

April 4, 1961

W. G. DALLAS, JR
THERMAL BLANKET

2,978,225

Filed Jan. 9, 1957

3 Sheets-Sheet 1

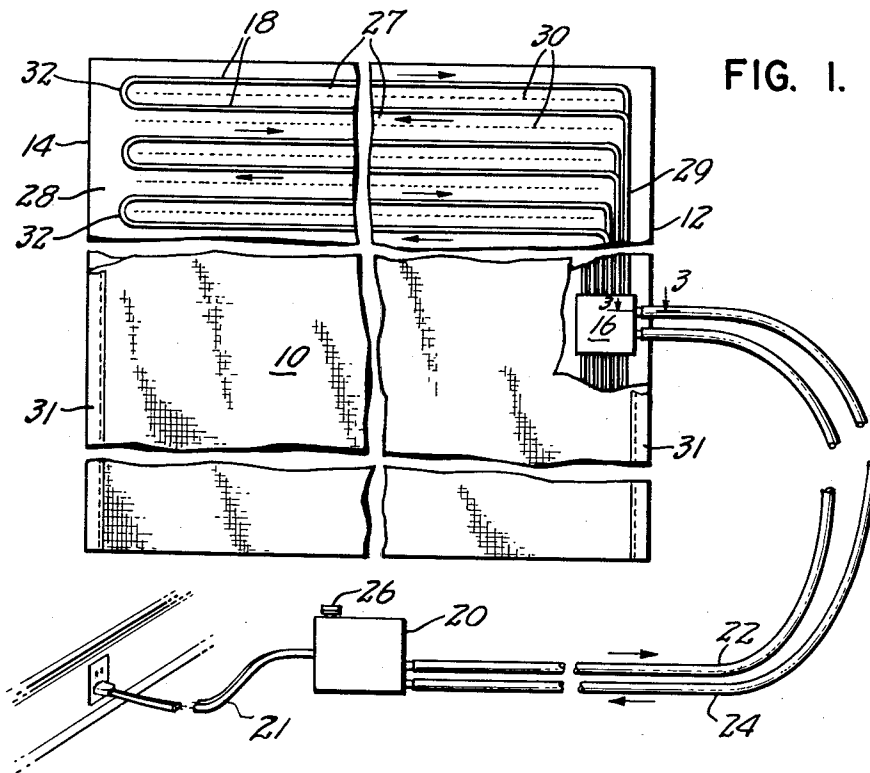
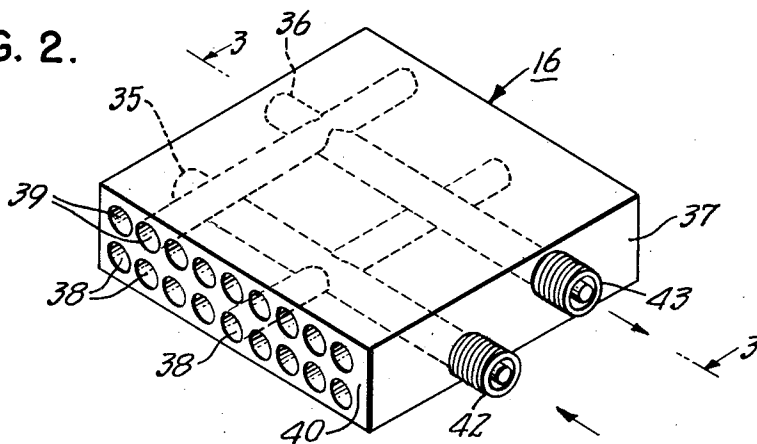


FIG. 2.



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FIG. 6.

