United States Patent

Schering

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[54] **THERMOELECTRIC DEVICE**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **62/3,** 136/203, 136/204

[51] **Int. Cl.**..**F25b 27/00**

[58] **Field of Search** 136/203, 204; 62/3

[56] **References Cited**

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[57] **ABSTRACT**

Thermoelectric device includes at least one Peltier block formed of a plurality of n and p-conductive semiconductor legs and metallic bridge members interconnecting the legs at opposite warm and cold sides of the Peltier block, heat exchanger means located respectively at the warm and the cold sides of the Peltier block and having a surface disposed adjacent a surface of the bridge members located at the warm and the cold sides respectively of the Peltier block, and an intermediate layer of solid insulating material and deformable medium for improving heat transfer sandwiched between the surfaces at the warm and the cold sides respectively of the Peltier block, the insulating material being in the form of crystalline particles having a grain diameter exceeding the sum of the roughness depths of the surfaces between which the respective intermediate layer is sandwiched.

9 Claims, 2 Drawing Figures

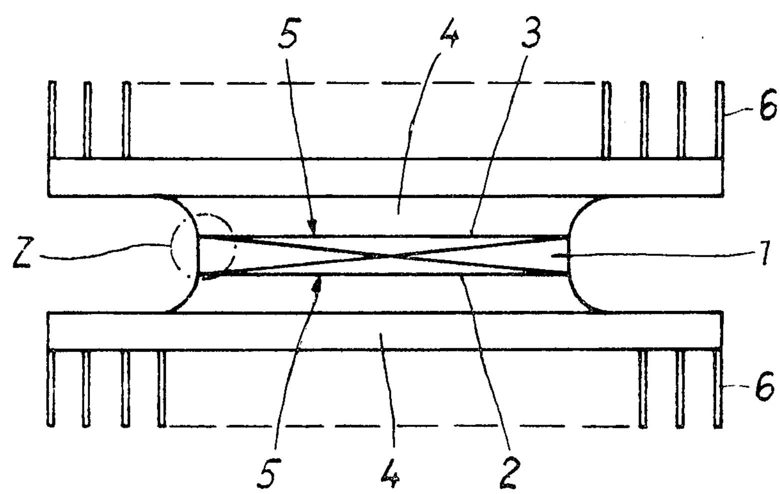

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Fig. 1

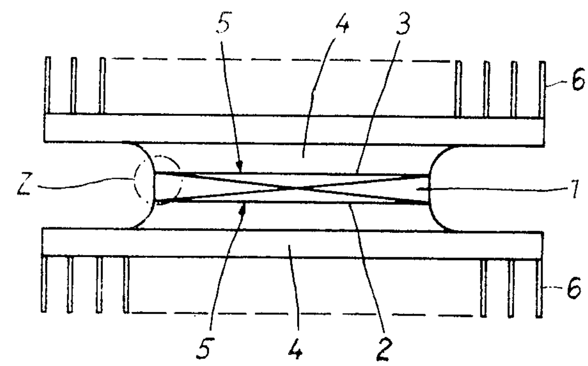
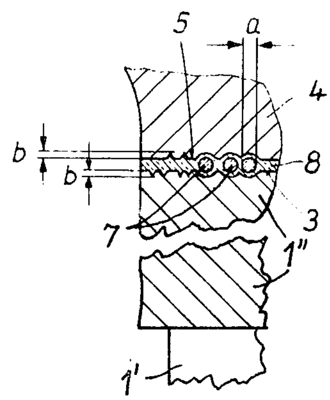


Fig. 2



THERMOELECTRIC DEVICE

My invention relates to thermoelectric device having at least one Peltier block formed of a plurality of n and p-conductive semiconductor legs and metallic bridge members interconnecting the legs at opposite warm and cold sides respectively of the Peltier block, and having a surface disposed adjacent a surface of the bridge members located at the warm and cold sides respectively of the Peltier block, and an intermediate layer of solid insulating material and deformable medium for improving heat transfer, sandwiched between the surfaces at the warm and the cold sides respectively of the Peltier block.

As a general rule, Peltier blocks are constructed so that the n and p-conductive semiconductor legs are traversed in a meandering manner by electrical current. The metallic bridge members between the semiconductor legs of the Peltier block are provided with respective opposite surfaces, on of which is located at the cold and the other at the warm side of the Peltier block. Both sides of the Peltier block are usually provided with heat exchanger devices in order to dissipate heat produced at the warm side thereof to the surroundings or to a cooling medium and in order to absorb heat from the surroundings at the cold side of the Peltier block or to cool a warm medium thereat.

Since the metallic bridge members at one side of the Peltier block have different potentials from one another, electrical insulation is required to be located between them and the heat exchanger element adjacent thereto, so as to prevent a short circuit through the metallic heat exchanger element. However, such electrical insulation causes temperature drop between the respective sides of the Peltier block and the respective surface of the heat exchanger elements located adjacent thereto. This is undesirable from the standpoint of optimum utility of the temperature difference that is available between the Peltier block and the respective heat exchanger elements.

It has been known to dispose heat exchanger element foils such as mica foil or foils of plastic material, for example, between the Peltier blocks and the respective heat exchanger elements, the foils being of solid insulating material which electrically insulates the metallic bridge members from the respective surfaces of the heat exchanger element. To improve heat transfer, auxiliary pasty or soft masses can be applied between the Peltier block on the one hand and the heat exchanger element on the other hand for filling in unevenesses and roughness depths of the surfaces.

Even when great care is taken, it is possible to damage the electrically insulating foil, i.e. to rupture or tear the mica or plastic material foil, during the manufacture of the thermoelectric device, rendering the thermoelectric device unserviceable.

