Aug. 15, 1967 E. M. GIENAPP 3,335,724

REMOTE CONTROL, REPEATING, VARIABLE STROKE HYPODERMIC SYRINGE DEVICE

Filed July 24, 1964

3 Sheets-Sheet 1

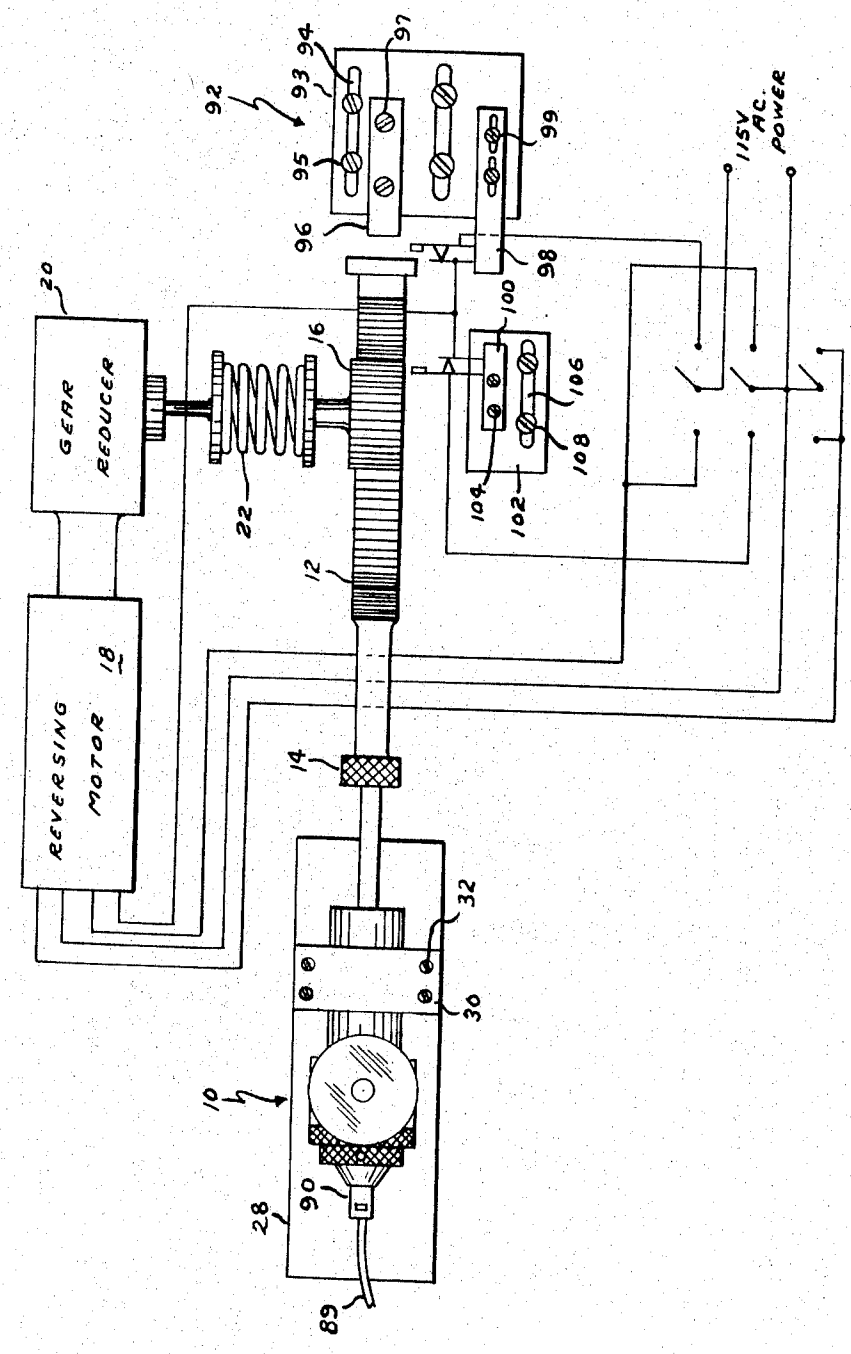


FIG-1

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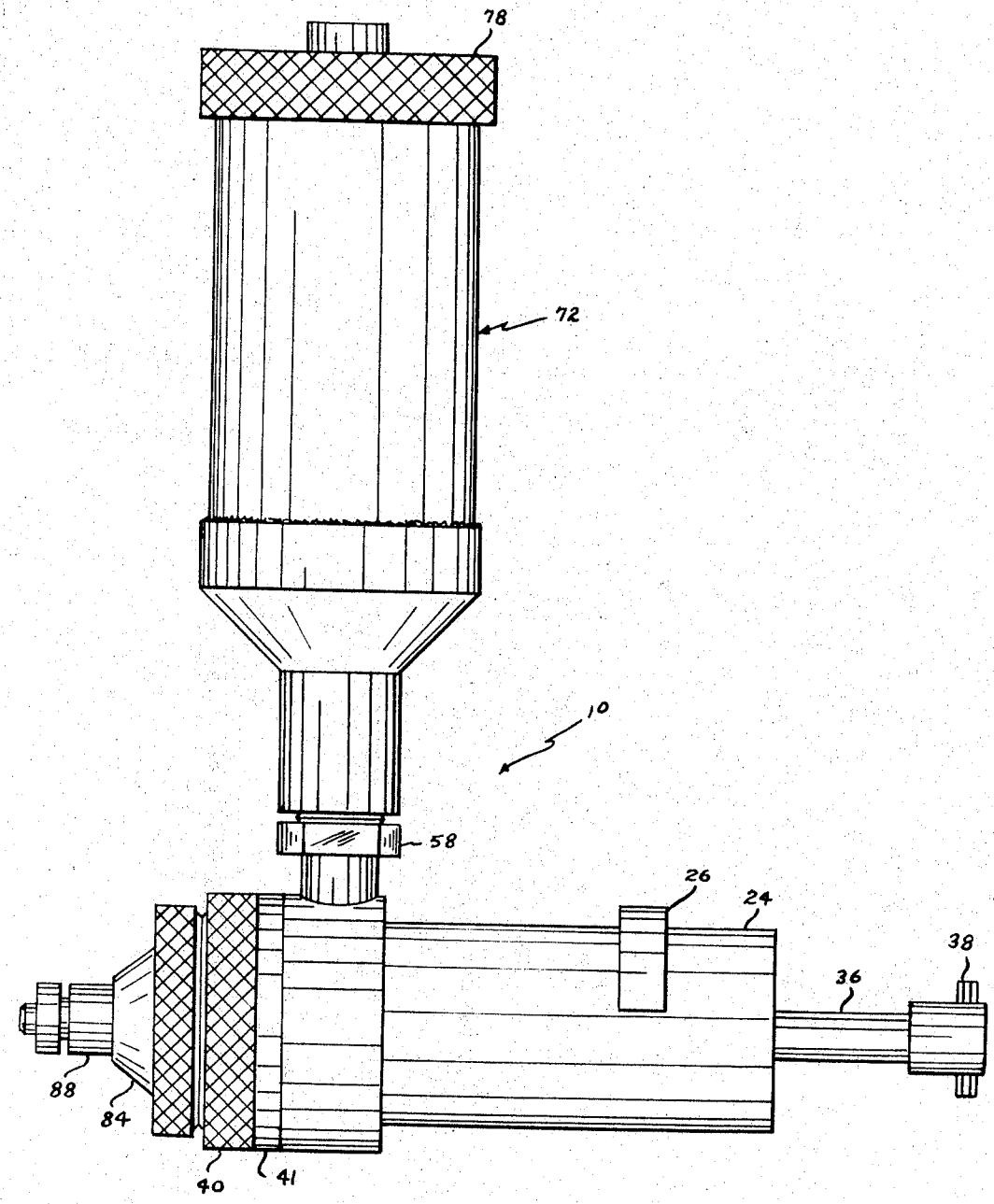