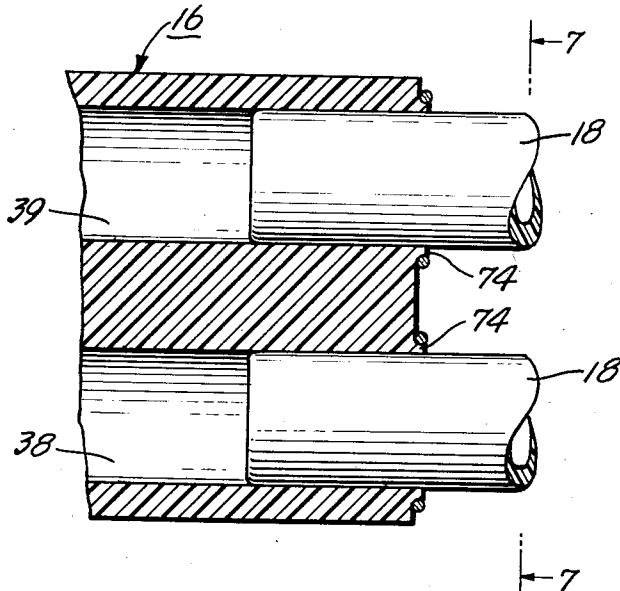
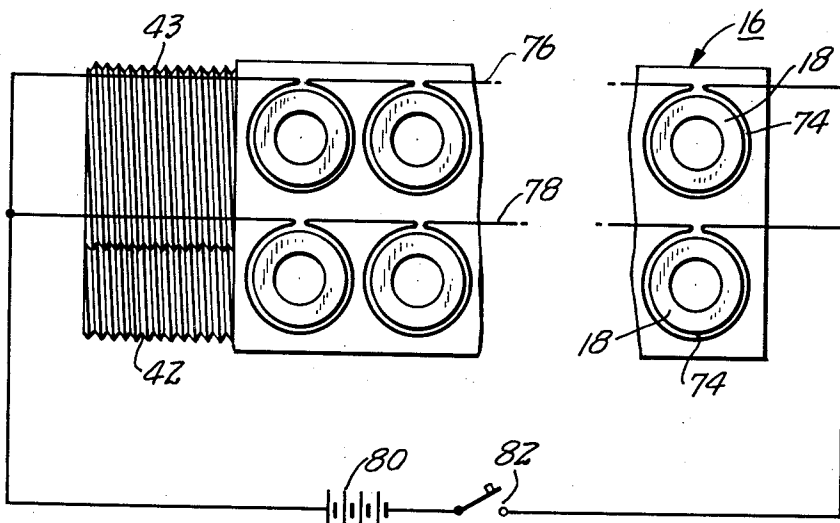


FIG. 7.



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3 Claims. (Cl. 257—12)

The present invention relates to improved thermal blankets and their construction, and more particularly to improved thermal blankets having liquid-conducting heat transfer means included therein and to a compact manifold for assembling the heat transfer means. In this improved thermal blanket a heat transfer liquid is conducted through the heat transfer means for controlling the temperature of the blanket as desired by the user. This improved blanket is adapted for easy connection to and disconnection from external liquid supply and return lines and advantageously includes self-actuating shut off valves to prevent any loss of fluid from the blanket or lines when disconnected from each other.

The improved thermal blanket of the present invention is described as being utilized with a circulating liquid which is warmed so as to keep the user comfortable in cold weather and has many advantages for this purpose. However, as will be understood from the specification, this improved thermal blanket also has many advantages when used with a circulating liquid which is cooled so as to withdraw excess heat from the user's body.

In recent years considerable effort has been made to develop thermal blankets of the type utilizing a circulating heat transfer liquid. This type of circulating liquid blanket has very many advantages over the electric-type blankets utilizing a grid of insulated resistance wires enclosed in the fabric, as will be appreciated from the specification.

In the improved thermal blanket described herein as an illustrative embodiment of the present invention, a relatively large number of small diameter flexible, tubular passageways are provided throughout the blanket for conducting a suitable heat exchange liquid. As described, these tubular passageways are formed by a number of flexible plastic tubes of small diameter. These tubes are arranged with portions of the various tubes substantially parallel to one another forming a heat-transfer grid throughout the blanket. These tubes are connected in a liquid-conducting circuit in parallel relationship with one another between an inlet header passageway arranged to supply a suitable heat transfer liquid to the blanket and an outlet header passageway arranged to return the liquid to suitable circulator and control means.

