

May 7, 1963

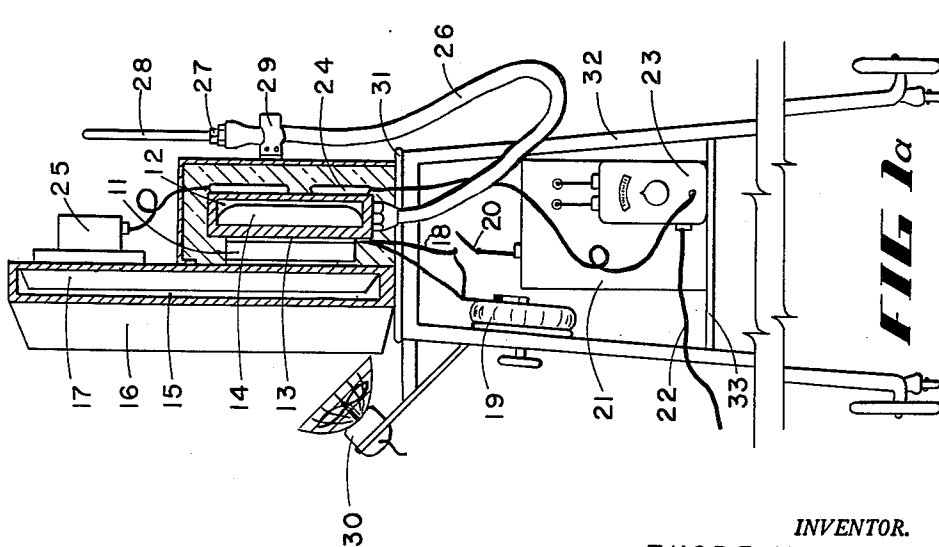
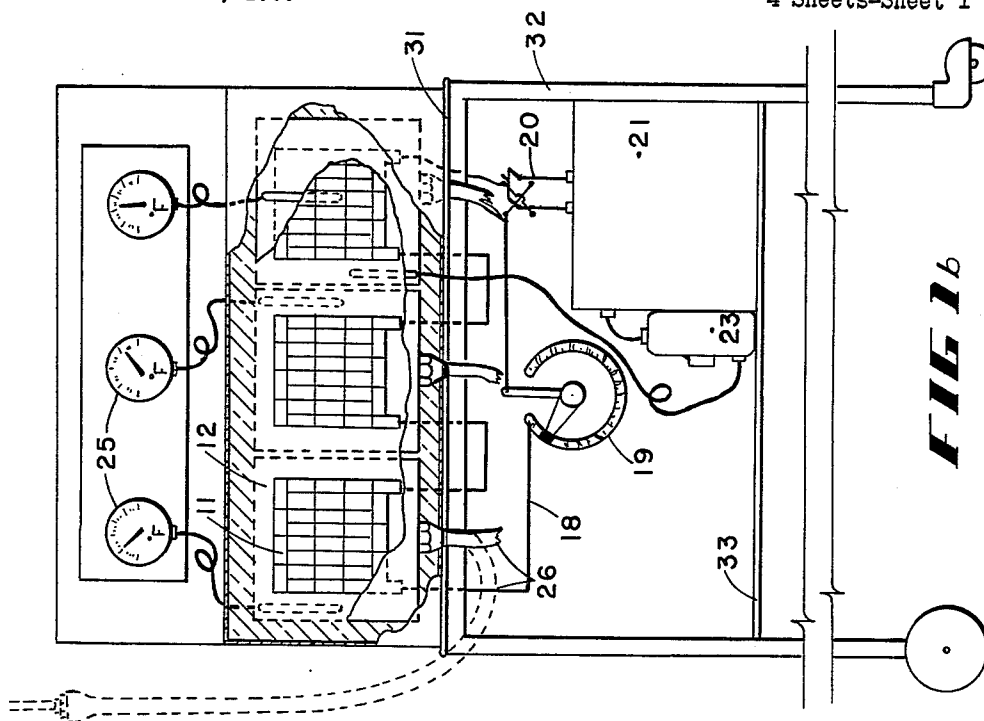
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3,088,288

THERMOELECTRIC REFRIGERATION SYSTEM

Filed Dec. 21, 1960

4 Sheets-Sheet 1



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THERMOELECTRIC REFRIGERATION SYSTEM

