Aug. 27, 1963 J. ISREELI 3,101,675

PUMP

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Fig. 1.

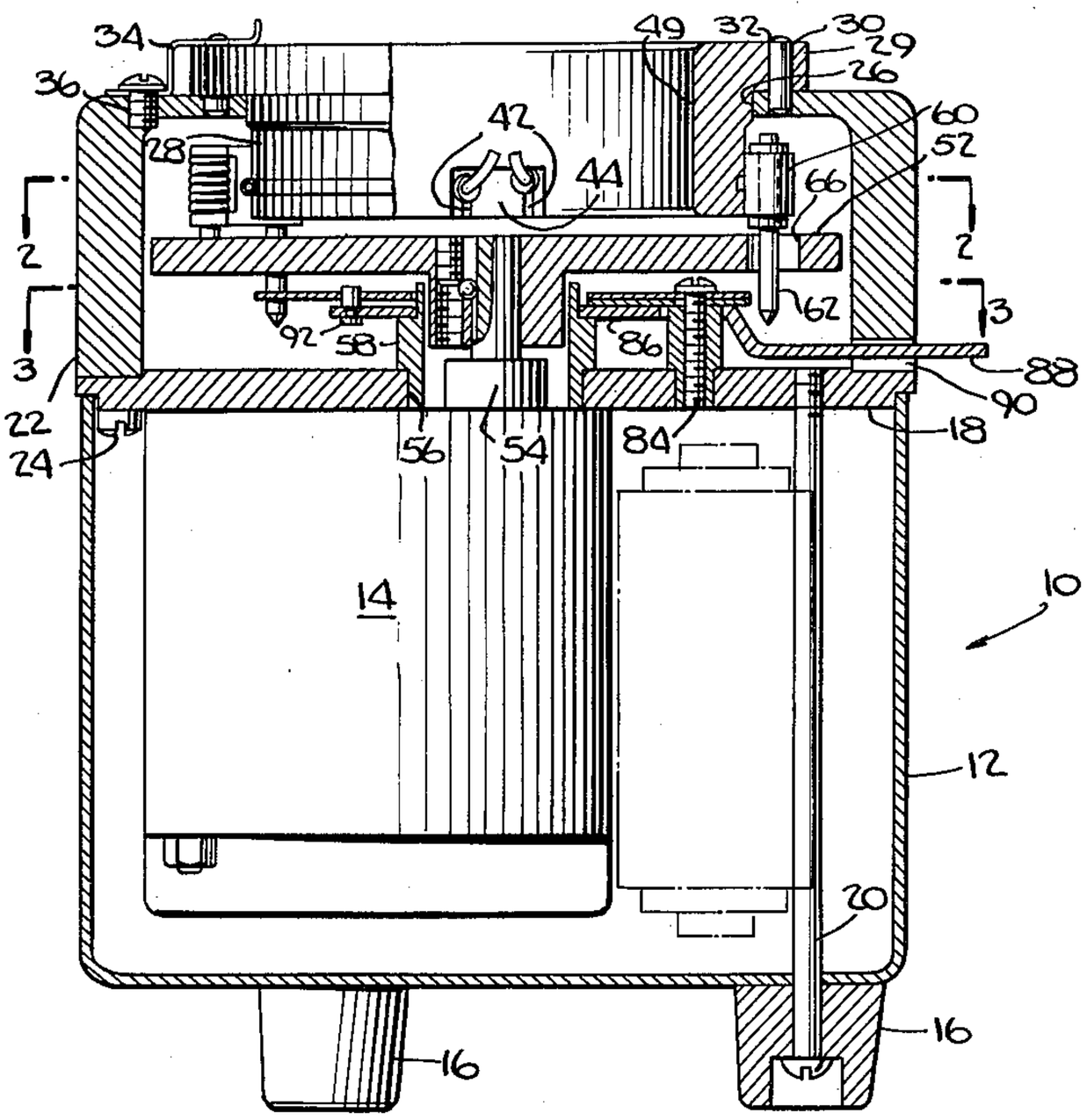


Fig. 7.

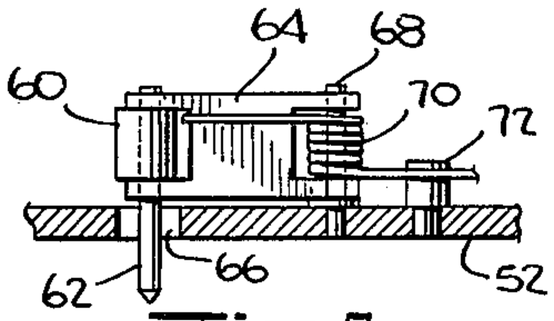


Fig. 2.