Fig-2

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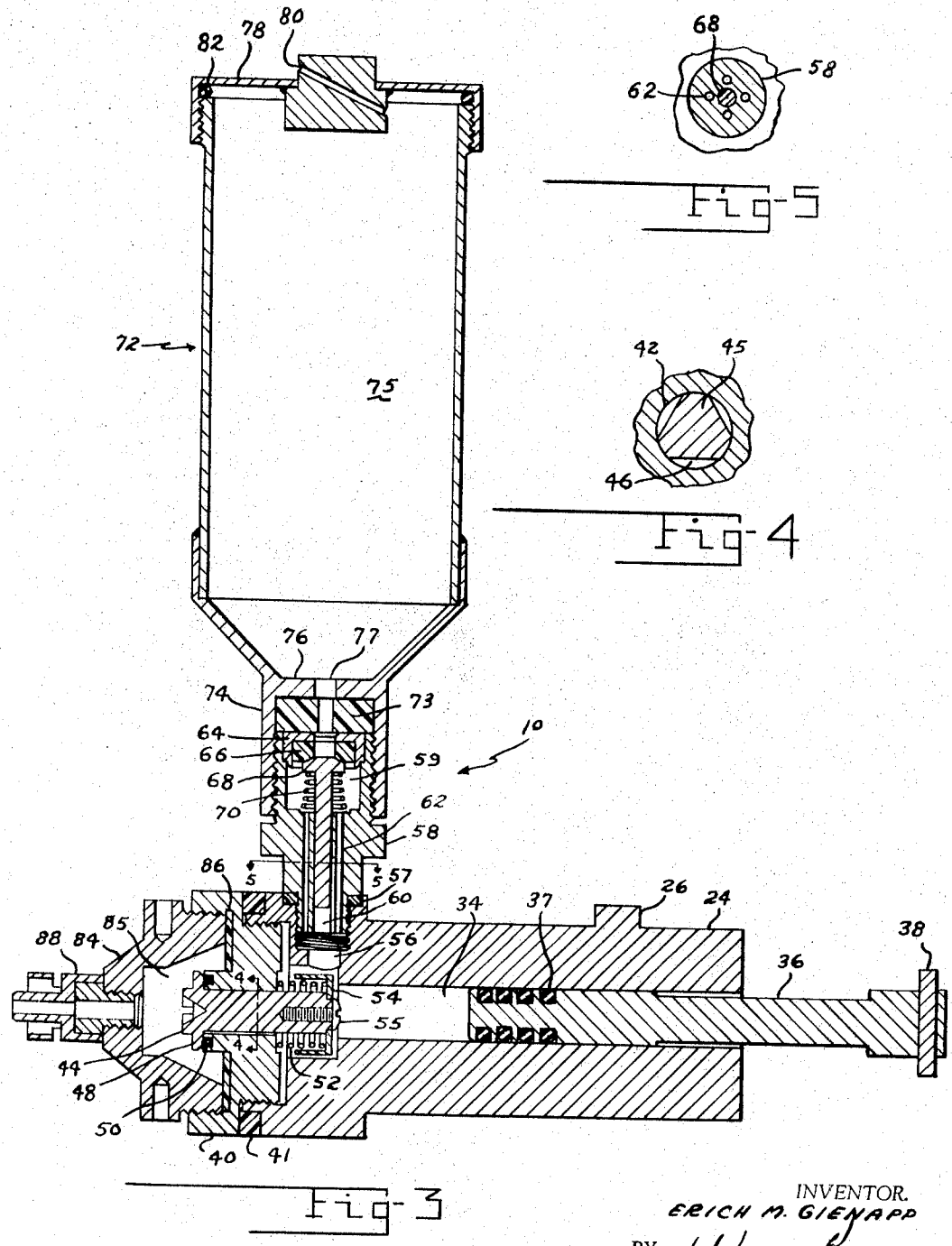


Fig-3

Fig-5

Fig-4

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REMOTE CONTROL, REPEATING, VARIABLE STROKE HYPODERMIC SYRINGE DEVICE

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ABSTRACT OF THE DISCLOSURE

A remote control, repeating hypodermic syringe apparatus comprising a body having an elongated bore, a plunger reciprocal in the bore of the body to provide a variable area fluid chamber, a fluid controlled inlet valve means in a passage connecting the fluid chamber to a fluid reservoir, a fluid controlled outlet valve means in a passage connecting the fluid chamber to a living test subject, an actuating means for actuating the plunger, and remote control means for controlling the actuating means; the apparatus thus described having the primary function of injecting fixed quantity injections of fluid from the reservoir to the test subject, the injections being made at variable intervals upon command of the operator.

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

This invention relates to medical apparatus, and more specifically to fluid injection devices such as hypodermic syringes. Still more specifically this invention provides such a device embodied for making remote-controlled multiple injections.

