



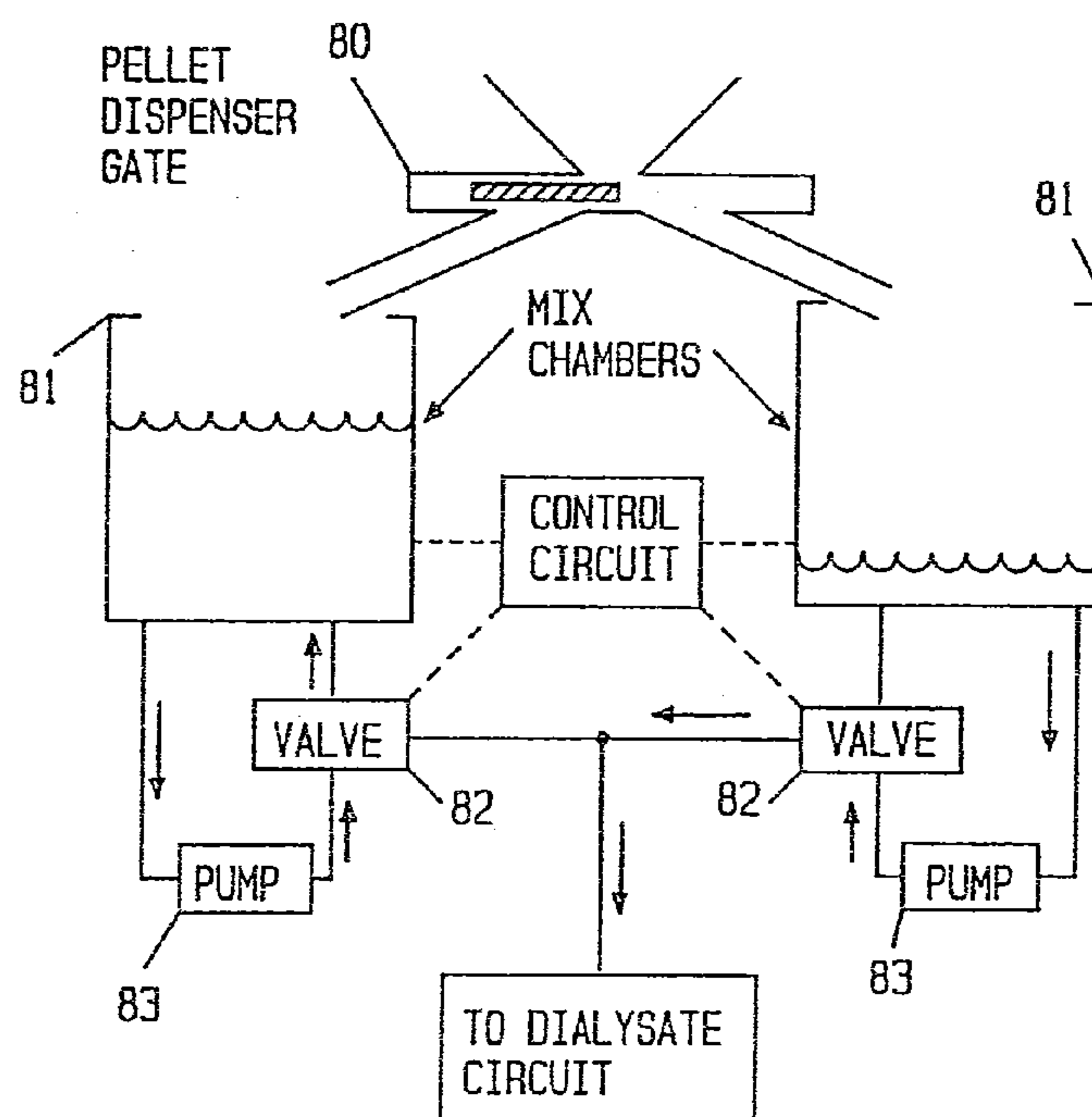
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(54) **SYSTEME DE PRODUCTION DE DIALYSATS A PASTILLES**

(54) **DIALYSATE PRODUCTION SYSTEM WITH DIALYSATE
PELLETS**



(57) Pastilles sèches de produit chimique renfermant un acide, une base et un sel, comprenant les agents chimiques nécessaires pour former un dialysat lorsqu'on les mélange avec une quantité prédéterminée d'eau stockée dans des réservoirs de mélange, à partir desquels le dialysat peut être mis en circulation vers un circuit d'hémodialyse. On peut varier les pastilles en fonction de leur composition et les distribuer suivant l'ordre prescrit pour modifier le dialysat afin qu'il s'adapte aux besoins du patient.