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4 Sheets-Sheet 2

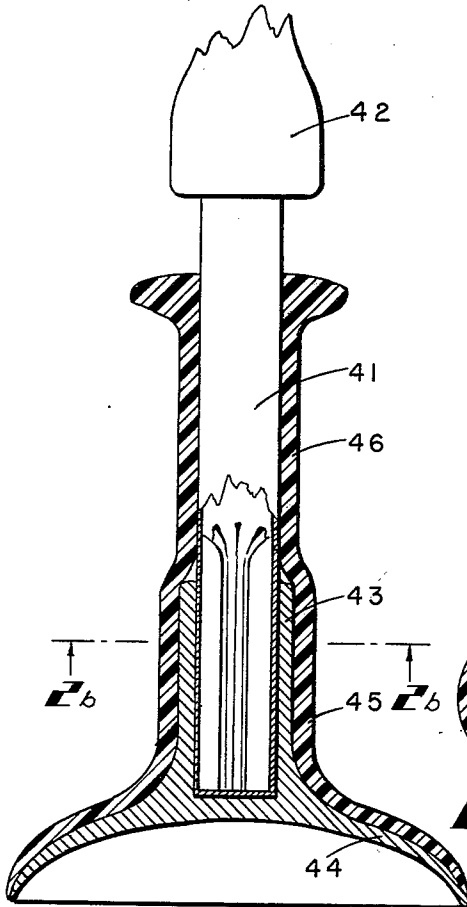


FIG. 2a



FIG. 2b

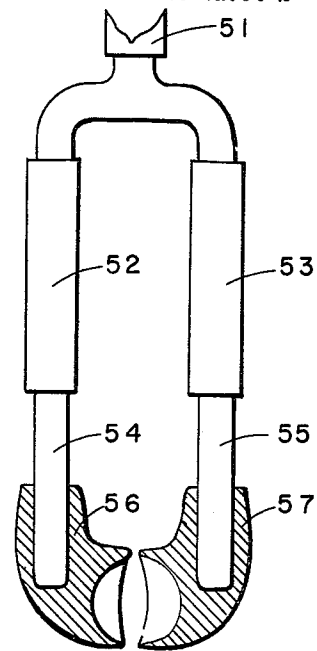


FIG. 2d

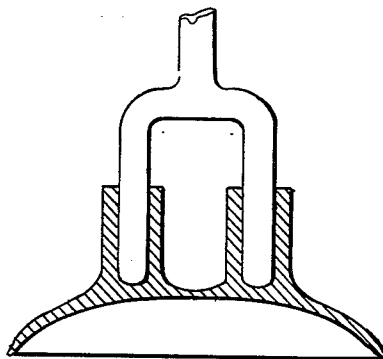


FIG. 2c

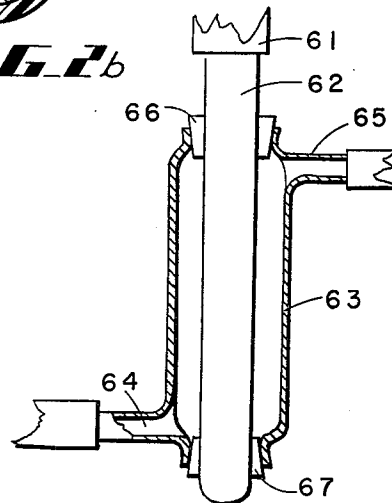


FIG. 3

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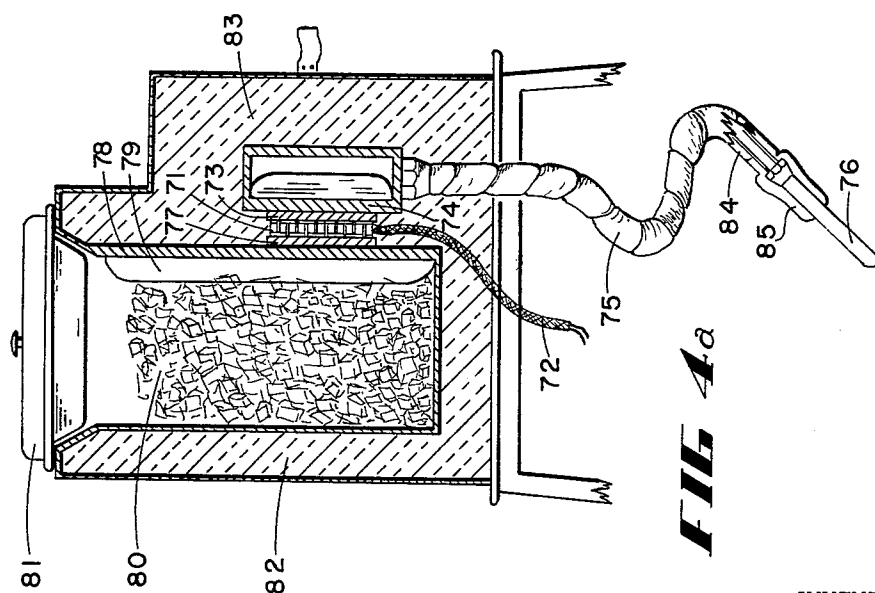
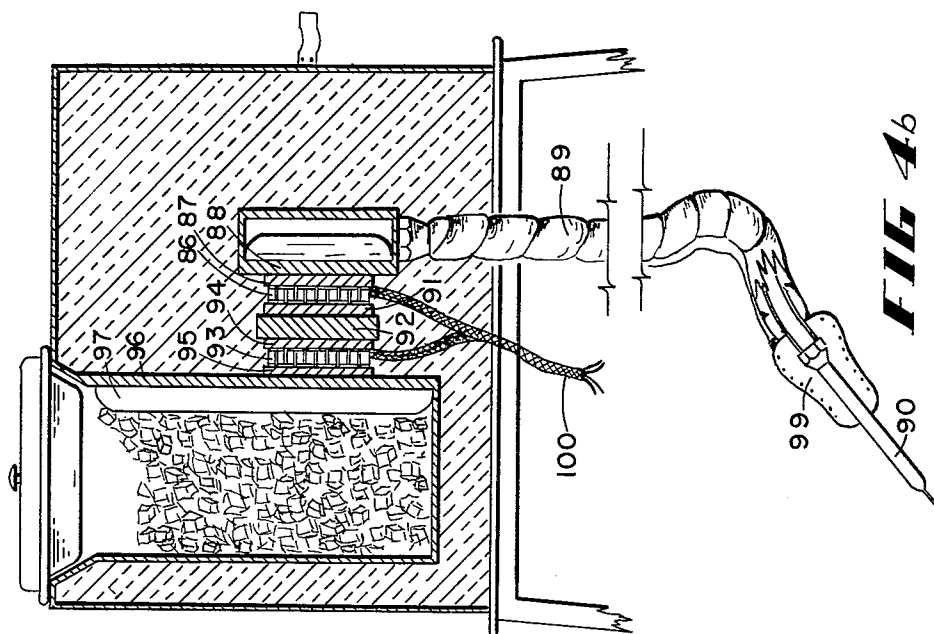
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4 Sheets-Sheet 3



