The present invention relates to a novel and improved thermo-electric instrument for hypothermia treatments and the like.

In plastic and cosmetic surgery, cold applications are required to be maintained on the skin surface during post-surgery convalescence in order to reduce swelling, promote healing and inhibit edema. Conventionally, cold compresses or ice packs are applied to the affected area, usually, the face, for this purpose, providing a cooling effect to the area, but having the disadvantage of contacting the skin and applying the pressure of its weight upon the highly sensitive area. This is extremely painful to the patient, and in part offsets the astringent effect of the applied cold. In addition, the physical application of cold articles of this type provide an uncontrolled cooling effect to the body area, incurring the risk of frostbite or other damage to the skin or body tissues.

Heating and cooling applications are also required in dermatology, treatment of burns and traumatic treatment; in each instance, contact with the body being undesirable.

It is an object of the present invention to provide a device capable of producing cooling by thermo-electric means, and so constructed that the cooling application can be applied remote from the sensitive body area without physical contact therewith. The device is adapted to utilize the Peltier effect for producing extreme cooling at a heat conductive surface positioned adjacent the area to be treated.

Another object of the invention is the provision of a thermo-electric device of the character described which is adjustable to conform to various areas or surfaces of the body.

Still another object of the invention is the provision of a thermo-electric device of the character described which is adjustable mounted so that it may be set in a fixed position above and surrounding the body area to be treated, with the cooling portion of the device spaced from the body area to apply cold without direct physical contact.

A further object of the invention is the provision of a thermo-electric device of the character described in which the degree of cooling can be selectively controlled to provide the optimum temperature for the particular application.

In accordance with the invention, there is provided a thermo-electric instrument for hypothermia treatment including a plurality of members hinged to each other and selectively adjustable to vary the angles therebetween, each of the members incorporating a thermo-electric module arranged to produce cooling at the lower surface of said members, and an adjustable mounting member carrying said members and capable of positioning the members in selected spaced relationship to the body area being treated.

Additional objects and advantages of the invention will become apparent during the course of the following specification when taken in connection with the accompanying drawings, in which:

FIG. 1 is a side elevational view of the thermo-electric instrument made in accordance with the invention showing the manner in which it is applied to the face of a patient;

FIG. 2 is a partial top plan view of the thermo-electric assembly of the instrument with a portion thereof broken away for convenience of illustration;

FIG. 3 is a side elevational view of the thermo-electric assembly of the hypothermia instrument;

FIG. 4 is a section taken along line 4-4 of FIG. 2;

FIG. 5 is a section taken along line 5-5 of FIG. 2; and

FIG. 6 is a schematic view showing the electrical circuit for the thermo-electric device.

Referring in detail to the drawings, it will be seen in FIG. 1 that the hypothermia instrument 10 comprises in general an adjustable stand 12 carrying a thermo-electric assembly 14. The latter comprises a plurality of individual thermo-electric members 16, 18, 20 and 22, four of such members being shown by way of preferred example, the members being adjustably hinged to each other for selective positioning.

The members 16, 18, 20 and 22 are of the same general construction, and each comprises a flat plate 24 made of a thermally-conductive material, such as brass, and having a flat bottom surface 26 constituting a heat-transfer surface. Each of the plates 24 also has a flat upper surface 28 to which is secured a thermocouple assembly or module 30. The latter comprises a suitable number of semiconductor elements connected in series, as shown in FIGS. 5 and 6.

Specifically, the thermocouple assembly 30 is composed of a series of semiconductor elements 34 of the p-type alternating with semiconductor elements 36 of the n-type. Both elements 34 and 36 are preferably made of barium telluride; the p-type differing from the n-type in physical properties of the semiconductor employed. Barium telluride thermocouples of this type are well known and are commercially available.

Each individual pair of semiconductor elements 34 and 36 is connected at their upper ends by thin plates 38 of electrically conductive metal such as copper, while adjacent pairs of elements 34 and 36 are connected at their lower ends by similar copper plates 40. The plates 38 and 40 are thus arranged to connect the elements 34 and 36 in series, as best shown in FIG. 6. When electrical current is passed through the thermocouple series in one direction, the lower plates 40 will serve as cold junctions and the upper plates 38 as hot junctions. If the direction of the electrical current is then reversed, the lower plates 40 will become the hot junctions and the upper plates 38 the cold junctions.