(57) Dry chemical pellets containing an acid, base, and salt, have the necessary chemicals to form a dialysate when mixed with a predetermined amount of water stored in mixing tanks from which the dialysate can be circulated to a hemodialysis circuit. The pellets can be varied in composition and dispensed in a prescribed order to vary the dialysate in accordance with the patient's needs.



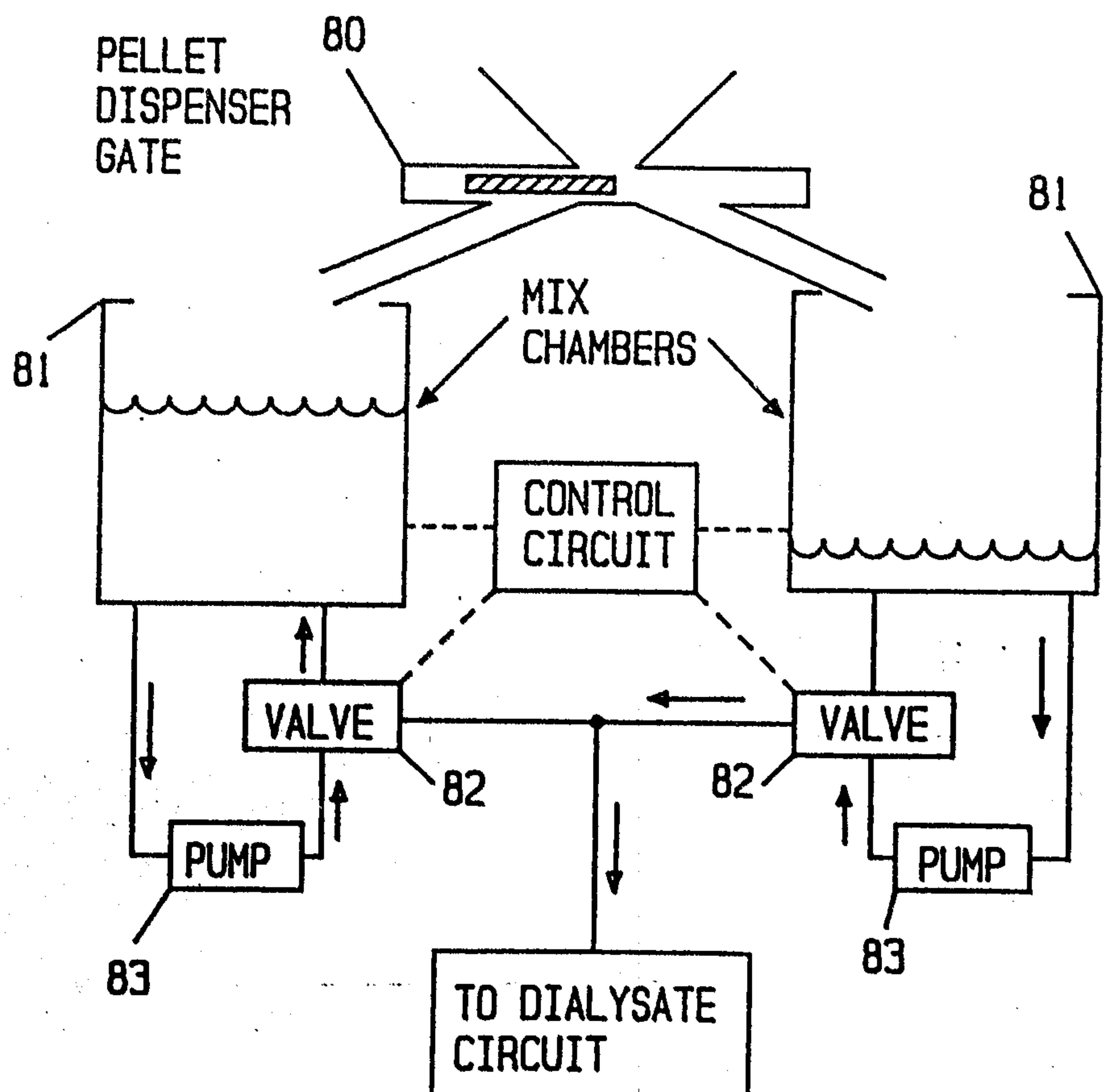
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(21) International Application Number: PCT/US90/07480 (22) International Filing Date: 18 December 1990 (18.12.90) (71) Applicant: THE BOARD OF REGENTS OF THE UNIVERSITY OF WASHINGTON [US/US]; 3755 University Way N.E., Seattle, WA 98105 (US). (72) Inventors: AHMAD, Suhail ; 10301 40th Avenue N.E., Seattle, WA 98125 (US). COLE, James, J. ; 19512 Jordan Road, Arlington, WA 98223 (US). JENSEN, William ; P.O. Box 75262, Seattle, WA 98125 (US). (74) Agents: SEED, Richard, W. et al.; Seed and Berry, 6300 Columbia Center, Seattle, WA 98104-7092 (US).		(81) Designated States: AT (European patent), AU, BE (European patent), CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent). Published <i>With international search report.</i> <i>With amended claims.</i>