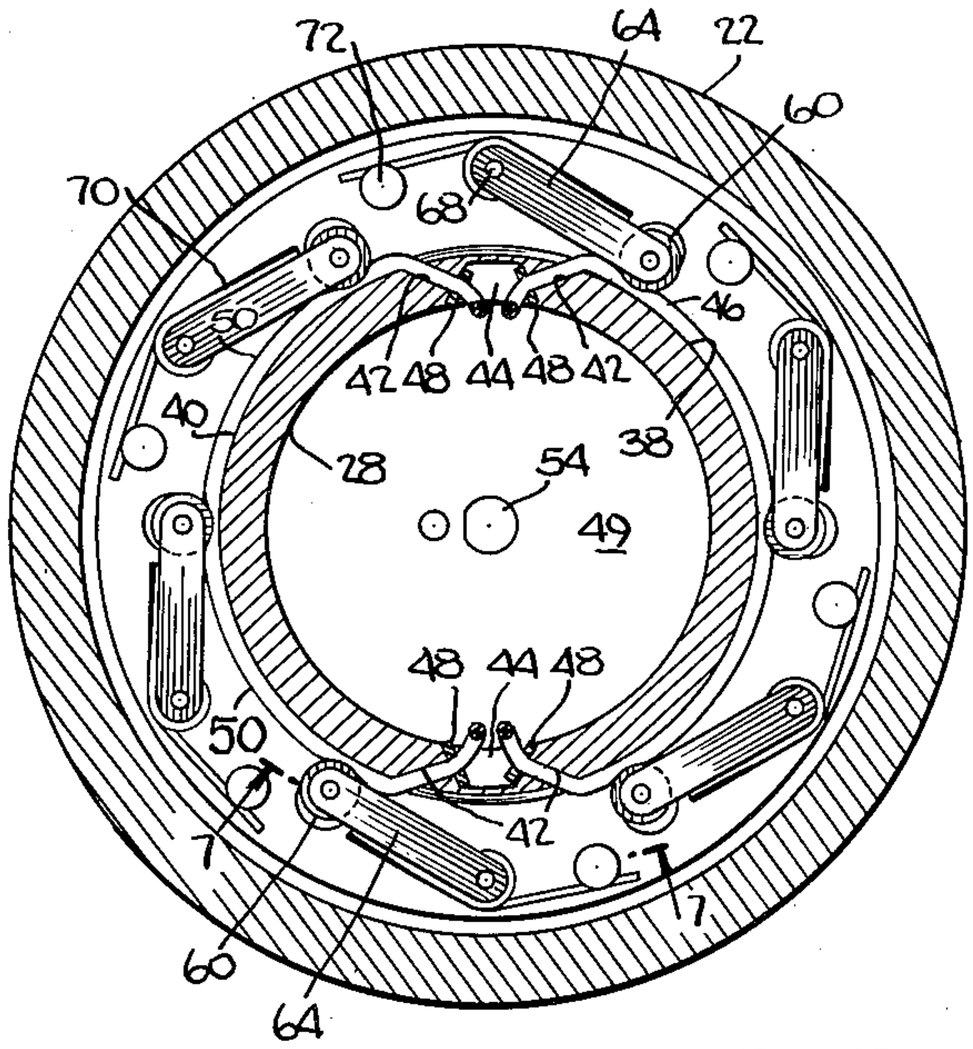


Fig. 8.

