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[54] **PERITONEAL DIALYSIS APPARATUS**

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[73] Assignee: **American Medical Products Corp.**, Freehold, N.J.

[21] Appl. No.: **781,031**

[22] Filed: **Mar. 24, 1977**

Related U.S. Patent Documents

Reissue of:

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Issued: **Mar. 25, 1975**
Appl. No.: **384,316**
Filed: **Jul. 31, 1973**

[51] **Int. Cl.**[4] **A61M 5/00; A61M 1/03**

[52] **U.S. Cl.** **604/29**

[58] **Field of Search** ..... 128/213, 214 R, 214 E, 128/214 Z, 227, 230, 273, 274

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Attorney, Agent, or Firm—Panitch, Schwarze, Jacobs & Nadel

[57] **ABSTRACT**

A peritoneal dialysis apparatus comprising a plurality of components including a catheter, a fluid heater, a fluid weighing means and a control device. The components are interconnected by conduits so that fluid can flow from the heater to the peritoneal cavity by way of the catheter, and then from the peritoneal cavity to the weighing means. The weighing means measures the quantity of discharged fluid as a result of the introduction of the dialysis fluid to check that the dialysis fluid is causing fluid to drain from the peritoneal cavity. The flow of fluid between the components of the system is controlled by valves which are selectively opened and closed.

11 Claims, 9 Drawing Figures

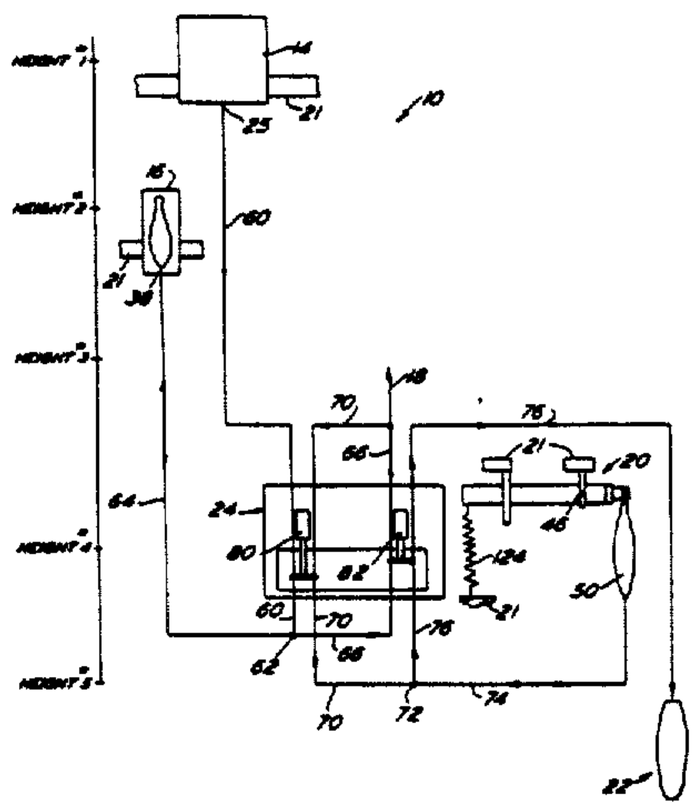
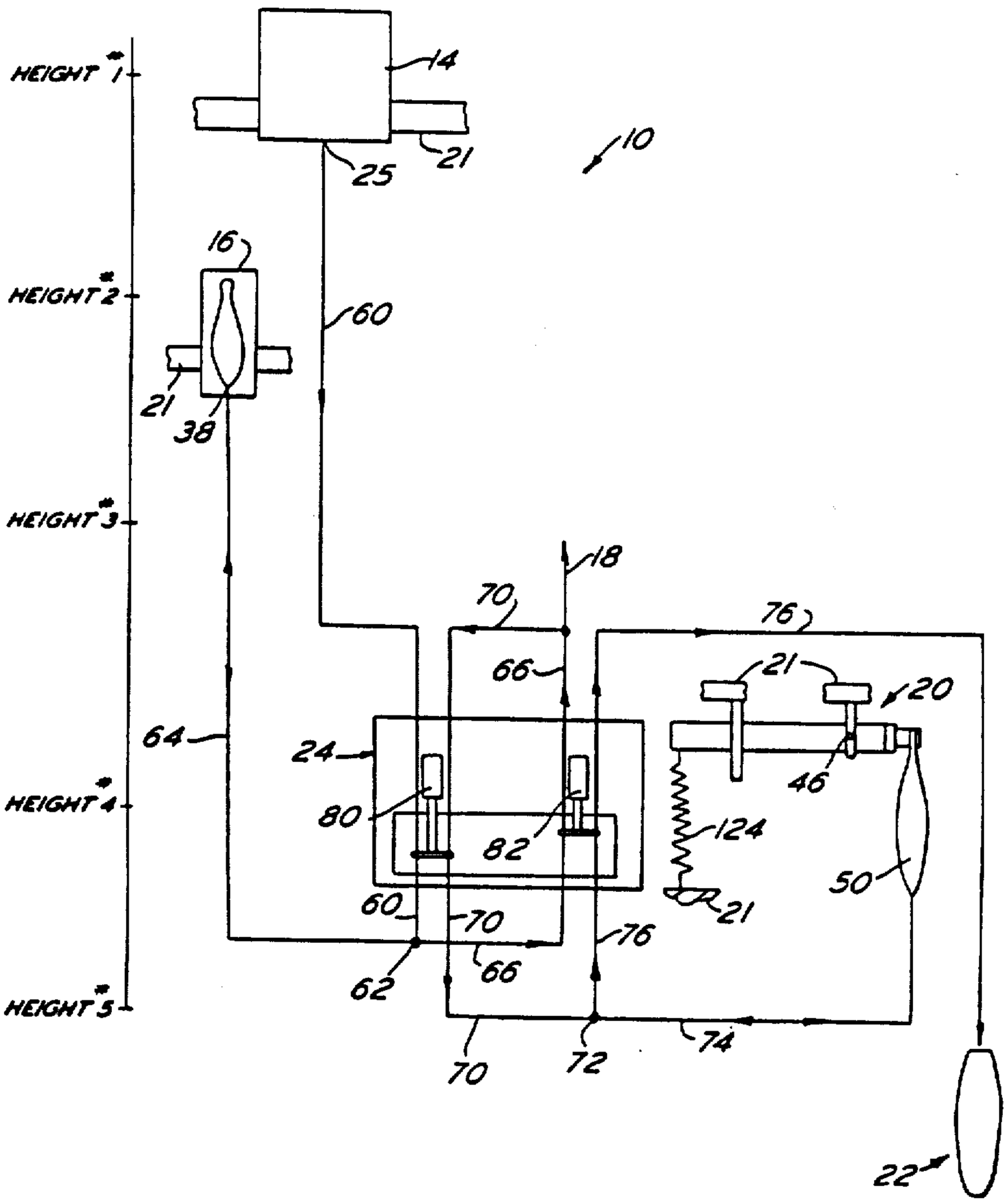


FIG. 1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HEIGHT #2
HEIGHT #3
HEIGHT #4
HEIGHT #5
14
25
21
10
16
60
21
38
18
70
76
66
64
24
80
82
21
20
46
124
50
21
60
70
76
62
66
70
72
74
22