(54) Title: DIALYSATE PRODUCTION SYSTEM WITH DIALYSATE PELLETS**(57) Abstract**

Dry chemical pellets containing an acid, base, and salt, have the necessary chemicals to form a dialysate when mixed with a predetermined amount of water stored in mixing tanks from which the dialysate can be circulated to a hemodialysis circuit. The pellets can be varied in composition and dispensed in a prescribed order to vary the dialysate in accordance with the patient's needs.



Description

DIALYSATE PRODUCTION SYSTEM WITH DIALYSATE PELLETS

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Technical Field

The present invention relates to hemodialysis systems, and more particularly, to an improved system for
10 supplying dialysates.

Background of the Invention

Hemodialysis treatment is employed as a therapeutic measure when a patient's kidneys no longer
15 perform their blood purifying function because of disease or traumatic removal. Kidney failure results in the accumulation of toxic waste in the patient's blood and eventual death from uremic poisoning, unless the waste material is removed by some artificial means. In
20 hemodialysis of the type to which the present invention relates, the patient's blood is circulated from the patient in a closed blood circuit by a pump to one side of a membrane contained within a hemodialyzer (i.e., artificial kidney). The membrane has pores of microscopic
25 size through which waste products from the blood pass. The pores are, however, too small to permit blood cells and proteins to leave the body. A dialysis fluid (dialysate) is circulated on the other side of the hemodialyzer membrane to remove the waste products. The
30 dialyzed blood is returned to the patient.

Commonly the dialysate for hemodialysis systems is supplied as a liquid concentrate in containers from which it is blended and diluted with sterile water by the use of proportional pumping systems.

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Brief Description of the Invention

The present invention provides an on-site dialysate production system for supplying dialysate directly to a hemodialysis system by utilizing dry chemical pellets or tablets, wherein the pellet or tablet contains an acid or acids, a base or bases, and salts, with the proviso that the acid component be separated from the base component. The pellets are added to mixing chambers containing treated water to form the dialysate. The mixed dialysate from the chambers flows into the dialysate circuit through the hemodialyzer and/or hemofilter. Preferably, the acid component is citric acid, and this forms an effervescence upon contact with water and other chemicals to facilitate the solution of the dry chemical into the dialysate and maintains a pH below 7.4. Moreover, the more acid pH prevents calcium carbonate from forming an insoluble precipitate in the aqueous solution.

Brief Description of the Drawings

Figure 1 is a schematic of the main components in a traditional hemodialysis system.

Figure 2 is a schematic of a dialysate production system embodying the present invention.

Detailed Description of the Invention

Referring to Figure 1, an "arterial" line runs from the patient to a blood pump and then to one side of the membrane in the hemodialyzer. The blood then flows to a drip chamber in the "venous" line and back into the patient. This forms the blood circuit. Conventionally, the dialysate circuit has been formed by mixing liquid dialysate concentrate with sterile water and passing the resulting dialysate on the other side of the hemodialyzer membrane and then continuing out to waste.

