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METHOD AND APPARATUS FOR TREATING BURN PATIENTS WITH PHYSIOLOGICAL SOLUTIONS

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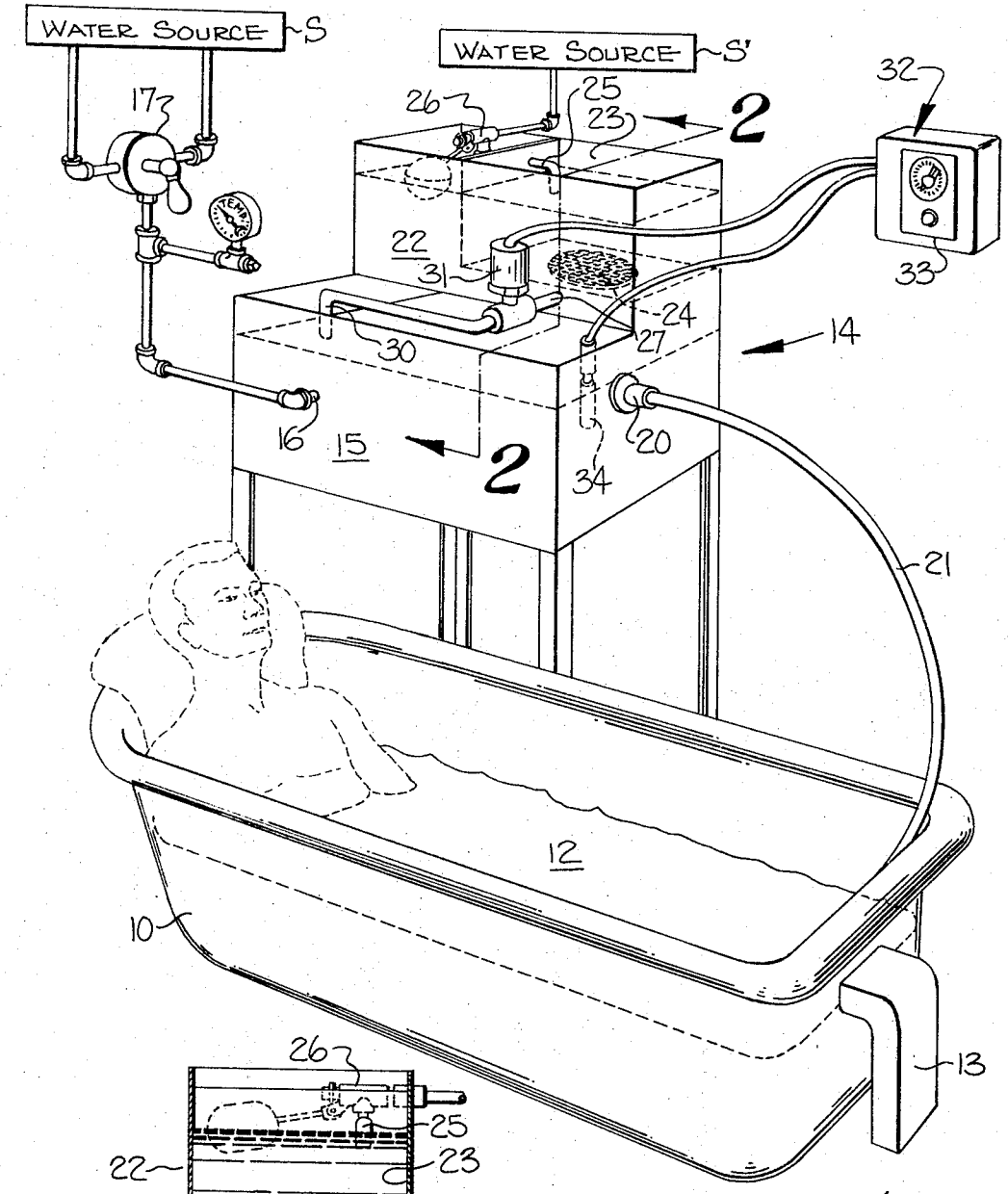