FIG. 2

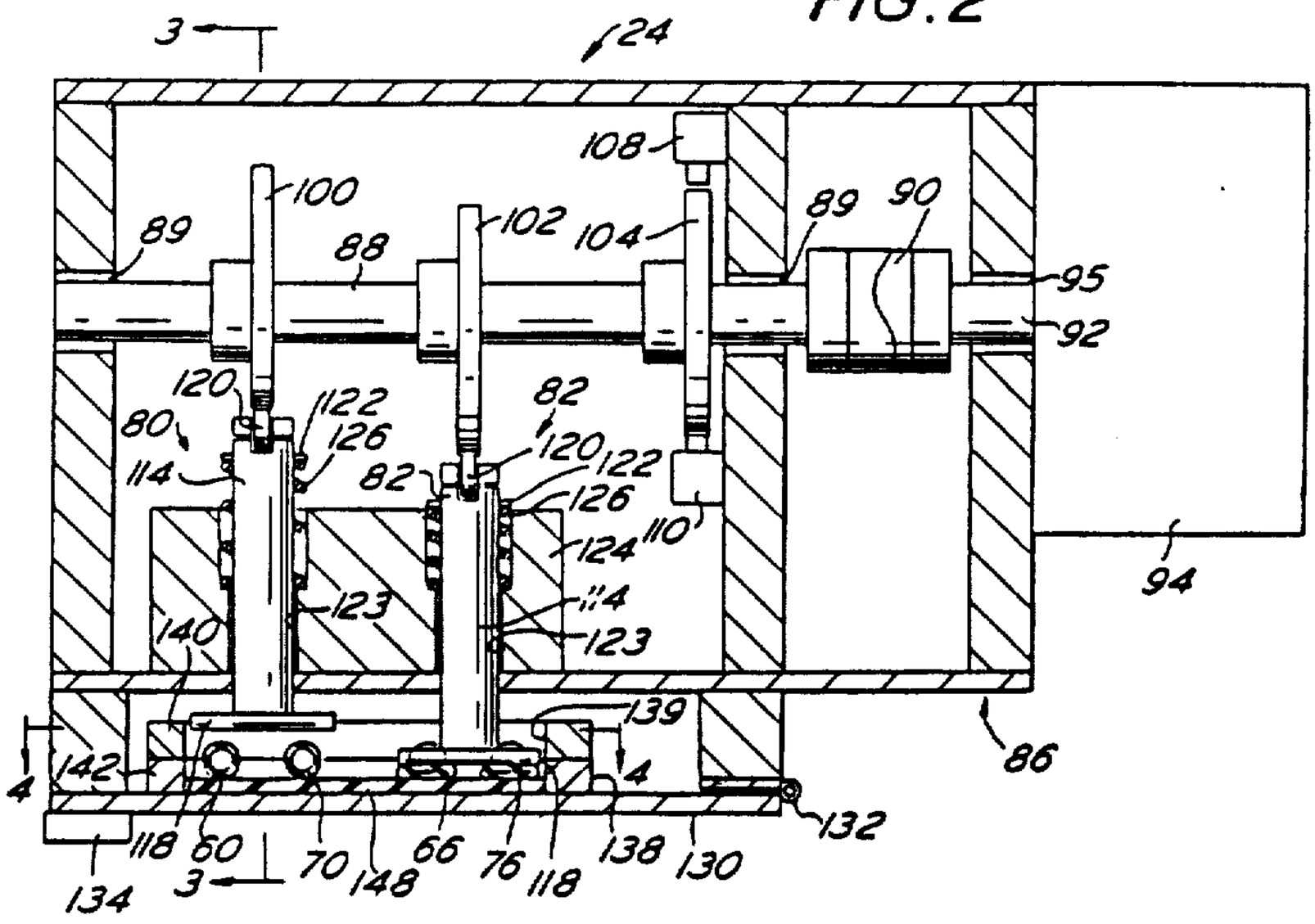
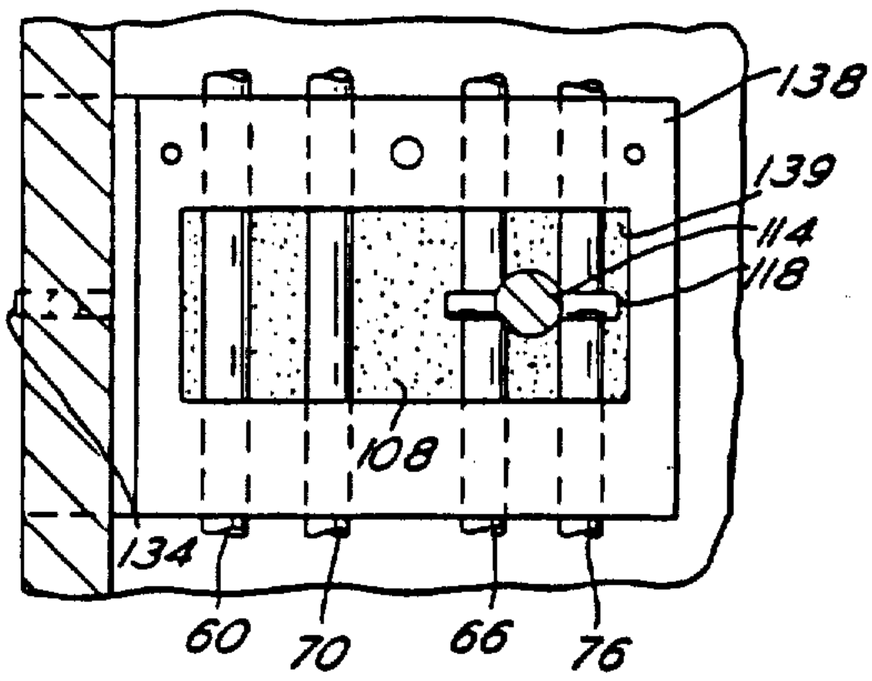


FIG. 4



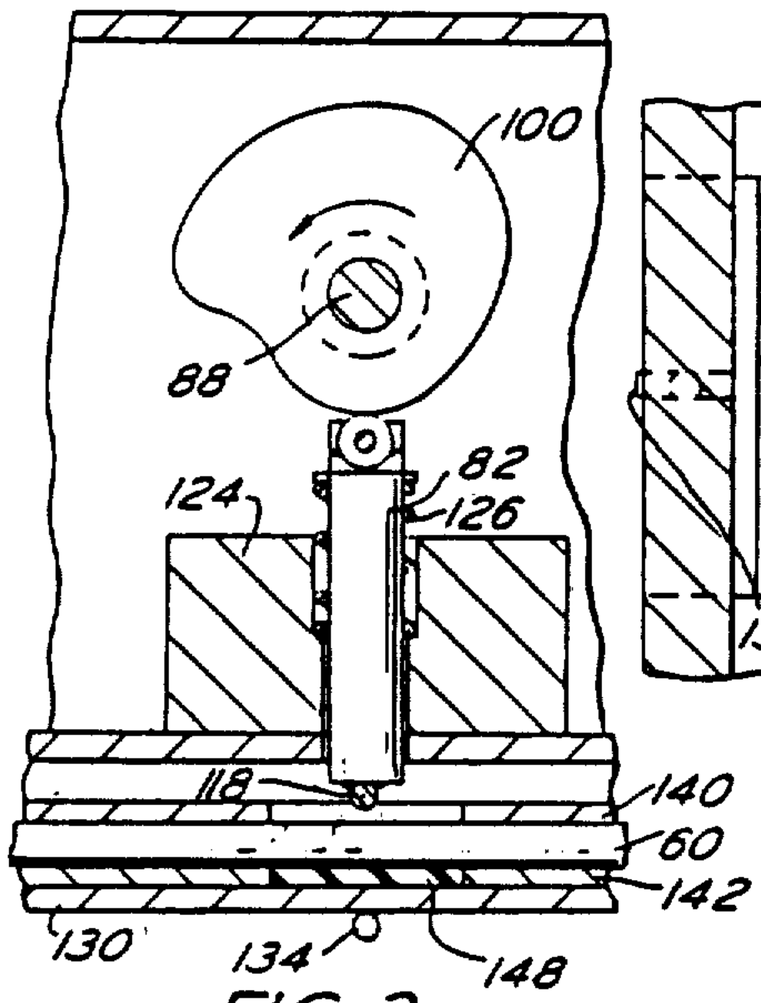
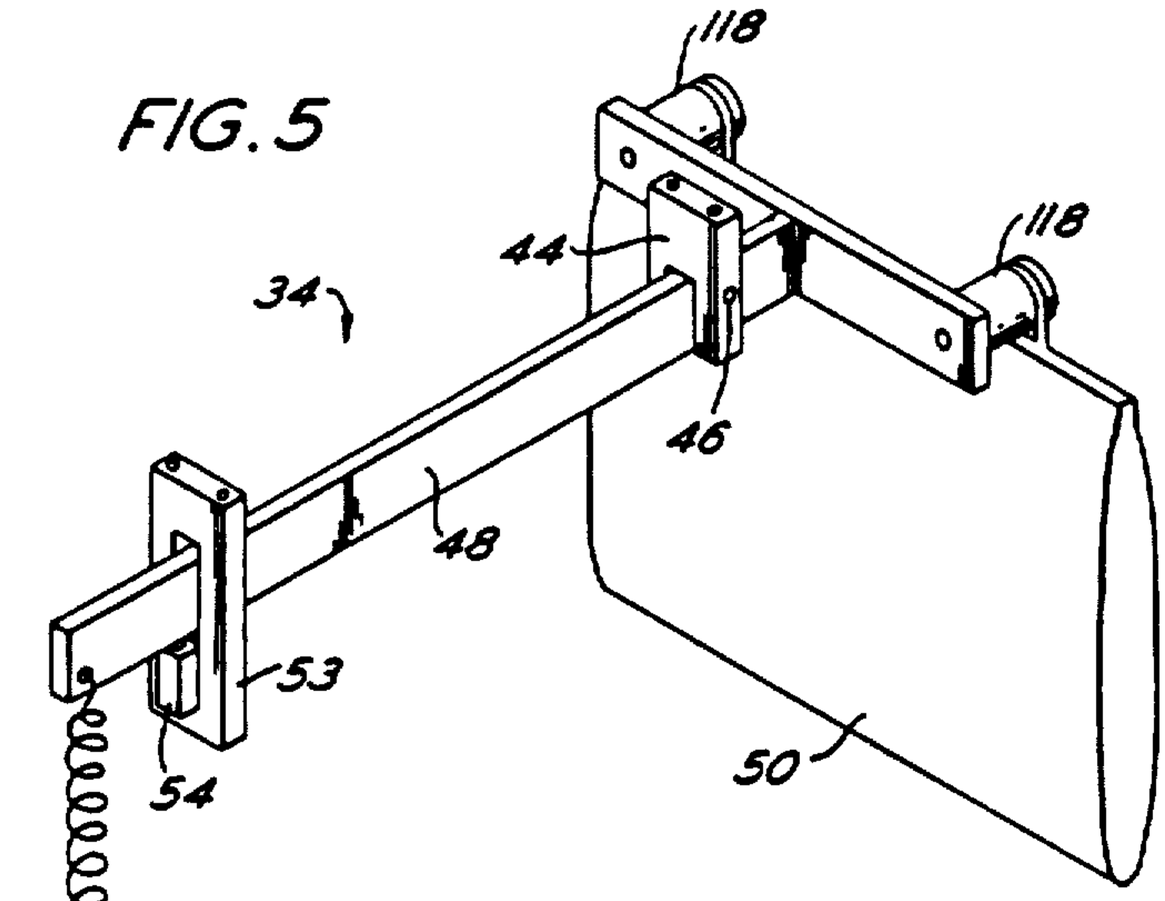