Referring to Figure 2 in the dialysate production system of this invention, dry chemical pellets

or tablets in a hopper or magazine are dropped, or otherwise fed, into a pellet dispenser gate (80) and then added to one of two mixing chambers (81) containing a predetermined amount of sterile water. Preferably, a pump
5 (83) circulates the water in the mix chamber to dissolve the pellet, and form a dialysate solution. Citric acid in the pellet regulates the pH of the dialysate to pH 7.4 or below to prevent calcium carbonate precipitate from forming. A valve (82) controls the addition of the
10 dialysate in the mix chamber to the dialysate circuit. This system eliminates the need for use of a concentrate proportioning pump in prior art systems.

In accordance with the present invention, dry chemicals are formed into the pellets in premeasured
15 amounts. Each pellet contains an acid, base, and salt in dry form. Preferably, the acid is citric acid and is separated from the base and salt. Preferably, the pellets are formed and stored under low humidity conditions. The pelletized dry chemicals are capable of forming dialysates
20 with either acetate-based or bicarbonate-based dialysates without equipment conversion. Preferably, the salt forms a barrier layer between the acid and the base in the pellet.

The dry chemicals suitable for use in the
25 pellets include salts comprising an anion and a cation, wherein the anions are selected from the group consisting of bicarbonate, citrate, chloride, acetate, lactate, and combinations thereof; and wherein the cations are selected from the group consisting of sodium, potassium, magnesium,
30 calcium, and combinations thereof. Additional organic dry chemicals suitable for use as salts include dextrose and urea. Useful acids include citric acid, lactic acid, ascorbic acid and acetic acid. Typical bases include bicarbonate, carbonate, lactate and citrate. Preferably,
35 sodium, potassium, calcium, and magnesium are the cations. A suitable dry dialysate composition in pellet form that can be mixed with one liter of water to form one liter of

dialysate comprises from about 130 to about 150 mEq Na, from 0 to about 4.0 mEq of K, from about 2.0 to 3.5 of mEq Ca, from 0 to about 1.5 mEq Mg, from about 25 to about 45 mEq bicarbonate, from 0 to about 2 g/L glucose, and from about 90 to about 120 mEq chloride ion. Acetate or lactate can be substituted for bicarbonate at the same concentration range. Preferably, citric acid is used at a concentration from about 2 to 12 mEq to maintain an acid pH of the dialysate.

Each mix chamber 81 can contain, for example, from about 2 to about 10 liters of dialysate. Each dialysate chamber volume can be prepared by mixing an appropriate volume of water with a single pellet. The valves 83 located in the pump circuit can switch a mix chamber into a dialysate reservoir to pump dialysate through the dialysate circuit to the hemodialyzer and out to waste. The second mix chamber can be preparing the next reservoir of dialysate for use when the first mix chamber becomes empty. Hence, preferably there are at least two mixing chambers 81.

The use of citric acid in conjunction with conventional dialysate chemicals produces a mixture which will dissolve quickly and completely in the time required by the system. The resulting citrate load is well tolerated, and causes no disturbance of the blood calcium level. Construction of the pellet, such that the more acid components dissolve first, maintains the pH of the solution below the level of 7.40 at all times. This chemical environment prevents the formation of insoluble precipitates, especially calcium salts.

The pellets can be loaded in prescribed order in a suitable pellet dispenser means controlled by the pellet dispenser gate 80 to change the ion gradient of the dialysate during the treatment process to better suit the individual patient's treatment needs.

It is possible to attach a bar code to the pellet and an optical scanner in the means for adding

pellets to the mixing chambers to ensure proper gradient formation and to allow the mixing system to adjust monitoring according to pellet composition. The pellets can be preloaded in magazines or cassettes.

5 As previously indicated, the utilization of discrete tables or pellets makes it possible to easily change the chemical makeup of the dialysate during treatment in accordance with changing requirements of the individual patient. For example, Raja et al., "Role of
10 Varying Dialysate Sodium and Bicarbonate in the Improvement of Dialysis Vascular Stability," Prog. Art. Organs, Nose et al. (eds.), ISAO Press, Cleveland, 1985, pp. 237-39 [Raja et al. I], and Raja et al., "Sequential Changes in Dialysate Sodium (DNa) During Hemodialysis,"
15 Trans. Am. Soc. Artif. Intern. Organs 29:649-651, 1983 [Raja et al. II] describe several schemes to vary dialysate ion concentrations during treatment. The ability to introduce, in prescribed order, pellets with different chemical makeup into the mixing chambers makes
20 possible the timed adjustment in individual dialysate ion concentrations during dialysis treatment in accordance with the prescription of the managing physician.