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THERMOELECTRIC REFRIGERATION SYSTEM

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4 Sheets-Sheet 4

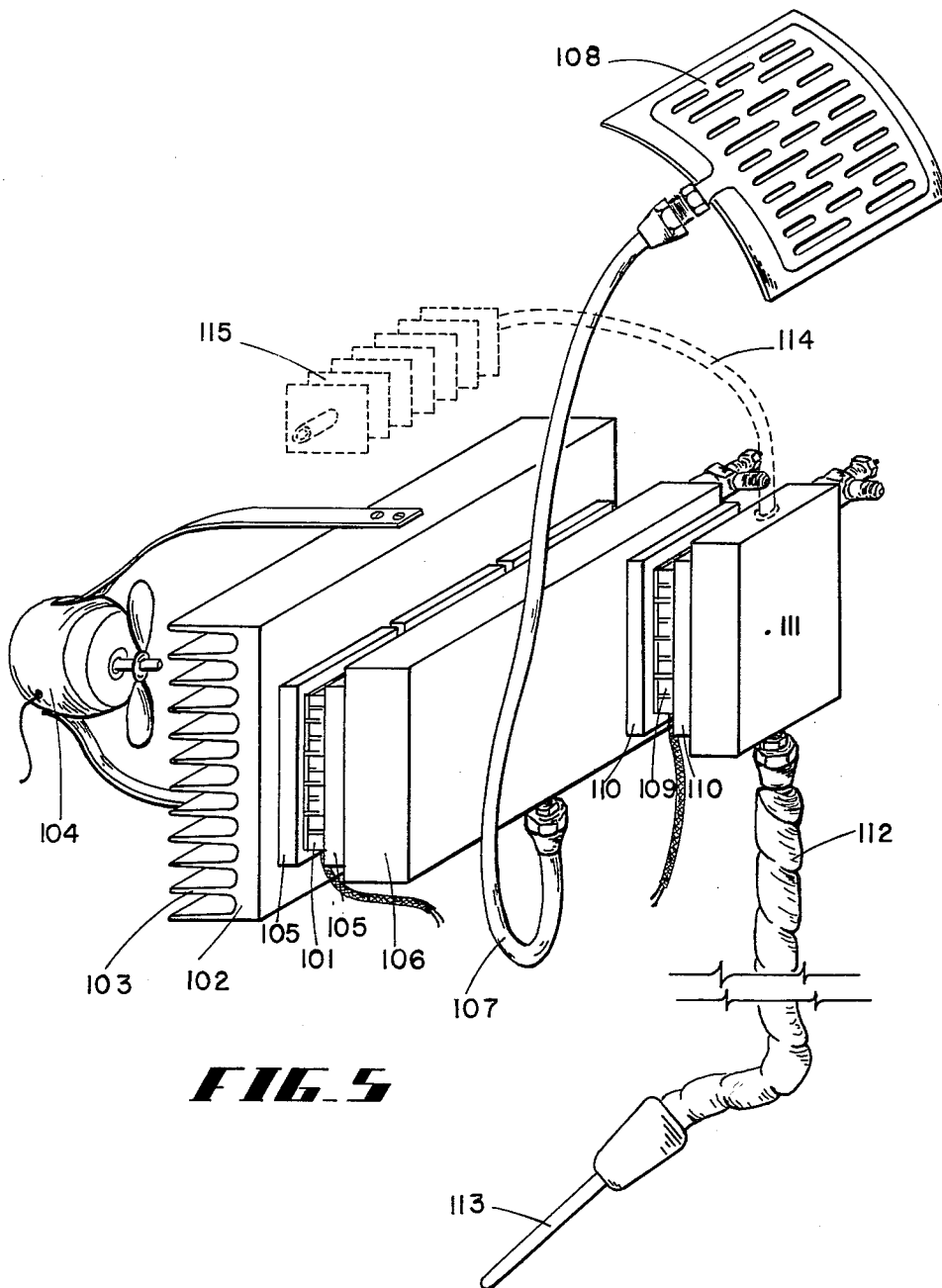


FIG. 5

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THERMOELECTRIC REFRIGERATION SYSTEM
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Filed Dec. 21, 1960, Ser. No. 77,390
15 Claims. (Cl. 62—3)

The present invention relates to a thermoelectric refrigeration system and more particularly to a system suitable for cooling objects and liquids in direct contact with cooled surfaces. The invention is applicable for use in the medical and laboratory field where silent operation and convenient temperature control is desirable.

