The present invention relates to a refrigeration system, and particularly to an improved refrigeration structure that employs thermo-electric cells to accomplish a temperature differential, and which unit is well suited for automotive use.

In recent years, thermo-electric refrigeration systems have been developed to accomplish a temperature differential directly from an electrical current. One such system is shown and described in co-pending application Serial Number 266,757, by the present inventor, which application will issue as United States Patent No. 3,194,005, the subject matter of which is related to the structure hereof.

In general, prior systems employing thermo-electric techniques, have included a plurality of short rods, made for example of bismuth telluride, which rods are stacked in alignment between conductors so as to be energized by an electrical current. The electrical current then causes a temperature differential across the rods that is sufficient for either heating or cooling. Various structures employing the thermo-electric rods have generally had certain attendant disadvantages. Specifically, for example, it is important that refrigeration units of this type possess good insulation characteristics; however, with heating and cooling, the units undergo significant physical deformation which is often difficult to accommodate in a well-insulated structure.

Another aspect of structures employing thermo-electric rods is the difficulty of providing the desired electrical connections to the rods in an array. For example, it may be desirable to connect the individual rods in a serial circuit; however, as the rods are physically disposed in parallel between two plates, and as the plates have been formed normally of metal to provide good thermal conductivity, the rods have generally been employed in a parallel electrical connection although in many instances some serial connection may have been desired. In addition to these considerations, any technique which can improve the effective operation of a thermo-electric unit represents a substantial advantage in the art.

Accordingly, it is an object of the present invention to provide an improved thermo-electric unit which is not subject to these and other disadvantages of prior structures.

Another object of the present invention is to provide an improved thermo-electric unit which incorporates effective insulation characteristics and rugged mechanical support structure capable of accommodating physical changes attendant temperature changes.

Still another object of the present invention is to provide an improved mounting structure for thermo-electric rods, whereby they may be connected in various parallel and serial relationships, by employing mounting plates of heat-conductive ceramic, clad with conductive patterns to accomplish the desired connections.

A further object of the present invention is to provide an improved thermo-electric structure incorporating economical mounting for a plurality of thermo-electric cells, and incorporating structure to define air-flow ducts through the structure.

One further object of the present invention is to provide an improved system for air conditioning an automobile by either warming or cooling the interior of the automobile through use of a thermo-electric structure particularly adapted for such application.

Still one further object of the present invention is to provide an improved thermo-electric structure employing thermo-electric cells, and incorporating improved heat-flow paths, whereby to obtain effective operation in a variety of installations.

Briefly, these and other objects and advantages of the present invention are achieved in accordance with the structural features of one example of the invention which includes a group of thermo-electric cells, each of which comprises an array of thermo-electric rods mounted between plates of heat-conductive ceramic and interconnected by metallic foils; the cells then being clamped between metallic plates which are supported in a chamber defined by elongate face opposing channels which are in turn enclosed within an insulating body.

Further details of the structure of the present invention as well as additional objects and advantages thereof will become apparent and will be best understood from a consideration of the following description taken in conjunction with the accompanying drawings which are all presented by way of illustrative example only; and in which:

FIGURE 1 is a diagrammatic representative of a system constructed in accordance with the principles of the present invention;

FIGURE 2 is a sectional view of the temperature control unit of FIGURE 1;

FIGURE 3 is a sectional view along the line 3—3 of FIGURE 4;

FIGURE 4 is a sectional view along the line 4—4 of FIGURE 3;

FIGURE 5 is a fragmentary view of a portion of the structure of FIGURE 4; and

FIGURE 6 is a sectional view taken along line 6—6 of FIGURE 5.

Referring initially to FIGURE 1, the diagram discloses the elemental component structure of an automotive air conditioning system. In this regard, effective automotive air conditioning requires capability to cool as well as heat the interior of an automobile. Various systems for cooling and heating an automobile have come into widespread use; however, usually the systems include two distinctly separate structures for heating and cooling. Specifically, for example, the interior of an automobile is typically heated by the engine coolant and cooled by a compressor refrigeration system driven by the engine. These dual systems are usually complex and require substantial maintenance. Furthermore, many automobiles employ air-cooled engines, which are not well suited to provide heat to the interior of the automobile.