FIG. 3

FIG. 5



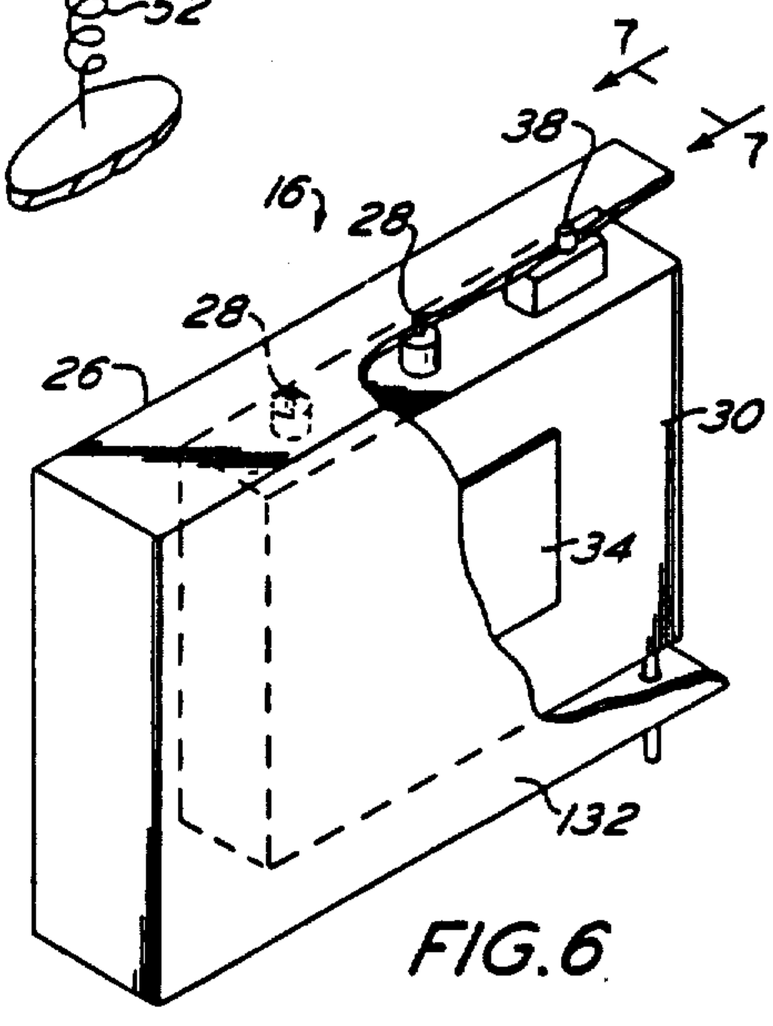
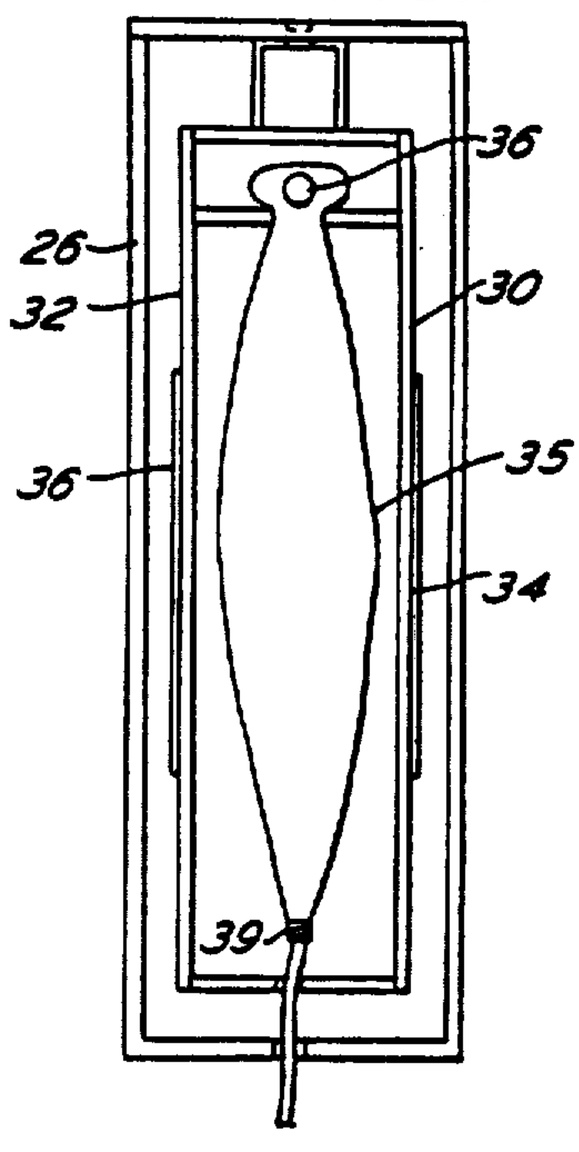