Fig-1

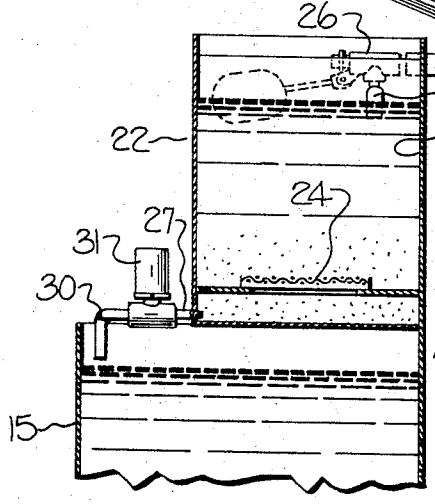

Fig-2

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METHOD AND APPARATUS FOR TREATING BURN PATIENTS WITH PHYSIOLOGICAL SOLUTIONS

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This invention pertains to a method and apparatus for treating burn patients in physiological solutions, and more particularly, to a method and apparatus wherein a physiological solution such as physiological saline is produced and supplied in a continuous flow to the patient undergoing such treatment.

Physiological solutions as used herein applies to chemical solutions which approximate chemically the human body fluids. One of the most widely used such solutions is physiological saline which is a salt water solution containing 0.88% to 0.90% sodium chloride by weight. It is commercially produced by combining C.P. grade sodium chloride and triple distilled water and its general use before and after skin grafting to sooth the patient, promote healing and aid in growth of grafted skin areas is well known. Preferably, the burned skin areas should be irrigated with, rather than soaked in, the physiological saline. That is, the physiological saline should be flowed past the affected skin areas and then, having picked up bacteria-containing debris from such areas, it should be disposed of and replenished with a fresh supply. However, it has heretofore been impractical to do this from a commercial point of view, since the cost of commercially available physiological saline (approximately $3.00 per liter) is prohibitive. Thus, because of the economies involved, fluid treatment of burned skin areas has generally centered around a soaking treatment in stagnant physiological saline or plain water irrigation—the latter being effective to carry away debris, but lacking the efficacy of physiological saline.

In accordance with the present invention, I have found that the foregoing deficiencies can be eliminated by continuously producing physiological saline in an economical manner at the situs of a patient treatment vessel and flowing such saline into and through the treatment vessel to thereby irrigate with physiological saline the affected skin areas of the patient disposed therein. This is accomplished generally by providing an apparatus capable of first producing a brine, and then metering amounts of such brine into a body of water to form physiological saline.

Accordingly, it is a primary object of this invention to promote healing and comfort of burn patients by providing an improved method and apparatus for treating such patients with a physiological solution, such as physiological saline, in which the solution is continuously produced and supplied to the patient for irrigation of the affected skin areas.

A further object of this invention is to promote healing and comfort of burn patients by providing a method of treating such a patient with physiological saline by producing brine, diluting the brine with tap water to produce economical physiological saline at a predetermined rate, and irrigating the patient with the physiological saline at substantially the same rate.

A further object of this invention is to provide an apparatus for use in combination with a treatment vessel for continuously producing a physiological solution, such as physiological saline, and flowing the solution to and through the treatment vessel for treatment of the affected skin areas of a burn patient disposed in the vessel.

A further object of this invention is to provide an improved apparatus for treating a burn patient with physiological saline in which economical physiological saline is produced by the addition of brine to tap water and then supplied to a treatment vessel for treatment of the affected areas of a patient disposed in the vessel.

Some of the objects of the invention having been stated, other objects will appear as the description proceeds, when taken in connection with the accompanying drawing, in which—

FIGURE 1 is a perspective view of an apparatus constructed in accordance with this invention, showing a patient undergoing treatment with physiological saline; and

FIGURE 2 is a sectional view of a portion of the apparatus of this invention, taken along the line 2—2 in FIGURE 1.