For example, the dialysate sodium concentration can be progressively changed from 150 to 135 mEq/L in
25 decrements of 1 or 2 mEq/L during the course of treatment. At the same time, the bicarbonate concentration might be altered from 20 to 35 mEq/L in 5 mEq/L increments during the first 3 hours of the procedure. The dialysate chemical composition can be flexibly changed every few
30 minutes, as each new pellet is introduced, to produce optimal treatment results according to the defined needs of the individual patient. It will be appreciated that the system can be automated and programmed to control the feeding of the pellets and delivery of the dialysate to
35 the dialysis circuit.

Another example of the benefit of being able to vary the dialysate ion concentration during treatment is

to control the rate of osmolar change during dialysis. Several treatment-related symptoms during dialysis have been shown to be related to osmolar decline, and the reduction or blunting in this decline can also reduce treatment symptoms, thus improving the quality of dialysis. One way to achieve this goal is to use sodium modeling. The sodium concentration in the dialysate is increased in the early phase of dialysis and then is slowly reduced to lower concentrations, thus blunting the rate of decline of blood osmolarity. Sodium modeling can only be accomplished, at present, with additional equipment added to a basic dialysis system, and then the procedure is nonselective, altering both sodium and other ions proportionally. The present invention achieves sodium modeling by loading dry dialysate pellets with higher sodium concentrations for the early part of dialysis treatment and then gradually using pellets with lower sodium concentrations throughout the remainder of the treatment. Similarly, other osmolar agents, for example urea, can be added.

In present dialysis systems, changing the sodium concentration also proportionally alters the concentrations of other constituents, such as calcium and magnesium. Because individual pellets can be introduced at frequent intervals with the inventive system, the concentrations of all ionic species, except those whose change is desired, can be held constant.

It will be appreciated that, although the invention has been described with respect to dialysate for hemodialysis, it is also applicable to supplying dialysate for peritoneal dialysis, in which case greater quantities of glucose can be used, and the dialysate circuit connects to the patient rather than to the hemodialyzer.

WHAT IS CLAIMED IS:

1. A dry dialysate composition comprising an acid, bicarbonate and a salt, where the acid is separated from
5 the bicarbonate, wherein the acid will dissolve first in an aqueous solution and the bicarbonate will dissolve after solution of the acid, and where said composition upon mixing with water forms a solution comprising from about 2 to about 12 mEq/L of the acid, from about 25 to about 45
10 mEq/L of the bicarbonate, and from about 1.5 to about 150 mEq/L of the salt.
2. The dry dialysate composition of claim 1 wherein the acid is citric acid.
15
3. The dry dialysate composition of claim 1 wherein, upon dissolving in water, the pH is about 7.0 to below 7.4.
4. A dry dialysate composition comprising bicarbon-
20 ate, acetate, lactate or combinations thereof, sodium, calcium, chloride, citric acid, and optionally potassium, magnesium, and glucose, wherein said composition, upon mixing with water, forms a solution comprising:

25 from about 130 to about 150 mEq/L of sodium ion;
from about 0 to about 4.0 mEq/L of potassium ion;
from about 2.0 to about 3.5 mEq/L of calcium ion;
from about 0 to about 1.5 mEq/L of magnesium ion;
from about 25 to about 45 mEq/L of bicarbonate ion;
30 acetate, lactate or combinations thereof;

from about 0 to about 2.0% glucose;
from about 90 to about 120 mEq/L of chloride ion; and
35 from about 2 to about 12 mEq/L of citric acid.

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5. A dry dialysate composition comprising an acid, a base and a salt wherein the acid is selected from the group consisting of citric acid, lactic acid, ascorbic acid, acetic acid and combinations thereof, wherein the
5 base is selected from the group consisting of bicarbonate, carbonate, lactate, citrate and combinations thereof, and where said composition upon mixing with water forms a solution comprising from about 2 to about 12 mEq/L of the acid, from about 25 to about 45 mEq/L of the base, and from
10 about 1.5 to about 150 mEq/L of the salt.

6. A dry dialysate composition comprising bicarbonate, acetate, lactate or combinations thereof, sodium, calcium, chloride, and citric acid, wherein said composition,
15 tion, upon mixing with water, forms a solution comprising:

from about 130 to about 150 mEq/L of sodium ion;
from about 2.0 to about 3.5 mEq/L of calcium ion;
from about 25 to about 45 mEq/L of bicarbonate ion;

20

acetate, lactate or combinations thereof;

from about 90 to about 120 mEq/L of chloride ion; and
from about 2 to about 12 mEq/L of citric acid.