FIG. 6

FIG. 7



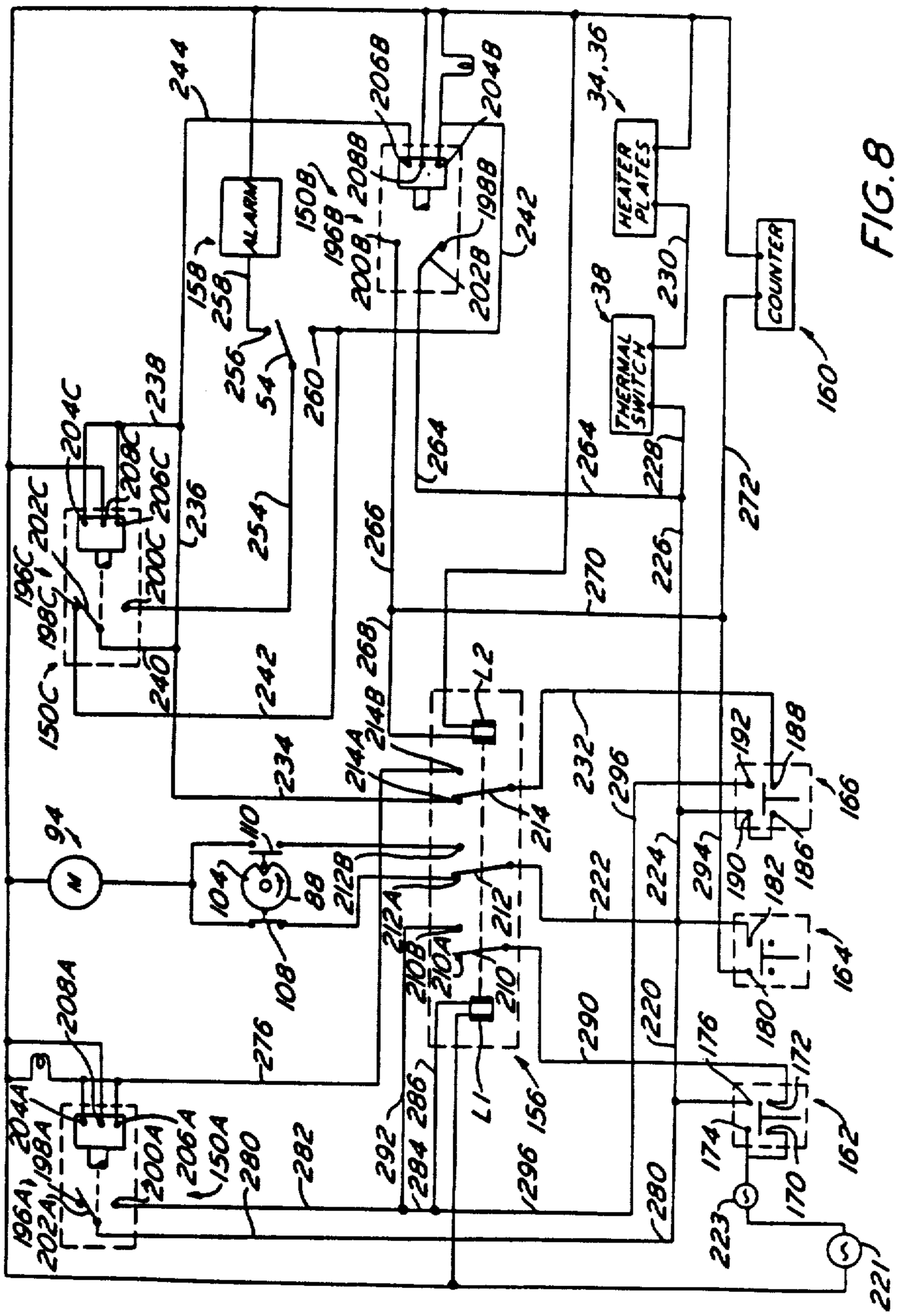

244
34,36
HEATER PLATES
THERMAL SWITCH
COUNTER
160
158
256
150B
196B
198B
202B
204B
206B
208B
238
236
240
242
254
256
54
260
264
266
268
270
272
226
228
230
38
232
234
212
214
222
224
294
296
192
188
166
190
182
186
164
180
176
172
162
174
170
223
221
94
104
110
88
212B
108
276
212A
208A
210A
210
L2
L1
156
290
220
280
292
284
286
196A
202A
198A
204A
206A
150A
280
282
296

FIG. 8

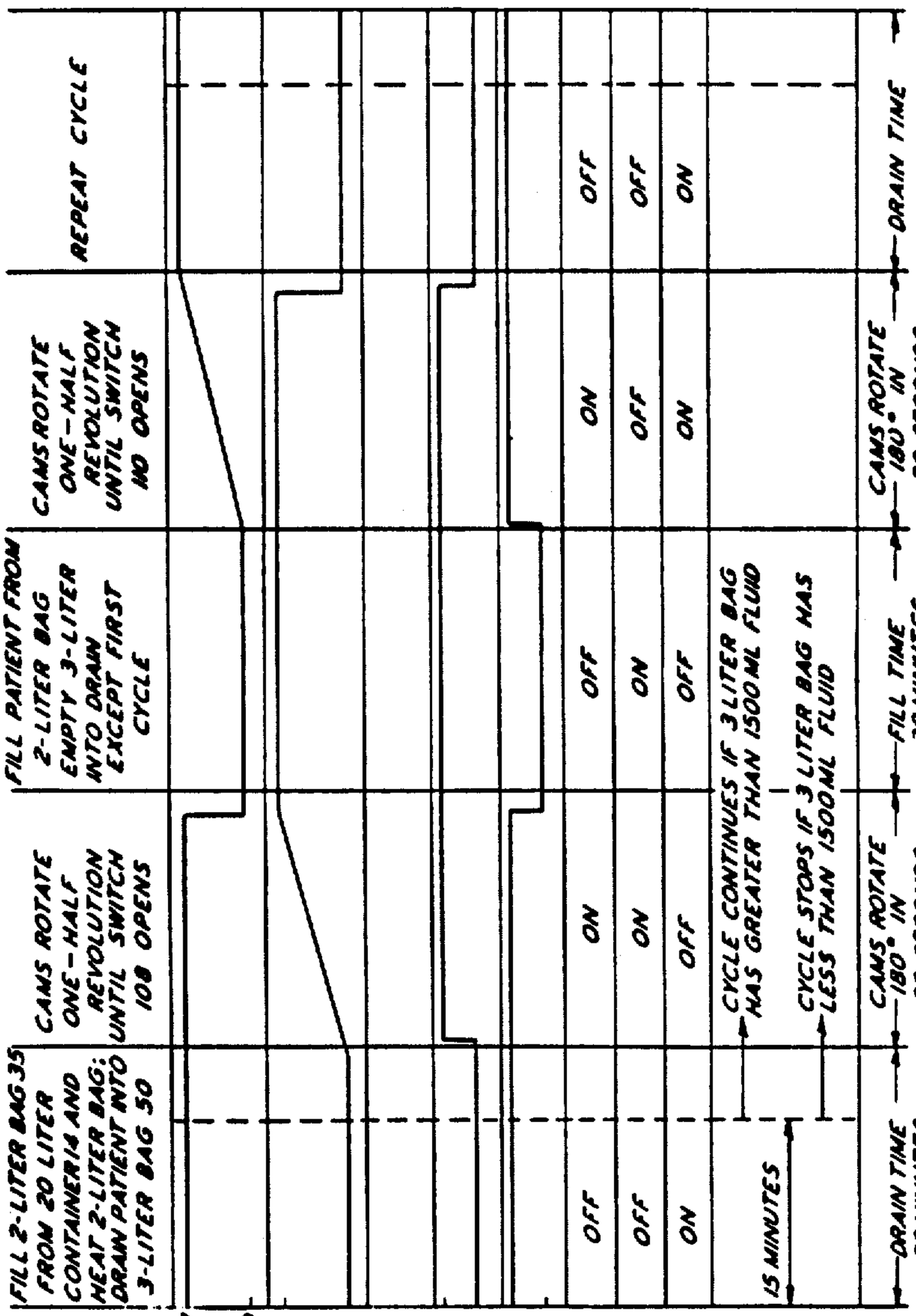

PROCESS DESCRIPTION
FILL 2-LITER BAG 35 FROM 20 LITER CONTAINER 14 AND DRAIN PATIENT INTO 3-LITER BAG 50
HEAT 2-LITER BAG; FILL PATIENT FROM 3-LITER BAG 50
2-LITER BAG EMPTY INTO DRAIN EXCEPT FIRST CYCLE
CAMS ROTATE ONE-HALF REVOLUTION UNTIL SWITCH 108 OPENS
CAMS ROTATE ONE-HALF REVOLUTION UNTIL SWITCH 108 OPENS
REPEAT CYCLE
DRAIN TIME
VALVE 80
OPEN
CLOSED
VALVE 82
OPEN
CLOSED
SWITCH 110
CLOSED
OPEN
SWITCH 108
CLOSED
OPEN
MOTOR 94
ON
OFF
FILL TIMER 150A
DRAIN TIMER 150B
ALARM TIMER 150C
15 MINUTES
DRAIN TIME 30 MINUTES
FILL TIME 30 MINUTES
CYCLE CONTINUES IF 3 LITER BAG HAS GREATER THAN 1500 ML FLUID
CYCLE STOPS IF 3 LITER BAG HAS LESS THAN 1500 ML FLUID
CAMS ROTATE 180° IN 30 SECONDS
CAMS ROTATE 180° IN 30 SECONDS
TIME

FIG. 9

PERITONEAL DIALYSIS APPARATUS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This invention relates to a dialysis apparatus and more particularly to a peritoneal dialysis apparatus.

