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a part interest

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[54] HEATING DEVICE FOR PARENTERAL FLUID

6 Claims, 9 Drawing Figs.

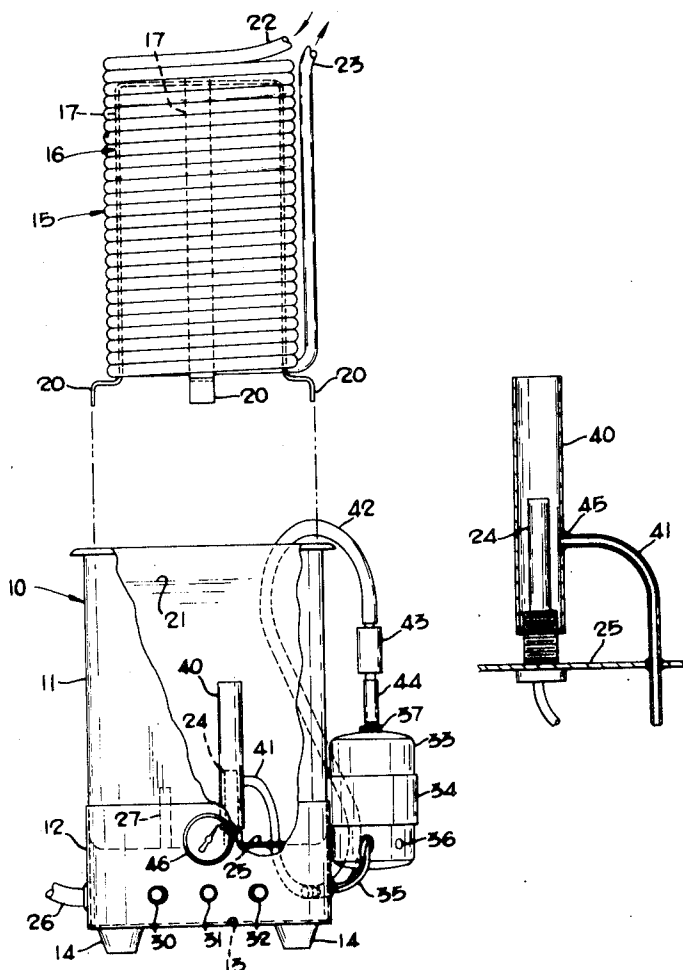
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ABSTRACT: A heating device for parenteral fluid includes a container holding a quantity of heat transfer liquid to which heat is imparted by a thermostatically controlled electric immersion heating element. A coil of flexible plastic tubing having adjacent coil turns fused together to form a disposable coil envelope for conveying the parenteral fluid from a reservoir to the patient is suspended within the heat transfer liquid by means of an independent, removable support frame which holds the coil envelope in an open cylindrical configuration to facilitate heat transfer from the liquid to the parenteral liquid flowing through the envelope. The frame includes extensions removably engageable with seating portions in the container. The circulation of the heat transfer liquid about the envelope is augmented by an aeration system.