The thermocouple units are embedded in a filler 42 of polyurethane foam which acts as heat insulating means to prevent the heat generated at the hot junctions from overcoming the cold prevailing at the cold junctions. The outer surfaces of the junction plates 38 and 40 are, however, exposed at the respective top and bottom edges of the foam filler 42, as shown in FIGS. 5 and 6, in order to be intimately associated with the metal pieces to which the thermocouple assembly is attached.

The thermocouple assembly 30 is mounted flat against the upper surface 28 of the plate 24 by a plurality of anchor elements in the form of channel members 44. These channel members 44 are secured to the plate 24 and are embedded within the plastic foam filler 42. Similarly, channel members 42 are secured to a heat dissipating member 48 and are embedded within the plastic foam filler 42 for anchoring heat dissipating member 48 to the thermocouple assembly 30. Heat dissipating member 48 is made of brass or other heat conductive material. The top copper plates 38 of the thermocouple assembly are electrically insulated from the heat dissipating member 48 by a thin layer 50 of paint, epoxy resin, or other suitable material having insulating properties. In a similar manner, the lower junction plates 40 are insulated from the plate 24 by an insulating layer 52.

In FIG. 6, three pairs of semiconductor elements 34 and 36, connected in series at their top and bottom ends, are shown as constituting a single thermocouple
3.282,267

assembly or module. In actual practice, however, each module 30 is formed of twenty pairs of elements 34 and 36, the elements being arranged to cover the entire area of the plate 24.

Each heat dissipating member 48 comprises a flat body portion 56 formed with a series of upstanding fins 58. The member 48 serves as a heat sink when its associated thermocouple assembly is used for cooling at the heat transfer surface 36 of the device 18. Heat generated at the upper thermocouple plates 38 is absorbed by the body portion 56 and transferred to the fins 58, from which such heat is dissipated into the surrounding atmosphere.

Each of the inner thermo-electric members 18 and 20 is formed with a pair of ears 60 and 62 at its opposite ends, these ears being formed integrally with the plate 24 or being permanently secured as by welding to the edges of said plate 24. Similarly, the end members 16 and 22 are formed with a single pair of ears 64 at their inner ends. These pairs of ears are formed to overlap with the ears of the adjacent thermo-electric members as shown in FIGS. 2 and 4, and each ear is formed with a circular aperture 66 which, as shown in FIG. 4, registers with the aperture of the overlapping ear. A pivot rod 68 extends through the aligned apertures 66 of each set of overlapping ears, as shown in FIG. 4, to provide a hinge for each adjacent pair of thermo-electric members. Each pivot rod 68 has an enlarged head 70 at one end and is provided with threading 72 at the other end. A knurled nut 74 is mounted on this threaded end 72.

A rigid tubular sleeve 76 is mounted on each of the pivot rods 68, the sleeve 76 being of such length to extend snugly between the overlapping ears. When the nut 74 is screwed down tightly, the ears are clamped to each other and to the end of sleeve 76 locking the hinge in adjusted position.

The adjustable stand 12 comprises a base 80 having a member 82 swivelled mounted thereon for rotation about a vertical axis. A pair of spaced, parallel tubular rods 84, 86 are pivotally mounted at one end of the member 82 and at their other end on a link 88. A second pair of tubular rods 90 and 92 are also pivotally mounted at spaced points on the link 88, the other ends of rods 90 and 92 being pivotally connected to a link 94. Also pivot to link 94 is a swivel member 96, upon which a U-shaped bracket 98 is rotatably mounted. As shown in FIGS. 1 and 4, the arms of bracket 98 are mounted at their ends upon the central pivot rod 68, between the ears of overlapping ears 60, 62 and the sleeve 76.

The rods 84, 86 and 90, 92, together with their connecting links 82, 88 and 94, form a pair of parallelogram linkages which permit the thermocouple assembly to be raised and lowered, rotated, and moved in transverse directions. The stand 12 is thus capable of wide adjustment to position the thermocouple assembly properly in relationship to the patient being treated. A spring 100 may be included in the stand assembly, as shown in FIG. 1, to counterbalance the weight of the thermo-electric assembly 14.