Peritoneal dialysis is a well known medical procedure for removing impurities from the blood stream. It is accomplished by introducing a suitable dialysis fluid into the peritoneal cavity and then withdrawing the fluid after a suitable period of time. During the time that the dialysis fluid is in the peritoneal cavity, impurities in the blood stream are drawn through the walls of the blood vessels on the abdominal wall and in the viscera, and through the peritoneum membrane against which they lie through the osmotic effect of the dialysis fluid. The entire procedure may take up to 36 hours since the dialysis fluid must be replaced from time to time as the concentration of impurities in it increase.

Heretofore, peritoneal dialysis has been done in hospitals because of the high risk of infection and because trained personnel need to be available to perform the procedure.

Accordingly, the invention relates to a peritoneal dialysis apparatus which can be used by a patient at home thereby enabling the hospital bed to be free for use by others, and thus reducing the cost of the dialysis to the patient.

To this extent, the apparatus comprises means for supplying dialysis fluid to a means for measuring predetermined quantities and means for conducting the dialysis fluid to a catheter. The catheter is connected to the peritoneal cavity of a patient and to a means for detecting a minimum quantity of dialysis fluid. Means are provided for regulating the flow of dialysis fluid through the apparatus.

The invention can best be described by referring to the attached drawings wherein a presently preferred form of the invention is illustrated and wherein

FIG. 1 is a schematic drawing of a preferred form of the apparatus.

FIG. 2 is a sectional view of the means for controlling the flow of fluid through the apparatus.

FIG. 3 is a sectional view taken along line 3—3 of FIG. 2.

FIG. 4 is a sectional view taken along line 4—4 of FIG. 2.

FIG. 5 is a perspective view of a portion of the apparatus illustrated in FIG. 1 for weighing fluid discharged from the peritoneal cavity.

FIG. 6 is a perspective view of a portion of the apparatus shown in FIG. 1 which is used for heating the dialysis liquid.

FIG. 7 is an end view taken along line 7—7 of FIG. 6.

FIG. 8 is a schematic view of the circuitry for operating the apparatus.

FIG. 9 is a drawing graphically portraying the operation of the apparatus.

Now referring to the drawing for a detailed description of the invention, a peritoneal dialysis apparatus is schematically illustrated by the numeral 10 in FIG. 1.

The apparatus 10 comprises a container 14 in which a supply of dialysis fluid is stored for use as needed, a

means 16 for metering and heating the dialysis fluid after it is dispensed from container 14, a catheter (schematically) 18, a means for detecting discharge of fluid from the patient 20, a means for receiving fluid discharged from the apparatus 22 and a means for controlling the flow of dialysis fluid through the apparatus 24.

A pump or other positive driving means may be used to move the fluid through the apparatus. However, its construction is greatly simplified and its reliability is substantially increased by relying on the force of gravity.

Accordingly, the components of the apparatus are supported by a suitable means indicated schematically by numeral 21 at successively lower heights than the preceding components. The successive components in the apparatus may be interconnected by suitable resilient flexible plastic conduits. A typical plastic is commercially available and is sold as tubing under the trademark "TYGON."

The container 14 may be of any convenient size. Preferably it should contain enough dialysis fluid to enable a complete dialysis procedure to be performed and should be constructed so that the dialysis fluid can be kept sterile. An outlet 25 in the bottom of the container connects it with the rest of the system. Fluid used in peritoneal dialysis are commercially available and are well known to those skilled in the art. A typical fluid is sold under the trademark "DIANEAL" by Travenol Laboratories.

The means for metering and heating the dialysis fluid 16 is best seen in FIGS. 6 and 7. It includes an outer housing 26 which may be of any convenient shape. A heating unit is supported in housing 26 by a plurality of fasteners 28. It comprises front and rear thermally conductive plates 30 and 32 which are arranged in spaced parallel relation to each other. Each of plates 30 and 32 supports a heating element 34 and 36. The heating elements cover a substantial area of plates 30 and 32 to rapidly bring the plates to the desired temperature. A collapsible sterile bag 35 which may be made from "TYGON" is supported within housing 26. A typical means for supporting the bag may include suspending it from a rod 36 which is slipped through a sleeve along one edge of the bag. The bag 35 may have any convenient volume. However it is preferred that the volume be about two liters since introduction and discharge of this volume of fluid into the peritoneal cavity at intervals during the procedure achieves satisfactory results. A bag of reduced volume may be selected when the patient is a child.

The plates 30 and 32 are connected in a circuit which enables them to bring the dialysis fluid in bag 35 to a temperature of about 30° C. The circuit which will be described herein includes a thermal switch 38 in contact with the bag 35. An outlet 39 in the bottom of the bag connects it to the rest of the apparatus. Since the bag 35 is collapsible it can be filled and emptied without exposing its contents to the air.

The catheter 18 may be permanently implanted in the patient or it may be a disposable catheter. Both types of catheters are well known and are commercially available for use in peritoneal dialysis.

The means for detecting discharge of fluid from the patient 20 can best be seen in FIG. 5. It may be mounted to a support frame (not shown) by a bracket 44. The bracket supports a pin 46 which serves as a fulcrum for an elongated lever arm 48. A collapsible bag 50 for collecting fluid discharged from the patient is supported

at one end of lever arm **48**. The other end of lever arm **48** is connected to a counterweight such as spring **52**. A second bracket **53** on the support frame carries a microswitch **54** so that the operator of the microswitch is in contact with the lower surface of lever arm **48**.

The volume of bag **50** may be about three liters so that if any fluid has collected in the peritoneal cavity, it also will be discharged along with the dialysis fluid. The counterweight is selected so that microswitch **54** is closed until a sufficient volume of fluid, preferably about 1500 grams, is collected in bag **50**. At 1500 grams, the force of the counterweight is overcome and the lever arm **48** rotates about pin **46** to open microswitch **54**. The microswitch is connected to an alarm signal in a manner which will be explained herein.

Normally, microswitch **54** is closed. However, if at a predetermined interval microswitch **54** is still closed, the alarm is activated to notify the patient that the expected quantity of fluid has not drained from the peritoneal cavity.

The means for receiving fluid discharged from the apparatus **22** may comprise any convenient receptacle such as a disposable bag. In the alternative it could be a conventional drain.

The container **14** is connected to both the means for heating and metering dialysis fluid **16** and the inlet of catheter **18**. To this extent a length of tubing **60** is connected between the bottom opening **25** in container **14** and an arm of a "T" **62**. Another length of tubing **64** is connected between the second arm of the "T" **62** and the opening **38** in the means for heating and metering dialysis fluid **16**. The third arm of "T" **62** is connected by a length of tubing **66** to the catheter **18**.

The outlet of the catheter **18** is connected to both the means for detecting discharge of fluid from the patient **20** and the means for receiving discharged fluid **22**. To this extent a length of tubing **70** is connected between the catheter **18** and one arm of a "T" **72**. Another length of tubing **74** is connected between a second arm of "T" **72** and the bag **50**. The third arm of "T" **72** is connected to the means for receiving discharged fluid **22** by a length of tubing **76**.

The lengths of tubing **60, 66, 70** and **76** pass through control means **24**.

From FIG. **1** it is apparent that the control means **24** may comprise first and second valves **80** and **82**. First valve **80** selectively opens and closes tubes **60** and **70**. Second valve **82** selectively opens and closes tubes **66** and **76**. The valves regulate the flow of fluid through the apparatus.

When valve **80** is open and valve **82** is closed, the fluid in container **14** is permitted to flow through tubes **60** and **64** into the heating and metering means **16**. Simultaneously, fluid is drained from the patient through the catheter **18** and tubes **70** and **74** into bag **50**.

When the valve **82** is open and valve **80** is closed, fluid flows from the heating and metering means through tubes **64** and **66** into catheter **18** and thence into the patient. Simultaneously fluid is drained from the bag **50** through conduits **74** and **76** into the discharge receiving means **22**.

Thus, by controlling the duration of time for which the valves **80** and **82** are opened and closed and by regulating the volume of dialysis fluid which can be stored in the heating and metering means **16**, an efficient, safe peritoneal dialysis apparatus is achieved. Significantly, it should be noted that bag **50** is provided on the downstream side of the patient in order to detect

an insufficient drainage of fluid from the peritoneal cavity.

The control means **24** is illustrated in FIGS. **2–4**. It comprises a housing **86** which rotatably supports a shaft **88** in bearings **89**. The shaft **88** is connected by way of a clutch **90** to the output shaft **92** of a motor **94**. Output shaft **92** is rotatably supported by bearing **95**.