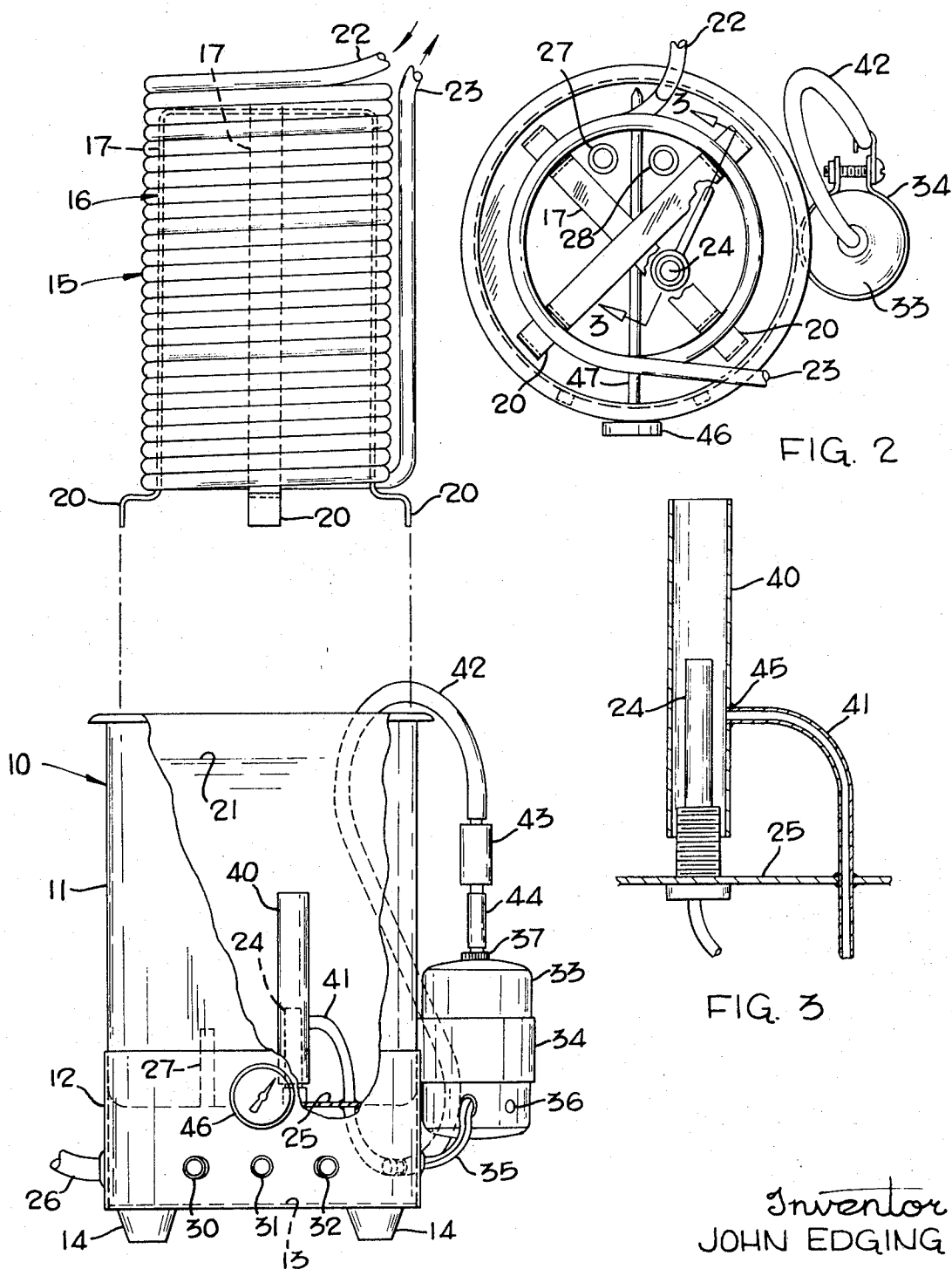


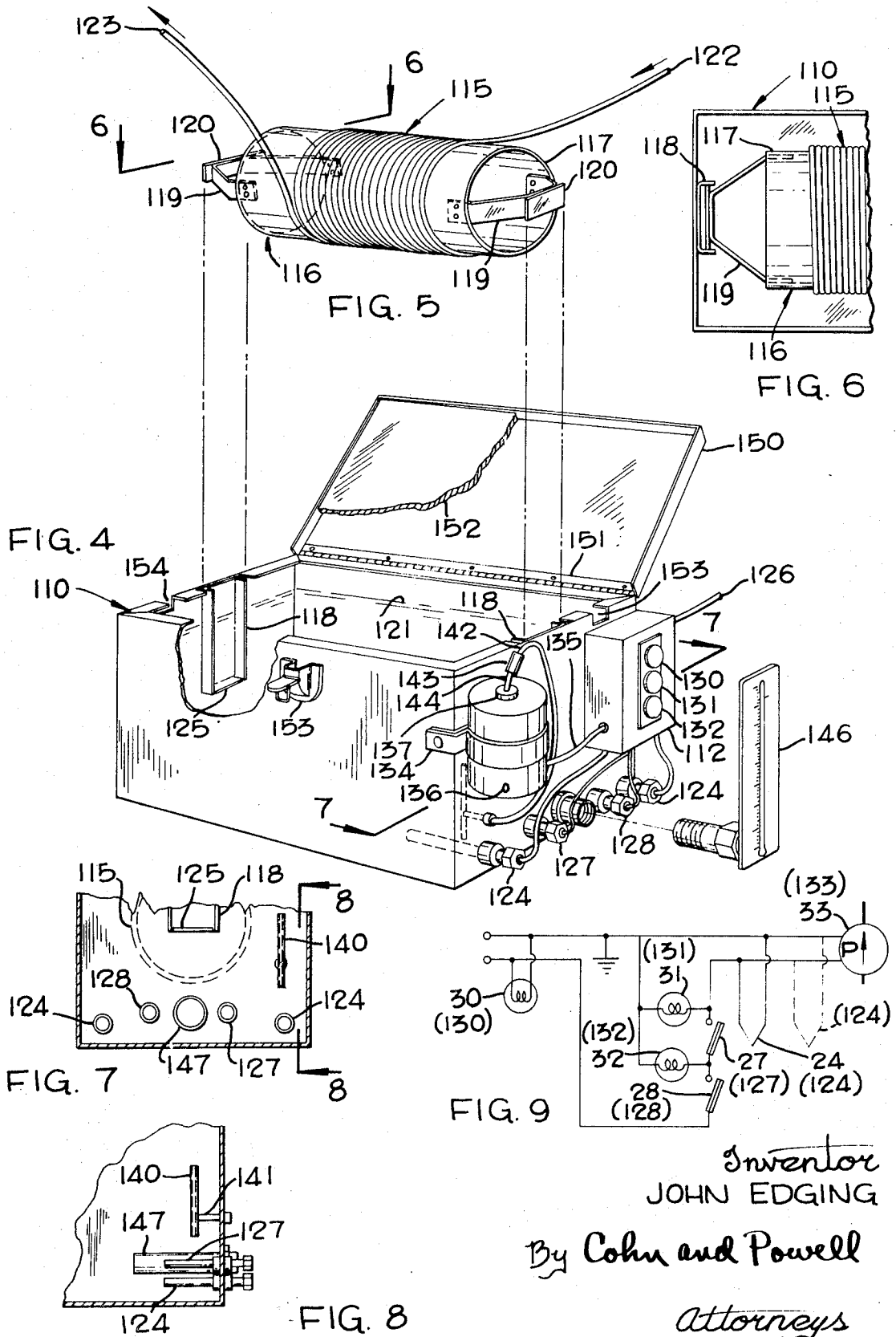
FIG. 1

FIG. 2

FIG. 3

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HEATING DEVICE FOR PARENTERAL FLUID

BACKGROUND OF THE INVENTION

This invention relates to a heating device for fluids, and particularly to a device for maintaining parenteral fluids such as blood at a selected temperature.

Blood transfusions are a common occurrence when severe blood loss is suffered in accidents and when patients hemorrhage during surgical operations. In such situations, large quantities of blood are required and the blood is usually taken from a blood bank where it is stored at a temperature of about 40° F., which is only 8° above freezing and almost 60° below normal body temperature. It is necessary to store the blood in cool conditions to prevent deterioration and often, in emergencies where there is an immediate requirement, it is not possible to delay a transfusion until the temperature can be raised even as high as room temperature. Thus, the blood must be transfused at a relatively low temperature to patients who may be in shock. At the very least, this can cause extreme discomfort and in some cases, may cause cardiac malfunction.

Heating devices are known in the art but they are not used extensively. The reason for this is either the inefficiency or expense of such items because a need for an effective blood-warming device has certainly been established.

A factor directly related to the efficiency of blood-warming devices is the necessity for maintaining high sanitary and sterilization requirements. To this end, one of the known devices in the art incorporates a steam sterilization feature for use in sterilizing the line from the source to the patient, a portion of said line being a permanent part of the device.

Another device incorporates a heating unit within a solid metallic block, which indirectly provides a source of heat for warming liquid through which a bloodline is passed. Obviously, such a structure tends to be expensive.

SUMMARY OF THE INVENTION

This blood-warming device utilizes a disposable blood-warming coil and sterilization problems are thereby minimized. The coil is not attached directly to the device and may be removed and replaced quickly and simply. The heat transfer medium is liquid and is in direct contact with a heating conductor. The liquid is thoroughly circulated around the coil to ensure that an even temperature is maintained.