As shown in FIG. 4, a two-conductor electrical cable 102 is provided for energizing the thermocouple assemblies 30. The cable 102 extends through the base 80 and rods of the stand 12, and through the pivotal mount of the bracket 98, as shown in FIG. 4, and the leads 104 and 106 of cable 102 extend through insulating bushings 108 in the fins 58 of the heat dissipating members 48.

Each of the thermocouple modules 30 has a pair of terminal strips 108 and 110, as shown in FIG. 6. The leads 104 and 106 are connected to the terminal strips 108 and 110 at the ends of the thermocouple series, that is the strips of the modules in thermo-electric members 16 and 22. The other terminal strips 108 and 110 are interconnected by short leads 112 in such a manner that the thermocouple modules 30 of the members 16, 18, 20 and 22 are connected in series through leads 104 and 106 to an electrical power source 114, as shown in FIG. 6. The power source 114 may be a source of line direct current, or may be a self-contained unit including nickel-cadmium or other dry cells.

As shown in FIG. 6, the terminals of power source 114 are connected by leads 116 and 118 through an on-off switch 120 which is controlled by a heat sensitive relay 122, and a polarity-reversing switch 124 to the leads connected to the series of thermocouple modules 30.

It is well known that when direct current is fed to thermocouple modules of the type shown herein, a Peltier effect is produced, causing one side of the semiconductor elements 34, 36 to produce refrigeration, and the other sides thereof to produce heat. Thus, in one set of junction plates, for example, the lower plates 40 will become the "cold side" of the module and the upper plates 38 will become the "hot side." If the polarity of the direct current is reversed, the lower plates 40 will become the "hot side" and the upper plates 38 the "cold side." In normal use of the hypothermia instrument, the electrical circuit is arranged to provide a current of such polarity to the series of modules 30 that the lower plates 40 will be cooled and the upper plates 38 will be heated. If desired, however, the polarity-reversing switch 124 can be utilized to reverse each adjacent pair of thermo-electric members. Since the lower plates 40 of each module 30 are in heat-exchange relationship with one of the plates 24, it will be appreciated that the cooling effect produced at the lower module plates 40 will be transferred to plates 24 and thus distributed over a wide area to the surrounding atmosphere. The heat produced at the upper module plates 38 will be transferred to the heat dissipating member 48 and distributed to the atmosphere through fins 58 remote from the cooling effect, the member 48 thus serving as an efficient heat sink.

The switch 120 is of the usual single-pole, single throw type and may be manually operated to open and close the circuit, or may be associated with a timer (not shown) to automatically open the circuit after a designated heating or cooling period. The variable resistor 122 may be employed to regulate the power supplied and therefore the degree of heating or cooling produced.

In one commercial embodiment of the device, twenty thermocouple units, each consisting of a pair of barium telluride rods of 5 mm. diameter and 5/6 inch length were assembled in series to form a module 30, and four such modules were wired in series and operated at 6 volts at 8 amperes. Under these operating conditions, and with the thermocouple assembly wired to produce a cooling effect at the plates 24, a steady state temperature of between -20° C. and -25° C. was produced at said plates 24. This temperature may, of course, be varied by adjustment of the variable resistor 122.

FIG. 1 shows the manner in which the hypothermia instrument is used for the treatment of facial plastic or cosmetic surgery. The stand 12 is adjusted to bring the thermocouple assembly 14 over and close to the face of the patient A, care being taken to avoid physical contact with the patient's face. The nuts 74 are then progressively loosened and re-tightened to adjust the angles between the individual thermo-electric members 16, 18, 20 and 22, in such a manner that these members surround the affected facial areas in close proximity thereto.

The thermocouple assembly 14 is then energized by closing switch 120, and the modules operate as previously described to cool the plates 24 of each thermo-electric member. A volume of relatively cold air is thus maintained between the assembly 14 and the patient's face, the cooling effect acting as an anesthetic, reducing swelling, and providing other recognized benefits. Because the cooling elements are not in contact with the affected body areas, tissue repair is not disrupted, and there is no tissue damage produced.
If desired, the fins 58 of the heat-dissipating member 48 may be replaced with hollow containers through which cold water is circulated to provide a more efficient heat sink and thus maintain lower temperatures at the heat-transfer plates 24.