In my copending application Serial No. 47,161, filed August 3, 1960, there is described a thermoelectric refrigeration system which employs one or more hermetically sealed heat transfer systems in thermal contact with thermoelectric modules. The present invention incorporates features of the invention disclosed in said copending application in a refrigeration system suitable for use in medical and laboratory refrigeration applications.

The refrigeration system according to the present invention is characterized by its flexibility and efficient application on the objects to be cooled. The system may include coolers which can be freely maneuvered by hand as is preferable when used for medical cooling of organs and parts of the body in connection with surgery. A medical or laboratory refrigeration system, according to the invention, allows exact, rapid and convenient temperature control of the contact surfaces used for the application of localized cooling and will permit a continuous cooling at constant temperature for any length of time.

Surgery under refrigeration usually requires the cooling down of the organ to be operated on to temperatures around $+10$ – $+15^{\circ}$ C. Because of the large amount of blood circulating through organs like the brain or the kidneys, the cooling down process can not be carried out locally from the beginning. Thermoelectric cooling is by its nature limited to relatively small refrigeration capacities and does not at present provide suitable means for the rapid cooling down of the entire body. If, however, the body temperature first is brought down by conventional means (ice bath, ice water rubber blankets, etc.) to a temperature of, say $+28^{\circ}$ C., then the blood supply through the arteries to said organs can be partly or completely restricted so that local cooling down to the desired temperature can rapidly take place. In this way the heart and the main part of the body can stay at a safe higher temperature while the organ operated on is locally cooled to a much lower temperature.

It is an object of the present invention to provide a thermoelectric refrigeration system which can be used in conjunction with detachable probes, cups, plates and other contact coolers of a great variety of shapes. The detachable contact coolers may be continuously or intermittently cooled and placed in direct contact with body organs or parts, or for other localized cooling.

According to an other object of the invention, means are also provided for cooling liquids or blood under complete temperature control.

It is a further object of the present invention to provide a thermoelectric refrigeration system capable of providing a plurality of cooling temperatures.

It is another object of the present invention to provide a thermoelectric refrigeration system including a plurality of heat pumps which can be operated to provide a variety of temperatures and refrigeration capacities.

Other objects and features of my invention will appear from the following description of the invention with reference to the accompanying drawings.

Referring to the drawings:

FIGURES 1a and 1b are elevational views, partly in

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section, showing a thermoelectric refrigeration system incorporating the present invention;

FIGURES 2a, 2b, 2c and 2d show elevational views, partly in section, of various contact coolers which may be employed in the present invention;

FIGURE 3 shows a thermoelectric blood or liquid cooler;

FIGURES 4a and 4b show in sectional, elevational views embodiments of the invention for obtaining relatively low temperatures; and

FIGURE 5 is a perspective view, partly in section, showing another embodiment of the invention in which a plurality of temperatures can be obtained from the same system simultaneously or independently.

In FIGURES 1a and 1b, there is shown a thermocouple assembly or module 11, which is in thermal but not electrical contact with a hollow condenser 12, preferably made from aluminum or copper. The condenser 12 has a plane surface 13 thermally contacting the normally cold side of the modules 11 and is preferably provided with inside fins 14 extending from the surface 13.

The normally warm side of the module 11 is in thermal contact with a hollow radiator 15. The radiator is provided with air-cooled outside fins 16 for dissipating heat to the surrounds. Inside fins 17 extend from the surface which is in contact with the hot side of the module 11. The module 11 is supplied with unidirectional current, for example, a direct current, through the leads 18. The current is controlled by variable resistor 19.

A reversing switch 20 connects the thermocouple module 11 and variable resistor 19 to a D.-C. power supply 21. Alternating current power is supplied to the power supply through a thermostat 23 connected to lead 22. The thermostat has its temperature sensitive bulb 24 in contact with the condenser 12 and can be set to interrupt or cut-off the A.-C. power when the condenser reaches a predetermined temperature. The switch 20 can be connected to reverse the current through the modules whereby the normally cold side is heated, and vice versa, for purposes to be presently described. It is apparent that other sources of D.-C. power may be employed. Furthermore, other types of power control can be employed in place of variable resistors. Various types of D.-C. supplies are known in the prior art and will not be described here.

A thermometer 25 may be provided to indicate the temperature of the condenser 12. The thermometer sensing element is disposed in thermal contact with the condenser.

The condenser 12 normally forms the upper heat dissipating part of a closed heat transfer system partly filled with a suitable volatile liquid such as Freon 114 or similar nonpoisonous refrigerant. The rest of this heat transfer system comprises a pressure resistant insulated hose 26 connected to the bottom part of the condenser, a coupling 27 and a hollow metal body 28, which in FIGURE 1a is shown in the form of a pipe or cylinder. The lower portion of the heat transfer system is shown attached to a holder 29, in which position the heat transfer system just described is inactive with the filling stored in the insulated hose.

The hollow radiator 15 is partly filled with a similar heat transfer medium in liquid contact with the inside fins 17, which part of the radiator serves as a heat absorbing boiler while the upper and outside portion serves as a heat dissipating condenser cooled by air through natural convection or by help of the fan 30.

