July 13, 1965 G. H. SUDMEIER 3,194,023

THERMO-ELECTRIC REFRIGERATOR UNIT

Filed March 20, 1963 2 Sheets-Sheet 1

FIG. 1.

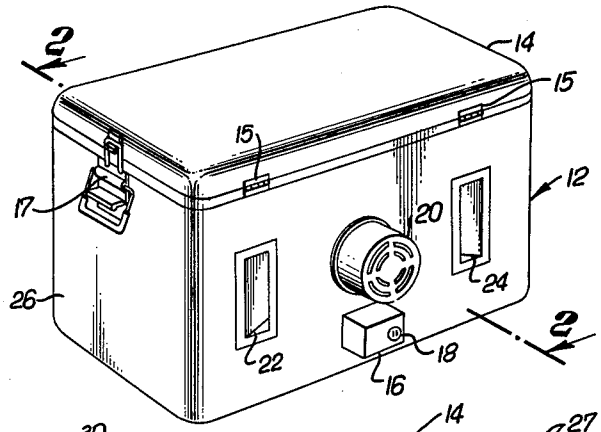
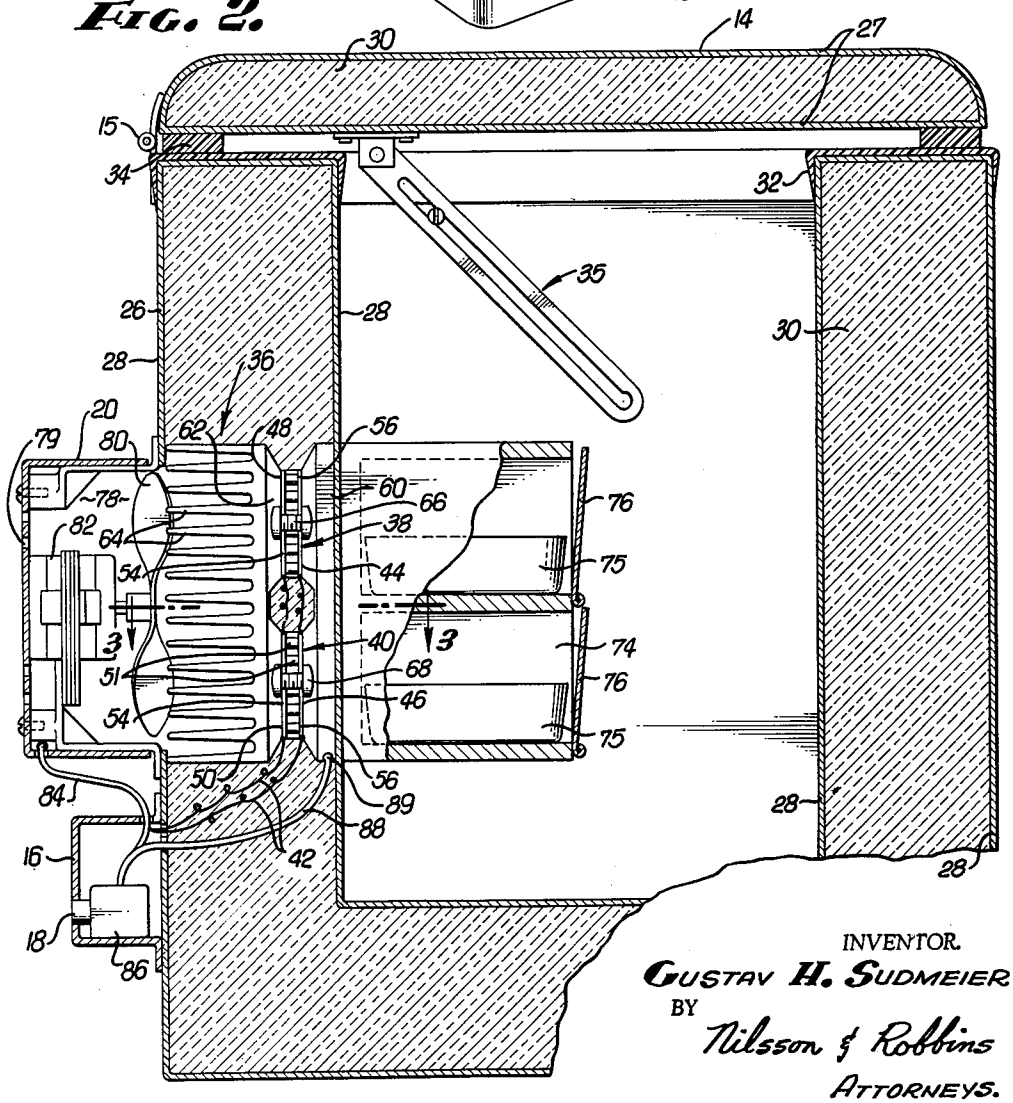


FIG. 2.