Recent years have witnessed man's entry into the space age with its numerous environmental problems which must be solved. In addition to research relating directly to space craft, extensive research is in progress to adapt man himself to a foreign environment; both physically and psychologically. Much of this research is being conducted on test specimen animals confined within simulation tanks or chambers. Such animals are often physically restrained for a reasonable period of time in order that they may be instrumented and their various physical reactions observed and recorded. On various tests it is often necessary to make fluid injections such as dyes or saline solutions. It is obvious that such injections cannot be made during the course of an experiment unless a method and apparatus can be devised for permitting the experimenting personnel on the outside of the test chamber to control the device within the chamber.

The present invention provides a device which may be joined to the bloodstream of a test specimen through a needle, or through a catheter tube sutured to the animal. Furthermore, the device may be adjusted to a specific volume of fluid per injection, and the injection rate controlled from without the test chamber.

One object of the present invention is to provide a hypodermic syringe device which will repeatedly and by remote control inject a predetermined amount of fluid into a test specimen animal undergoing tests in a space simulation chamber.

Another object of this invention is to provide a hypodermic syringe device in which the stroke limits may be adjusted to vary the volume of fluid injected.

Still another object of this invention is to provide a hypodermic syringe device having a fluid reservoir storing sufficient injection fluid for a multiplicity of injections.

A further object of this invention is to provide a hypodermic syringe device which may be readily disassembled for cleaning and for the replacement of elements.

A still further object of this invention is to provide a hypodermic syringe device for use with hospital patients where it is desired to inject a small amount of fluid at fixed intervals over a period of time without the necessity for human attendance.

Additional objects, advantages and features of the invention reside in the construction, arrangement and combination of parts involved in the embodiment of the invention as will appear from the following description and accompanying drawings, wherein:

FIG. 1 is a schematic plan view of the device coupled to elements necessary to effect remote control,

FIG. 2 is an enlarged elevation of the syringe pump proper,

FIG. 3 is a vertical cross section through the pump device of FIG. 2 and showing construction details,

FIG. 4 is a section on line 4—4 of FIG. 3 and showing one method of construction to provide flow passages, and

FIG. 5 is a section on line 5—5 of FIG. 3 showing the flow passages in the inlet valve housing.

Referring to FIG. 1, the syringe pump **10** is axially coupled to a rack **12** by means of a detachable coupling **14**. The rack is axially moved to actuate the syringe pump **10** by means of a pinion gear **16** which engages the rack and is driven by a reversible electric motor **18** driving through a reduction gear **20** and a spring **22**. The spring **22**, which is firmly joined between the reduction gear and the pinion, so as to form an integral element of the drive train, is representative of overtravel devices. In addition to the simple spring depicted, such overtravel devices are made in various spring and friction-slipping forms, and do not constitute a part of this invention. The purpose of the overtravel device will be subsequently explained.

The reversing motor **18** is activated by a conventional A.C. power supply controlled by any convenient reversing switch as is shown in schematic.

Referring now to FIG. 2, and in particular to FIG. 3, the syringe pump **10** has a body member **24** having an external locating lug **26** which forms a convenient means for axially locating and retaining the syringe pump in a fixed axial position on a sub-base **28**, as shown on FIG. 1. The syringe pump is held onto the sub-base by means of a holddown bracket **30** having an internal cavity which engages the locating lug on the body member and which is retained by means of screws **32**.

Again referring to FIG. 3, the rear end of body member **24** contains an axial bore **34** open at the rear, and which forms a cylinder for slidably receiving plunger **36** to provide a variable displacement pump chamber. The inner end of the plunger is provided with a plurality of O-rings **37** which act as sealing members to prevent leakage from the pump chamber. The O-rings are preferably made of a material, such as nylon or Teflon, which is chemically inert to the fluid to be dispensed. The outer end of the plunger is provided with means for engaging coupling **14**. As illustrated, the plunger is provided with a pin **38** which is engaged by the bayonet type coupling **14**. The forward end of body member **24** terminates in an internally threaded counterbore communicating with the axial bore **34** and engaging the discharge valve housing **40**. A sealing member, such as ring gasket **41**, is provided to prevent leakage through the thread joining the body member **24** and the valve housing **40**. Axially extending through the valve housing is a bore **42** as best shown on FIG. 4. A discharge valve plug **44**, having a rearward extending stem portion **45**, as best shown on FIG. 4, is in sliding engagement with the bore in the discharge valve housing. The stem portion is relieved as shown on FIG. 4 to provide flow passages **46** for fluid transfer. The forward end of the discharge valve plug **44** is provided with a flange portion **48** for seating against O-ring **50** retained by the discharge valve housing **40**. When the flange portion of the dis-