While a preferred embodiment of the invention has been shown and described herein, it is obvious that numerous omissions, changes and additions may be made in such embodiment without departing from the spirit and scope of the invention.

What is claimed is:

1. A hypothermia instrument comprising an adjustable stand, a thermo-electric assembly mounted on said stand and including a plurality of thermo-electric members hinged to each other, each thermo-electric member comprising an outer heat-transfer plate communicating with the atmosphere, a thermo-couple module having hot junctions and cold junctions, and means mounting the thermo-couple module flush against said heat-transfer plate with one of said junctions in heat-exchange relationship therewith, means for locking said thermo-electric members in adjusted hinged positions with the heat-transfer plates thereof at selected angles with relationship to each other, and means for connecting each of said thermo-couple modules to a power source.

2. A hypothermia instrument comprising an adjustable stand, a thermo-electric assembly mounted on said stand and including a plurality of thermo-electric members, hinge means connecting together said thermo-electric members in a linear array, each thermo-electric member comprising an outer heat-transfer plate communicating with the atmosphere, a thermo-couple module having hot junctions and cold junctions, and means mounting the thermo-couple module flush against said heat-transfer plate with one of said junctions in heat-exchange relationship therewith, means for locking the hinge means of said thermo-electric members in adjusted positions with the heat-transfer plates of said members arranged at selected angles with relationship to each other, and means for connecting said thermo-couple modules in series to a power source.

3. A hypothermia instrument according to claim 2 in which each heat-transfer plate is in heat-exchange relationship with the cold junctions of its associated module.

4. A hypothermia instrument according to claim 3 in which each thermo-electric member has a heat-dissipating member mounted in heat-exchange relationship with the hot junctions of said module, said heat-dissipating member having a plurality of spaced heat-conductive fins communicating with the atmosphere and remote from the heat-transfer plate.

5. A hypothermia instrument comprising an adjustable stand, a thermo-electric assembly mounted on said stand and including a plurality of interconnected thermo-electric members, each thermo-electric member comprising a flat, rectangular heat-transfer plate communicating with the atmosphere, a thermo-couple module having hot junctions and cold junctions, and means mounting the thermo-couple module flush against said heat-transfer plate with said cold junctions in heat-exchange relationship therewith, hinge means interconnecting said thermo-electric members with their heat-transfer plates in linear alignment, manually-adjustable clamping means associated with each of said hinge means for individually varying and locking the thermo-electric members in selected angular positions relative to each other, means for connecting said thermo-couple modules in series to an electrical power source for energization of said modules to produce cooling at said heat-transfer plates, the cooling being transferred to said plates to the surrounding atmosphere in the vicinity of said plates, and a heat sink mounted in heat exchange relationship with the hot junctions of each of said modules, said heat sinks being remote from said heat-transfer plates.

6. A hypothermia instrument according to claim 5 in which said stand comprises a base, a pair of parallel arms upstanding from said base and pivoted thereon, a second pair of arms carried by said first pair, links connecting the ends of said pairs of arms and forming therewith parallelogram linkages, and means swivelly mounting said thermo-electric assembly at the ends of said second pair of arms for adjustable positioning of said thermo-electric assembly in closely spaced proximity to a body area to be treated by said hypothermia instrument.

7. A hypothermia instrument according to claim 5 in which said hinge means comprises pairs of overlapping ears at adjacent ends of said thermo-electric members, and pivot pins extending through and connecting each set of overlapping pairs of ears, and said clamping means comprises a nut mounted on each of said pivot pins and manually turnable to a position in which it clamps together said pairs of ears.

8. A hypothermia instrument according to claim 5 in which said connecting means includes a variable resistor located in series with said modules and said power source for controlling the temperature of said plates.

References Cited by the Examiner

UNITED STATES PATENTS

2,476,645 2/1949 Wazenberg 128—405
2,978,875 4/1961 Lackey et al. 62—3
3,093,135 6/1963 Hirschhorn 128—303.1
3,238,944 3/1966 Hirschhorn 128—400

FOREIGN PATENTS

237,596 2/1962 Australia.

RICHARD A. GAUDET, Primary Examiner.
W. E. KAMM, Assistant Examiner.