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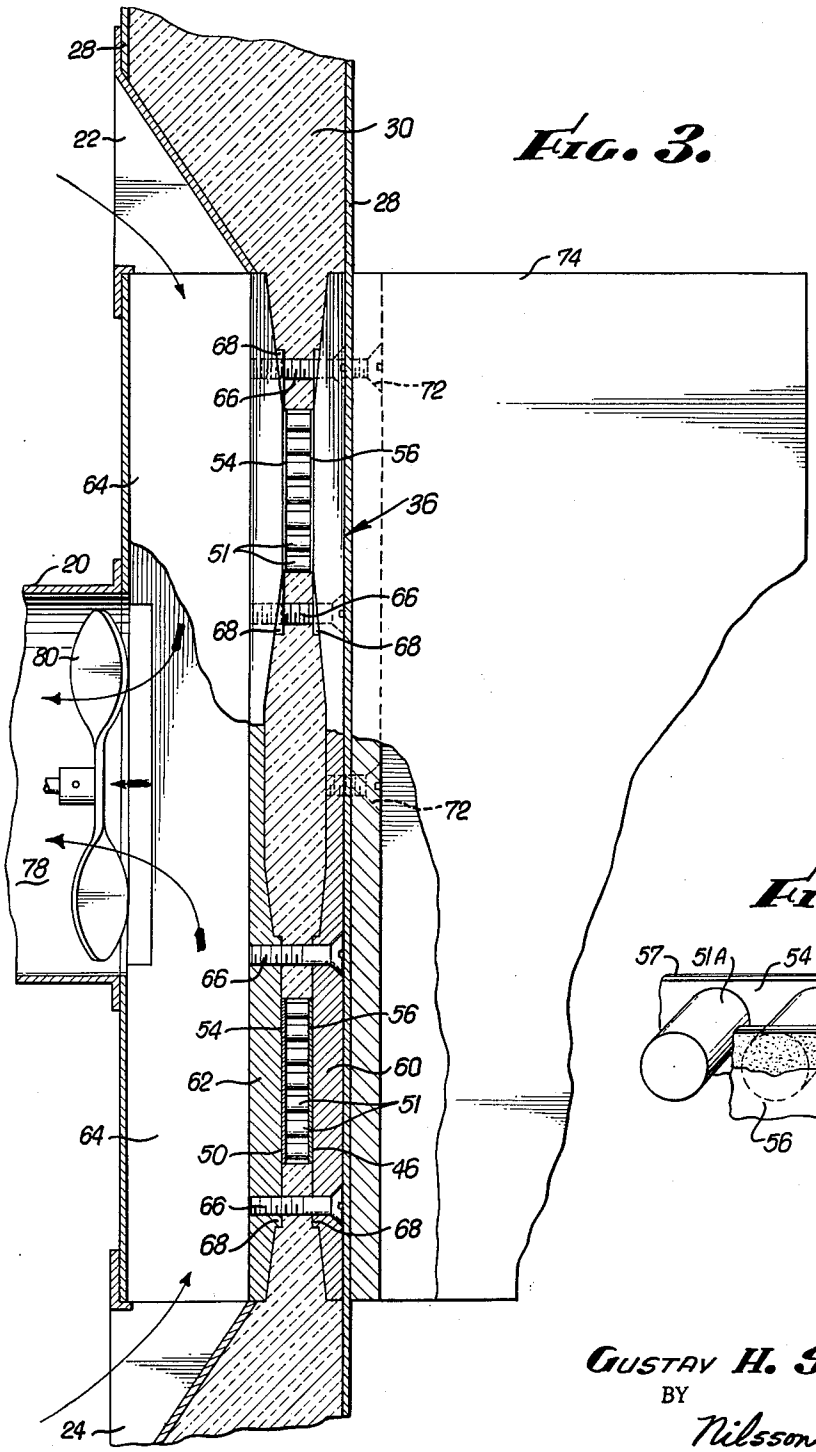


FIG. 3.