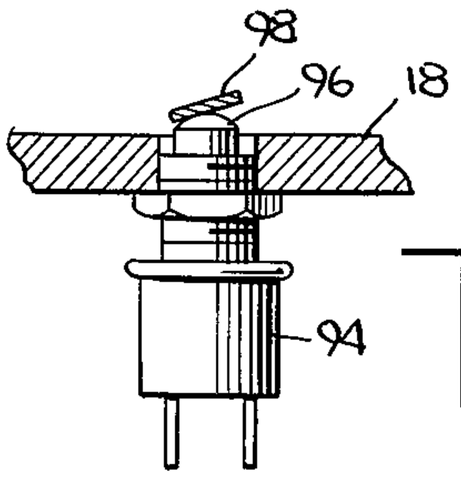


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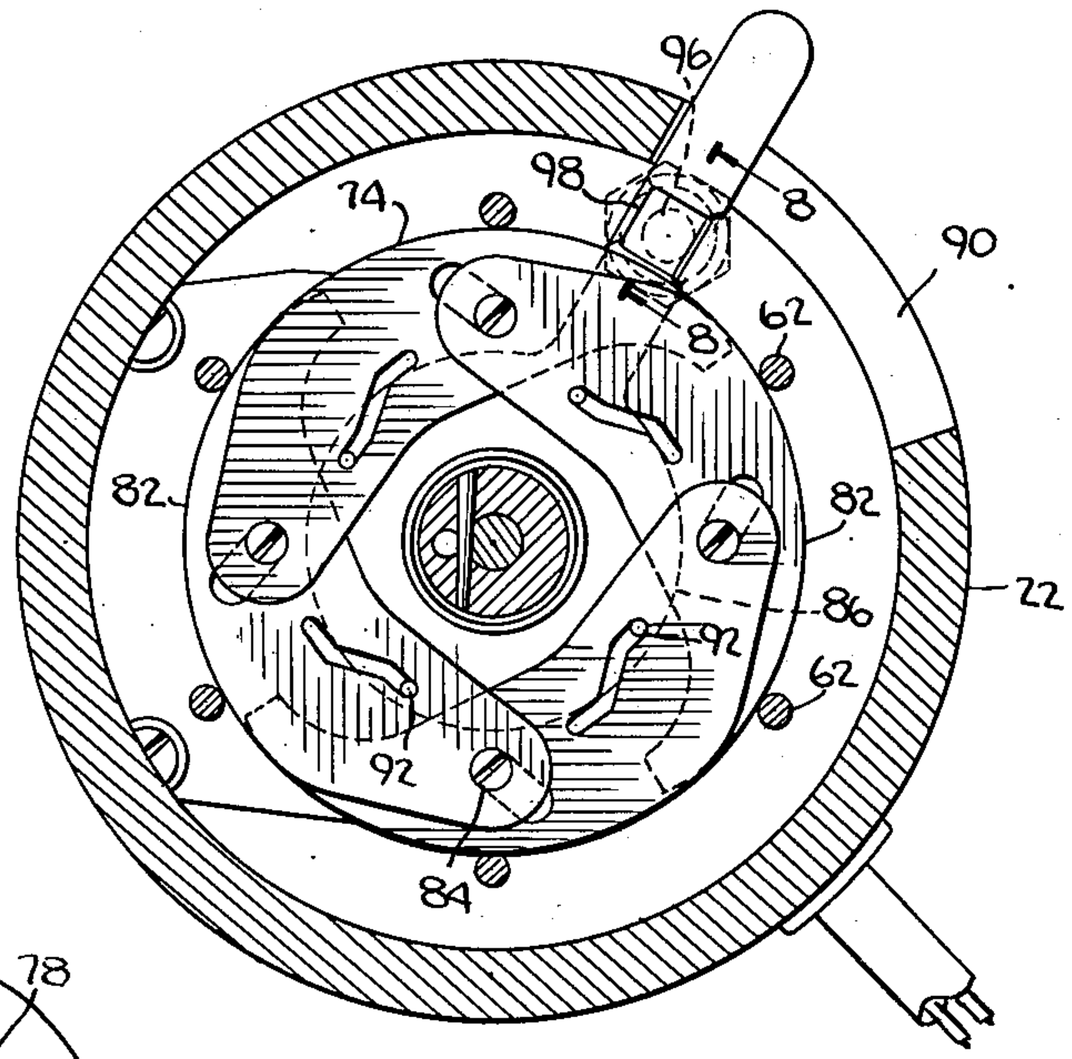
Fig. 4.



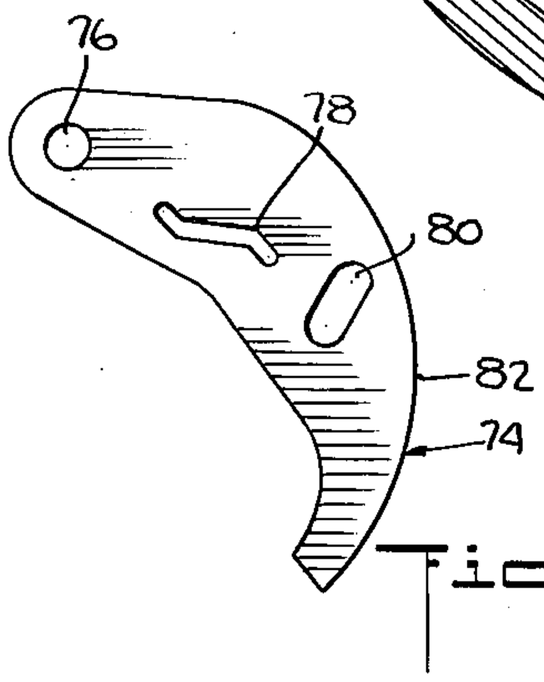




Fig. 8.