The described part of the invention functions in the following way: After closing the switch 20 in a "refrigeration" position, D.-C. current is supplied to the thermoelectric module 11 whereby the condenser 12 is cooled and the radiator 15 is heated by the heat pumping action

of the thermocouple. As soon as the cylinder 28 is taken from the holder 29 and lowered to a position where it constitutes the lowest part of the described heat transfer system, the volatile liquid will fill the hollow body 28 and start boiling until the temperature of the body 28, which according to the invention, constitutes a contact cooler has reached the approximate temperature of the condenser 12. The heat given off in the condenser 12 will be absorbed by the cold junctions of the thermocouple assemblies 11. The heat pump delivers heat energy at a higher temperature to the radiator 15 where it is absorbed in the boiler portion and finally dissipated to the air through the fins 16. The temperature of the condenser 12 and thereby also of the hollow pipe 28 can be regulated by the variable resistance 19 but can never go lower than the setting of the thermostat 23 as previously indicated.

As indicated in FIGURE 1b, the condenser 12 can be divided into several separate condensers, each provided with its own closed heat transfer system as previously described, but all together using the radiator 15 as the final heat dissipating device. On the drawing 1b is shown how each of these separate condensers is provided with thermoelectric modules in series whereby the current can be controlled by the same rheostat modulator and the same thermostat. It is, however, obvious that the individual condensers, according to the invention, can be cooled by heat pumps which are individually fed with D.-C. current from the power supply through separate rheostats so that an individual temperature control for each heat transfer system can be obtained. Each heat pump system can also be provided with its own thermostat for the control of the desired temperature limit. Each heat pump system can also be provided with its own D.-C. power supply, in which case the thermostats are acting on the A.-C. supply lines leading to each individual power supply. Each condenser system may be, as indicated in FIGURE 16, provided with its own thermometer.

As a safety measure, the radiator 15 can also be divided into as many hermetically closed heat transfer systems as there are condensers, each radiator mounted beside each other as indicated on the drawing. Each heat pump system will then be independent of the other with exception of the insulation and the support. It goes without saying that by separately insulating each heat pump system and arranging electric conduits in a suitable manner, the heat pumps included in the panel can be made completely independent and their temperatures adjustable in relation to each other.

The shape of the hollow contact coolers 28 which, according to the invention, act like a boiler in a closed heat transfer system will be discussed later. One condenser can be connected with more than one contact cooler by having more than one hose connected to its condensing area or by forking the hose into two or more hoses each provided with its contact cooler of suitable shape. The amount of liquid heat transfer medium in such a multiple array of contact coolers working on a common condenser has to be larger than the volume of one or more of the contact cooler boilers with their connecting hoses in order to avoid the possibility that some of the coolers run dry by accumulation of the liquid heat transfer medium in other coolers.

In FIGURES 1a and 1b, the panel of thermoelectric contact cooling heat pumps is shown mounted on a shelf 31 supported by a stand 32, on which another shelf 33 is arranged for the power supply, thermostat, control rheostat and other electric equipment. The height of the shelf 31 is adjustable in any known way so that the flexible hoses can be extended if necessary for the unhampered flow of heat transfer medium between the contact coolers and the condensers.

The rectifier or power supply shown in the drawings does not have to be included in the transportable unit. Instead, the power supply can be located outside the

operation room and the unit supplied with D.-C. current through a suitable cable. By including in the cable a lead to the thermostat in series with the A.-C. outlet, which supplies the rectifier with current, the automatic safety control will work as previously described.

FIGURES 2a, 2b, 2c and 2d show details of various forms of contact coolers for medical purposes. Because of sterilization problems, it is desirable to be able to detach the parts in contact with the patient. This can be achieved by using self-closing disconnect couplings as indicated by 27 in FIGURE 1a. Such couplings can be used for refrigeration lines under pressure and can also be used here under certain conditions, in which case the hollow heat absorbing part or boiler of the heat transfer system on the cold side of the modules can be given any suitable form for contact cooling. It can, for instance, be shaped like a double walled bowl as later illustrated in FIGURE 2a. In connection with surgery, the sterilization requirements are so strict that steaming at temperatures of +300° F. and above are desirable. Under such circumstances, detachable secondary contact coolers are preferable.

Such contact coolers according to the invention comprise a primary hollow cooler in the form of a cylinder or probe serving as boiler in the thermoelectrically cooled heat transfer system and a secondary detachable solid cooling body in intimate thermal contact with the primary cooler and shaped according to the organ to be cooled.

FIGURE 2a shows a contact cooler for brain surgery. The primary cooler 41 comprises a hollow cylinder attached to the flexible hose 42 and provided with extended surfaces on the inside as illustrated by the cross section detail shown in FIGURE 2b. The secondary cooler comprises a hollow metal shaft 43 in which the primary cooler is inserted with a close fit. The shaft 43 forms a continuation of a bowl-shaped contact surface 44 of a size and shape corresponding to the brain of the patient under surgery. The upper part of the bowl 44 and the shaft 43 is covered by a plastic compound 45 which is extended into a handle 46 around the primary cooler to prevent condensation on top of the secondary contact cooler. The plastic compound used will resist sterilization temperatures. In order to avoid significant temperature differences in the secondary detachable cooler, more than one primary cooler can be used as illustrated by FIGURE 2c, which shows two primary metal boilers inserted into two shafts of the secondary cooler.