Among the many advantages of the improved thermal blanket of the present invention are those resulting from the fact that the inlet and outlet header passageways are formed in a desirably small and compactly arranged distribution manifold unit included in the blanket at a convenient and accessible position. Pairs of branch passageways within the manifold unit communicate with the inlet and outlet header passageways respectively. The opposite ends of various flexible heat exchange tubes are connected to successive pairs of these branch passageways.

Improved methods of assembling this thermal blanket including the compact manifold are described herein. The ends of all the tubes are simultaneously secured to the manifold unit by means of heat sealing. In one method described induction heating is used. Small loops

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of electrically conductive material around each of the tubes near the ends act as stops to aid in properly positioning the ends of the tubes as they are inserted in the branch passages of the manifold unit. Advantageously, these conductive loops are utilized for the induction heating process to produce the desired strong fused connection between the ends of each tube and the manifold unit. In another method utilizing conduction heating, small loops of wire are wrapped around each of the tubes adjacent to the manifold unit and current is conducted through the wire for heat sealing.

Thermal blankets of the heat transfer liquid circulating type have been proposed including a pair of large diameter header tubes extending parallel to one another along one edge of the blanket. In the prior blanket a plurality of small diameter tubes are connected between these header tubes. These small diameter tubes extend across this blanket and have U-shaped bends near the opposite edge of the blanket from the header tubes. In this prior arrangement all of the U-shaped tubes are connected in parallel between the headers and are supplied thereby.

This prior thermal blanket is described and claimed in a copending application Serial No. 309,416 filed September 13, 1952, and assigned to the same owner as the present application. This prior thermal blanket has many advantages over the electric blankets known theretofore. The present invention is in the nature of a further improvement over the thermal blankets described in this prior application.

Among the advantages of the improved assembly utilizing the compact manifold of the present invention is the elimination of the expense and time consumed in completing the numerous connections between the opposite ends of the U-shaped tubes and spaced points along the two header tubes in the prior blanket.

In one of the thermal blankets described and claimed in this prior application, the opposite ends of all of the small diameter heat exchange tubes are brought back to a pair of short header tubes. The improved thermal blanket of the present invention has certain features similar thereto and is in the nature of a further improvement thereover.

Among the many advantages of the present invention are those resulting from the fact that the small diameter flexible heat exchange tubes are all distributed from a common manifold unit at a convenient and accessible position in the blanket. This improved blanket has the advantage that it can be rolled up into a tight bundle in any direction. No tendency to "kink off" the flow of the heat transfer liquid through any of the tubes occurs. The common distribution manifold unit advantageously is small in size, occupying only about one and one-half square inches of the blanket area at a midpoint along one edge of the blanket. When the blanket is in use, this edge may conveniently be positioned at the foot of the bed.

The heat transfer tubes are flexible and of small diameter. They are substantially no larger than the insulated resistance wires commonly used in electric blankets. They are much more flexible and, of course, are far safer than resistance wires. In addition, these flexible tubes in the present blanket are much lighter than resistance wires. Thus, the improved thermal blanket described herein has a much more natural feeling in use than any of the prior blankets.

In smoothing, bending, or folding the blanket, the flexible heat exchange tubes readily conform with the flexure of the fabric panel. The blanket advantageously drapes and smooths out in the same manner as an ordinary blanket.

Even when the tubes and manifold in the blanket are

all filled with the heat-transfer liquid and in condition for use, it is found that the improved blanket of the present invention is considerably lighter and much more flexible than an electric blanket having a similar fabric and having a corresponding heat capacity or rating.

A further advantage of the improved thermal blanket described herein is its ease of connection to and disconnection from the external liquid supply and return lines. In use these lines are conveniently coupled to the manifold unit and extend to a circulator and control. Self-actuating shut off valves advantageously are provided in the manifold unit and at the ends of the supply and return lines to prevent any loss of fluid when the blanket and lines are uncoupled for storage or for cleaning of the blanket.