Fig. 6.

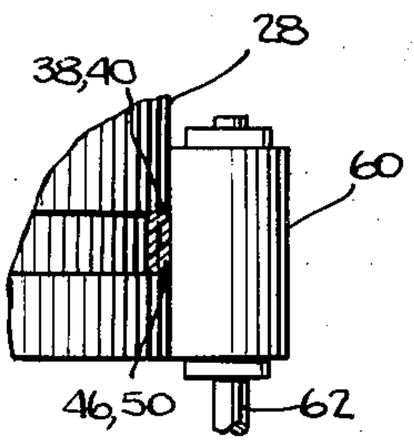



Fig. 5.

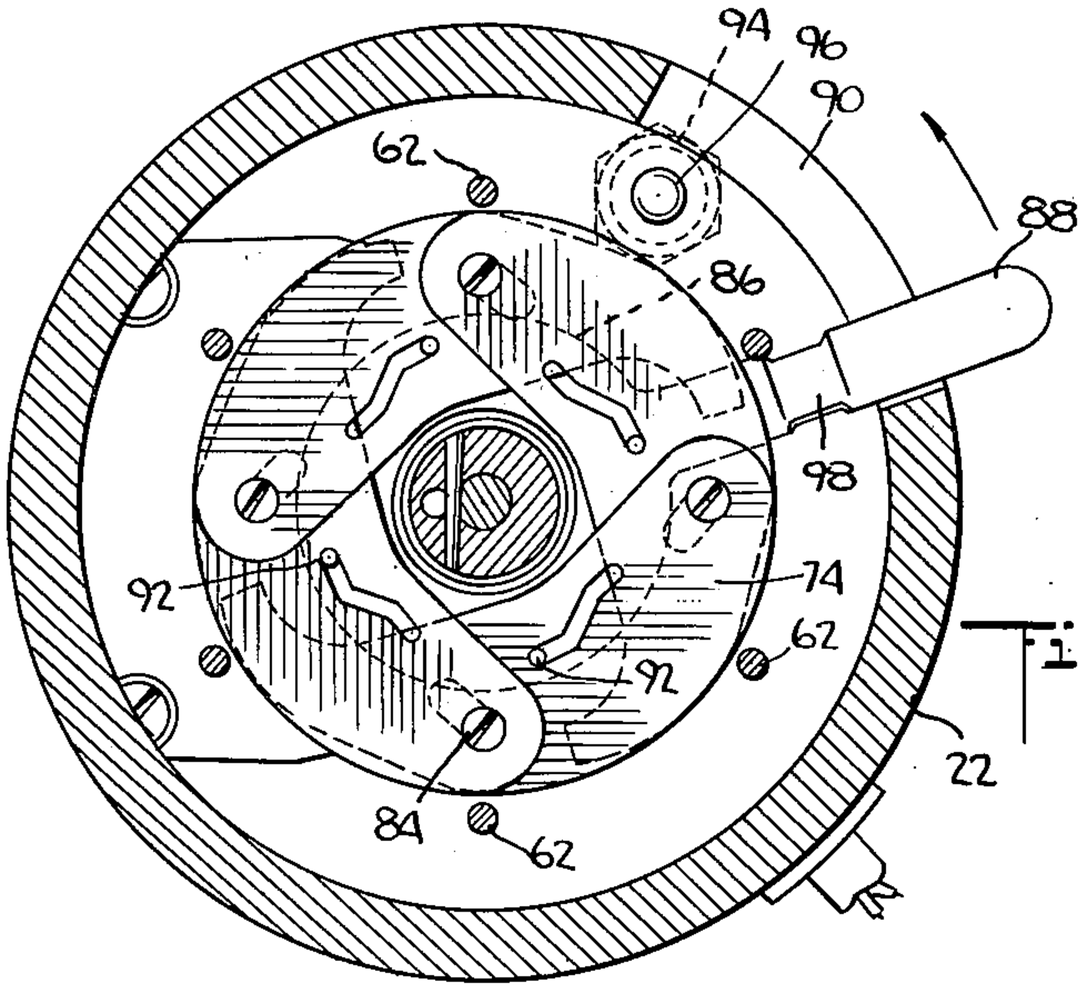
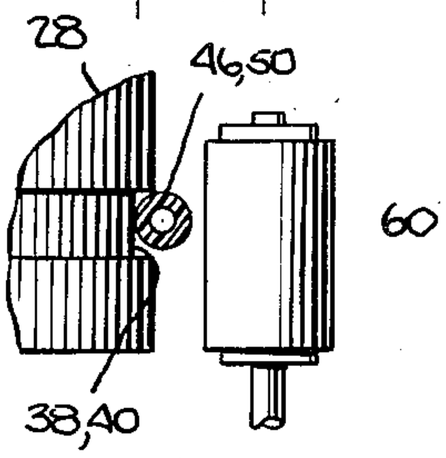



Fig. 7.