charge valve plug 44 engages the O-ring 50, the flow passages 46 are blocked; when the flange portion is axially moved from the O-ring, the flow passages are open. The rear end of the stem portion of valve plug 44 extends through the discharge valve housing 40 where it is coaxially surrounded by a compression spring 52 which is disposed between the rear face of the discharge valve housing 40 and flanged retaining cup 54 which is joined to the protruding end of the valve plug by screw 55. The compression spring biases the valve plug against the O-ring to provide a normally closed discharge valve. The distance between the rear face of the valve housing and the end of the flange on the retaining cup limits the amount of the valve opening when the plunger moves forward to produce a pressure increase above ambient in the pump chamber.

As shown on FIG. 3, the body member 24 contains a passage 56 which is transverse to and is in communication with the forward end of the axial bore 34. The outer end of passage 56 is counterbored and internally threaded to receive the inlet valve housing 58. A sealing member, such as a ring gasket 57, is provided to prevent leakage through the thread joining the body member 24 and the inlet valve housing 58. The upper end of the inlet valve housing is provided with external threads; and further, contains a counterbore 59. Extending between the lower end of the inlet valve housing engaging the body member 24 and the bottom of the counterbore 59, is an axial bore 60 and a plurality of flow passages 62 which surround bore 60. The relationship between bore 60 and flow passages 62 is more clearly shown on FIG. 5. A valve seat retainer shell 64 which retains valve seat 66, is pressed into the upper end of the counterbore in the inlet valve housing as shown. The valve seat 66 is preferably made of an inert plastic such as nylon or Teflon. Axially movable within bore 60 is an inlet valve plug 68, having a downward extending stem portion slidably engaging bore 60, and a head portion engaging valve seat 66. Coaxially surrounding the stem portion of the valve plug 68 and disposed between the head portion of the valve plug and the bottom of the counterbore in the inlet valve housing 58, is a compression spring 70. The compression spring biases the inlet valve plug 68 against valve seat 66 to provide a normally closed inlet valve which opens when the plunger moves backward to produce a pressure drop below ambient in the pump chamber.

A fluid reservoir 72, having an internally threaded neck 74, is in engagement with the upper end of inlet valve housing 58. Gasket means 73 are provided to prevent leakage. The neck portion 74 is separated from the main cavity 75 by means of a partition 76 containing a passage 77. Passage 77 permits the fluid contained in the cavity 75 to flow into the inlet valve. The fluid reservoir is provided with a suitable cap 78 which contains a vent passage 80. A gasket means 82 is provided to prevent leakage.

The forward end of the discharge valve housing 40 is counterbored and internally threaded to receive discharge cap 84 which contains a cavity 85 for receiving fluid flowing through the discharge valve. A suitable gasket means 86 is provided for preventing fluid leakage through the threads joining the discharge cap 84 and the discharge valve housing 40. The forward end of the discharge cap 84 contains an internally threaded passage for engaging the male connecting portion of a standard syringe such as the "HYPO" syringe No. PV 189 furnished by the Surgical Supply Corporation. Such syringes and their various elements and combinations are well known in the medical profession and will not be further described. The male connecting portion 88 is shown in threaded engagement with the discharge cap 84. In use, a catheter tube 89 is joined to connector 88 by a mating female connector plug 90, as shown on FIG. 1. Other methods for fluid transfer between the syringe device and the test specimen may be provided without departing from the invention.

The operation of the syringe pump 10, above described, is as follows: a partial withdrawal of plunger 36 creates a pressure drop within the axial bore 34, which in turn opens the inlet valve against the biasing action of compression spring 70 and draws in an amount of fluid equal to the volumetric displacement of the plunger. When the plunger movement ceases, spring 70 closes the inlet valve. When the plunger is moved inwardly, the discharge valve is forced to open, and an amount of fluid equal to the volumetric displacement of the plunger is discharged; after which spring 52 closes the discharge valve.