FIG. 4.

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THERMO-ELECTRIC REFRIGERATOR UNIT

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6 Claims. (Cl. 62—3)

The present invention relates to refrigeration systems, and particularly to an improved refrigeration unit which employs thermo-electric cells to accomplish cooling with electrical energy.

In past years refrigeration has been accomplished almost universally by systems that circulate fluid which is alternately condensed and evaporated to carry heat from an insulated chamber. The widespread use of such systems attests to their value; however, certain disadvantages are attendant all of the circulating-fluid systems. Specifically, these systems are quite complex and are therefore somewhat expensive even when manufactured in very large quantities. Furthermore, as the systems normally include moving mechanisms, they are subject to wear, and produce noise. Still further, the containment of the fluid refrigerant is sometimes a problem even though it is carried in a completely-sealed system.

The phenomenon of thermo-electric cooling has been recognized for some time as a possible theory of operation to avoid the disadvantages of circulating-fluid refrigeration systems. In general, this phenomenon occurs when electrical current is passed through certain materials which then develop cold at one junction surface and heat at the other surface. One prior structure utilizing this phenomenon, termed a thermo-electric cell, includes short rods of bismuth telluride stacked in alignment between conductors that carry current to the rod. The conductors are formed into two opposed surfaces at the ends of the rods. In operation, when electrical current is passed through the rods, one of the surfaces becomes cold while the other becomes hot.

Although the efficiency of thermo-electric cells as described above, and in various other structural forms, has been effectively increased during recent years, considerable difficulty has been encounted in incorporating them into a commercially-feasible refrigeration unit. One specific problem is that the hot and cold sides of the cells are physically quite close together. Therefore, considerable difficulty is experienced in heat insulating the two surfaces. Furthermore, in order to obtain the maximum effectiveness of thermo-electric cells in a refrigeration unit, it is important to provide effective heat-transfer paths to accommodate heat flow out of the insulated chamber. Difficulty has been experienced in this regard.

The present invention, in general, comprises a refrigeration unit incorporating at least one thermo-electric cell which is electrically driven to produce cold. A cold-producing surface on each thermo-electric cell is contacted by a cold plate, through a heat-transfer paste or fluid to avod insulating spots on the cold-producing surface. The cold plate extends outwardly to increase its cross section as it enters a cold chamber, thus permitting improved insulation for the cold plate from the heating or hot portion of the thermo-electric cell. The heat-producing surface of each thermo-electric cell is similarly contacted by a heat-radiating plate, which extends outwardly to include integrally-formed fins. A blower then cools the fins by producing an airstream which is directed freshly to the fins adjacent each thermo-electric cell.

An object of the present invention is to provide an improved refrigeration unit.

Another object of the present invention is to provide an economical and efficient refrigeration unit which employs thermo-electric units energized by electrical energy.

Still another object of the present invention is to provide a refrigeration unit employing thermo-electric cells, in which effective insulation and heat transfer provide considerable improvement.

A further object of the invention is to provide a compact refrigeration unit which is relatively silent in operation, requires very little maintenance, and is economical to manufacture and use.

These and other objects and advantages of the present invention will become apparent from a consideration of the following taken in conjunction with the drawings, wherein:

FIGURE 1 is a perspective view of a refrigeration unit constructed in accordance with the present invention;

FIGURE 2 is a vertical sectional view taken along line 2—2 of FIGURE 1;

FIGURE 3 is a horizontal sectional view taken along line 3—3 of FIGURE 2; and

FIGURE 4 is a segmented view of a portion of a thermo-electric cell as constructed in the unit of FIGURE 1.