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3,101,675
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# 3,101,675
# PUMP

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Filed Apr. 24, 1961, Ser. No. 104,918
6 Claims. (Cl. 103—149)

This invention relates to pumps of the type which operate to pump fluid through a resiliently flexible tube by the compression of the tube progressively along its length.

One object of the invention is to provide a pump of the indicated type which is reliably operable with the use of compressible tubes of very small internal diameters to pump predetermined minute quantities of fluid with a high degree of accuracy.

Another object is to provide a pump of the indicated type with tube carrying platen means having an arcuate outer surface for supporting a resiliently flexible and compressible tube and with tube compressing means positioned externally of said tube carrying means and operable to progressively compress the pump tube along its length against said platen means for the pumping operation.

Another object is to provide a pump of the indicated type with means automatically operable to prevent the tube compressing means from engaging the pump tube unless the pump is in operation.

A further object is to provide a pump with a series of movable members which are operable to engage pressure applying rollers and prevent said rollers from engaging the resiliently flexible pump tube unless the pump is being operated.

Another object is to provide an improved pump which is relatively light and of simple construction and is especially well suited to pump with accuracy one or more fluids in small predetermined quantities.

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

In the drawings:

FIG. 1 is a vertical sectional view of a pump according to the present invention;

FIG. 2 is a sectional view taken on line 2—2 of FIG. 1;

FIG. 3 is a sectional view taken on line 3—3 of FIG. 1;

FIG. 4 is a sectional view, similar to FIG. 3, but showing the inoperative position of the pump;

FIG. 5 is a detail view showing the pump tube in its uncollapsed condition;

FIG. 6 is a detail view showing the pump tube in its collapsed condition;

FIG. 7 is a detail sectional view taken on line 7—7 of FIG. 2;

FIG. 8 is a detail sectional view taken on line 8—8 of FIG. 4; and

FIG. 9 is a view illustrating one of the parts of the pump.

Referring now to the drawings in detail, the pump 10 comprises a housing 12 in which the pump-operating motor 14, preferably a capacitor motor, is mounted. The housing is supported on the legs 16. The upper part of the housing is closed by a plate 18 which is secured to



the housing by the bolts 20 which also secure the legs 16 to the housing. A cylindrical casing 22, which is secured to plate 18 by screws 24, is provided with an opening 26 through which extends a stationary cylindrical platen or tube carrier 28. The tube carrier 28 has an end flange 29 by which said carrier is mounted on casing 22. Pins 30 are fixed to and extend upwardly from the casing into apertures 32 provided in the tube carrier. Spring retaining clips 34 are mounted on casing 22 by screws 36 and are movable to overlie the upper ends of the pins 30 to removably retain the tube carrier 28 in its mounted position on the casing.

As best seen in FIG. 2, the tube carrier is essentially a hollow cylindrical drum which is provided with a groove 38 that extends peripherally along the outer surface of the carrier a distance equal to about one-half of the circumference of said outer surface. Diametrically opposed to groove 38 is another groove 40 which is similar to the first mentioned groove and may be a continuation thereof. The ends of each of the grooves are continuous with passages 42 provided in the tube carrier and each passage extends from the end of its respective groove to an open ended recess 44 which is contiguous with the hollow inner portion of the tube carrier and it will be seen that passages 42 are also open ended, as best seen in FIG. 1. A resiliently flexible and compressible pump tube 46 is mounted in groove 38 and is provided with retaining rings 48 which are fixed thereto and fit into the recesses 44 and bear against the sides of the recess at passage 42 to hold the pump tube under tension in its groove. Parts of tube 46 extend from the ends of groove 38 through recesses 44 and through the hollow central portion 49 of the tube carrier, externally of the pump, for connection at one end of the tube to a source of fluid supply and at the opposite end of the tube to the delivery point of the pumped fluid.