FIGURE 2d illustrates a double secondary cooler for the use in connection with kidney surgery. The flexible hose 51 is forked into two hoses 52 and 53 leading to the primary cooling tubes 54 and 55 to which the kidney-shaped contact coolers 56 and 57 are attached. The contact coolers can suitably be made from aluminum, stainless steel or chrome plated copper. The movable contact coolers can enclose a kidney from two sides and cool it down to a predetermined temperature in short time, whereafter one or both of the coolers can be removed.

In FIGURE 3 is shown how the invention is used for the cooling of blood or other liquids in relatively small quantities. In FIGURE 3 is shown a flexible hose 61 which in its upper end is attached to a thermoelectrically cooled condenser as previously described. The hose 61 is connected to a hollow metal tube 62 which constitutes the primary cooler as described in FIGURE 2a. Around the primary cooler 62 is placed a glass tube 63 with inlet and outlet connections 64 and 65. The glass tube is sealed to the metal tube 62 by rubber stoppers 66 and 67. By circulating blood or other liquids through the glass container, it will be cooled by the central cooler 62 in a self-explanatory way.

When applying cooling to human tissues or organs in connection with surgery, the desirable temperature of the contact cooler usually is not lower than 0° C. or slightly below. In certain cases, such as cautery and

for external treatment, much lower temperatures can be used and a medical refrigeration system according to the invention can, for such purposes, provide low temperatures by means of another embodiment of the invention. FIGURES 4a and 4b show details of special embodiments of the invention whereby very low controllable temperatures can be obtained for ultra-cold cautery and other purposes.

In FIGURE 4a, 71 represents a thermocouple assembly supplied with D.-C. current through the cable 72. The cold junctions are glued to a preferably grooved aluminum plate 73, which is in close thermal contact with a condenser 74. The condenser 74 together with a flexible hose 75 and a metal hollow probe 76 attached to this hose form a hermetically closed heat transfer system functioning as previously described. The probe 76 as well as the condenser 74 are preferably provided with inside extended surfaces. The hot junctions of the assembly 71 are in a similar way glued to a preferably grooved highly conductive plate 77, which is in close thermal contact with the metal wall 78 which is preferably provided with fins 79. The wall 78 is part of a vessel or container 80 which, according to the invention, is filled with crushed ice and serves as a heat sink of about 0° C. temperature for the described thermoelectric heat pump. The ice container 80 has a lid 81 and is preferably insulated by the insulation 82. The condenser 74 is similarly heavily insulated with insulation 83 and so is the flexible hose 75 by the flexible insulation 84. The probe 76 may be provided with an insulated handle 85.

Because of the low temperature heat sink at the hot junctions, a one-stage thermoelectric heat pump can easily bring the temperatures on the cold junctions down to -40° C. or below, which temperature consequently will be attainable on the contact probe 76.

By controlling the current supply to the thermocouple assembly by means of a rheostat, a complete control of the temperatures can be achieved.

In FIGURE 4b is shown a similar arrangement for a two-stage thermoelectric heat pump assembly whereby the temperature can be brought down to -90° C. or below. The first stage thermocouple assembly 86 is on its cold junction side glued to a metal plate 87 of approximately the same thickness as the thermoelectric assembly itself and preferably grooved on both sides. The plate 87 is in thermal contact with the condenser 88 which, together with the insulated hose 89 and the hollow probe 90, constitute a hermetic heat transfer system which is filled with suitable volatile liquid whereby the probe 90 is cooled to approximately the same temperature as the cold junctions of the first stage assembly 86 previously described. The hot junctions of the assembly 86 are glued to a similar metal plate 91 which is in thermal contact with an intermediate plate 92 of highly conductive material which on the other side is in thermal contact with the cold junction side of the second stage thermocouple assemblies 93 over preferably grooved metal plates 94 glued to the hot junctions of the assemblies 93. The hot junctions of the second stage assemblies 93 are, through similar metal plates 95, in thermal contact with a plane wall 96 provided with fins 97 and forming a part of a container 98. The insulated container is filled with ice and serves as a heat sink for the dissipation of the total heat given off by the two-stage heat pump system. By maintaining an overall temperature difference in each stage of 45° C., a final temperature of -90° C. is possible on the probe for cautery and other ultra cold applications. The condenser 88 as well as the hose 89 is provided with a heavy insulation. The handle 99 on the probe can preferably be heated on the outside surface by an electric wire as illustrated in the drawing. The two thermocouple assemblies have their heat pumping capacity balanced to each other and can be supplied with D.-C. current in series with each other through the cable 100. The ultimate temperature of the probe can, as previously

described, be regulated by a variable resistance illustrated in FIGURE 1.