In this specification and in the accompanying drawings are described and shown an illustrative embodiment of the improved thermal blanket and method of assembly of the present invention and various modifications thereof are indicated, but it is to be understood that these are not intended to be exhaustive nor limiting of the invention, but on the contrary are given for purposes of illustration in order that others skilled in the art may fully understand the invention and the manner of its application in practical use and so that others may modify and adapt it in various forms, each as may be best suited to the conditions of a particular use.

The various objects, aspects, and advantages of the present invention will be more fully understood from a consideration of the following specification in conjunction with the accompanying drawings, in which:

Figure 1 is a plan view of the improved thermal blanket of the present invention with certain portions of the blanket fabric being illustrated as broken away so as better to illustrate the heat transfer passageways and liquid flow distribution manifold unit coupled in circuit with a suitable circulator and control adapted to be positioned anywhere convenient to the user;

Figure 2 is a perspective view of the distribution manifold unit in Figure 1, illustrated on enlarged scale and showing the internal arrangement of the various interconnecting passageways and showing the coupling means for the supply and return lines;

Figure 3 is a partial sectional view taken along the line 3—3 in Figures 1 and 2 and showing, on enlarged scale, an edge of the block near the coupling means and showing the self-actuated cut-off valves in the couplings and at the ends of the supply tubes;

Figure 4 is an enlarged sectional view of a portion of Figure 3 showing one of the respective self-actuated valves in closed position upon disconnection of the lines;

Figure 5 is a partial sectional view taken along the line 5—5 of Figure 3 illustrating an improved method of assembling the manifold unit and the heat transfer tubes;

Figure 6 is a partial perspective view corresponding with Figure 5 and illustrating another method of sealing the heat transfer tubes to the manifold unit; and

Figure 7 is a partial sectional view taken along the line 7—7 in Figure 6, looking to the left.

As illustrated in Figure 1 the improved thermal blanket, generally indicated at 10, includes a plurality of fluid passageways disposed in spaced parallel relationship and extending from a first edge of the blanket 12 across the blanket toward the opposite edge 14. When the blanket is tucked in place on a bed, the edge 12 is usually arranged at the foot of the bed. This edge 12 includes a liquid distribution manifold unit 16 positioned at a convenient and accessible place. This manifold unit is shown as being positioned at the midpoint at the foot of the blanket. There are a number of advantages in this relationship as will be appreciated from the detailed description hereinafter.

The fluid passageways throughout the blanket are formed by a plurality of small diameter flexible plastic

tubes 18 connected in a liquid conducting circuit in parallel relationship with one another by means of the distribution manifold unit 16.

A suitable heat transfer liquid which may be heated or cooled depending upon the desired use of the blanket is circulated through these tubes 18. The arrangement of the heat exchange passageways 18 with the return trip flow in each tube parallel to and near the incoming flow is such that the blanket desirably provides a substantially uniform temperature throughout its extent. This uniform temperature is obtained regardless of changes occurring in the temperature of the circulating liquid resulting from its heat transfer function as it flows through the heat exchange tubes in the blanket.

Suitable circulating and control means 20 are provided automatically to control the temperature of the blanket as a desired joint function of (1) the ambient temperature in the room and (2) the heat dissipation actually occurring within the blanket as measured by the temperature of the liquid returning from the blanket to the control means 20. The control means 20 may desirably have the features of the improved circulator and control disclosed and claimed in the application being filed simultaneously herewith. This improved circulator and control includes a motor and circulating pump for circulating the liquid through the blanket together with a heating mechanism and an automatic and manually adjustable control therefor. As shown, it is energized by a wire 21 which is plugged into a standard 115 volt outlet, illustrated as a base board receptacle.

A pair of flexible liquid supply and return lines 22 and 24 couple the circulator and control 20 with the distribution manifold 16. These lines 22 and 24 are of plastic material. They are flexible and of suitable length to enable the user to place the control unit 20 on the floor or a stand within convenient reach near the head of the bed. A control knob 26 on the top of the unit 20 enables the user to adjust the temperature response control characteristics to provide the desired uniform temperature throughout the blanket 10.