Briefly, this invention comprehends the irrigation treatment of affected areas of a burn patient by placing the patient in a treatment vessel, continuously producing a physiological solution and flowing the same into and through the treatment vessel. The physiological solution is produced at substantially the same rate as the flow through the treatment vessel, by mixing tap water and a concentrated electrolytic solution such as brine. The quantity of concentrate mixed with the water to produce a physiological solution is closely controlled by variations in the electrical conductivity of the mixture of the concentrate and water. A preferred apparatus for treating burn patients in accordance with this invention is used in combination with a treatment vessel, and has a mixing reservoir to which water and brine are supplied to produce physiological saline, which in turn is supplied to the treatment vessel. Brine is supplied to the mixing reservoir from a primary reservoir, where it is produced by the admission of water into a hopper containing substantially pure sodium chloride. The flow of brine from the primary reservoir into the mixing reservoir is controlled by an electrical control means including a conductivity cell immersed in the physiological saline, and such flow is responsive to small variations in the electrical conductivity from a predetermined value (i.e., the value for physiological saline) of the brine-water mixture in the mixing reservoir.

In treating a patient in accordance with this invention, the patient **11**, or affected area of the patient, is immersed into the treatment fluid. Where a large body area of a patient is to be treated, the treatment vessel used is preferably a tub **10**, as shown in the drawing. The treatment vessel has a drain outlet **13**, and the level of the body of treatment fluid **12** is determined by the height of the drain outlet **13**, as treatment fluid will overflow the drain outlet **13** and be discarded on leaving the treatment vessel **10**.

According to this invention, apparatus, indicated generally at **14**, is provided for continuously producing a physiological solution, such as physiological saline, and flowing that solution to and through the treatment vessel **10**. The apparatus **14** comprises a mixing reservoir **15**, which contains the physiological solution produced by the apparatus and supplied to the treatment vessel **10**. The mixing reservoir **15** has an inlet **16** connected to a water source S, which may include in association there-

with a thermostatic temperature regulating valve 17 supplying tap water at a predetermined constant temperature, preferably the patient's body temperature. The water inlet 16 is so positioned relative to the mixing reservoir 15 and so constructed, preferably with a constricted nozzle area, as to cause a turbulent flow within the mixing reservoir 15, for purposes to be made more clear subsequently. The mixing reservoir also has an outlet 20 for the physiological solution, which is connected by a conduit means 21 to the treatment vessel 10. With the level of the physiological solution within the reservoir 15 above the outlet 20, as indicated by the dotted line, the physiological solution will flow through the outlet 20 and conduit means 21 to the treatment vessel 10, forming the flowing body of treatment fluid 12. In turn, the physiological solution flows through the treatment vessel 10 while irrigating the affected area of the patient and then flows out the drain outlet 13 to be discarded.

In order to provide for a continuous flow of physiological solution from the apparatus 14 into and through the treatment vessel 10, the apparatus of this invention continuously produces the physiological solution in the mixing reservoir 15 at a rate substantially the same as the rate of flow of physiological solution to the vessel 10 through the conduit means 21 and from the vessel 10 through the drain outlet 13. In using the apparatus shown in the drawings, it has been found that a rate of flow of about 6 gallons per minute of physiological saline can be maintained while producing highly satisfactory results in irrigating the affected areas of the burn patient. This is accomplished by supplying water to the mixing reservoir 15 through the inlet 16 from the water source S at a rate of flow sbstantially equal to the rate of flow of treatment fluid out the drain outlet 13 while mixing brine with that water within the mixing reservoir 15. The brine is supplied to the mixing reservoir 15 in the amounts required to produce, when mixed with the water supplied through the inlet 16, physiological saline in the precise range of from 0.88% to 0.90% of sodium chloride by weight. The mixing of the brine with the water is accomplished by the turbulent flow of the water into the mixing reservoir 15.