Shaft **88** supports cams **100** and **102** which operate valves **80** and **82** respectively, and cam **104** which operates microswitches **108** and **110**. Cams **100** and **102** have profiles that correspond to FIG. **9** wherein it is seen that each valve **80, 82** opens slowly and closes quickly. The microswitches **108** and **110** are supported by housing **86** so that their operators can be displaced into a notch formed in the cam (see FIG. **8**). Hence rotation of cam **104** through a complete revolution causes each microswitch to be tripped once. The cams **100** and **102** are supported on shaft **88** so that they are 180° out of phase with respect to each other. Thus when one of valves **80** and **82** is open, the other is closed. As will be explained in greater detail herein, the power to motor **94** is supplied through microswitches **108** and **110**. When the switch operators fall into the notch in the cam, the motor **94** is stopped. This positions the valves **80** and **82** in accordance with the configuration of cams **100** and **102** until the motor is energized through the microswitch whose operator is not in the notch.

Each valve includes a stem **114** with a cross bar **118** at one end and, if desired, a roller **120** at its other end. Each valve stem **114** includes a radially directed flange **122** near roller **120**.

The valve stems **114** are supported in apertures **123** formed in a support member **124** mounted in housing **86**. Each of valve stems is biased toward its respective cam **100, 102** by a spring **126** which bears against the flange **122**.

A plate **130** is supported in spaced relation from the front wall of housing **86** by a suitable hinge **132**. Suitable latching means such as member **134** may be provided for retaining plate **130** in the position illustrated in FIG. **2**.

Plate **130** supports a housing **138** having the appearance of a frame with a central opening **139**. The housing **138** is comprised of two separate members **140, 142** which have grooves in which the tubes can be received. When the members **140, 142** are assembled the tubes are held in the position illustrated in FIGS. **2** and **4**. Thus, tubes **60** and **70** are positioned so that they can be pinched closed by valve **80**. Tubes **66** and **76** are positioned so that they can be pinched closed by valve **82**.

A layer of relatively soft backing material **148** such as foam rubber, felt or the like is secured to plate **130** adjacent tubes **60, 70, 66** and **76**.

Suitable means is provided for selectively energizing motor **94** at predetermined intervals during the dialysis treatment. The motor causes shaft **88** to rotate with the result that the tubes **60** and **70**, and **66** and **76** are alternately pinched and released to permit fluid to flow through the apparatus.

The energization means for the motor comprises the circuit illustrated schematically in FIG. **8**.

The circuit comprises timers **150A, 150B** and **150C**, a two-position latching relay **156**, an alarm signal **158** and a counter **160**.

Additionally, the circuit includes the heating plates **34** and **36**, thermal switch **38**, switch **54**, motor **94** and switches **108** and **110**.

The circuit is energized by closing on-off switch **162**. Switch **164**, which may be called the fill switch, is operative when closed to cause the dialysis fluid in bag **35** to enter the patient by way of catheter **18**. Switch **166**, which may be called the drain switch, is operative when closed to cause the dialysis fluid in the patient to be discharged therefrom into bag **50**.

On-off switch **162** may be a two-position push button switch. When the switch is "OFF" a circuit is completed across terminals **170** and **172**. When the switch is "ON" a circuit is completed across terminals **174** and **176**. Fill switch **164** may be a push button switch which is biased to a normally "OPEN" position. However, when the push button is monentarily "CLOSED," a circuit is enabled across terminals **180** and **182**.

Drain switch **166** may be a push button switch of the same type as switch **164** in that it is biased to a normally "OPEN" position. In its "OPEN" position it enables a circuit across terminals **186** and **188**. When this switch is momentarily "CLOSED" a circuit is enabled across terminals **190** and **192**.

Timers which may be used satisfactorily in the invention are identified commercially as Singer Industrial Timers, Type GTD, 30 minutes. These timers may be set to run for a maximum time of 30 minutes. Each timer **150A**, **150B** and **150C** is essentially the same. Thus, the same part in each timer is identified by the same reference numeral with the different timers being distinguished by the letters "A," "B" and "C" following the numerals.

The following description will suffice for all timers **150**. Each timer includes a switch **196** which is comprised of contacts **198** and **200** and throw **202**. It also includes a timer motor which is connected by an electrically energized clutch to throw **202**.

The timer motor runs continuously as long as power is applied to motor terminal **204**.

The clutch is energized as long as power is applied to clutch terminal **206**. Every time the clutch is energized, the timer is reset to the maximum time thereon (this feature is an aspect of the particular timer identified herein).

Both the timer motor and the clutch are connected to common terminal **208**. While the motors are connected to the throws by the clutches, the throws **202** engage contacts **198** in each switch **196**. When each timer has run out, the throws **202** move from contacts **198** to contacts **200**.

Relay **156** includes three separate but interconnected single throw switches. In each switch the throw, **210** **212** and **214**, respectively is movable between first and second contacts **210A** and **210B**, **212A** and **212B** and **214A** and **214B**.

The throws are shifted by energizing coil "L1" or "L2". Energization of coil "L1" completes a circuit through contacts **210A**, **212A** and **214A**. Energization of coil "L2" completes a circuit through contacts **210B**, **212B** and **214B**. The throws remain in engagement with the contacts until the other coil ("L1" or "L2") is energized, then they shift.

The source of electromotive force **221**, which may be an ordinary electrical outlet, is connected by way of fuse **223** to terminals **170** and **174** on on-off switch **162**.

The circuit is designed so that when the apparatus is shut off the relay throws are at rest on contacts **210A**, **212A** and **214A**. Therefore the apparatus always starts on that portion of its cycle which permits fluid to be drained from the patient into bag **50**. The mechanism by which this occurs is explained herein.

Upon the closing of on-off switch **162** on terminals **174** and **176** a number of circuits are completed or enabled from the source of power **221** and fuse **223**. These circuits permit fluid to be discharged from the patient for a predetermined interval as will be explained herein.

Thus, a circuit is completed to motor **94** from on-off switch terminal **176** by way of lines **220**, **222** and through switch **108**. A circuit is completed to thermal switch **38** and heater plates **34**, **36** by way of lines **220**, **224**, **226**, **228** and **230**.

The motors and clutches on timers **150B** and **150C** are energized and the timers begin to wind down by virtue of circuit through drain switch **166** and relay **156**. The circuit includes lines **224**, terminals **190**, **186** and **188**, line **232**, relay contact **214A** and line **234**.

The motor and clutch of timer **150C** is energized by way of line **234** and lines **236** and **238** which are connected to timer motor terminal **204C** and clutch terminal **206C**.

Switch **196C** receives power by way of lines **234**, **240** and throw **202C**. Since throw **202C** is touching contact **198C**, a circuit is completed by way of line **242** to the motor terminal **204B** in timer **150B**. An indicator lamp may be connected to line **242** to indicate when the timer motor is energized. Clutch terminal **206B** receives power from line **236** by way of line **244**.

The motor **94** causes shaft **88** to rotate in the direction indicated by the arrow in FIG. **8** until the operator of switch **108** falls into the notch in cam **104**. This opens the circuit to the motor thereby halting the rotation shaft **88**. By virtue of the positions of cams **100** and **102** on shaft **88** they have been rotated to the position illustrated in FIG. **2** where valve **80** is open and valve **82** is closed. As illustrated in FIG. **1**, when the valves are in this configuration dialysis fluid is permitted to drain from container **14** to the heating and metering means **16** and at the same time fluid is permitted to drain from the patient by way of catheter **18** into the bag **50**.

If for some reason, cam **104** is not in the position illustrated when on-off switch **162** is closed and switch **108** is open, the motor **94** will not operate since the valves **80** and **82** will be in the correct positions to permit fluid to be drained from the patient.

Timer **150C** is set to run for a shorter time than timer **150B**. Timer **150C** cooperates with switch **54** to indicate that fluid is draining from the patient at an adequate rate. To this extent a circuit is normally enabled through switch **54** by way of contact **200C** in timer **150C**, line **254**, switch contact **256** and line **258** to alarm **158**. But when the weight of fluid in bag **50** reaches 1500 grams, or any predetermined weight deemed desirable, the throw in switch **54** is moved to contact **260**.

With the foregoing in mind, when timer **150C** runs out, as for example fifteen minutes after it is energized, throw **202C** moves to contact **200C**. If the predetermined quantity of fluid is not in bag **50**, the circuit through alarm **158** is completed by way of line **254**, contact **256** and line **258**. The alarm **158** may be visible, audible or a combination of both, provided it alerts the patient to the fact that inadequate drainage from the body is taking place. Since there is no power in line **242**, the motor in timer **150B** is stopped. Thus, the apparatus remains in the drain portion of the cycle and the alarm **158** remains energized until the apparatus is shut off or the fill switch **164** is depressed.