The heating device includes a liquid container having a coil of tubing forming an envelope which is removably mounted within the container and operatively immersible in the liquid.

The liquid within the container is heated by means of an electrical immersion heater in the form of a conductor projecting interiorly of the container and into the liquid. Thermostatic switching means connected to the heating element regulates the heat emission from the conductor in response to the temperature of the liquid. Air is supplied to the liquid below the surface to facilitate circulation thereof and the means by which aeration is provided includes an air pump, mounted exteriorly of the container, an upright, open-ended pipe, mounted interiorly of the container and passage means interconnecting the air pump and pipe. The open-ended pipe provides a housing for the heating element projecting interiorly of the container.

Adjacent coil turns of the coil of tubing are fused to form the disposable coil envelope and an independent support frame, removably mounted in the container, receives the coil envelope in separable relation. The support frame may be withdrawn from the container to facilitate disposal and replacement of the coil envelope and said frame includes extension means projecting outwardly of the coil. The container includes seating means adapted to engage the extension means whereby to hold the coil suspended in the liquid. The support frame provides a drum which holds the coil in an open substantially cylindrical position to facilitate heat transfer from the liquid to the parenteral fluid flowing through the coil.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary, elevational view of the container with the coil withdrawn;

FIG. 2 is a plan view of the container with the coil in position;

FIG. 3 is an enlarged cross-sectional detail taken on line 3-3 of FIG. 2;

FIG. 4 is a perspective view of a second embodiment with the coil withdrawn;

FIG. 5 is a perspective view of the withdrawn coil and support frame;

FIG. 6 is a fragmentary view taken on line 6-6 of FIG. 5;

FIG. 7 is a fragmentary view taken on line 7-7 of FIG. 4;

FIG. 8 is a fragmentary view taken on line 8-8 of FIG. 7, and

FIG. 9 is a schematic view representing the circuitry.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now by characters of reference to the drawings, and first to FIGS. 1 through 3 and FIG. 9, it will be understood that the container 10 of the first embodiment is provided by a substantially cylindrical, stainless steel canister 11 having a subjacent hollow control compartment formed from a cylindrical sheath 12, said sheath and canister 11 being welded or otherwise attached together. A removal access plate 13 provides entry into the control compartment and the access plate 13 includes a plurality of feet 14 on which the container 10 stands.

A coil of flexible plastic material is provided including adjacent turns fused together to form a cylindrical envelope 15 which may be slipped over an independent support frame 16. The support frame 16 includes a pair of substantially U-shaped elements 17 forming a drum which receives the coil envelope 15 in separable relation. At its lower end, each leg of the U-shaped element 17 is bent outwardly and downwardly to form a foot 20. The feet 20 have a circumscribing diameter somewhat less than the internal diameter of the cylindrical canister 11 and the support frame 16 may thereby be conveniently slipped into and supported by the canister 11. This structural arrangement of the frame 16 effectively suspends the coil 15 clear of the interior of the canister 11 in the heat transfer liquid 21. The suspension of the coil 15 avoids heat which would otherwise result if the coil 15 were in direct contact with the canister. This spaced arrangement also permits the grasping of the support frame 16 for ease of withdrawal. The relative depth of the liquid 21 and the chosen height of the coil 15 are such that the coil 15 is substantially immersed when the frame 16 is operatively in position within the canister 11. Although the coil envelope 15 is formed from a plurality of fused turns of a flexible, tubular plastic material, it will be understood that the fusion of adjacent turns is such that by holding the coil 15, the tubular material of which it is composed may be unwound by applying a sufficiently strong pull to the free end of said coil 15. The fusion does not penetrate sufficiently deeply to prevent such an unwinding of the individual coils.

The space between the exterior face of the coil envelope 15 and the interior of the canister 11 is such that the heat transfer medium 21, when circulated, passes freely over substantially the whole of the exterior face and through the interior of the coil 15. Preferably, the coil envelope 15 in its open position on the frame 16 is coaxially disposed within the container 10. Cool blood constituting a parenteral fluid, enters the coil envelope 15 at its upper end 22. The blood passes through some 25 feet of coil before leaving the proximity of the heat transfer liquid 21 and achieves the substantially same temperature as the liquid 21. Thus, if the considerably greater mass of heat transfer liquid 21 is maintained at a constant temperature, the relatively small mass of blood in the coil at any one time will be brought to the same temperature by the time the tube emerges from the heat transfer medium at the other end of the coil indicated by the numeral 23.