FIGURE 5 shows an embodiment of the invention whereby both medium low and very low temperatures can be produced by the same thermoelectric heat pump equipment for application in contact coolers or for other purposes. The numeral 101 represents one of several thermocouple assemblies in thermal contact on their hot junction side with the cast aluminum radiator 102 provided with fins 103 and cooled by the air stream from the fan 104. The thermocouple assemblies represented by 101, which on both sides are glued to grooved relatively thin aluminum plates 105, are on their cold sides in thermal contact with the hollow condenser 106 of a hermetic heat transfer system filled with a volatile liquid as previously described. Other parts of this hermetic system are the flexible hose 107 and the metal plate evaporator 108 for contact cooling of large surfaces in accordance with the invention as previously described. On the other side of the condenser 106 and in close thermal contact therewith is shown a single thermocouple assembly 109 which also is connected on both sides to heat equalizing plates 110 similar to 105. The thermocouple assembly 109 has its hot junction side facing the condenser 106 and its cold junction side in thermal contact with a condenser 111 which forms the heat dissipating part of a second hermetic heat transfer system comprising the insulated hose 112 and the hollow probe 113 and functioning as previously described.

Shown in the figure are electric leads for supplying D.-C. current to the thermocouple assemblies and electric switch means for disconnecting the current to the single assembly 109 when temperatures below freezing are not wanted.

The condenser system 111 with its thermocouple assembly 109 forms a first stage low temperature heat pump system cooled by the condenser 106 and its thermocouple assemblies 101, which constitute a second stage heat pump system in relation to the described first stage, but which also independently through its hermetic heat transfer system can deliver medium temperature cooling to surrounding objects. Both stages can deliver their cooling effect simultaneously when both the hose 107 and the hose 112 are in an active lower position. When the hose 107 is in a raised position as illustrated in the figure, the external load on condenser 106 will discontinue and only the first stage low temperature system is active. In the same way, the hose 112 with its probe 113 can be raised in an inactive position in which the first stage heat pump system is picking up no external heat load. When no low temperatures are wanted, the current supply to the first stage assembly 109 can preferably be cut off with maximum capacity on the medium temperature system as a result.

It is also possible to reverse the current in the thermocouple assembly 109 by a suitable switch so that its cold side will be facing the condenser 106, while its hot junction side faces the condenser 111 which now becomes a boiler. The hose 112 with its probe 113 can preferably be in a raised position so that the volatile liquid fills the hollow vessel 111, where it will boil under heat absorption. The probe 113 will now serve as an air cooled condenser and can be provided with detachable extended surfaces of known type. The heat pumping capacity of the thermocouple assembly 109 will now be added to the refrigeration effect of the assembly 101 on the other side of the condenser 106. In order to increase the heat pumping capacity of the assembly 109 in this reversed current position, the hermetic heat transfer system belonging to the "condenser" 111 can be extended by a pipe 114 to an extra heat dissipating member 115 located above the member and preferably air cooled as indicated by dotted lines in FIGURE 5. Such a heat dissipating member would have no influence on the functioning of assembly

109 as a first stage low temperature system but would increase its capacity when working, as described, together with the assembly 101. Thus, all the thermocouples included in the heat pump equipment can work together as an efficient single-stage system when no low temperatures are wanted or maximum capacity of the medium temperature system is needed.

Experiments have shown that a combined one-stage and two-stage system, as described, with a hollow member serving both as a condenser on the cold junction side of a medium temperature heat pump system and as a heat sink on the hot junction side of a low temperature heat pump system is the most efficient way of obtaining two different temperature ranges from the same equipment.

The two stages have to be balanced to each other as described in my copending application Serial No. 47,161, that is, the heat pumping capacity of the second stage has to correspond to the number of B.t.u.'s absorbed by the heat absorbing parts of both hermetic systems plus the energy supplied to the first stage thermocouple assembly. The energy input to the first stage which for many applications below freezing can work with a relatively small ΔT between the hot and the cold junctions is normally only $\frac{1}{6}$ – $\frac{1}{2}$ of the energy input to the second stage, and the current through the first stage module can often be only half or less of the current fed to the second stage modules. Means may be provided for separately regulating the current to the two stages. By arranging three or more stages in the same way, it is possible to simultaneously provide three or more temperature ranges from a thermoelectric heat pump assembly, if desirable.

The primary metal coolers can, according to the invention, be sterilized simply by raising the flexible part of the heat transfer system to a position indicated by dotted lines in FIGURE 1b and reversing the current through the thermocouples so that the module will heat the condenser 12 instead of cooling it. In this position, the volatile liquid in the secondary system will flood the condenser which now becomes a boiler under increased pressure. The volatile liquid and vapor will equalize the temperature of the whole heat transfer system so that the metal body 28 assumes the same high temperature as the "boiler" 12. By choosing a suitable heat transfer medium, for instance, Freon 11, moderately high sterilization temperatures can be reached without too high pressures for the hose, which has to be adequately reinforced. Thus, according to the invention, the flexible heat transfer system connected to the normally cold side of the thermoelectric heat pump equipment can be located in three positions: One position in which the heat transfer system is inactive; a second position in which the contact coolers are applied; and a third position in which the contact coolers are being heated.

It is apparent that the refrigeration system described can be used in many applications other than in the medical and laboratory field. Reference to these fields was for purposes of illustration, and the invention is not intended to be limited in this respect.

I claim:

1. A thermoelectric heat pump comprising a thermocouple assembly having hot and cold junctions, a condenser in heat exchange relationship with the cold junctions of said thermocouple assembly, an evaporator, a flexible hose forming a hermetic connection between said evaporator and condenser to thereby form a hermetically sealed system and a volatile liquid partly filling said hermetically sealed system, said flexible hose permitting positioning of the evaporator whereby the same may be operative or inoperative.