In an adequate amount of fluid is in bag **50** when timer **150C** runs out, the alarm is bypassed and power to motor terminal **204B** is achieved by way of line **254**, contact **260** and line **242**.

Assuming that there has been adequate drainage to bag **50**, when the time on timer **150B** runs out, throw **202B** moves to contact **200B** to start filling the patient with dialysis fluid. This energizes coil "L-2" in relay **156** by way of lines **226**, **264**, throw **202B**, contact **200B**, lines **266** and **268**. Coil "L2" moves all of the throws in the relay clockwise so that circuits are completed to terminals **210B**, **212B** and **214B**.

Energization of coil "L2" energizes counter **160** by way of lines **266**, **270** and **272**. Hence a count is taken on each time the circuit shifts to cause dialysis fluid to enter the patient.

Clockwise movement of the relay throws **210**, **212** and **214** completes or enables a number of circuits.

A circuit is completed to motor **94** through line **222**, relay contact **212B** and through switch **110**. The switch is closed since the notch in cam **104** is now adjacent switch **108**. The motor rotates shaft **88** until the operator on switch **110** falls into the notch whereupon the motor stops rotating the shaft. At this point valves **80** and **82** are in the positions illustrated in FIG. **1** wherein fluid is permitted to fill the patient by way of catheter **18** from the heating and metering means **16** and the fluid in bag **50** is permitted to be discharged to the drain means **22**.

The motor and clutch on timer **150A** are energized and the timer begins to wind down by way of a circuit through relay throw **214**, relay contact **214B** and line **276**. Line **276** is connected to motor terminal **204A** and clutch terminal **206A**. An indicator lamp may be coupled to motor terminal **204** to indicate that the motor is energized.

The throw **202A** in switch **196A** is on contact **198A** while the timer is running. When the time on timer **150A** runs out, after, for example 30 minutes, throw **202A** shifts to contact **200A** to complete a circuit through coil "L_1" by way of line **280**, relay throw **202A** and lines **282**, **284** and **286**.

Energization of coil "L_1" shifts all the relay throws in relay **156** counterclockwise so that they engage contacts **210A**, **212A** and **214A**. This completes a circuit through timer **150B** and timer **150C** so that the cycle is repeated as described above. In the event that timer **150C** should run out before an adequate amount of fluid is received in bag **50**, alarm **158** will be energized.

When timer **150B** runs out the relay **156** shifts and the motor **94** energized to rotate shaft **88** to permit dialysis fluid to again fill the patient. At the same time, timer **150A** is energized.

Significantly, it should be noted that the timers are reset to the maximum time thereon each time they are energized. In timers **150A** and **150B** the maximum time is externally adjustable. To this extent, they may be mounted on a panel and have knobs extending therefrom for that purpose.

On the other hand, timer **150C** is designed to be non-adjustable. Thus, it may be set at the factory. It is preferably permanently mounted within an enclosing structure so that it cannot be tampered with by the user.

At any time in its cycle the apparatus may be shut down by moving switch **162** to the "OFF" position so that it completes a circuit across terminals **170** and **172**.

If the relay throws are in their clockwise positions when on-off switch **162** is moved to its "OFF" position,

a circuit is completed to coil "L1" from terminals **170** and **172** by way of line **290**, relay contact **210B**, and lines **292**, **284** and **286**. This moves the throws counterclockwise which then opens the circuit from on-off switch **162** since relay contact **210A** is not connected to the rest of the circuit.

If, on the other hand, the relay is closed on contact **210A**, moving switch **162** to its "OFF" position so that it completes a circuit across terminals **170** and **172** merely shuts down the apparatus.

The apparatus can be switched from the drain cycle to the fill cycle or from the fill cycle to the drain cycle by depressing fill switch **164** or drain switch **166** respectively.

For example, if the apparatus is draining fluid from the patient and it is desired to switch it to fill the patient, switch **164** is depressed momentarily to complete a circuit across terminals **180** and **182**. This completes a circuit from the source of electromotive force through contacts **174** and **176**, line **220**, through switch **164** by way of terminals **180** and **182**, and line **294**. Counter **160** is energized by way of lines **294** and **272**. Coil "L2" is energized by way of lines **294**, **270**, and **268**. When coil L2 is energized, it shifts the throws (they are in their counterclockwise position when fluid is draining from the patient). This completes a circuit to relay contact **212B** and a circuit to relay contact **214B** so that circuits are completed through switch **110** to motor **94** and to timer motor and clutch terminals **206A** and **204A** in timer **150A**. Shaft **86** rotates until switch **110** opens thereby deenergizing motor **94**. This opens valve **82** to fill the patient from the metering and heating means **22**.

When the time on timer **150A** runs out, throw **202A** moves to contact **200A**. This completes a circuit from terminal **176** in on-off switch **162** to coil "L1" by way of line **280**, throw **202A**, contact **200A** and lines **282**, **284** and **286**. Energization of coil "L1" shifts the relay throws counterclockwise to energize and reset timers **150B** and **150C** and motor **94** (through switch **108**) to start the drain portion of the cycle.

The drain cycle continues as explained above with both timers **150C** and **150B** being energized. If timer **150C** runs out before an adequate amount of fluid is in bag **50** an alarm is sounded.

On the other hand, if an adequate amount of fluid is in bag **50** when timer **150B** runs out, the relays are again thrown and the fill portion of the cycle takes over.

If the apparatus is in the fill portion of its cycle and it is desired to shift it to the drain portion, switch **166** is depressed momentarily to complete a circuit across terminals **190** and **192**. This completes a circuit to coil "L1" by way of terminal **192** and lines **296** and **286**. Energization of coil "L1" shifts the relay throws counterclockwise to complete circuits to relay contacts **212A** and **214A** so that circuits are completed to motor **94** and to timers **150B** and **150C**. In this regard, the circuit components assume the same configuration that they have when on-off switch **162** is moved to its "ON" position as described in detail above.

From the foregoing it is apparent that at any part of its cycle the apparatus can be shifted to the opposite part of the cycle.

In order to use the apparatus described, each of the components of the system, namely, container **14**, metering and heating means **16**, the patient and catheter **18**, the weighing means **20** and the drain **22** are arranged so that each component has a higher elevation than the component following it so that the natural tendency of

the dialysis fluid in container **14** is to flow through the apparatus.

The sequence of operation of the apparatus is shown in FIG. **9**. The apparatus can go through a complete cycle in up to one hour. Up to 30 minutes can be used to fill the patient and up to 30 minutes can be used to drain the patient. The duration of the fill and drain intervals are controlled by timers **150A** and **150B**. Since the timers are externally adjustable these periods can be varied as desired.

The motor **94** is energized at the end of each fill and each drain interval. The motor is selected so that each time it is energized shaft **88** rotates through half a turn in about 30 seconds. As explained earlier the motor is energized at the end of each fill and drain interval. Cams **100** and **102** are profiled to enable valves **80** and **82** to gradually open over each thirty second interval of shaft rotation, but to close abruptly. This is so that the dialysis fluid does not surge or drip through the tubing. During each thirty second period of cam rotation, the positions of valves **80** and **82** are reversed, and, due to cam **104**, one of microswitches **108**, **110** is opened while the other is closed.

A commercial embodiment of the invention would comprise sufficient dialysis fluid in container **14** to discharge a two liter does of dialysis fluid into the patient every half hour with the succeeding half hour being consumed in withdrawing the dialysis fluid. Thus, the heater bag acts as a measuring device in order to control the amount of fluid being introduced to the peritoneal cavity in any given time.

It is contemplated that with the present apparatus a complete dialysis can be achieved in a period of about 10 hours as opposed to an interval of 36 to 72 hours as in present procedures.

The substantial reduction in time is achieved by virtue of the fact that the dialysis fluid is changed rather rapidly.

Thus, it is a well known fact that in an osmotic process, as the fluids on each side of the membrane approach equilibrium, the rate of exchange across the membrane decreases. Thus, it is advantageous to change the dialysis fluid as the rate of transfer across the peritoneal membrane begins to slacken.

This can readily be done with the present apparatus by merely externally adjusting the time available on timers **150A** and **150B**.

At the same time since the presence of an attendant is not necessary in order to change the fluid in container **14**, a sufficient amount of fluid in order to perform the entire dialysis may be made available at one time. It is contemplated that an adequate amount of fluid to satisfactorily dialyze an adult patient would be about 20 liters. Thus, over a period of 10 hours, at a rate of 2 liters per cycle, the entire quantity of fluid would be consumed.