The manner of maintaining the heat transfer medium at a substantially constant temperature will now be described. The heat transfer liquid 21 in the container 10, may, if the time by which transfusion is to be effected is exceedingly short, be brought to approximate body temperature by a portable immersion heating rod, not shown. If more time is available, the heating device itself will provide sufficient power to warm the heat transfer liquid 21 to body temperature within a few minutes. Basically, the heat transfer system includes an electrical immersible heating element 24 attached to the bottom wall 25 of the cylindrical canister 11. The heating element 24 is supplied with electric power from a cable 26 which enters the control compartment of the container 10.

A pair of thermostats 27 and 28 is connected to the heating element 24 to regulate the heat emission therefrom in response to the desired temperature of the heat transfer liquid 21 to which the thermostats 27 and 28 are preset. In the preferred embodiment, two such thermostatic elements 27 and 28 are provided as a safety precaution in the event of malfunction of one of the elements 27 and 28 by sticking or otherwise. The malfunction simultaneously of two such elements is so improbable as to eliminate any likelihood of the heat transfer liquid reaching a dangerously high temperature. As a further precaution, each thermostat 27 and 28 is connected to a pilot light 31 or 32 respectively. If a thermostat is malfunctioning and open, at least one pilot light will be unlit. A master pilot 30 indicates that power is being supplied to the heat transfer system.

In order to ensure that a maximum uniformity of temperature is achieved throughout the heat transfer liquid 21, an aeration device is provided to supply air below the surface of the liquid 21 and thereby facilitate the circulation of said liquid. The aerating means includes an air pump 33 mounted to the exterior of the container 10 by means of a strap 34 welded or otherwise attached to the exterior sidewall of the container 10. The pump 33 is preferably electrically operated and supplied by power from a cable 35. Air drawn in through an inlet port 36 at the lower end of the pump 33 is exhausted at the upper end through an adjustable exhaust port 37. Mounted interiorly of the container 10 is an open-ended pipe 40. The lower end of the pipe 40 is held in spaced relation from the bottom wall 25 of the canister 11 by means of a rigid metal pipe 41 which is welded or otherwise attached to said bottom wall 25. A length of flexible tubing 42 is attached at one end to the rigid pipe 41 and at the other end to a spring-loaded one-way check valve 43 which is connected to the adjustable exhaust outlet 37 by means of a short length of pipe 44. The rigid pipe 41, the flexible pipe 42, the check valve 43 and the length of the pipe 44 constitute a passage means interconnecting the air pump to the open-ended pipe.

In the embodiment presently under discussion, the open-ended pipe 40 is coaxially disposed over the heating element conductor 24. In this way, heat emitted from the conductor 24 is circulated with a maximum of efficiency, the open-ended pipe 40 providing a housing directing the circulating stream of the heat transfer medium. It will be observed from FIG. 3 that the rigid pipe 41 communicates with the open-ended pipe 40 at a location 45 disposed between the open end of said pipe 40. Because of this arrangement, air bubbles rising upwardly from 45 tend to draw circulating water upwardly over the conductor 24 with minimum heat energy waste.

A thermometer 46 having a sensor 47 projecting interiorly of the canister 11 provides a visual indication of the preselected temperature. It will be understood that this temperature may be slightly above body temperature in order to compensate for heat loss in the parenteral fluid as it passes from the canister to the patient.

The second embodiment, illustrated in FIGS. 4 through 8, is sufficiently similar to the first embodiment with respect to the individual parts so that the prefix numeral 1, together with the numeral denoting the corresponding part of the first embodiment has been used to indicate parts of the second embodiment where convenient. Thus, the container denoted by numeral 10 in FIG. 1 is denoted by numeral 110 in FIG. 4.

In the second embodiment, the container 110 is substantially rectangular and includes a lid 150 hingedly attached thereto by means of a piano hinge 151, the lid being provided with insulating material 152. A fastener 153 enables the lid to be secured during operation and apertures 153 and 154 accommodate the respective ends 122 and 123 of the coil envelope 115.

