular to Figs. 1 to 5 inclusive, there is shown motor driven injection and extraction apparatus according to the present invention, generally designated by the numeral 10, which includes a support 12 having a base or pedestal 14 and a pair of standards or uprights 16, 18. The flat top faces 16*a*, 18*a* of the standards are disposed in a common horizontal plane and are formed with transversely-extending seating depressions or slots 20, 22. In the illustrative form, the top face 16*a* is provided with four spaced apart seated depressions, while the top face 18*a* of the standard 18 is formed with a pair of seating depressions 22, the pair 22 being disposed in substantial alignment with the outermost pair of seating depressions 20 on the standard 16.

The sections of the respective seating depressions 20, 22 are all the same, and as seen in Fig. 6 each includes opposed upright walls 22*a*, 22*b* and a V-shaped base or floor 22*c*. An appropriate liner 24, as of soft rubber, is provided coextensive with the walls of the seating depressions 20, 22 to provide a cushioned mount for the respective syringes, each of which have been generally designated by the reference numeral 26. As is well understood, the syringes 26 include a main cylindrical body or barrel 28 adapted to contain fluid, a reciprocating plunger 30 movable through a predetermined linear thrust within the barrel or cylinder 28, and a needle 32 in communication with the barrel or cylinder 28. When the plunger 30 is thrust forwardly, pressure is created within the cylinder 28 causing fluid to be discharged through the needle 32; and when the plunger 30 is drawn backward, a vacuum is created within the barrel 28 causing the extraction of fluid from the body or tissue into which the needle 32 is inserted.

The respective syringes 26 are fixed in place through provision of pivoted clamping or locking members 34, 36 associated with the seating depressions 20, 22. The clamp or locking members 34, 36 are all of the same structure and accordingly only one will be described in detail in conjunction with the showing of Fig. 6. Specifically, locking member 36, which is seen to straddle the seating depression 22 and to rest against the adjacent upper face 18*a* of the standard 18, is mounted on a first pivot bolt 38 tapped into the standard 18 at one side of the seating depression 22, and is lockable in position by a keeper bolt 40 likewise tapped into the standard 18. The clamping plate 36 is formed with a bore 36*a* for the extension therethrough of the threaded shank of the pivot bolt 38 and is formed with a lateral slot 36*b* which ac-

commodates the shank of the keeper bolt **40** when the member **36** is pivoted into the engaged full line position (illustrated at the upper end of the standard **18** in Fig. 1). Upon tightening down on one or both of the bolts **38**, **40**, the associated syringe may be accurately seated and locked in place in its depression **22**.

By the described arrangement of the seating depressions **20**, **22** and associated clamping members **34**, **36**, it is possible to mount a first set of the syringes, generally designated by the notation S_1, with their respective plungers extending inwardly from the standard **16** and in substantial parallelism, and a second set of syringes, generally designated by the notation S_2, with their plungers extending inwardly from the standard **18** and in substantial parallelism. As seen in Fig. 1, the end adjacent pair of syringes S_2 on the standard **18** have their plungers in substantial end to end alignment with the end adjacent pair of syringes S_1 on the standard **16**.

Traversing the uprights or standards **16**, **18** is a lead screw **42** which, as seen in Fig. 2, includes an intermediate threaded section **42***a* and end adjacent bearing sections **42***b*, **42***c*. The bearing sections **42***b*, **42***c* extend through appropriate sleeve bearings or brushings **44** provided in the standard **16**, **18** and mount the lead screw for turning movement about its own axis. Operatively connected to the end of the lead screw **42** adjacent the bearing section **42***b* is a knob **46** for manual turning of the lead screw **42**.

Drive is imparted to the lead screw **42** from an appropriate synchronous timing motor **48** removably yet rigidly mounted on the base **14** through provision of a right angle bracket **50** which is held in place by the screws **52** tapped into the base **14**. The motor preferably is a fractional horse power unit of standard construction, such as those sold and commercially available under the trade-mark "Telechron" and is designed to provide a substantially constant and low rate of turning at its output shaft **52**. The motor **48** is energized from an appropriate source of line potential via the leads **54**, **56** connected through a voltage stepdown transformer **58**. The output shaft **52** of the motor is coupled via an appropriate releasable clutch mechanism to the lead screw **42**. In the illustrative form of the invention, a sylphon bellows **60** is fixed to the motor shaft and is provided with a slotted forward end **60***a* which engages oppositely directed pins **62** fixed on the adjacent end of the lead screw **42**. The use of the bellows **60** facilitates the more or less permanent attachment of the motor to the base, yet permits release of the motor shaft **52** from the lead screw **42** when the motor is to be removed from the base and replaced by a motor capable of providing a different driving rate for the lead screw.

The lead screw **42** carries a follower nut **64** which is movable toward and away from the respective standards **16**, **18** at a rate predetermined by the pitch of the lead screw and/or the drive of the motor **48**. The follower nut **64** carries a cross head or actuating member **66** which is disposed intermediate the standards **16**, **18**. The cross head **66**, as seen in Figs. 1 and 2 extends generally parallel to the standards **16**, **18** and is disposed in substantially the plane of the sets of syringes S_1, S_2. Appropriate guide means are operatively connected to the follower **64** to preclude rotative displacement of the same in relation to the lead screw **42** and to assure the required follower action. In the illustrative form, the guide means includes a depending bracket **68** secured to the follower nut **64** which engages one side of a guide rod **70** fixed between the standards **16**, **18** and a depending finger **72** on the bracket **68** which engages the opposite sides of the guide rod **70**.