In the system as shown in FIGURE 1 an automobile engine 10 drives an alternator 12 through a mechanical coupling indicated by a dashed line 14. The alternator 12 then provides electrical energy through conductors 16 to a battery 18. As a result, the pulsating direct current output of the alternator 12 (as well known in the prior art) is transformed into steady-state direct current output from the battery 18 which appears on conductors 20 and 22. The condenser 24 contains a manually-operated switch 26 and is connected to a switch terminal 28, the conductor 22 is connected directly to a switch terminal 30. Both the conductors 20 and 22 are connected to blowers 32 which serve to transport air through a temperature control unit 34 as described in detail below. The temperature control unit 34 is connected to the movable terminals of a reversing switch 36 which alternately engage the terminals 28 and 30 depending upon the state of a relay coil 38. The relay coil 38 is in turn controlled by a thermostat 40.
In the operation of the system as shown in FIGURE 1, closure of the switch 26 initiates either a cooling or a heating operation by the temperature control unit 34, depending upon the temperature sensed by the thermostat 40 which in turn serves to control the coil 38. Specifically, if the thermostat 40 senses a temperature below the actual temperature, the relay coil 38 is energized and the switch 36 contacts the terminals 28 and 30 in such a manner as to cause the temperature control unit 34 to provide cold air to the interior of the automobile as a result of the operation of the blowers 32. Conversely, if the thermostat 40 senses a temperature below the existing temperature, the coil 38 reverses the switch 36 to oppositely engage the contacts 28 and 30 resulting in an oppositely sensed current into the temperature control unit 34 which now provides hot air into the automobile, again by means of the blowers 32. Thus, the temperature control unit 34 may alternately heat and cool the interior of an automobile depending upon automatic setting of the switch 36 or alternatively by manual control is desired.

Considering the detailed structure of the temperature control unit 34, reference will now be had to FIGURE 2 which shows a section of an automobile body 44 defining a space occupied by the temperature control unit 34. The automobile body 44 as shown is contemplated for a rear-engine automobile with the result that the temperature control unit 34 is mounted on the side and supported on a platform bracket 48. Of course, a wide variety of different mounting arrangements and installation techniques may be employed in placing the temperature control unit within an automobile; however, the arrangement as shown in FIGURE 2 has been found to operate satisfactorily.

The temperature control unit 34 contains two distinct air flow passages serving to stabilize the temperature of operation and to provide either warm or cool air into the automobile, as desired. Specifically, a passage 50 through the temperature control unit 34 is connected to an intake duct 52 which is in turn connected to a blower 32a provided with an intake at a vent 54. The exhaust of the passage 50 is connected to an exhaust duct 56 which is in turn connected to an exhaust vent 58. Therefore, ambient air outside the automobile body 44 is drawn into the intake vent 54 by the blower 32a, passed through the intake duct 52 and the passage 50 to be exhausted through the exhaust duct 56 and the vent 58. As a result, undesired heat or cold is carried from the temperature unit 34.

The desired heat or cold as the case may be, is provided inside the body 44 by convection currents which flow through a passage 60 in the temperature control unit 34. That is, a blower 32c forces air from the interior of the body 44 through an intake duct 62 against a divider vane 64, causing the air to flow through the sides 65 and 66 of the passage 60. The side 65a exhausts through a duct 68 while the side 66a exhausts through a duct 70.

At a time when the temperature control unit 34 is functioning to heat the interior of the automobile body 44, air flowing through the passage 60 is heated while air flowing through the passage 50 is cooled. Conversely, during the operation of cooling the interior of the automobile, air flowing through the passage 60 is cooled while air flowing through the passage 50 is heated. As indicated above, the selection of heating or cooling for the interior of the automobile, is determined by the sense of electrical currents which flow through the individual thermo-electric cells contained between the passages 50 and 60 as described in detail below.