As here shown, another resiliently flexible pump tube 50 is provided in its companion groove 40 in the same way as tube 46, so that two fluids can be simultaneously pumped in predetermined quantities according to the internal diameter of each tube. The fluids are pumped through the respective tubes by progressively compressing the tubes along their lengths. The tube compressing means comprises a rotary circular shaped carrier 52 which is fixed to the shaft 54 of the motor 14. Plate 18 is provided with a central aperture 56 through which the shaft extends and a hollow cylindrical sleeve 58 is press-fitted to plate 18 at aperture 56. The rotary carrier 52 is provided with a series of pressure applying rollers 60 which are arranged in a circular row in circumferentially spaced relation and are positioned externally of the tube carrier 28 in position to overlie the grooves 38 and 40 to engage the pump tubes and compress them for the pumping operation. As best seen in FIGS. 1, 2 and 7, each pressure roller 60 is mounted for rotation on a pin 62, one end of which is secured to a bifurcated I-shaped member 64 and the opposite end of which extends through an opening 66 in carrier 52 and projects transversely of the side of the carrier. Member 64 is pivotally mounted on a pin 68 which is fixed to and extends from the side of the rotary carrier. A torsion spring 70 is mounted on pin 68 and one end of the spring engages member 64 to bias said member and the roller 60 carried thereon into tube engaging position which, as shown in FIG. 2, requires a clockwise rotation of member 64

about pin **68**. The force of the spring need only be large enough to collapse the pump tube. The opposite end of the spring is held in position by the abutment pin **72** which is secured to the carrier **52**. Thus it is seen that the normal position of the pressure applying rollers is a tube engaging position.

In order to avoid a permanent set or deformation of the tubes which might result if the tubes were compressed by the rollers **60** for extended periods of time when the pump is not operated, means are provided to move the rollers outwardly in a counter-clockwise direction, as seen in FIG. 4, to disengage the pump tubes, and the rollers are retained in this disengaged position until the pump is operated. At that time the rollers are automatically moved into their operative position wherein they engage the pump tubes for the pumping operation. The roller positioning means comprises a series of cam plates **74** which are arranged in overlapped fashion concentrically about the longitudinal axis of the pump. As herein shown, there are four plates and each plate is provided with an aperture **76** at one of its ends, an elongated S-shaped channel **78** intermediate its ends, an elongated slot **80**, and a cam edge **82** which is adapted to engage pin **62** and move the roller **60** outwardly against the tension of the spring **70** to disengage said roller from the pump tube and retain said roller in its disengaged position. The overlapped arrangement of the plates **74** is readily apparent from FIGS. 3 and 4 and it will be observed that the forward part of one plate lies beneath the rear part of the next plate with the aperture **76** of said next plate overlying the slot **80** of the underlying plate. The plates are retained in this overlapped position by the screws **84** which are secured to the plate **18**. Four screws are provided and each screw passes through the aperture **76** of one plate and the slot **80** of the underlying plate. Each plate pivots about screw **84** at its aperture **76** and its slot **80** permits movement of the plate relative to the screw **84** which extends through said slot.

The actuating means for pivotally moving the overlapped plates inwardly into roller disengaging position or outwardly into roller engaging position comprises the circular disk **86** which is mounted for pivotal movement on sleeve **58** and is provided with an operating handle **88** which extends through a slot **90** provided in casing **22**. The disk is provided with four pins **92** and each pin extends into the channel **78** of one of the plates **74** for actuating said one plate. In the position shown in FIG. 3, the pump is in its operating position with handle **88** at one end of slot **90** in its On position and with each pin **92** at one end of its corresponding channel **78**. In this position, the plates **74** are in their withdrawn or closed position and the cam edges **82** of the plates do not engage the pins **62** so that rollers **60** are biased by springs **70** into their tube engaging positions. When handle **88** is moved to its opposite Off position, each pin **92** moves to the other end of its corresponding channel **78** causing the respective plates to pivot about their respective screws **84** and move outwardly into an extended condition wherein the cam edges **82** engage the pins **62** and lift the rollers **60** off the pump tubes. It will be observed that the shape of edges **82** and the arrangement of the plates results in the edges forming a circle when the plates are in their extended condition.

The movement of handle **88** controls the operation of the start and stop switch **94** of the pump so that in the Off position of the switch the rollers are disengaged from the pump tubes and in the On position of the switch the rollers engage the pump tubes and this occurs automatically thereby preventing any inadvertent errors by the operator which would leave the rollers in engagement with the tubes when the pump isn't operating which can seriously injure the tubes. The switch is mounted on plate **18** and its movable actuating button **96** is in the path of movement of the canted portion **98** of handle **88** so that in the Off position of the pump, as shown in FIGS. 4 and 8, portion **98** engages button **96** and depresses said button thereby opening the circuit through switch **94** and motor **14**. When handle **88** is moved into its On position, as shown in FIG. 3, portion **98** of the handle releases button **96** and the button moves outwardly to close the circuit to the operating motor **14**. Movement of the handle **88** to the On position also withdraws the plates **74** so that they release pins **62** to permit the rollers **60** to engage the pump tubes, as previously explained.