The improved thermal blanket 10 includes fabric-like material of a pleasing and comfortable quality. The fabric material which is used should be generally similar in appearance and texture of that commonly employed in ordinary blankets, and desirably should be washable. It is an advantage of the present invention that the improved heat transfer mechanism of the thermal blanket 10 is readily washable without requiring any precautions to prevent damage or weakening. Unlike electric-type blankets, no hazard is associated with the use of this improved blanket following repeated washings.

In order to support the small diameter flexible heat transfer tubes 18 properly spaced in a grid pattern within the thermal blanket 10, the fabric material provides a plurality of elongated pockets 27 extending along the length of the blanket and opening at their upper ends into a transverse pocket 28 near the edge 14. A similar transverse pocket 29 or channel extends along near the foot edge 12 and includes the manifold unit 16. These pockets may be formed in any suitable fashion. However, as illustrated herein these heat transfer tubes are quickly and easily assembled into pockets formed between a pair of fabric panels stitched together along parallel lines as shown at 30. An attractive binding 31 runs along the foot and top edges 12 and 14 as in an ordinary blanket.

This improved thermal blanket is shown as including eighteen flexible small diameter heat exchange tubes 18. Each tube has both of its ends connected into one of the side faces of the manifold block 16. The two portions of each tube run along within the transverse channel 29 and then curve and run through adjacent elongated pockets 27 to a U-shaped bend 32 lying within the transverse channel 28. In this way the temperature along the incoming and outgoing fluid paths are effectively

averaged to produce a uniform heat transfer capacity and temperature throughout the area of the blanket.

In assembling the heat transfer grid within the blanket, the tubes 18 are first bent into a U-shape forming two parallel adjacent legs. The two legs of the various tubes are then pulled through pairs of adjacent pockets 27 from the edge 14 toward the edge 12. The ends of the tubes are all collected at the manifold block 16 and all connections there are simultaneously made in accordance with the improved method described further below. Thus, each half of each tube is individually pocketed in the pockets 27. Moreover, the border of each pocket between the two legs of each tube, which is here shown as formed by the stitching 30, advantageously lies within the bights of the U-bends 32. The tubes are thus effectively prevented from shifting within the blanket during use or during washing.

Nine of the tubes 18 connect into each side face of the manifold block 16, forming a total of thirty-six heat transfer passageways extending substantially the full length of the blanket as here shown, very suitable for use on an ordinary single bed width.

To obtain the desired heat transfer capacity and the features of flexibility and lightness, it is found advantageous to use plastic tubes having an over all diameter (O.D.) less than $\frac{1}{8}$ of an inch and more than .075 of an inch. An O.D. value of about .100 of an inch is preferred. The bore of these tubes desirably lies in the range from .040 to .085 of an inch. Experiments have shown that plastic tubes having an O.D. of .100 of an inch, a bore of .076 of an inch and a wall thickness of .012 of an inch provide highly suitable flexibility, heat transfer capacity, and light weight. Polyvinyl chloride tubing moderately plasticized may be used.

As shown in Figure 2 the distribution manifold unit 16 is compactly formed from a solid rectangular plate or block which is thin and blends with the plane of the fabric. As illustrated the block has a height of only $\frac{5}{16}$ of an inch and is formed from relatively rigid plastic material. For example, unplasticized polyvinyl chloride has proven to be a highly satisfactory material. The manifold unit includes a pair of inlet and outlet header passageways 35 and 36, respectively, being formed within the body of the block as indicated by the dashed and dotted broken lines. These header passageways extend from the front face 37 back toward the rear face and terminate just short of the rear face. The passageway 35 forms the inlet header passageway and its axis is positioned below a horizontal plane passing through the center of the manifold unit. The passageway 36 forms the outlet header passageway and has its axis positioned in the upper half of the unit 16 above such a horizontal plane.