In the second embodiment, the coil envelope 115 is received in slidable relation over a cylindrical tubular member 117 which forms part of a drumlike frame 116 constituting an independent support frame. The support frame 116 includes at its ends, opposed, substantially U-shaped struts 119 each having a transverse lug member 120 attached to the bight portion thereof. The overall length of the support frame 116 is somewhat less than the interior longitudinal dimension of the container 110 and the container 110 is provided at each end with a channel member 118 providing a track structure. Each of the members 118 receives an associated lug 120 in slidable relation and at the lower end of each of said members 118 is a seating member 125 which engages the lug 120 and provides a stop preventing further downward movement of the frame 116 within the container 110. The structural frame 116 may conveniently be grasped by an operator and lowered into place within the interior of the container 110 and the coil envelope 115 is thereby effectively suspended in the interior of the container 110 clear of the sides and bottom of the container 110. Because of the hollow nature of the drumlike support frame 116, the heat transfer liquid 121 may circulate interiorly of the coil 115 as well as exteriorly over the outer surface of said coil. The cylindrical element 117 is made from a material of high heat conductivity such as metal and in consequence, heat transfer is rapidly and effectively accomplished, both interiorly and exteriorly of the coil 115. As shown in FIGS. 7 and 8, a pair of heating elements 124 extend interiorly of the container 110. Power is supplied to these heating elements 124 by way of a junction box constituting a control compartment 112 which is supplied by power from the cable 126. Thermostats 127 and 128 are connected to the heating element conductors 124 as indicated in FIG. 9 and pilot lights 131 and 132 serve to indicate when the thermostats are switched to the closed position. Each pilot light is lit only when its associated thermostat is in the closed position supplying energy to the conductors 124.

Visual indication of the temperature of the heat transfer medium 124 is provided by a thermometer 146. The thermometer 146 is in contact with the heat transfer liquid 121 by means of a sensing stem 147 projecting interiorly of the container 110.

Air is supplied to the heat transfer liquid 121 by means of an air pump 133 which is connected to an open-ended pipe 140. The pipe 140 is suspended interiorly of the container 110 by means of a rigid pipe arm 141 which is attached as by welding to the sidewall of the container 110. The rigid pipe 141 communicates with the interior of the open-ended pipe 140 between the ends of said pipe. It will be observed from FIG. 7 that the pipe 140 is disposed in spaced relation above one of the heating elements 124. This arrangement facilitates the circulation of a stream of liquid proximate to and warmed by the heating element 124 below the pipe 140. Air drawn into the pump by way of inlet aperture 136 at the lower end of the pump 133 leaves the pump 133 by way of the adjustable outlet 137 and the rigid pipe 141, the flexible pipe 142, the check valve 143 and the flexible pipe 144 provide a passage means interconnecting the air pump 133 to the open-ended pipe 140. It will be understood that in the circuitry shown in FIG. 9, the second embodiment is indicated by the numerals in parentheses.

It is thought that the functional advantages of these warming devices have become fully apparent from the foregoing description of parts but for completeness of disclosure, the operation of these devices will be briefly described.

Each of the two devices includes a support frame 16 (116) capable of receiving a fused coil of tubing 15 (115) in separable relation. In each case, the support frame 16 (116) can be

easily lifted clear of its container 10 (110) and the coil 15 (115) removed and replaced with utmost simplicity. Further, in each case, the support frame 16 (116) has a structure which permits the coil 15 (115) to be effectively suspended in the heat transfer liquid 21 (121), clear of the container sidewalls and bottom wall, thereby to achieve maximum exposure to the heat transfer effect of the liquid and the frame 16 (116) holds the coil envelope 15 (115) open in its most advantageous, cylindrical configuration for this purpose. In the first embodiment, the support frame 16 includes four outstanding and downwardly depending feet 20 which extend radially from the axis of the coil 15, a distance greater than the radius of the coil 15 and seat on the bottom plate 25 of the canister 11, so as to space the coil effectively from the interior face of the canister 11. It will be understood that the nature of the right-angularly related U-shaped elements 17 provides a very simple and effective means of removing said frame 16 and its coil 15 digitally by simply pulling upwardly on the bights of the U-shaped elements 17.