Significantly, at the end of each cycle of the apparatus, the fluid discharged from the peritoneal cavity is weighed in order to assure that the patient is draining properly. In the event that inadequate drainage is taking place, a suitable alarm is activated.

A further safety device is present by virtue of the fact that when the apparatus is initially turned on as, by pushing switch **162** to close a circuit across terminals **174** and **176** the apparatus automatically starts on a drain cycle. Thus, there is no possibility that two liters of dialysis fluid would be in the patient as two additional liters are being introduced.

Finally, it should be noted that the apparatus always shuts off in the drain position.

While the invention has been described with respect to one preferred embodiment thereof, it is apparent that many other forms and embodiments will be obvious to those skilled in the art in view of the foregoing description. Thus, the scope of the invention described herein should not be limited by that description but, rather, only by the scope of the claims appended hereto.

We claim:

1. A dialysis apparatus comprising first means for supplying dialysis fluid, second means for measuring a predetermined quantity of dialysis fluid, a catheter, third means for detecting a minimum quantity of dialysis fluid, means for supporting said first means above said second means, said second means above said catheter, and said third means below said catheter so that dialysis fluid moves through said apparatus under the force of gravity, fluid flow conduits interconnected between said first and second means[,] *and between* said second means and said catheter and *between* said catheter [in] *and* said third means, fourth means *including a single actuator for plural valves* for *simultaneously* regulating the flow of dialysis fluid [and] *in* said [conduits] *conduit* between said first and second means and *the conduit between* said catheter and said third means *in a manner so that flow is simultaneously on or off*, fifth means *including a single actuator for plural valves* for *simultaneously* regulating the flow of dialysis fluid *in the conduit* between said second means and said catheter[,] and *a conduit* from said third means *in a manner so that flow is simultaneously on or off*, and means for controlling said *actuators for said* fourth and fifth means to alternately permit flow of dialysis fluid in the conduits regulated thereby so that the dialysis fluid is permitted to flow through said apparatus and a patient and then from said third means.

2. A dialysis apparatus as defined in claim **1** including an alarm, means coupling said third means to said alarm, and means for enabling said alarm if said third means fails to detect a minimum quantity of dialysis fluid.

3. A dialysis apparatus as defined in claim **2** wherein said third means comprises a frame, an arm, said arm being pivotally supported by said frame intermediate its ends, a fluid receptacle coupled to said arm on one side of said pivot, means comprising a counterweight coupled to said arm on the other side of said pivot, and said means for enabling said alarm is disposed adjacent said arm for actuation thereby if the weight of dialysis fluid in said fluid receptacle is insufficient to overcome the force of said counterweight means.

4. A dialysis apparatus as defined in claim **1** wherein said second means [includes] *is removably mounted in a housing* means for heating dialysis liquid [therein] *in said second means* to a predetermined temperature.

5. A dialysis apparatus as defined in claim **1** including a fluid flow conduit extending from said third means, and a discharge receptacle connected to said last named fluid flow conduit to receive dialysis fluid from said third means.

6. A dialysis apparatus as defined in claim **1** wherein said control means comprises a shaft, first and second cams mounted on said shaft, one of said cams controlling said fourth means *actuator*, the other cam controlling said fifth means *actuator*, energizable means for rotating said shaft, and means for selectively energizing and de-energizing said energizable means to selectively rotate said shaft.

7. A dialysis apparatus comprising first means for supplying dialysis fluid, second means for measuring a predetermined quantity of dialysis fluid, a catheter, third means for detecting a minimum quantity of dialysis fluid, said third means comprises a frame, an arm, said arm being pivotedly supported by said frame intermediate its ends, a *removable* fluid receptacle coupled to said arm on one side of said pivot, means comprising a counter weight coupled to said arm on the other side of said pivot, and said means for enabling said alarm is disposed adjacent said alarm for actuation thereby if the weight of dialysis fluid on said fluid receptacle is insufficient to overcome the force of said counter weight means, fluid flow conduits interconnected between said first and second means, said second means and said catheter, and said catheter and said third means, fourth means for *simultaneously* regulating the flow of dialysis fluid in said conduits between said first and second means and said catheter [in] *and* said third means, fifth means for *simultaneously* regulating the flow of dialysis fluid between said second means and said catheter, and from said third means, and means for controlling said fourth and fifth means to alternately permit flow of dialysis fluid in the conduits regulated thereby so that the dialysis fluid is permitted to flow through said apparatus and the patient and then from said third means, said control means comprises a shaft, first and second cams mounted on said shaft, one of said cams controlling said fourth means, and other cam controlling said fifth means, energizable means for rotating said shaft, and means for selectively energizing and de-energizing said energizable means to selectively rotate said shaft.

8. A dialysis apparatus comprising first and second means for regulating the flow of dialysis fluid through said apparatus, means coupling said first and second regulating means to each other so that when said coupling means is a first position said first regulating means stops the flow of dialysis fluid and said second regulating means permits the flow of dialysis fluid, and when said coupling means is in a second position said first regulating means permits the flow of dialysis fluid while said second regulating means stops the flow of dialysis fluid, selectively energizable means for alternatively positioning said coupling means between its first and second positions, said selectively energizable means being mechanically connected to said coupling means, first, second and third timers, said first timer for controlling the duration of time in which said coupling means is in a first position, said first timer including means to emit a control signal when said first timer times out, electrical means for transmitting said control signal from said first timer to said selectively energizable means, said selectively energizable means adapted to be energized in response to said control signal so that said selectively energizable means causes said coupling means to be positioned in the second position, said electrical means also to transmit said control signal to said second and third timers, said second and third timers to automatically reset and start timing out in response to such signal, said third timer for controlling the duration of time in which said coupled regulating means are in the second position, said third timer including means to emit a control signal when said third timer times out, electrical means for transmitting said control signal from said third timer to said selectively energizable means, said selectively energizable means adapted to be energized in response to said control signal so that said selectively energizable means causes said coupling means to be positioned in the first position, said electrical means also to transmit said control signal to said first timer, said first timer to automatically reset and start timing out in response to such signal, an energizable alarm and a switch, said switch being operative to enable said alarm upon a condition, said second timer having a shorter timing duration than said third timer and being electrically connected to said third timer and said energizable alarm so that if the alarm is enabled when said second timer times out, said alarm is energized and said third timer stops timing out until said condition no longer exists.

9. A dialysis apparatus defined in claim 8, including overriding means for selectively generating a control signal to said first timer in said selectively energizable means, said first timer to automatically rewind and start timing out in response to said control signal, said selectively energizable means to be energized in response to said control signal so that selectively energizable means causes said coupling means to be positioned in the first position, said overriding means to be operable independently of said first, second or third timers.

10. A dialysis apparatus defined in claim 8, including overriding means for selectively generating a control signal to said second and third timers and to said selectively energizable means, said second and third timers to automatically rewind and start timing out in response to said control signal, said selectively energizable means to be energized in response to said control signal so that selectively energizable means causes said coupling means to be positioned in the second position, said overriding means to be operable independently of said first, second or third timers.

11. A prepackaged sterilized peritoneal dialysis apparatus comprising:

(a) a first collapsible measuring bag adapted to receive dialysis fluid and having a single inlet-outlet,

(b) a second collapsible weighing bag adapted to receive dialysis fluid from a patient and having a single inlet-outlet,

(c) at least six lengths of flexible tubing,

(d) a first length of said tubing having one end directly connected to the inlet-outlet of said first bag, a second length of said tubing having one end connected at a junction to the other end of said first length of tubing, the other end of said second length of tubing being adapted to be connected to a source of dialysis fluid,

(e) a third length of said tubing having one end adapted to be in communication with a catheter, the other end of said third length of tubing being connected through a junction to the interconnected ends of said first and second lengths of tubing,

(f) a fourth length of said tubing having one end directly connected to the inlet-outlet of said second bag,

(g) a fifth length of said tubing having one end in communication with said third tubing, the other end of said fifth length of tubing being connected through a junction to the other end of said fourth length of tubing,

(h) a sixth length of tubing having one end adapted to be connected to a waste disposal, the other end of said sixth length of tubing being connected at the last mentioned junction to the interconnected ends of said fourth and fifth lengths of tubing,

(i) whereby said third length of tubing may be used to feed fluid to a patient and the fifth tubing may be used to transfer fluid drained from a patient to said second bag via said fourth tubing.

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