The passages 50 and 60 are defined respectively by a pair of elongate channels 72 and 74 (FIGURE 3). The channels 72 and 74 may be formed from a single extrusion, and incorporate a bottom section 76 terminating in outwardly-extending sides 78 which carry lips 80 defining face opposing grooves 82 to receive a plate. Specifically, the grooves in the lips of the channel 72 receive a plate 86 which is integral with elongate fins 88 which extend into the passage 60 defined by the channel 72. The plate 86 along with the integral fins 88 may be formed of an aluminum alloy such as those fins 88 may incorporate serrations 89 to afford greater radiating area. The grooves 82 in the lips of the channel 76 receive a plate 90 having an array of pin fins 92 extending outwardly therefrom into the passage 56. The pin fins 92 are provided in an array of rows and columns; however, the rows and columns need not be regularly formed. In one form of the structure, the plate 90 has been formed of sheet copper, with the pin fins 92 spot welded thereto in the form of copper rods.

The plates 86 and 90 comprise a clamp held together by nylon studs 94 that are threadably received in the plate 90. Of course, other forms of insulating material may be employed as the studs 94. The individual thermo-electric cells 96 are thus held clamped between the plates 86 and 90 to which the radiating fins are attached so as to extend into the spaces defined by the channels 72 and 74. The integral unit is thus bound together as a flexible package and is covered by an insulating body 98 of light-weight foam material for example which may take the form of polyurethane. The exterior surface of the body 98 is then clad with a skin 100 of aluminum foil or other material. The insulating body 98 and the fins 92 comprise temperature control unit may be formed to various lengths, and easily accommodate various numbers of cells 96 depending upon each particular application. The spaced apart relationship of the cells 96 within the unit accommodates physical distortion resulting from temperature changes and furthermore in this regard, it is to be noted that the channels 72 and 74 having a cross section that is generally U-shaped, are somewhat resilient, also to accommodate distortion.

Considering the detailed structure of the cells 96, reference will now be had to FIGURES 5 and 6 showing individual rods 104 which are mounted in a regular array as shown. The rods 104 may be formed of bismuth telluride, as well known in the prior art, and are electrically connected between conductors in the form of foil sheets 106 and 108. The sheets 106 and 108 may comprise copper clad upon electrically insulating plates 110 and 112 respectively. These plates may comprise any of a variety of heat-transmissive, electrically-insulating ceramic materials for example, ceramic compositions comprising either aluminum oxide or beryllium as ingredient. The sheets 106 and 108 are then affixed to the interior surfaces of the plates 110 and 112 respectively as by various techniques widely employed in the printed-circuit arts. The arrangement of the conductive sheets 106 and 108 may be made to accommodate any desired combination of serial and parallel circuits. For example, the rods 104 within a particular cell and placed in a rectangular array, may all be connected in serial relationship by staggering the pattern of the sheets 106 and 108 on the plates 110 and 112. Of course, other electrical circuit configurations may be employed as desired, simply by providing the requisite patterns of connection.

The exterior surfaces of the plates 110 and 112 matingly engage the clamping plates 86 and 90. In this regard, the plate 112 is tinted or coated with solder in an exterior coating 114 while the exterior surface of the plate 110 is coated with a heat-transmissive paste, e.g. silicone grease in a coating 116. The solder coating 114 on the plate 112 is then fused to join that plate to the clamping plate 90. However, the paste coating 116 on the plate 110 serves to mate the surfaces of that plate with the plate 86 accomplishing good thermal conduction; however no physical connection, or attachment.

In the operation of the system, assume initially that it is desired to cool the interior of the automobile body 44
5 (FIGURE 2) by convection currents passing through the passage 60. Thereupon, the manual switch 26 (FIGURE 1) is closed and the switch 36 is permitted to engage the contact terminals 28 and 30 in the residual position, i.e. without manual change or change by the coil 38. As a result, a current flows from the battery 18 to the temperature control unit 34, and specifically to the rods 104 (FIGURE 5) through the conductive sheets 106 and 108. In one successful operating embodiment, the rods 104 are placed in a serial circuit by the array of sheets 106 and 108, as fixed on the insulating plates 110 and 112. The sense of the direct current thus passing through the rods 104 is such that the plate 110 is cooled while the plate 112 is heated. That is, the junctions at the terminals of the rods 104 are heated and cooled respectively so that the cold developed at the insulating plate 110 passes to the clamping plate 86 and the fins 88. Convection air currents propelled by the blower 32b (FIGURE 2) then flow past the fins 88 to flow as cool air from the ducts 68 and 70. As a result, the interior of the body 44 is effectively air conditioned by cool air.