Referring initially to FIGURE 1, the refrigeration unit of the present invention is there incorporated into a box or unit **12** which provides a cold chamber for the storage of food or other commodities to be refrigerated. The unit **12** is closed by a lid **14** bearing hinges **15** providing access to the refrigerated chamber. The lid may be locked in place by clamps **17**, mounted on the sides of the unit as shown. The forward side of the unit (as shown) carries an electrical protective cover **16** containing a receptacle **18** into which a cord from a source of electrical energy may be inserted to energize the refrigeration unit. Above the cover **16** a housing **20** is mounted to contain a blower for drawing air into the unit through the housing **20** and out of the unit through a pair of louvres **22** and **24** as will be considered below in greater detail. In general, the electrical system in the unit of FIGURE 1 is energized by electrical current applied through the receptacle **18** to transfer heat out of the interior of the chamber within the unit **12**, the heat being carried by air exiting through the louvres **22** and **24**.

Considering the unit in greater detail, reference will now be made to FIGURES 2 and 3, showing sections of the unit as indicated above. The lid **14** of the unit (FIGURE 2) is affixed to the box **26** by hinges **15** so that it may be lifted for access to the refrigerated interior of the box. The lid **14** and the refrigeration box **26** are formed of similar structure comprising double walls **27** and **28** of sheet aluminum, which enclose polyurethane foam linings **30** serving as an effective heat insulator or barrier to heat flow.

The upper edge surface of the box **26** carries a box collar **32** which may be formed of moulded plastic contacted by a closed loop **34** of polyurethane serving as an insulation gasket for the lid **14** and the box **26** when the lid is lowered to a closed position.

In raising and lowering the lid **14**, guidance is provided by a holding arm structure **36** which is affixed between the lid **14** and the box **26** which arm also supports the lid in an open position.

The actual cooling apparatus **36** is affixed in one of the larger-area walls of the box **26**. Cooling is accomplished by thermo-electric cells **38** and **40** located substantially at the center of the cooling apparatus **36**. These cells are energized through conductors **42** and provide cold at surfaces **44** and **46** and heat at surfaces **48** and **50**. Structurally, the cells comprise short rods **51** (FIG-

URE 4) which are mounted in a regular array between segmented plates, or conductors 54 and 56. The rods 51 may be formed of bismuth telluride as well known, and are electrically connected between conductors as conductors 54 and 56. The conductors 54 and 56 which may be copper plates, serve to interconnect the ends of the rods and provide junctions with the rods at which heating and cooling occurs.

Specifically, referring to FIGURE 4, electrical current is applied first to the forward end of the rod 51A, to pass to the rear of the rod and into the conductor 54, at which junction cooling occurs. The current then flows through the conductor 54 to the junction of that conductor and the rod 51B, at which cooling again occurs. The current then passes through the rod 51B to the forward conductor 56, which provides a junction of the heating type along with a connection to the following rod 51C. Of course, the actual cells 38 and 40 comprise a large number of the individual rods 51 mounted between many conductors; however, the illustration of FIGURE 4 indicates the manner of their interconnection and mounting. Depending upon the manner in which the lattice of conductors, that is conductors 54 and 56, are arranged, various combinations of parallel and serial interconnections may be affected. However, in the present system a satisfactory mode of operation has been accomplished by arranging the conductors and the rods to provide 12-volt operation useful in conjunction with a conventional automobile battery.

Referring now to FIGURES 2 and 3, it may be seen that the rods 51 are held between the plate conductors 56 to form the relatively flat, rectangular thermo-electric cells 38 and 40. The surfaces of the cells 38 and 40 are contacted by a heat-transfer liquid or paste coating 57 (FIGURE 4) which may take the form of heavy silicone grease. This coating avoids small insulating spaces on the cell surfaces. Therefore, an exceedingly thin coating 57 exists on each surface of the cells.

The internal surfaces 44 and 46 of the cells develop cold and are contacted by a cold-transfer plate 60 which may be formed of aluminum and is electrically insulating with reference to the cold surface of the cells 38 and 40. A somewhat similar plate 62 incorporating radiating fins 64 engages the heat-developing surfaces 48 and 50 of the cells through the coatings 57. The plates 60 and 62 may be formed of aluminum which is anodized. The anodized surfaces of the plates 60 and 62 (engaging the cells 38 and 40) are coated with a very thin layer of electrical insulating material as Formvar enamel. Of course, if desired, the entire plates may be coated. Therefore, the hot and cold surfaces of the cells 38 and 40 are electrically insulated from the plates 60 and 62; however, a good heat-transfer path exists between these elements.