The tube engaging position of the rollers is shown in FIG. 6 and it will be noted that during pumping operation the tubes are compressed and closed by the rollers and pumping is accomplished by movement of the rollers longitudinally of the tubes. The depth of grooves **38** and **40** is equal to about twice the wall thickness of the respective pump tube and the rollers **60** overlie and extend beyond the sides of the grooves, so that in the collapsed condition of the tubes, during the pumping operation, the rollers abut against the portions of the surface of the tube carrier, adjacent the grooves, whereby excess pressures from the rollers on the tubes are prevented by said portions during the pumping operation. Since both pump tubes **46** and **50** are simultaneously engaged by the rollers, as best seen in FIG. 2, fluids in each of these pump tubes are simultaneously pumped together in quantities which depend upon the internal diameter of the respective pump tubes but it will be understood that the quantity pumped by each tube is in proportion to the quantity pumped by the other tube because of the simultaneous pumping action. FIG. 5 shows the pump tube in its disengaged and uncollapsed condition.

The pump of the present invention is especially well adapted to pump minute quantities of fluids and for this purpose the sizes of the pump tubes are relatively small, for example the internal diameter of the pump tubes may range from .005 to .015 inch and a tube which has a .005 inch internal diameter may have a wall thickness in the order of .010 inch. The rotational speed of motor **14** is relatively slow, as will be readily apparent, for example in the order of about 3 r.p.m. The pump tube sizes and motor speed are illustrative examples only and may be varied as desired or as required.

The pump is well suited for pumping small quantities of a sample liquid to a continuous analysis apparatus of the type shown and described in U.S. Patent No. 2,797,149, assigned to the assignee of the present application, and in the case of blood analyses with this apparatus, very minute quantities of the blood samples can be transmitted to the apparatus with the pump of the present invention via pump tube **46** for example and, simultaneously with the transmission of the blood sample, an anti-coagulant or a diluent can also be pumped through the other pump tube **50**. Although especially useful for pumping minute quantities of fluids, as indicated, it will be understood that the pump is not limited to pumping small quantities but can be used to pump larger quantities, as will be readily apparent.

Another example of an important use of the pump is for simultaneously supplying two separate analysis systems with minute quantities of sample liquid which may be the same or different and which may be of different quantities depending upon the internal diameter of the respective pump tube. As previously indicated, the tube carrier **28** may be easily removed from the pump and replaced with another carrier provided with pump tubes of different sizes for pumping different quantities of fluids by merely rotating clips **34** to disengage pins **30** and lifting the carrier vertically upwardly from casing **22**.

While I have shown and described the preferred embodiment of the invention, it will be understood that the invention may be embodied otherwise than as herein specifically illustrated or described, and that certain changes in the form and arrangement of parts and in the specific manner of practicing the invention may be made without

departing from the underlying ideas or principles of this invention within the scope of the appended claims.

What is claimed is:

1. A pump, comprising a stationary drum having a circular outer surface provided with a groove extending circumferentially along at least a portion of said surface, a resiliently flexible and compressible pump tube supported in said groove, a plurality of rollers positioned externally of said drum and in position in relation to said groove for compressing, and thereby collapsing said tube for the pumping operation, means mounting said rollers for movement into and out of engagement with said tube and having spring means for normally biasing said rollers into engagement with said tube for the pumping operation, a series of roller operating plates movable into and out of engagement with said rollers for moving the latter out of and into tube engaging position, a motor operatively connected to said rollers for rotating the latter for the pumping operation, an operating member operatively connected to said plates to move the latter into and out of engagement with said rollers, and a switch for operating said motor mounted in the path of movement of said plate operating member so that movement of the latter and the resulting movement of said plates from roller engaging position to roller disengaging position results in the operation of said switch and the resulting rotation of said tube compressing means substantially concurrently with the engagement of said tube by said rollers.