The syringe pump 10, above described, has been found to be controllable, as to the volume of fluid dispensed, to an accuracy of over 99%. The method for controlling the stroke of the pump is shown on FIG. 1. The basic problem is to adjust the stroke of the plunger between firm limits to a desired displacement, and to provide an overtravel device to absorb the "coast" of the motor 18 and gear reducer 20 after the electrical circuit is opened. A firm limit for the forward movement is inherent in the apparatus by permitting coupling 14, which is made to have no axial clearance, to abut against the body member of the syringe pump. The rearward limit of the plunger movement is established by means of a stop-block assembly 92, which in common with the other elements shown on FIG. 1, is mounted on any convenient base (not shown). The stop-block assembly 92 has a base block 93 having elongated slots 94 for axially moving the stop-block assembly on screws 95, which when tightened, hold the stop-block assembly firmly on the base. A stop-block 96 is firmly affixed to base block 93 by means of screws 97. The forward end of stop-block 96 provides a firm but adjustable means for controlling the linear withdrawal of the plunger in the syringe pump by limiting the movement of rack 12 which actuates the plunger. A normally closed electrical switch, such as a microswitch 98, is adjustably mounted on base block 93 by means of screws 99. As shown on the wiring schematic, the microswitch is opened when the rack reaches a predetermined position and breaks the electrical circuit to the motor when the reversing switch is closed to actuate the plunger of the syringe pump in the withdrawal direction. The position of the microswitch is adjusted to open the electrical circuit before the end of the rack abuts against stop-block 96. The movement of the rack between the opening of the microswitch and its final abutment against the stop-block is produced by the "coast" of the motor 18 and the gear reducer 20 between the time interval during which the circuit is opened and the motor comes to rest. Since the "coast" will vary between cycles, the switch is adjusted in relationship to the stop-block to such a position that the motor will not have stopped by the time the rack has reached the abutment position against the stop-block. The residual "coast" is absorbed by spring 22. The volumetric displacement of the plunger in the syringe pump is controlled by repositioning the stop-block assembly 92.

A second microswitch 100 is joined to base block 102 by means of screws 104. The base block 102 has an elongated slot 106 for axially moving the base block 102 on screws 108, which when tightened hold the microswitch 100 at a selected position in relationship to the rear end of rack 12. Microswitch 100 is positioned to provide for "coast" in the manner previously described.

Other drive means may be provided to actuate the plunger in the syringe pump. The reversing motor 18 could be replaced with a motor having a magnetic brake; such a motor would eliminate the "coast." Hydraulic means could also be substituted; the microswitches cutting the hydraulic power.

The arrangement shown on FIG. 1 is manually operated by control means such as the reversing switch shown, in which a first position produces forward movement of the plunger and a second position produces rearward movement of the plunger. Automatic operation could be effected by replacing the manual reversing switch with a suitable timing device which will cycle the syringe device at predetermined intervals. Such a timing device could

easily include a counter to record the number of cycles from which the total volume of fluid injected would be determined.

It is to be understood that the embodiment of the present invention as shown and described is to be regarded as illustrative only, and that the invention is susceptible to variations, modifications and changes within the scope of the appended claims.

I claim:

1. A remote control hypodermic syringe device for making repeated periodic fluid injections on command through connecting means into a living test subject and comprising: a body having an elongated axial bore open at the rear, a reciprocating rearward extending plunger axially slidable forward and backward within the bore of said body to provide a pump chamber within said body, a fluid reservoir having inlet passage means joining said reservoir to the pump chamber within said body, said body further having a discharge passage means communicating with the pump chamber within said body and adapted for connecting to a living test subject, a normally closed inlet valve means within the inlet passage means joining said reservoir and the pump chamber within said body, said inlet valve means being openable by pressure drop below ambient in the pump chamber in said body, a normally closed discharge valve means within the discharge passage means in said body, said discharge passage means being openable by pressure increase above ambient in the pump chamber in said body, a power actuating means joined to said plunger for reciprocating said plunger in said body, said power actuating means having a rack the forward end of which is axially joined to the rear of said plunger, a pinion gear engaging the rack, and reversible drive means engaging the pinion, a displacement control means engaging the rear end of the rack of said power actuating means for varying the displacement of the pump chamber in said body by limiting the axial movement of said plunger in said body, and remote control means joined to said power actuating means.

2. A remote control hypodermic syringe device as set forth in claim **1** in which said remote control means has a first and a second position, the first position causing forward movement of said plunger and the second position causing rearward movement of said plunger.

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