2. A thermoelectric heat pump comprising a thermocouple assembly having hot and cold junctions, a condenser in heat exchange relationship with the cold junctions of said thermocouple assembly, an evaporator, a flexible hose forming a hermetic connection between said

evaporator and condenser to thereby form a hermetically sealed system, said flexible hose permitting positioning of the evaporator whereby the same may be operative or inoperative, a volatile liquid partly filling said hermetically sealed system, means for applying an electric current to said thermocouple assembly, means for regulating said current and control means for sensing the temperature of the condenser and controlling application of current to the thermocouple assembly.

3. A thermoelectric heat pump comprising a thermocouple assembly having hot and cold junctions, a condenser in heat exchange relationship with the cold junctions of said thermocouple assembly, a metal evaporator, a flexible hose forming a hermetic connection between the evaporator and the condenser to thereby form a hermetically sealed system, a volatile liquid partly filling said hermetically sealed system, said flexible hose permitting positioning of the evaporator whereby the same may be operative or inoperative, and a metal contact cooler detachably connected to said metal evaporator.

4. A thermoelectric heat pump as in claim 3 wherein said detachable metal contact cooler is shaped to accommodate a kidney.

5. A thermoelectric heat pump as in claim 3 wherein said detachable metal contact cooler is shaped to accommodate a brain.

6. A thermoelectric heat pump system comprising a thermocouple assembly having hot and cold junctions, an air cooled hermetically sealed heat transfer system having heat absorbing and heat dissipating parts in heat exchange relationship with the hot junctions of said assembly to cool the same, a second hermetically sealed heat transfer system having heat absorbing and heat dissipating parts having its heat dissipating part in heat exchange relationship with the cold junctions of said thermocouple, said second heat transfer system having a flexible connection between the heat absorbing and heat dissipating parts thereof, said flexible hose permitting positioning of the evaporator whereby the same may be operative or inoperative.

7. A system as in claim 6 wherein a metal contact cooler is detachably secured to the heat absorbing part of said second transfer system.

8. A thermoelectric heat pump system comprising a first thermocouple assembly having hot and cold junctions, a condenser forming the heat dissipating part of a first hermetic heat transfer system in heat exchange relationship with the cold junctions of said first thermocouple assembly, a second thermocouple assembly having hot and cold junctions, a second condenser forming the heat dissipating parts of a second hermetic heat transfer system, said second condenser in heat exchange relationship with both the hot junctions of the first thermocouple assembly and the cold junctions of said second thermocouple assembly and cooling means in heat exchange relationship with the hot junctions of said second thermocouple assembly.

9. Apparatus as in claim 8 in which said means for cooling the hot junctions of said second thermocouple assembly comprises an air-cooled radiator.

10. A thermoelectric heat pump as in claim 8 wherein an evaporator is connected to one of said first and second condensers by a flexible coupling whereby said evaporator may be disposed to be operative or inoperative.

11. A thermoelectric heat pump system as in claim 8 wherein evaporators are connected to the condensers of the first and second hermetic transfer systems by a flexible coupling whereby said evaporators may be disposed to be operative or inoperative.

12. A thermoelectric heat pump comprising a thermocouple assembly having hot and cold junctions, a condenser in heat exchange relationship with the cold junctions of said thermocouple assembly, an evaporator, a flexible coupling forming a hermetic connection between said evaporator and condenser to thereby form a her-

metically sealed system, said flexible hose permitting positioning of the evaporator whereby the same may be operative or inoperative, a volatile liquid partly filling said hermetically sealed system, means for applying a unidirectional electric current to said thermocouple assembly, and reversible switching means for controlling the polarity of said current.

13. A thermoelectric heat pump comprising a thermocouple assembly having hot and cold junctions, a condenser in heat exchange relationship with the cold junctions of said thermocouple assembly, an evaporator, a flexible hose forming a hermetic connection between the evaporator and the condenser to thereby form a hermetically sealed system, said flexible hose permitting positioning of the evaporator whereby the same may be operative or inoperative, a volatile liquid partly filling said hermetically sealed system, and means encircling said evaporator to direct a liquid to be cooled over said evaporator.

14. A thermoelectric heat pump system comprising a thermocouple assembly having hot and cold junctions, a hermetically sealed heat transfer system having heat absorbing and heat dissipating parts with the heat dissipating parts in heat relationship with the cold junctions of said thermocouple assembly, a liquid bath in heat exchange relationship with the hot junctions of said thermocouple assembly, said heat transfer system having a flexible connection between the heat absorbing and the heat dissipating parts thereof.

15. A thermoelectric heat pump system comprising a first thermocouple assembly having hot and cold junctions, a condenser forming the heat dissipating part of a hermetic heat transfer system in heat exchange relationship with the cold junctions of said first thermocouple assembly, a second thermocouple assembly having hot and cold junctions, the cold junctions of said second thermocouple assembly in heat exchange relationship with the hot junctions of said first thermocouple assembly and a liquid bath in heat exchange relationship with the hot junctions of said second thermocouple assembly, said heat dissipating part of said hermetic heat transfer system having a flexible connection with the rest of the system.

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