Brine is produced and stored within a primary reservoir 22, supported on the mixing reservoir 15. Within the primary reservoir is a salt hopper 23, which has a foraminous wall portion formed by a filter 24 of a screen size which is permeable to brine solution but not permeable to salt crystals. A water inlet 25 supplies water from a water source S' to the hopper 23, under the control of a float valve 26 which is responsive to the level of brine within the primary reservoir 22, as shown in the drawing by a dotted line. Substantially pure sodium chloride, of C.P. grade, is placed in the hopper 23, and on admission of water through the inlet 25, dissolves to form brine. The brine passes through the foraminous wall portion 24 to be retained within the brine reservoir 22 and operates the float valve 26. In practice, it has been found that saturated brine is produced with the foregoing arrangement. It should be noted, however, that the brine need not be a saturated salt solution since the control devices hereinafter described in detail will compensate automatically for differences in degree of saturation.

Where electrolytic physiological solutions other than pure physiological saline are desired, such as Hartman's solution or Ringer's solution, a salt or mixture of salts giving the required electrolyte ratios is added to the sodium chloride in the hopper 23.

The brine is supplied to the mixing reservoir 15 from the primary reservoir 22 through an outlet 27 and a conduit means 30 leading from the outlet to the mixing reservoir 15. A valve 31, such as a solenoid actuated valve, in the conduit 30 governs the flow of brine from the reservoir 22 and is operated in response to an electrical control means 32, which, in turn, is responsive to the electrical conductivity of the brine-water mixture within the mixing reservoir 15. The electrical control means 32 may be any apparatus suitable for controlling the valve 31 in response to the variations in the electrical conductivity of the solution in the mixing reservoir 15, but is here shown as a controller 33 including a bridge circuit and relay responsive to the bridge circuit (not shown) and a conductivity cell 34 immersed in the solution adjacent the mixing reservoir outlet 20. The controller 33 and conductivity cell 34 can be, for example, similar to those shown in Rosenthal Patent No. 2,764,892.

A conductivity cell, as used in the Rosenthal apparatus, has spaced electrode plates which are immersed in a fluid to be tested. When the fluid is electrically conductive, the electrodes and fluid connecting them form a resistor, the resistance of which is a function of the electrode areas, electrode spacing, and the fluid conductivity. In the Rosenthal apparatus, the area and spacing of the electrodes are known, and a Wheatstone bridge is used to accurately measure the resistance between the electrodes and indicate directly in terms of conductivity. As brought out in that patent, the conductivity of an electrolytic solution varies with both the temperature of the solution and the concentration of electrolytes. The effect of temperature variation is reduced, in the Rosenthal apparatus, by a compensating thermistor immersed in the fluid to be tested and used as part of one leg of the bridge circuit. As applied in this invention, a temperature compensated controller 33 is provided with a relay operated by an amplifier which has its input connections across a Wheatstone bridge, as in the Rosenthal apparatus, and the relay controls the valve 31.

In order to improve the accuracy of control, as well as provide for patient comfort, the temperature of water entering the mixing reservoir 15 is preferably closely controlled by the thermostatic valve 17. This thermal control and compensation of the controller together virtually eliminate temperature effects on conductivity, leading to an accurate response to variations in electrical conductivity of the solution. Further, the conductivity cell 34, in this invention, is preferably positioned immediately adjacent the outlet 20 from the mixing reservoir 15. In that position, the fluid sensed by the cell is the actual water-brine mixture being delivered to the treatment vessel as physiological saline.

Thus, due to the virtual elimination of temperature as a factor, the positioning of the cell 34 adjacent the outlet 20, and the accuracy of resistance measurement possible with a Wheatstone bridge, the concentration of the water-brine mixture entering the treatment vessel 10 is maintainable within the ideal range of from 0.88% to 0.90% sodium chloride by weight. In fact, tests conducted with the apparatus show that it is capable of producing physiological saline having a variance from isotonic saline of not more than about 2 milliequivalents per liter.

