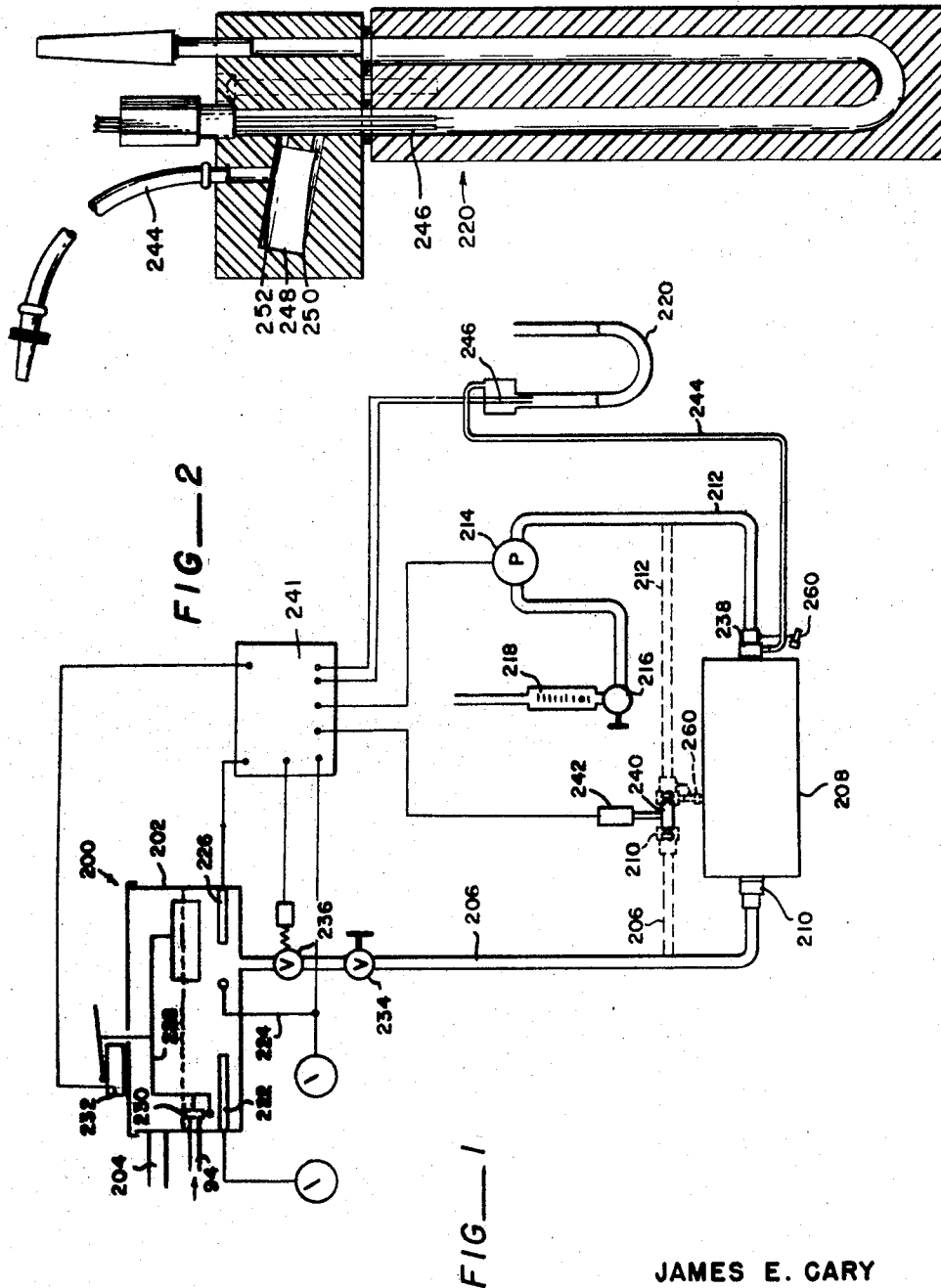


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DIALYSIS CONTROL SYSTEM
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DIALYSIS CONTROL SYSTEM

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ABSTRACT OF THE DISCLOSURE

A bedside hemodialysis station is provided for use in conjunction with a hemodialyzer to receive dialysis solution from a remotely located dialysis solution supply means and to supply the dialysis solution to the dialyzer under controlled temperature and pressure conditions. The bedside dialysis station comprises a reservoir tank adapted to be supplied with dialysis solution from a remotely located source thereof, a dialyzer supply conduit extending from the reservoir tank and adapted to be detachably coupled to the inlet to a dialyzer, a positive displacement pump and a waste conduit extending therefrom and adapted to be detachably connected to the outlet from the dialyzer, suitable to temperature and pressure controls, and a sterilizing bypass assembly. The sterilizing bypass assembly permits sterilization of those components of the bedside dialysis stations that come into contact with dialysis solution by simply disconnecting the dialyzer supply conduit and waste conduit from the dialyzer and connecting them to the sterilizer bypass assembly, without setting off the temperature and pressure alarms contained within the bedside dialysis station.