Supported at spaced locations along and transverse of the cross head **66** are coupling members, generally designated by the reference numeral **74**, which operatively engage the plungers of syringe set S_1, and are operatively connected to the plungers of syringe set S_2. Each of the coupling members **74** is of like structure and includes a

threaded bolt **76** tapped through the actuating member or cross head **66** and adjustable along the line or lines of action of the plungers **30** of the sets S_1, S_2. On each of the bolts **76** is a threaded nut **78** which is engageable against the adjacent side of the cross head **66** to lock the bolts in a selected position of transverse adjustment. As seen best in Fig. 7, the leading end **76***a* of the bolt is engageable against the plunger of the aligned syringe of the set S_1; the head end **76***b* of the bolt carries an appropriate spring clip **78***b* which is engageable about the enlarged end of the plunger of the aligned syringe of the set S_2. Thus, in response to movement of the cross head **66** away from the standard **18** and toward the standard **16**, the leading ends **76** of the coupling members will urge the plungers of the set S_1 through a forward thrust effective for injection of fluid, and simultaneously, the plungers of the second set S_2 will be retracted to effect fluid withdrawal.

In a typical installation, polyethylene tubing may serve as a lead from the needle of a hypodermic syringe, the tubing being connected to a glass capillary tube at the end remote from the needle. Glass capillary tubes from an infusion and extraction syringe are inserted into the tissue or organ. Employing apparatus in which the timing motor **48** produces one revolution of its shaft every four hours, and with a lead screw of one-half inch diameter and having forty threads to the inch, it was found possible to deliver and extract .0013 cubic centimeter per hour for prolonged time periods.

From the foregoing, it will be appreciated that the present apparatus finds numerous applications in both experimental and practical biology and medicine. By expedients well understood in the art, the apparatus can be arranged to feed discontinuously, to shut off after a prescribed period of infusion and extraction, and to provide a variable feed rate. Further, it will be appreciated that the device may be used successfully for the infusion of microvolumes by decoupling of the extraction needles S_2, and conversely for extraction of microvolumes only by decoupling of the infusion needles S_1.

Numerous modifications are intended in the foregoing disclosure and in certain instances some features of the invention will be used without a corresponding use of other features. Accordingly, the appended claims should be construed broadly as is consistent with the disclosure.

What we claim is:

1. In perfusion and extraction apparatus, a stationary support including a pair of spaced apart standards, means on each of said standards for supporting plunger-operated hypodermic syringes on said standards, said syringes being mountable to extend in opposite directions with their plungers extending into the space between said standards, an actuating member disposed between said standards and adapted to be connected to said syringes, means operatively connected to and mounting said actuating member for movement toward and away from the respective standards, and drive means operatively connected to the mounting means for said actuating member.

2. In a device for extraction and perfusion of microlevels of fluid from hypodermic syringes each of which includes a fluid-containing cylinder and a plunger operable in said cylinder, a base including a pair of spaced apart uprights, means for mounting one or more syringes on each of said uprights with their respective plungers extending inwardly, an actuating head interposed between said uprights, a driven lead screw and follower operatively connected to said head and mounting said head for movement at a predetermined rate away from one of said uprights and toward the other of said uprights, means adapted to operatively connect the plungers of the one or more syringes on said one upright to said head whereby in response to movement of said head away from said one upright, the plungers are retracted in their cylinders, and means adapted to operatively con-

nect the plungers of the one or more syringes on said other upright to said head whereby in response to movement of said heads toward said other upright, the plungers are advanced in their cylinders.

3. In a device for extraction and perfusion of microlevels of fluid, hypodermic syringes each of which includes a fluid-containing cylinder and a plunger operable in said cylinder, a base including a pair of spaced apart uprights, means for mounting one or more syringes on each of said uprights with their respective plungers extending inwardly, an actuating head interposed between said uprights, a driven lead screw and follower operatively connected to said head and mounting said head for movement at a predetermined rate away from one of said uprights and toward the other of said uprights, means operatively connecting the plungers of the one or more syringes on said one upright to said head whereby in response to movement of said head away from said one upright, the plungers are retracted in their cylinders, and means operatively connecting the plungers of the one or more syringes on said other upright to said head whereby in response to movement of said heads toward said other upright, the plungers are advanced in their cylinders.

4. A device for the simultaneous infusion and withdrawal of microvolumes of solutions over long periods of time comprising a base including spaced apart and parallel first and second uprights, a lead screw traversing said uprights, bearing means mounting said lead screws for rotation about its axis, a synchronous timing motor having a constant rate of revolution coupled to said lead screw, a first hypodermic syringe seated on said first upright and having its plunger disposed along a first line of action parallel to said axis, a second hypodermic syringe seated on said second upright and having its plunger disposed along a second line of action parallel to said axis and coinciding with said first line of action, a cross head

disposed between said uprights, a lead screw follower engaging said lead screw and operatively connected to cross head, and a coupling member disposed along said coinciding lines of action and operatively engaging the plunger of said first syringe and operatively connected to the plunger of said second syringe.

5. A device for the simultaneous infusion and withdrawal of microvolumes of solutions over long periods of time comprising a base including spaced apart and parallel first and second uprights, a lead screw traversing said uprights, bearing means mounting said lead screw for rotation about its axis, a synchronous timing motor having a predetermined rate of revolution coupled to said lead screw, a first hypodermic syringe seated on said first upright and having its plunger disposed along a first line of action parallel to said axis, a second hypodermic syringe seated on said second upright and having its plunger disposed along a second line of action parallel to said axis and coinciding with said first line of action, a cross head disposed between said uprights, a lead screw follower engaging said lead screw and operatively connected to cross head, and a coupling member disposed along said coinciding lines of action and operatively engaging the plunger of said first syringe and operatively connected to the plunger of said second syringe, said coupling member including a threaded bolt tapped through said cross head and adjustable along said coinciding lines of action and a nut on said bolt and engageable against said cross head to lock said bolt in selected positions of adjustment.

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