In the case of the second embodiment, the outstanding, U-shaped strut members 119 and the lugs 120 at the end thereof, ride in the track provided by the channel members 118 and seat on the seating members 125 so that the coil 115 is likewise suspended in the heat transfer liquid. As shown in FIG. 6, the diameter of the coil is substantially less than the width of the container 110, thereby permitting the support frame 116 and its associated coil 115 to be digitally placed by the simple expedient of grasping the coil and lowering it into seated relation with the container 110. The seating member 125 is located a sufficient distance above the bottom of the container 110 to ensure that the coil 115 is spaced from the bottom of the container.

By setting the thermostat to close at body temperature, or slightly above body temperature to compensate for the slight heat loss between the container and the patient, the heat transfer liquid imparts sufficient heat to the parenteral fluid passing through the coil to ensure that when this liquid enters the body of the patient, it will be at substantially the same temperature as his body temperature, thereby avoiding shock and discomfort. The aerating of the transfer liquid stimulates the circulation considerably and augments the natural tendency of the warm liquid to rise as heat energy is emitted from the heater elements which are disposed relatively close to the bottom of each container. In the first embodiment, the direction of the heat stream is upwardly through the interior of the coil and outwardly and downwardly over and about the exterior face of the coil.

In the second embodiment, parenteral fluid enters the coil at 122 and exits at 123. The heating elements are located at the same end of the container as the cool parenteral fluid is admitted and the heat stream is passed through and about the coil 115, thereby promoting the efficiency of the heat transfer.

The circuitry for both embodiments is illustrated in FIG. 9 and, to conform with the embodiments as described, one heating element 124 is shown in dotted outline. However, it will be understood that neither embodiment is limited to one heating element.

I claim as my invention:

1. A heating device for parenteral fluid and the like comprising:

- a. a container adapted to hold a quantity of liquid,
- b. an independent coil of tubing removably mounted within the container, the coil being adapted to be at least partially immersible in the liquid and spaced from the container to permit substantially free flow of the liquid over the exterior face of the coil, the coil providing a conduit adapted to convey the parenteral fluid through the liquid in heat transfer relation thereto,
- c. an electrical immersion heating element mounted to the container and disposed therewithin, said element being adapted to heat the liquid,
- d. thermostatic switching means adapted to be in contact with the liquid, the switching means being connected to

the heating element and regulating the heat emission therefrom in response to the temperature of the liquid, and

e. aerating means mounted to the container and adapted to supply air below the surface of the liquid whereby to facilitate the circulation thereof,

f. the aerating means including:

1. an air pump mounted exteriorly of the container,
2. a substantially upright, open-ended pipe mounted interiorly of the container and including an upper, air bubble escape orifice and a lower liquid intake orifice, and
3. air passage means interconnecting the air pump to the open-ended pipe intermediate the intake and escape orifices, and

g. the heating element including a heating portion disposed below the escape orifice and in the immediate vicinity of the intake orifice whereby heated liquid is drawn upwardly through the pipe.

2. A device as defined in claim 1, in which:

h. the open-ended pipe provides a housing for the heating element.

3. A heating device for parenteral fluid and the like comprising:

- a. a container adapted to hold a quantity of liquid,
- b. an independent coil of tubing removably mounted within the container, the coil being adapted to be at least partially immersible in the liquid and spaced from the container to permit substantially free flow of the liquid over the exterior face of the coil, the coil providing a conduit adapted to convey the parenteral fluid through the liquid in heat transfer relation thereto,
- c. an electrical immersion heating element mounted to the container and disposed therewithin, said element being adapted to heat the liquid,
- d. thermostatic switching means adapted to be in contact with the liquid, the switching means being connected to the heating element and regulating the heat emission therefrom in response to the temperature of the liquid,
- e. adjacent coil turns being fused to form a disposable coil envelope,
- f. an independent, unattached and substantially rigid support frame removably mounted in the container and receiving the coil envelope thereabout in slidably separable relation, whereby the support frame may be withdrawn from the container to facilitate disposal and replacement of the coil envelope,
- g. the support frame including extension means projecting outwardly of the coil, and
- h. the container including an upper margin defining an open end and seating means adapted to engage the extension means below the upper margin whereby to hold the coil in suspended relation in the liquid the open end affording access to the coil within the container.