The cold plate 60 is affixed to the hot plate 62 by plastic screws 66 (FIGURE 3) which pass through short bosses 68 formed in the facing surfaces of the two plates. These bosses facilitate drilling the threaded bores which receive the screws 66. It is to be noted, that the plastic material of the screws 66 renders these screws electrically insulating as well as heat insulating, so that neither a heat path or a current path exists between the two plates as a result of the coupling screws 66.

The facing surfaces of the plates 60 and 62 taper away from one another at the edges of the cells 38 and 40 in all four directions. This tapering gradually and smoothly increases the cross-sectional area of the plates. Therefore, a structure is provided with no sharp abutments, yet which permits greater insulation of the hot plate from the cold plate. That is, the tapered surfaces permit an increased thickness for the insulation layer 70 which may be polyurethane foam. By smooth tapering to provide a gradually-increasing space, concentrated or cold spots which would occur at corners or other sharp points of demarkation in the surfaces are avoided.

To provide support for the cooling apparatus 36, the

cold plate 60 is affixed to the inner liner or inner wall 28 of the box by metal screws 72 (FIGURE 3), which pass through a rear wall of an ice-tray box 74 which may be formed as a single integral aluminum casting. These mating surfaces are also coated with heat conductive paste or liquid as silicone grease to avoid insulating air pockets. The surface of the box 74 which engages the wall 28 mates with the area of the cold plate 60 affixed to the wall. Therefore, an effective cooling path is developed by the structure. The box 74 may contain a pair of ice trays 78 (FIGURE 2) in separate chambers which are closed by spring-biased hinged doors 76.

Consider now the structure for transferring the heat away from the cells 38 and 40 and out of the cooling apparatus 36. Referring to FIGURE 2, the exterior of the fins 64 extend outward to abutt the outer wall 28 of the box 26 acting as a shroud to close off the inner wall of the box. Furthermore, this abutment provides physical support for the cooling apparatus 36.

The fins 64 also provide transverse channels extending across the rear of the box. These channels are closed by the outside wall 28 of the box, except for an intake duct 78 entering the housing 20 (FIGURE 1) through a grill 79 (FIGURE 2), and discharge louvres 20 and 22. Positioned within the housing 20 is a blower 80 (FIGURE 2) driven by an electric motor 82 energized through conductors 84 which are connected to the electrical control box 86 within the cover 16. The control box 86 is also connected by conductors 88 to a thermo bulb 89 which regulates the application of power to the motor 82 and the cells 38 and 40 in accordance with the temperature of the cold plate 60, as well known in the prior art.

In the manufacture of the unit of the present invention, the cells 38 and 40 are first assembled in accordance with various well known prior techniques. Next, the exterior surfaces of these cells are coated with heat-conductive paste or fluid to form the coating 57, and plastic screws 66 are inserted to join plates 62 and 60 clamping the cells between. Next, the ice-tray box 74 is positioned inside the refrigeration chamber and screws 72 are inserted through the rear wall of the box into the cold plate 60, thereby mounting the box 74 and the cooling apparatus 36. Thereafter, the electrical connections to the thermo bulb 88 and the cells 38 and 40 are brought to the control box 86. As a last stage of assembly, the motor 82 (mounted in the housing 20) is affixed to the exterior wall 26 so that the blower 80 is positioned adjacent the fins 64. The motor 82 is then connected to the control box 86.

In using the unit of the present invention as described in exemplary form above, an electrical cord is connected to the control box 86 to provide electrical energy to the motor 82 and the cells 38 and 40. Upon initial energization, the thermo bulb 86 senses a relatively high temperature at the cold plate 60; therefore, a control switch in the control box 86 permits the energization of the motor 82 and the cells 38 and 40. Upon energization of the cells 38 and 40, heat is generated at their external surfaces 48 and 50 while cold develops at the internal surfaces 44 and 46. As a result of the effective heat-transfer paths set up with respect to these surfaces, heat is rapidly moved from the box 74 and the interior wall 28 through the cold plate 60, and the cells 38 and 40, into the fins 64. The blower then forces air at ambient temperature through the exhaust duct 78 to form a jet which draws air freshly over the fins adjacent each of the separate cells 38 and 40. As a result, ambient air strikes the fins adjacent each cell at substantially ambient temperature. Therefore, the heat-transfer between the fins 64 and the air is more effective, permitting the air to be raised in temperature and carry heat from the fins 64.