This invention relates to apparatus for use in hemodialysis, and more particularly to a system for supplying a dialysis solution to a dialyzer employed in hemodialysis and for controlling dialysis.

In recent years, artificial kidneys have been employed to treat patients with acute renal failure and to rehabilitate patients who would otherwise die of chronic uremia. An essential feature of an artificial kidney system is the dialyzer. A kill-type dialyzer, which is generally preferred, comprises two cellophane semipermeable envelopes through which small portions of a patient's blood passes in counterflow to a dialysis solution passing on the outer surfaces of the cellophane envelopes. The dialysis solution removes waste from the blood portions by a permeation phenomenon. Because of the nature of hemodialysis, the permeation process, or dialysis, must be conducted under carefully controlled conditions.

One of the major problems in the use of artificial kidney systems has been the complexity of the apparatus associated with hemodialysis techniques. Such apparatus requires the constant attention of highly trained personnel and further is quite bulky and expensive. Hence, dialysis control is often wasteful of the time of trained hospital personnel. Furthermore, as artificial kidney systems become less complex and expensive, such systems will be frequently used by patients at home rather than at a hospital or clinic. Consequently, dialysis control must be pro-

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vided that can be easily and safely operated by members of a patient's family at home.

It is a primary object of the invention to provide a dialysis control system that is easy and safe to operate and that is suitable for use either in the home or in a hospital or clinic. Another object is to provide apparatus for supplying a dialysis solution to a dialyzer.

These and other objects and advantages of this invention will become apparent from the following description in conjunction with the accompanying drawings, of which:

FIG. 1 is a schematic diagram of the system of this invention; and

FIG. 2 is an elevation view in cross-section of a manometer employed in the system of this invention.

Briefly, the invention comprises a reservoir means for receiving and holding a supply of dialysis solution, supply conduit means for connecting the reservoir to an inlet of a dialyzer, pumping means, exhaust conduit means for connecting the pumping means to an outlet to the dialyzer, and suitable control means for controlling dialysis conditions such as the temperature and pressure of the dialysis solution.

With reference to FIG. 1, the invention comprises a reservoir tank 202 with a dialysis solution inlet connected to supply conduit 94, a vent and overflow conduit 204, and a dialyzer supply conduit 206. Dialyzer supply conduit 206 connects to the inlet of a dialyzer 208 through a quick disconnect coupler 210. A waste conduit 212 connects the outlet of dialyzer 208 to a positive displacement pumping means 214, a manually-operable shut-off valve 216 and a flow metering means 218. A manometer pressure sensing means 220 is connected to waste conduit 212 and is adapted to stop dialysis if a negative pressure greater than about 150 mm./Hg is sensed. The pressure sensing means may be a manometer as shown or may be a Bourdon tube pressure gauge.

Reservoir tank 202 is provided with a heating means 222 that is manually adjustable to temper the dialysis solution within reservoir tank 202 for patient comfort, e.g. to 98° F., and to hold temperature settings within a reasonable range, for example $\pm 2^\circ$ F. Temperature sensor 224 and a high temperature switch 226 are set to stop dialysis if the dialysis solution reaches an unacceptably high temperature on the order of 106° F. The reservoir tank 202 is also provided with a dialysis solution valve control means 228 comprising a float-controlled inlet valve 230 which prevents overfilling and a dry float switch 232 which stops dialysis if the quantity of dialysis solution in reservoir tank 202 falls below a predetermined minimum level.

Dialysis solution supply conduit 206 is provided with a manually adjustable negative pressure valve 234 to control pressure of the dialysis solution being drawn through the dialyzer 208 by pumping means 214. If desired, a solenoid-operated control valve means 236 may also be provided in conduit 206 to control dialysis solution flow to the dialyzer 208.

Waste conduit means 212 connects to the outlet to dialyzer 208 through a quick disconnect coupler 238. A sterilizing connector 240 is provided and adapted to receive couplers 210 and 238 to bypass dialyzer 208 when

the bedside station is to be sterilized. Connector 240 includes a sterilize switch means 242 which is actuated when couplers 210 and 238 are attached to connector 240 as indicated by broken lines in FIG. 1 and which shuts off control circuitry associated with manometer 220, high temperature switch 226, and alters circuitry 241 associated with float means 228 so that high temperature sterilizing water can be drawn through the bedside station by pumping means 214 without automatically shutting down pumping means 214. If high temperature sterilizing water is inadvertently passed to the bedside station without connecting couplers 210 and 238 to bypass dialyzer 208, high temperature switch 226 would automatically shut off pumping means 214 and close solenoid-operated control valve means 236 (if provided) to stop dialysis.

The connecting tube 244 for the manometer sensing means 220 is disconnected from waste conduit 212 at a port in coupler 238 and then this port is sealed with plug means 239 (conveniently hung on a chain) so that the manometer will be disconnected when coupler 238 is attached to connector 240 for sterilizing. One leg of the manometer is so connected at coupler 238 through pressure line 244 and contains electrical contacts 246 which are electrically connected when mercury rises to cover the contacts 246 at a negative pressure greater than about 150 mm./Hg to inactivate pumping means 214 and close solenoid-operated control valve means 236 (if provided) and thereby stop dialysis. The other leg of the manometer is open to atmosphere.