In order to provide a natural flexibility and stretchability in the blanket, the manifold unit is desirably arranged for compactness. It is found preferable to have this block 16 no more than $\frac{3}{8}$ of an inch thick and no more than $1\frac{1}{2}$ inches along each edge. In the present successful blanket as measured in a direction from the front face 37 parallel to the axes of the passageways 35 and 36, the block is $1\frac{7}{32}$ inches long. As shown this block is $1\frac{1}{4}$ inches wide, thus giving a total area of only 1.52 square inches. This small compact manifold advantageously blends into the blanket and enables the blanket to be rolled up or folded in any direction as desired without any difficulty and without any kinking off of the fluid flow to any portion of the blanket. A plurality of pairs of transverse branch inlet and outlet passageways 38 and 39, respectively, are included in the manifold unit 16 extending from a first side face 40 over to the other side face. As shown there are nine pairs 38 and 39 of these branch passages. Each of the outlet branch passages 39 lies directly over the corresponding inlet branch passage 38, and the axes of all of these branch passages are parallel to each other.

In order to connect all of the heat transfer tubes in circuit in parallel liquid-conducting relationship, each of the respective inlet and outlet branch passages intersects the inlet and outlet header passages 35 and 36, respectively. The axes of these respective branch passages lie farther from the plane passing through the center of the block than the axis of the respective header passageway communicating therewith (see also Figure 3).

This construction is found desirable as making the manifold unit compact. In effect, as indicated by the dotted lines in Figure 3, the inlet and outlet header passages 35 and 36 overlap as seen from either side face of the block. However, by virtue of the fact that the smaller diameter branch passages are offset farther from the central plane of the block they intersect only the desired header passage and pass by the other one without intersecting. This provides optimum utilization of the small volume of the block while effectively providing all of the desired thirty-six connections.

In a particularly successful blanket the branch passages are .096 of an inch in diameter so as snugly to embrace the ends of the tubes 18 which are .100 of an inch O.D. Their respective axes are positioned .081 of an inch from the respective top or bottom face of the block. They are spaced horizontally .130 of an inch from center to center.

The header passageways 35 and 36 are shown as having a bore $\frac{1}{8}$ of an inch in diameter, and they have their axes spaced from the respective top and bottom faces of the block a distance of $\frac{3}{32}$ of an inch each. Their axes are spaced apart horizontally a distance of $\frac{7}{16}$ of an inch.

In order to facilitate storage or washing of the blanket 10, a pair of coupling nipples 42 and 43 are provided for the inlet and outlet header passages 35 and 36, respectively, projecting from the front edge 37 of the manifold unit. These nipples are $\frac{3}{16}$ of an inch in diameter and are externally threaded to mate with coupling sleeves 44 carried on connector fittings 46 which are press fitted into the ends of the supply and return lines 22 and 24. Advantageously, these nipples are formed integral with the manifold block 16 by molding the plastic. The passages and nipples are all formed simultaneously during the molding process.

A further feature of this improved thermal blanket is its ability to be stretched as freely along either diagonal direction as an ordinary fabric layer. All of the heat exchange tubes are independent of one another except for their common connection to the manifold unit. Thus, they are enabled readily to accommodate sharp folds or rolls in the blanket in all directions and readily accommodate stretching of the blanket in diagonal directions and readily accommodate any combination of folding, rolling, or stretching, just as an ordinary blanket does.

These natural flexural characteristics of this improved thermal blanket are tremendously important as giving the user complete confidence in the use of the blanket and in its safety. The user is enabled to sleep under the blanket entirely relaxed in full confidence and can roll over freely in his sleep without any of the fears and hazards which are often experienced with the use of electric blankets.

In order to prevent any loss of circulating fluid when the lines 22 and 24 are uncoupled from the manifold, co-operating self-actuating shut off valves 50 and 52 are included within each of the nipples and within the connector fittings 46, respectively. These four valves are all identical in construction and include an axial stem member 54 having an enlarged conical plug 56 formed on its inner end. A helical spring 58 fits upon an internal shoulder 60 and biases the stem member to seat the plug 56 upon an annular nylon element 62 serving both as a seat and as a gasket, secured within the mouth of the respective nipple or fitting.