In operation, water from the water source S' is admitted through the hopper inlet 25 to dissolve sodium chloride within the hopper and form a brine solution which is stored in the primary reservoir 22. Water is also admitted from the water source S through the inlet 16 into the mixing reservoir 15. As the mixing reservoir 15 is filled to a level sufficient to immerse the cell 34, the control means 32 (which has been preset, for example, for the electrical conductivity of physiological saline) operates the valve 31 to admit sufficient brine into the mixing reservoir 15 to produce physiological saline. Simultaneously, as the level of the liquid in the mixing reservoir 15 moves above the outlet 20, saline flow through the outlet 20 and into the treatment vessel 10 begins. Once the body of treatment fluid 12 within the treatment vessel 10 reaches the level of drain 13, the treatment fluid overflows the drain outlet 13 and a continuous flow of physiological saline through the treatment vessel 10 begins. Thereafter, the intermittent flow of water from the source S' into the hopper 23 to form brine in the primary reservoir 22; the flow of water from source S and brine into the mixing reservoir 15 to produce

physiological saline; and the flow of the physiological saline from the mixing reservoir **15** into and through the treatment vessel **10** and out the drain outlet **13** continues so long as treatment of the patient is desired.

In the drawings and specification there have been set forth preferred embodiments of the invention and although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being defined in the claims.

I claim:

1. That method of treating a burn patient in physiological saline which comprises

(a) placing the patient in a treatment vessel,

(b) providing a brine solution,

(c) metering predetermined amounts of said brine solution into water contained in a reservoir in response to variances in the electrical conductivity of the mixture of water and brine from a predetermined value to produce physiological saline in said reservoir, and

(d) directing the physiological saline from the reservoir into and through said treatment vessel at a predetermined rate of flow while continuing to produce additional physiological saline in the reservoir to replenish that being passed into and through said treatment vessel.

2. That method according to claim **1** wherein the physiological solution is produced in the reservoir at a rate substantially equal to the rate of flow of such solution into and through said treatment vessel.

3. That method of treating a burn patient in physiological saline which comprises

(a) placing the patient in a treatment vessel,

(b) producing a brine solution by combining substantially pure sodium chloride and tap water,

(c) metering predetermined amounts of said brine solution into water contained in a reservoir in response to variances in the electrical conductivity of the mixture of water and brine from a predetermined value to produce physiological saline in the reservoir, and

(d) directing the physiological saline from the reservoir into and through the treatment vessel at a predetermined rate of flow while continuing to produce additional physiological saline in the reservoir to replenish that being passed into and through the treatment vessel.

4. That method of treating a burn patient in physiological saline which comprise

(a) placing the patient in a treatment vessel,

(b) producing in a first reservoir a brine solution by combining substantially pure sodium chloride and tap water,

(c) metering predetermined amounts of said brine solution from said first reservoir into water contained in a second reservoir in response to variances in the electrical conductivity of the mixture of water and brine from a predetermined value to produce physiological saline in the second reservoir, and

(d) directing the physiological saline from the second reservoir into and through the treatment vessel at a predetermined rate of flow while continuing to produce brine solution in the first reservoir to replenish that being metered into the second reservoir and while continuing to produce additional physiological saline in the second reservoir to replenish that being passed into and through the treatment vessel.

5. That method of treating a burn patient in physiological saline which comprises

(a) placing the patient in a treatment vessel,

(b) producing in a first reservoir a brine solution by combining substantially pure sodium chloride and tap water,

(c) metering predetermined amounts of said brine solution from the first reservoir into water contained in a second reservoir in response to variances in the electrical conductivity of the mixture of water and brine from a predetermined value while directing additional water into the second reservoir to produce physiological saline having a variance from isotonic saline of not more than about 2 milliequivalents per liter in the second reservoir,

(d) directing the physiological saline from the second reservoir into and through the treatment vessel at a predetermined rate of flow while continuing to produce brine solution in the first reservoir to replenish that being metered into the second reservoir and while continuing to produce additional physiological saline in the second reservoir to replenish that being passed into and through the treatment vessel, and

(e) continuing the production of physiological saline in the second reservoir throughout the entire period of treatment of the patient in the treatment vessel.