FIG. 2 shows a preferred construction of manometer 220. The low pressure side of the manometer communicates with the connecting tube 244 through an expansion chamber 248 within the upper end section of the manometer. This chamber is provided with two small ports 250 and 252 which open to the manometer low pressure leg, and a bottom that slopes downwardly toward the lower port 250. If the pressure in the waste conduit 212 should suddenly fall below a predetermined level such that mercury in the manometer low pressure leg would tend to surge through connecting tube 244 into waste conduit 212, the mercury would have to surge through the restricted ports 250 and 252, and then fill the expansion chamber 248 before it could surge through the connecting conduit 244. Thus, as a practical matter, mercury will never escape the manometer to surge through the connecting conduit 244. Any mercury that reaches the expansion chamber 248 will run back in the low pressure leg because of the chamber's sloping bottom.

The system of this invention is particularly adapted for use as a bedside dialysis station for use by a dialysis patient either at home or at a hospital or clinic. The station components can be conveniently housed in a cabinet such that the dialyzer supply conduit 206 and waste conduit 212 extend therefrom and such that the flow-metering means 218, manometer 220, the indicator for temperature sensor 224, the adjuster for heating means 222 and the flow control 216 are exposed for reading or adjusting. Such a cabinet could be attached to a wall next to a patient's bed or supported on a pedestal or supported on a cabinet. It is preferred that the bedside station be mounted at a higher elevation than the dialyzer so that gravity will produce a positive pressure on the dialysis solution inlet to the dialyzer.

It is believed that the invention will have been clearly understood from the foregoing detailed description of my now-preferred illustrated embodiment. Changes in the details of construction may be resorted to without departing from the spirit of the invention and it is accordingly my intention that no limitations be implied and that the hereto annexed claims be given the broadest interpretation to which the employed language fairly admits.

What is claimed is:

1. A dialysis control system which comprises a reservoir having an inlet communicable with a dialysis solution supply means and an outlet, a dialyzer supply con-

duit extending from the reservoir outlet and communicable with an inlet to a dialyzer; dialysis solution pumping means having an inlet; a waste conduit extending from the pumping means inlet and communicable with an outlet to the dialyzer; and sterilizing connector means adapted to detachably couple said dialyzer supply conduit to said waste conduit to bypass the dialyzer.

2. A dialysis control system which comprises a reservoir having an inlet communicable with a dialysis solution supply means and an outlet; a dialyzer supply conduit extending from the reservoir outlet and communicable with an outlet to a dialyzer; dialysis solution pumping means having an inlet; a waste conduit extending from the pumping means inlet and communicable with an outlet to the dialyzer; means for sensing dialysis solution pressure in said waste conduit upstream of the pumping means inlet and for terminating dialysis solution flow through the dialyzer when the sensed pressure falls below a predetermined range; means for sensing dialysis solution temperature within said reservoir and for terminating dialysis solution flow to the dialyzer when the sensed temperature exceeds a predetermined range; and sterilizing connector means adapted to detachably couple said dialyzer supply conduit to said waste conduit to bypass the dialyzer and adapted to inactivate the pressure and temperature sensing means.

3. A system according to claim 2 including means for tempering dialysis solution within said reservoir within a predetermined temperature range.

4. A system according to claim 2 including control valve means for controlling dialysis solution flow from said reservoir through said dialyzer supply conduit to a dialyzer.

5. A system according to claim 2 wherein said means for sensing dialysis solution pressure includes a U-type manometer having an expansion chamber interconnecting a low pressure outlet to a low pressure leg through restricted openings, said expansion chamber having a bottom sloping downwardly toward one of said restricted openings.

6. A dialysis system including at least one dialysis station which comprises:

- a dialyzer having an inlet and outlet for dialysate;
- a reservoir tank having an inlet communicable with said dialysis solution reservoir means and having an outlet;
- a dialyzer supply conduit extending from the reservoir tank outlet and detachably connectable to the dialyzer inlet;

- dialysis solution pumping means having an inlet and an outlet; a waste conduit extending from the pumping means inlet and detachably connectable to the dialyzer outlet; first quick disconnect means for detachably coupling said dialyzer supply conduit to said inlet;

- second quick disconnect means for detachably coupling said waste conduit to said dialyzer outlet;

- means for sensing the pressure of dialysis solution in said waste conduit upstream of the dialysis solution pumping means inlet and for inactivating said dialysis solution pumping means when the sensed pressure falls below a predetermined range;

- means for tempering dialysis solution within said reservoir tank within a predetermined temperature range;

- means for sensing the temperature of the dialysis solution within said reservoir tank and for inactivating said dialysis solution pumping means when the sensed temperature exceeds a predetermined range;

- and sterilizing connector means adapted to detachably couple said dialyzer supply conduit to said waste conduit to bypass the dialyzer and adapted to inactivate the pressure and temperature sensing means controls.

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