2. A pump, comprising a stationary drum having a circular outer surface provided with a groove extending circumferentially along at least a portion of said surface for supporting a resiliently flexible and compressible pump tube therein, a resiliently flexible and compressible pump tube supported in said groove, said groove having a bottom wall spaced from said outer surface a distance equal to about twice the wall thickness of said tube, a plurality of rollers positioned externally of said drum and in position in relation to said groove for compressing, and thereby collapsing, the tube mounted therein for the pumping operation, said pressure applying rollers being arranged in a circular row in concentric relation with said outer surface of said drum and in position overlying said groove, means mounting said rollers for movement into and out of engagement with said tube and having spring means for normally biasing said rollers into engagement with said tube for the pumping operation, said rollers having their ends extending beyond the sides of said groove so that in the tube engaging position of said rollers, the ends thereof abut against the portions of said outer surface, adjacent said groove, and said rollers are thereby prevented by said portions from applying excess pressures on said tube during the pumping operation, a series of roller operating plates movable into and out of engagement with said rollers for moving the latter out of and into tube engaging position, a motor operatively connected to said tube compressing means for rotating the latter for the pumping operation, an operating member operatively connected to said plates to move the latter into and out of engagement with said rollers, and a switch for operating said motor mounted in the path of movement of said plate operating member so that movement of the latter and the resulting movement of said plates from roller engaging position to roller disengaging position results in the operation of said switch and the resulting rotation of said tube compressing means substantially concurrently with the engagement of said tube by said rollers.

3. A pump, comprising a hollow cylindrically shaped drum having a groove extending circumferentially along at least a portion of the outer surface of said drum for supporting a resiliently flexible and compressible pump tube therein, a resiliently flexible and compressible pump tube supported in said groove, said drum having an opening at each end of said groove extending from the outer surface of the drum to the hollow part thereof for extending the opposite ends of said tube, from the corresponding ends of said groove, through said drum and into the hollow part thereof, said parts of said drum at said openings, respectively, providing abutting surfaces for the adjacent parts of said tube to prevent longitudinal movement of said tube in said groove during the operation of said pump, carrier means surrounding said outer surface of said drum and positioned in concentric relation thereto, a plurality of tube compressing rollers mounted on said carrier and in relation to said groove for compressing the tube in said groove, said groove having a depth which is about twice the wall thickness of said tube and said rollers having parts which engage the surface of said drum beyond said groove when the tube is compressed in said groove whereby the pressure of said rollers on said tube is limited by engagement with said surface of the drum, said drum and said tube compressing means being mounted for relative movement with respect to each other for compressing said tube progressively along its length by said compressing means for the pumping operation.

4. A pump, comprising a tube carrying member having a circular outer surface provided with a groove extending longitudinally of said surface, a resiliently flexible and compressible pump tube supported in said groove, tube compressing rollers positioned externally of said member and in position in relation to said groove for compressing the tube mounted therein, and means for rotating said rollers for compressing and thereby collapsing said tube progressively along its length for the pumping operation, said groove having a bottom spaced from said outer surface a distance equal to about twice the wall thickness of said tube so that in the collapsed condition of said tube during said pumping operation, said compressing rollers abut against the portions of said outer surface, adjacent said groove, throughout the engagement of said rollers with said tube and are thereby prevented by said outer surface from applying excess pressure on said tube during the compressing thereof.

5. A pump, comprising a stationary tube carrying member having a circular outer surface provided with a groove, a resiliently flexible and compressible pump tube mounted in said groove, rotary tube compressing rollers positioned externally of said member in position in relation to said groove for compressing the tube mounted therein, said tube compressing means comprising a series of pressure applying rollers arranged in a circular row and circumferentially spaced from each other in concentric relation to said outer surface of said member, and means for rotating said rollers to engage and collapse said tube progressively along its length for the pumping operation, said groove having a bottom spaced from said outer surface a distance equal to about twice the wall thickness of said tube and said rollers having their ends extending beyond the sides of said groove, so that in the collapsed condition of said tube during said pumping operation, said ends of said rollers abut against the portions of said outer surface, adjacent said groove, and said rollers are thereby prevented by said portions from applying excess pressures on said tube during the compression thereof.

6. A pump, comprising a stationary tube carrying member having a circular outer surface provided with means for supporting a resiliently flexible and compressible pump tube on said outer surface, a resiliently flexible and compressible pump tube supported on said surface, a rotary carrier member provided with a series of pressure applying rollers arranged in a circular row in concentric relation to said circular outer surface and externally of said tube carrying member, said rollers being movable from an inoperative position wherein said rollers are disengaged from said tube to an operative position wherein said rollers engage said tube, and means operatively connected to said rollers and operable for moving said rollers from their disengaged position to their engaged position, said roller moving means having roller engaging parts movable from a position wherein said parts engage

said rollers and prevent the latter from engaging said tube to a position wherein said parts are disengaged from said tube to permit engagement of said tube by said rollers, means for moving said roller moving means to and from said positions, an electric motor for rotating said carrier member, and switch means for controlling the operation of said motor under the control of said means for moving said roller moving means, so that the motor is energized when said tube is engaged by said rollers and is deenergized when said rollers are disengaged from said tube.




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