In the event that it is desired to warm the interior of the body 44, the reversing switch 36 (FIGURE 1) is alternated to effectively reverse the sense or flow direction of current through the rods 104. This change of direction has the effect of rerouting the junctions which previously were cold, now hot and similarly changing the previously hot junctions to cold junctions. That is, the ends of the rods 104 shunting the conductive sheets 108 now become hot to in turn heat the plate 110 and the plate 86 with the fins 88. As a result, the convection currents over the fins 88 now warm the flowing air currents and heat the interior of the automobile body 44. Thus, the temperature control unit 34 may serve either as a heater or as a cooling air conditioner. As a result, considerable economy both in maintenance, space, installation expenses, and so on from the combined temperature control unit having dual capability.

A further important feature of the present invention resides in the structure hereof which is sturdy but sufficiently resilient to accommodate physical distortion resulting from temperature changes attendant the operation of the unit. In this regard, it is also important to note that the unit is essentially of elongate structure and may be somewhat cut or tailored to length depending upon any of a variety of custom installations. Further in relation to the ability of the system to accommodate individual applications, an important feature resides in the structure of the electrically-insulating, thermo-conductive ceramic plates which in cooperation with conductive foil permit virtually any selected electrical circuit for the parallel rods. These as well as other features of the present invention are evident from the embodiment described herein which represents merely one exemplary form hereof. However, the scope of the invention is not to be limited by the embodiment disclosed but rather shall be defined in accordance with the following claims.

What is claimed is:

1. A thermo-electric temperature-control structure, comprising:

a plurality of thermo-electric cells for receiving electrical energy to produce a temperature differential between a first exterior surface and an opposed second exterior surface;

clamming means including a pair of parallel clamp plates to hold said cells in clamped alignment with said exterior surfaces thereof contiguous said interior surfaces of said parallel clamp plates;

a pair of elongate open channel means in faced relationship whereby to define a space therebetween, said channel means each engageably receiving one of said clamp plates whereby to contain said cells and said clamping means within said space; and

an insulating body of resilient foam material laid with metal foil encircling said channel means to close said structure.

2. A thermo-electric temperature-control structure in accordance with claim 1 wherein said cells comprise a plurality of thermo-electric rods; a pair of opposed holding plates of heat-conductive metallic ceramic for holding said rods aligned; and plural sheets of metal foil disposed on an interior surface of each of said holding plates for electrical contact to said rods whereby to provide a temperature differential between a first exterior surface of one of said holding plates and a second exterior surface of the other of said holding plates.

3. A thermo-electric temperature-control structure according to claim 2 wherein said metallic ceramic comprises beryllium oxide as a principal ingredient.

4. A thermo-electric temperature-control structure according to claim 2 wherein said metallic ceramic comprises beryllium oxide as a principal ingredient.

5. A thermo-electric temperature control structure, comprising:

at least one thermo-electric cell including a plurality of thermo-electric rods; a pair of opposed holding plates of heat-conductive metallic ceramic for holding said rods aligned; and plural sheets of metal foil disposed on an interior surface of each of said holding plates for electrical contact to said rods whereby to provide a temperature differential between a first exterior surface of one of said holding plates and a second exterior surface of the other of said holding plates; said structure further comprising;

clamping means including a pair of parallel clamp plates to hold said cells in clamped alignment with said exterior surfaces thereof contiguous said interior surfaces of said parallel clamp plates; and

heat exchange means affixed to each of said parallel clamp plates for stabilizing the temperature thereof.

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