6. That method according to claim **5** wherein the physiological saline is produced in the second reservoir at a rate substantially equal to its rate of flow into and through the treatment vessel.

7. That method of treating a burn patient in physiological saline which comprises

(a) placing the patient in a treatment vessel,

(b) producing in a first reservoir a brine solution by combining substantially pure sodium chloride and tap water,

(c) metering predetermined amounts of said brine solution from the first reservoir into water contained in a second reservoir in response to variances in the electrical conductivity of the mixture of water and brine from a predetermined value while directing additional water into the second reservoir to produce physiological saline having a variance from isotonic saline of not more than about 2 milliequivalents per liter in the second reservoir,

(d) directing the physiological saline from the second reservoir into and through said treatment vessel at a rate of flow of about 6 gallons per minute while continuing to produce brine solution in the first reservoir to replenish that being metered into the second reservoir and while continuing to produce additional physiological saline in the second reservoir at substantially the same rate as said rate of flow to replenish the physiological saline being passed into and through the treatment vessel, and

(e) continuing the production of physiological saline in the second reservoir throughout the entire period of treatment of the patient in the treatment vessel.

8. In combination with a therapeutic treatment vessel adapted to accommodate a burn patient, apparatus for producing and supplying a physiological solution to such treatment vessel in a continuous flow to treat affected skin areas of a patient disposed therein, said apparatus comprising

(a) a reservoir for containing the physiological solution,

(b) means connecting said reservoir to the treatment vessel for continuously delivering the physiological solution from said reservoir into the treatment vessel, and

(c) means operatively associated with said reservoir for continuously producing therein additional amounts of such solution in predetermined concentrations to replenish that solution being passed into said treatment vessel, and

(d) means operatively associated with said solution producing means (c) and with said reservoir (a) for sensing and governing the concentration of the physiological solution in said reservoir.

9. In combination with a therapeutic treatment vessel adapted to accommodate a burn patient, apparatus for producing and supplying physiological saline to such treatment vessel in a continuous flow to treat affected

skin areas of a patient disposed therein, said apparatus comprising

(a) a mixing reservoir for containing the physiological saline,

(b) means connecting said reservoir to the treatment vessel for continuously delivering the physiological saline from said reservoir into the treatment vessel, and

(c) means operatively associated with said reservoir for continuously producing additional amounts of physiological saline in said reservoir to replenish that being passed into said treatment vessel, said latter means comprising

(1) means operatively connected to said reservoir for delivering metered amounts of brine to said reservoir, and

(2) water supply means connected to said reservoir for delivering metered amounts of water into said reservoir to combine with the brine therein to produce additional amounts of the physiological saline.

10. Apparatus according to claim **9** wherein said brine delivering means (c) (1) includes

(a) a brine reservoir for containing the brine to be metered into said mixing reservoir, and

(b) means operatively associated with said brine reservoir for producing additional brine in said brine reservoir to replenish that being metered into said mixing reservoir.

11. Apparatus according to claim **9** wherein said brine delivering means (c) (1) is operable in response to measured variances in the electrical conductivity from a predetermined value of the mixture of brine and water in said mixing reservoir and includes

(a) a brine reservoir for containing the brine to be metered into said mixing reservoir,

(b) means operatively associated with said brine reservoir for producing additional brine in said brine reservoir to replenish that being metered into said mixing reservoir, and

(c) means operatively associated with said mixing reservoir for measuring said variances in the electrical conductivity.