25

7. A dry dialysate composition comprising an acid, a base and a salt wherein the acid is selected from the group consisting of citric acid, ascorbic acid and combinations thereof, wherein the base is selected from the group
30 consisting of bicarbonate, carbonate, lactate, citrate and combinations thereof, and where said composition upon mixing with water forms a solution comprising from about 2 to about 12 mEq/L of the acid, from about 25 to about 45 mEq/L of the base, and from about 1.5 to about 150 mEq/L of
35 the salt.

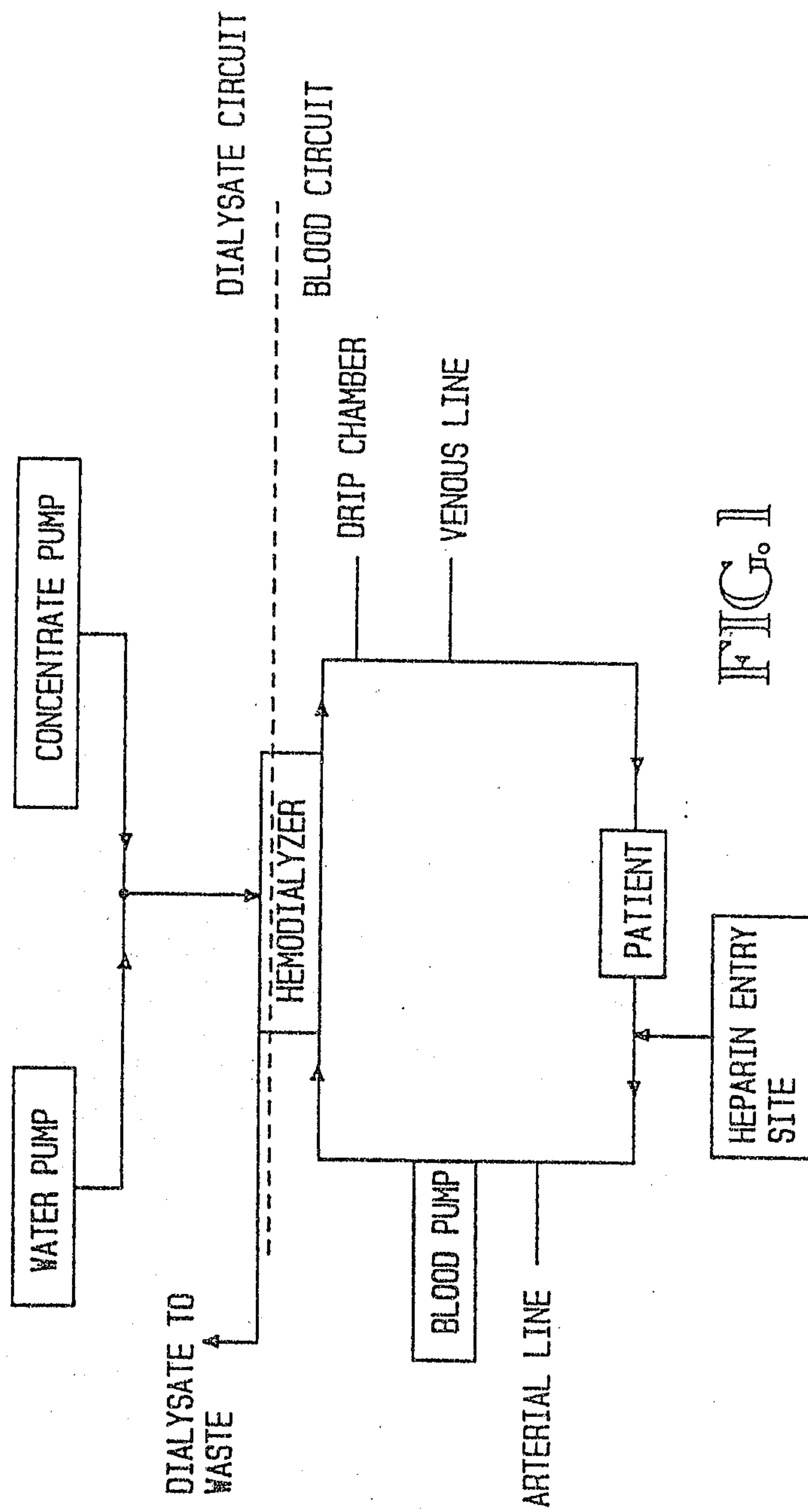


FIG. 1

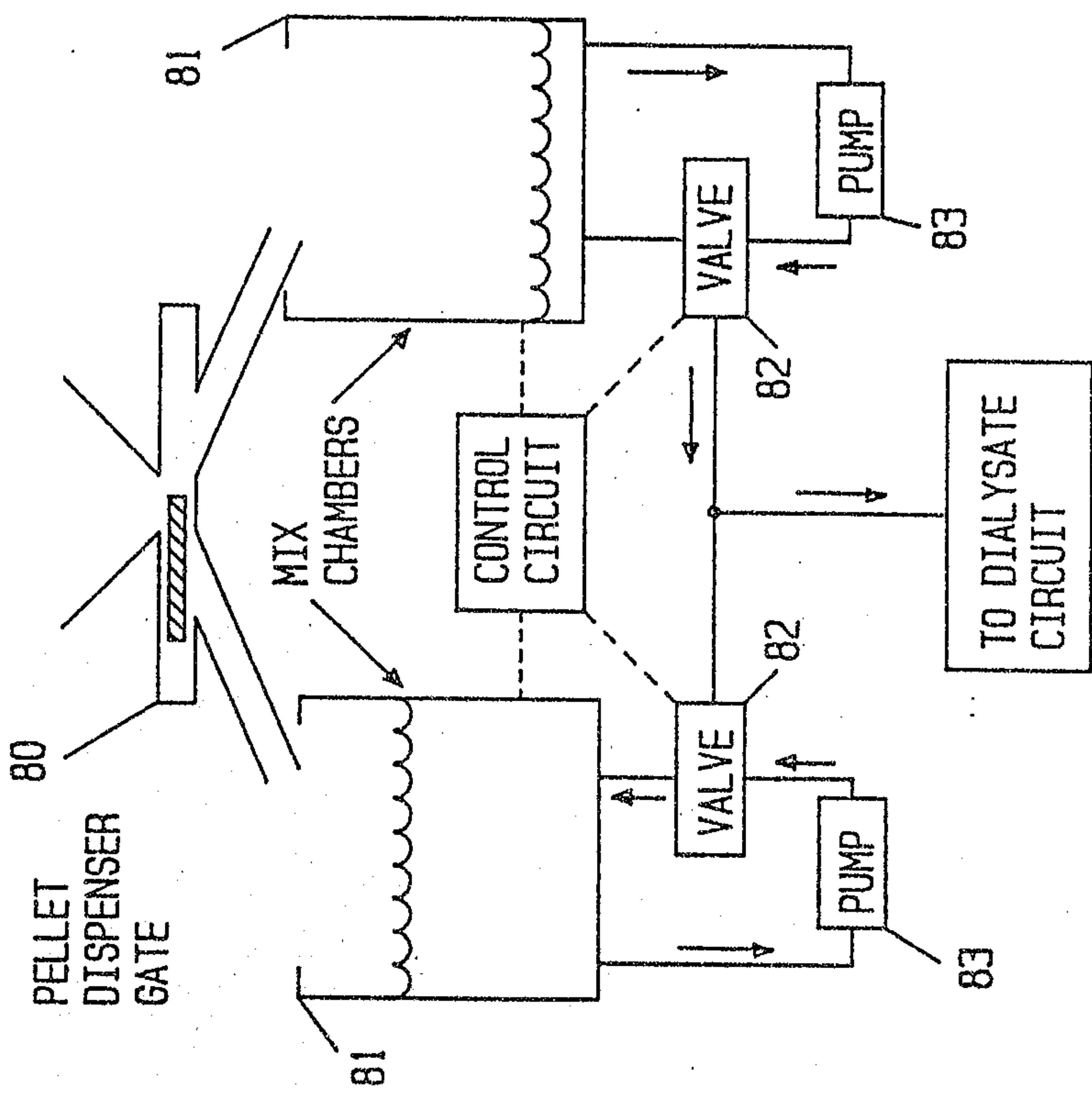


FIG. 2