These annular elements 62 abut against each other when the sleeve 44 is screwed onto the nipple, thus providing a fluid-tight seal. As shown in Figure 3 the valve

stem members of the respective shut-off valves contact each other when the line connections are made. Their mutual engagement compresses the springs 58 and opens both valves. This enables the liquid to flow freely through the convolutions of the springs and along beside the stem members as shown by the flow arrows.

Whenever a line is disconnected, each shut-off valve automatically closes, as shown in Figure 4. This advantageously prevents any loss of fluid from either the line or the blanket. As soon as the line is reconnected the valves are opened again.

Among the advantages of the conical configurations of the plugs 56 is the fact that they automatically center themselves. Thus, the axial stems 54 are always centered in proper position to engage each other to open the valves when the couplings are fastened together.

As indicated by the flow arrows in Figure 3, when the valves are opened, the fluid flow passes through the convolutions of the springs 58 past the rims of the conical plugs 56 and along beside the abutting valve stems 54.

As illustrated in Figure 5, in the first step of an improved method of simultaneously connecting all of the tubes 18 into the common manifold block, a loop 70 of electrically conductive material is wrapped around each of the tubes 18 about $\frac{5}{32}$ of an inch from the end. As shown, this loop is formed by a ring of fine wire.

In order to receive the loops 70, an annular groove 72 is provided in the side face 40 and in the other side face around the mouths of each of the branch passages 38 and 39. The grooves 72 have a size corresponding to that of the rings 70.

In the next step of the assembly as indicated in the lower half of Figure 5 all of the tube ends are inserted. The ring 70 in seating within the groove 72 acts as a stop and limits the insertion to a desired amount.

An electrical induction field is applied, inducing electrical currents in the loops 70. These quickly heat up and fuse all of the tube ends into the manifold block.

In certain instances a solvent sealing action may be used in lieu of the final step of induction sealing. However, the induction heating is easier to apply simultaneously to all of the tubes. Induction heating enables uniformly good results to be obtained more quickly and is the preferred step in this improved method of assembly.

The total amount of heat transfer liquid contained during operation in the whole system including the blanket 10, lines 22 and 24 and circulator and control means 20 is approximately one cup. For most purposes water is used containing anti-freeze to protect the tubes in case the blanket happens to be stored in freezing conditions. A permanent type anti-freeze such as ethylene glycol may be used. This mixture of water and permanent anti-freeze provides a desirably high specific heat capacity per unit volume of circulating liquid. Moreover it has a desirably low viscosity enabling easy circulation.

Any harmless liquid having at least a moderately high specific heat capacity and a low viscosity and which is not deleterious to the heat transfer mechanism may be used.

As illustrated in Figures 6 and 7 another improved method for simultaneously connecting all of the tubes 18 into the common manifold block 16 uses conduction heat sealing. An annular lip 74 is provided on the block 16 around each of the mouths of the branch passages 38 and 39. After the ends of the tubes have been inserted into the respective passages 38 and 39, a resistance wire harness including a pair of wires 76 and 78 is placed against each side face of the block. Each wire includes nine horseshoe shaped loops 79 each snugly fitting around one of the lips 74. The pairs of wires 76 and 78 are in parallel and are energized from a current source 80 by closing a switch 82. Each of these loops quickly heats one of the annular lips 74, thus fusing them and strongly inter-connecting the block 16 and the tubes.

From the foregoing it will be understood that the im-

proved thermal blanket and method of assembly of the present invention described above are well suited to provide the advantages set forth, and since many possible embodiments may be made of the various features of this improved thermal blanket and as the method and apparatus herein described may be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense and that in certain instances, some of the features of the invention may be used without a corresponding use of other features, or without departing from the scope of the invention.