12. In combination with a therapeutic treatment vessel adapted to accommodate a burn patient, apparatus for producing and supplying physiological saline to such treatment vessel in a continuous flow to treat affected skin areas of a patient disposed therein, said apparatus comprising

(a) a mixing reservoir for containing the physiological saline,

(b) means connecting said reservoir to the treatment vessel for continuously delivering the physiological saline from said mixing reservoir into the treatment vessel,

(c) means communicating with said mixing reservoir for producing and delivering metered amounts of brine to said mixing reservoir,

(d) water supply means connected to said mixing reservoir for delivering metered amounts of water into said reservoir to combine with the brine therein,

(e) a conductivity cell positioned in said mixing reservoir for measuring variances in the electrical conductivity from a predetermined value of the brine-water mixture in said mixing reservoir, and

(f) control means operatively associated with said brine producing and delivering means (c) and operable in response to the measurement of variances by said conductivity cell for metering the brine into water contained in the mixing reservoir to produce additional physiological saline.

13. Apparatus according to claim **12** wherein said brine producing and delivering means (c) includes

(a) a reservoir for containing the brine,

(b) a hopper adapted to contain sodium chloride and communicating with said brine containing reservoir,

(c) water supply means communicating with said hopper for supplying water thereto in response to a decrease in the brine level in said brine containing reservoir to form additional brine therein, and

(d) a filter positioned between said hopper and said brine containing reservoir for preventing the passage of salt particles into said brine containing reservoir.

14. In combination with a therapeutic treatment vessel adapted to accommodate a burn patient, apparatus for producing and supplying physiological saline to such treatment vessel in a continuous flow to treat affected skin areas of a patient disposed therein, said apparatus comprising

(a) a mixing reservoir for containing the physiological saline, said mixing reservoir having an outlet,

(b) a conduit communicating with said outlet of said mixing reservoir and the treatment vessel for continuously delivering the physiological saline from said mixing reservoir into the treatment vessel,

(c) means communicating with said mixing reservoir for producing and delivering metered amounts of brine to said mixing reservoir,

(d) water supply means connected to said mixing reservoir for delivering metered amounts of water into said reservoir to combine with the brine therein,

(e) a conductivity cell positioned adjacent said outlet in said mixing reservoir for measuring variances in the electrical conductivity from a predetermined value of the brine-water mixture passing through said outlet,

(f) control means operatively associated with said brine producing and delivering means (c) and operable in response to the measurement of variances by said conductivity cell for metering the brine into water contained in the mixing reservoir to produce additional physiological saline.

15. In combination with a therapeutic treatment vessel adapted to accommodate a burn patient, apparatus for producing and supplying physiological saline to such treatment vessel in a continuous flow to treat affected skin areas of a patient disposed therein, said apparatus comprising

(a) a mixing reservoir for containing the physiological saline, said mixing reservoir having an outlet,

(b) a conduit communicating with said outlet of said mixing reservoir and the treatment vessel for continuously delivering the physiological saline from said mixing reservoir into the treatment vessel,

(c) means communicating with said mixing reservoir for producing and delivering metered amounts of brine to said mixing reservoir, said brine producing and delivering means including

(1) a reservoir for containing the brine,

(2) a hopper adapted to contain sodium chloride and communicating with said brine containing reservoir (c) (1),

(3) water supply means communicating with said hopper for supplying water thereto in response to a decrease in the brine level in said brine containing reservoir (c) (1) to form additional brine therein, and

(4) a filter positioned between said hopper and said brine containing reservoir for preventing the passage of salt particles into said brine containing reservoir (c) (1),

(d) water supply means connected to said mixing reservoir for delivering metered amounts of water into said reservoir to combine with the brine therein,

(e) a conductivity cell positioned adjacent said outlet in said mixing reservoir for measuring variances in the electrical conductivity from a predetermined

value of the brine-water mixture passing through said outlet, and

(f) control means operatively associated with said brine producing and delivering means (c) and operable in response to the measurement of variances by said conductivity cell for metering the brine into water contained in the mixing reservoir to produce additional physiological saline.

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