4. A heating device for parenteral fluid and the like comprising:

- a. a container adapted to hold a quantity of liquid,
- b. an independent coil of tubing removably mounted within the container, the coil being adapted to be at least partially immersible in the liquid and spaced from the container to permit substantially free flow of the liquid over the exterior face of the coil, the coil providing a conduit adapted to convey the parenteral fluid through the liquid in heat transfer relation thereto,
- c. an electrical immersion heating element mounted to the container and disposed therewithin, said element being adapted to heat the liquid,
- d. thermostatic switching means adapted to be in contact with the liquid, the switching means being connected to the heating element and regulating the heat emission therefrom in response to the temperature of the liquid,
- e. the container including a substantially cylindrical sidewall defining an opening means at the upper end and a bottom wall,

- f. the coil being of flexible plastic material and including entrance and exit portions received by the opening means and adjacent coil turns being fused to form a disposable coil envelope coaxial with the container; and
- g. a support frame providing a substantially rigid drum having opposed ends one of which is carried by the container and the other of which is substantially free of transverse projections to permit the disposable coil to be slidably withdrawn directly from the drum.
- 5. A heating device for parenteral fluid and the like comprising:
 - a. a container adapted to hold a quantity of liquid,
 - b. an independent coil of tubing removably mounted within the container, the coil being adapted to be at least partially immersible in the liquid and spaced from the container to permit substantially free flow of the liquid over the exterior face of the coil, the coil providing a conduit adapted to convey the parenteral fluid through the liquid in heat transfer relation thereto,
 - c. an electrical immersion heating element mounted to the container and disposed therewithin, said element being adapted to heat the liquid,
 - d. thermostatic switching means adapted to be in contact with the liquid, the switching means being connected to the heating element and regulating the heat emission therefrom in response to the temperature of the liquid,
 - e. the container including a substantially cylindrical sidewall defining an opening means at the upper end and a bottom wall,
 - f. the coil including entrance and exit portions received by the opening means and adjacent coil turns being fused to form a disposable coil envelope coaxial with the container,
 - g. an independent support frame removably mounted in the container and providing a substantially rigid drum receiving the coil envelope in separable relation, the support frame being adapted to hold the coil in suspended relation in the liquid,
 - h. aerating means mounted to the container and adapted to supply air below the surface of the liquid whereby to facilitate circulation thereof, the aerating means including:
 - 1. an air pump mounted exteriorly of the container,

- 2. a substantially upright, open-ended pipe mounted interiorly of the container, the lower end being spaced from the bottom wall, and
- 3. passage means interconnecting the air pump to the open-ended pipe between the ends of said pipe, and
- i. the heating element being disposed adjacently of the lower end of the open-ended pipe whereby heated liquid is drawn upwardly through said pipe.
- 6. A heating device for parenteral fluid and the like comprising:
 - a. a container adapted to hold a quantity of liquid,
 - b. an independent coil of tubing removably mounted within the container, the coil being adapted to be at least partially immersible in the liquid and spaced from the container to permit substantially free flow of the liquid over the exterior face of the coil, the coil providing a conduit adapted to convey the parenteral fluid through the liquid in heat transfer relation thereto,
 - c. an electrical immersion heating element mounted to the container and disposed therewithin, said element being adapted to heat the liquid,
 - d. thermostatic switching means adapted to be in contact with the liquid, the switching means being connected to the heating element and regulating the heat emission therefrom in response to the temperature of the liquid,
 - e. aerating means mounted to the container and adapted to supply air below the surface of the liquid whereby to facilitate the circulation thereof,
 - f. the aerating means including:
 - 1. an air pump mounted exteriorly of the container,
 - 2. a substantially upright, open-ended pipe mounted interiorly of the container and including an upper, air bubble escape orifice, and a lower liquid intake orifice, and
 - 3. air passage means extending substantially between the air pump and the open-ended pipe and delivering air into the open-ended pipe below the escape orifice to facilitate the flow of liquid through the pipe from the intake orifice to the escape orifice, and
 - g. the heating element including a heating portion disposed below the escape orifice and in the immediate vicinity of the intake orifice whereby heated liquid is drawn upwardly through the pipe.

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