What is claimed is:

1. A thermal blanket adapted to have liquid circulated therethrough for controlling the temperature of the blanket as desired by a user, said thermal blanket having comfortable flexibility and adapted for folding or rolling in any direction without affecting its operation comprising an area of fabric-like material, a manifold including a first and a second header passageway defined therein in substantially parallel relationship, the axis of the first of said header passageways being positioned below a horizontal plane passing through the center of said manifold and the axis of the second of said header passageways being positioned above said horizontal plane, said manifold including a first and a second plurality of parallel branch passages extending transversely through said manifold substantially perpendicular to the direction of said header passageways, said branch passages extending from a first side of said manifold to a second side with opposite ends of said branch passages being open, said first plurality of transverse branch passages being positioned below said horizontal plane and intersecting with said first header passageway while passing by and being spaced below said second header passageway, said second plurality of transverse branch passages being positioned above said horizontal plane and intersecting with said second header passageway while passing by and being spaced above said first header passageway, and a first and a second plurality of small diameter flexible tubes secured to said material in a heat-exchange grid pattern, the respective opposite ends of the flexible tubes of said first plurality being connected on said first side of the manifold to the respective open ends of the branch passages above and below said horizontal plane, and the respective opposite ends of the flexible tubes of the second plurality being connected on said second side of the manifold to the respective open ends of the branch passages above and below said horizontal plane.

2. A blanket of the type adapted for the circulation of liquid therethrough to regulate the temperature of the blanket comprising a panel of fabric-like material, a manifold positioned near the center of one edge of said panel, said manifold including a first and a second header passageway extending longitudinally therein perpendicular to said edge of the panel, said first header passageway having its longitudinal axis positioned above a central horizontal plane passing through said manifold, said second header passageway having its longitudinal axis positioned below said central horizontal plane, a first plurality of substantially parallel branch passages in said manifold below said central horizontal plane and connecting to said first header passageway and having their opposite ends extending to first and second sides of said manifold, a second plurality of substantially parallel branch passages in said manifold above said central horizontal plane and connecting to said second header passageway and having their opposite ends extending to said first and second sides of said manifold above the level of the ends of said first plurality of branch passages, a first plurality of flexible tubes of small diameter, each of said tubes having ends secured to respective ends of said first plurality of branch pas-

sages at said first side of the manifold, said tubes extending from said first side of the manifold along said edge of the panel and then bending and extending across said panel, the other ends of said tubes extending back across said panel and bending and extending back along said edge and being secured to respective ends of said second plurality of branch passages at said first side of the manifold, and a second plurality of flexible tubes of small diameter, each of said latter tubes having ends secured to respective ends of said first plurality of branch passages at said second side of the manifold, said tubes extending from said second side of the manifold along said edge of the panel and then bending and extending across said panel, the other ends of said latter tubes extending back across said panel and then bending and extending back along said edge and being secured to respective ends of said second plurality of branch passages at said second side of the manifold.

3. A compact manifold for use in a flexible thermal blanket of the type wherein a fluid is circulated through a plurality of small diameter flexible tubes in the blanket for controlling the temperature of the blanket, said manifold having a first and a second header passageway therein, the longitudinal axes of said header passageways being parallel the longitudinal axis of said first header passageway being positioned below a horizontal plane passing through the center of said manifold, the longitudinal axis of said second header passageway being positioned above said horizontal plane, a first plurality of parallel branch passages of smaller cross-sectional area than said first header passageway intersecting with said first header passageway and extending

transversely thereto from one side of the manifold to the other for connection to the tubes, the longitudinal axes of said branch passages being positioned farther below said horizontal plane than the longitudinal axis of said first header passageway for passing by said second header passageway without intersection therewith, and a second plurality of parallel branch passages of smaller cross-sectional area than said second header passageway intersecting with said second header passageway and extending transversely thereto from said one side of the manifold to the other for connection to the tubes, the longitudinal axes of said latter branch passages being positioned farther above said horizontal plane than the longitudinal axis of said second header passageway for passing by said first header passageway without intersection therewith.

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