The feature of applying fresh cooling air to the heat radiators for each cell individually constitutes an important feature of the present invention, permitting more effective operation of the unit. Therefore, heat is re-

moved from the ice-tray box 74 until the refrigerated chamber is cooled to the temperature established by the control unit, at which time the motor 82 and the cells 38 and 40 are de-energized until a subsequent temperature rise. In view of the structure for insulating the cold cell surfaces 44 and 46 from the warm cell surfaces 48 and 50, along with the effective heat-transfer paths, the operation cycle is of relatively short time.

In this regard, an important feature of the present invention resides in the use of heat-insulating means as the screws 66 to join tapered surface transfer plates with the thermoelectric cells therebetween.

Still another important feature of the present invention resides in the use of heat-transfer paste or liquid to couple various members in the heat-transfer path whereby to avoid insulating spots on surfaces contained in the heat-transfer path.

Still a further important feature resides in the structure of anodized aluminum heat-transfer plates adjacent the thermo-electric cells, which plates are rendered electrically-insulating relative the cells by coating their anodized surfaces with a layer which is not heat-insulating.

These and other features of the present invention are evident from the embodiment described herein; however, the scope of the invention is not to be limited to this embodiment, but rather is to be defined by the following claims.

What is claimed is:

1. A refrigeration unit, comprising: a plurality of thermo-electric cells for receiving electrical energy to produce a temperature differential between a first surface and a second surface whereby said first surface cools and said second surface warms; a first heat-conductive member having plural first faces to engage said second surfaces, said first faces being separated by channels tapering to a bottom therein, said member further including radiating fins remote from said faces; a deformable layer of heat-transfer paste-like material between said first faces and said second surfaces; a second heat-conductive member including a first plate with plural second faces to engage said first surfaces, said second faces being separated by channels tapering to a bottom therein, and a second plate adapted to be affixed to said first plate; a deformable layer of heat-transfer paste-like material between said second faces and said first surfaces; an enclosure means to provide an insulated volume; means for mounting said plurality of thermo-electric cells in said enclosure, including an inner wall of said enclosure held between said first plate and said second plate; and a blower means for directing an airstream into said fins whereby said airstream is divided to flow over said fins.

2. A refrigeration unit, comprising: a plurality of thermo-electric cells for receiving electrical energy to produce a temperature differential between a first surface and a second surface whereby said first surface cools and said second surface warms; a first heat-conductive member having plural first faces to engage said second surfaces, said first faces being separated by channels tapering to a bottom therein, said member further including radiating fins remote from said faces; a deformable layer of heat-transfer paste-like material between said first faces and said second surfaces; a second heat-conductive member including a first plate with plural second faces to engage said first surfaces, said second faces being separated by channels tapering to a bottom therein, and a second plate adapted to be affixed to said first plate; a deformable layer of heat-transfer paste-like material between said second faces and said first surfaces; an enclosure means to provide an insulated volume; means for mounting said plurality of thermo-electric cells in said enclosure, including an inner wall of said enclosure held between said first plate and said second plate.

3. A refrigeration unit, comprising: a plurality of thermo-electric cells for receiving electrical energy to produce a temperature differential between a first surface and a second surface whereby said first surface cools and said second surface warms; a first heat-conductive member having plural first faces to engage said second surfaces, said first faces being separated by channels taperring to a bottom therein, said member further including radiating fins remote from said faces; a deformable layer of heat-transfer paste-like material beween said first faces and said second surfaces; a second heat conductive member including a first plate with plural second faces to engage said first surfaces, said second faces being separated by channels tapering to a bottom therein, and a second plate adapted to be affixed to said first plate; a deformable layer of heat-transfer paste-like material between said second faces and said first surfaces; an enclosure means to provide an insulated volume; means for mounting said plurality of thermo-electric cells in said enclosure, and a blower means for directing an airstream into said fins whereby said airstream is divded to flow over said fins, said blower being positioned at an exhaust location for said airstream directed over said fins.

4. The invention according to claim 2 in which said heat-transfer paste-like material is a relatively viscous silicone grease.

5. The invention according to claim 2 in which said thermo-electric cells comprise rods extending between said first and second surfaces and have a substantially metallic composition including bismuth telluride.

6. The invention according to claim 3 which further includes at least one polyurethane foam body disposed in at least one of said channels.

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