With respect to other known embodiments of the thermoelectric device wherein a mechanically stable or reliable connection between the Peltier blocks and the heat exchanger elements is provided, the aforedescribed heretofore known type of assembly has the advantage that the connecting bridge members, on the one hand, and the heat exchanger elements, on the other hand, can be selected without being concerned with the different coefficients or expansions of the material thereof, but only with the electrical and thermal conductivity thereof. It is especially desired that

the surfaces be movable relative to one another so that the metallic bridge members and the semiconductor legs rigidly connected thereto, are not additionally stressed mechanically.

It is accordingly an object of the invention, to provide thermoelectric device which avoids the disadvantages of the greater number of heretofore known types of thermoelectric devices and which is an improvement over the last mentioned advantageous type of thermoelectric device.

With the foregoing and other objects in view, I provide in accordance with my invention, thermoelectric device comprising at least one Peltier block formed of a plurality of n and p-conductive semiconductor legs and metallic bridge members interconnecting the legs at opposite warm and cold sides of the Peltier block, heat exchanger means located respectively at the warm and the cold sides of the Peltier block and having a surface disposed adjacent a surface of the bridge members located at the warm and the cold sides respectively of the Peltier block, and an intermediate layer of solid insulating material and deformable medium for improving heat transfer sandwiched between the surfaces at the warm and the cold sides respectively of the Peltier block, the insulating material being in the form of crystalline particles having a grain diameter exceeding the sum of the roughness depths of the surfaces between which the respective intermediate layer is sandwiched.

Due to the stated dimensions of the crystalline particles, a minimum spacing between the surfaces to be electrically insulated is established. The advantages of good heat transfer and high mechanical stability are provided by the crystalline structure of the insulating material. In accordance with a further feature of the invention, metallic oxides, such as berryllium oxide, aluminum oxide and quartz, having desirable coefficients of thermoconductivity have sufficiently high electrically insulating characteristics are suitably employed as the crystalline particles.

The properties of thermal conductivity between the surfaces of the device of the invention, is increased to the 10th power when the crystalline particles are formed of silicon carbide. Silicon carbide in itself is an electrical conductor; however, by suitable pre-treatment or when stored for a very long time, an oxide skin or layer is formed on the silicon carbide crystals and has the necessary electrical insulation properties.

In accordance with another feature of the invention, the crystalline particles consist of a multiplicity of substantially spherically shaped grains. The advantage thereof is that the desired flow characteristic between the surfaces which are to be thermally conductively connected, is increased.

In accordance with yet another feature of the invention, in order to increase the coefficient of heat transfer from the Peltier block to the heat exchanger, at least part of the crystalline particles is impressed into the surfaces that are being thermally connected.

In accordance with still another feature of the invention and in order to provide a simplified handling of the particulate material when applied to the surfaces that are to be thermally conductively connected, the particulate material is mixed with a carrier medium which is liquid at least when it is applied to the surfaces. Other added features of the invention are that the carrier medium has an effective viscosity of greater than 100 centistoke when applied to the surfaces, and may be formed at least partly of silicone oil.

In accordance with an additional feature of the invention, the carrier medium for the particulate material is formed of at least one hardenable plastic material which is elastically yieldable and affords equalization of the varying expansion between the heat exchanger and the Peltier block. In accordance with another, more specific feature of the invention, the hardenable plastic material is, for example, artificial resins based on castor oil or ricinus oil-isocyanate(known in the art by the trademark Desmodur).

Other features which are considered as characteristic for the invention are set forth in the appended claims.

Although the invention is illustrated and described herein as embodied in thermoelectric device, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

The construction and method of operation of the invention, however, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing, in which:

FIG. 1 is an elevational view of there thermoelectric device of my invention, showing schematically a Peltier block located between two heat exchanger elements; and

FIG. 2 is a much enlarged fragmentary sectional view of FIG. 1 enclosed within the circle Z thereof.

Referring now to the drawing and more particularly to FIG. 1 thereof, there is shown therein a thermoelectric device in accordance with my invention, which is formed with a Peltier block 1 having a cold side 2 and a warm side 3, both sides being connected to heart exchanger elements 4. Ordinarily, the connections between the heat exchanger elements 4 and the Peltier block 1 are effected by non-illustrated clamping members which press the engagement surfaces 5 of the respective heat exchanger elements 4 against the warm and cold sides 2 and 3 of the Peltier block 1. The heat exchanger elements 4 are provided with fins or ribs 6 through which an air current is passed for suitable warming or cooling the ribs or fins, as the case may be.

The Peltier block 1 is formed of a multiplicity of n and p-conductive semiconductor legs and metallic bridge members coordinated therewith, (only part of the one of the legs 1′ and part of one bridge member 1″ being shown in FIG. 2). The Peltier block is not shown in detail in the drawing, since such devices are well-known in the art. The semiconductor legs are connected electrically in series so that an electric current traverses the semiconductor legs and the connecting metallic bridge members in a meandering or tortuous path. The metallic bridge members are formed, for example, of copper, while the metallic heat exchanger elements 4 are formed of aluminum, for example. Insulation 7 formed of crystalline particulate material is disposed or sandwiched between the surfaces 5 of heat exchanger elements 4 of the adjacent surfaces of the respective bridge members at the warm or cold side of the Peltier block 1. The grain size or diameter a of the particles of the insulating material 7 exceeds the sum of the roughness depths b and b′ of the surfaces 3 and 5 respectively. In the embodiment of FIG. 2, the particulate material 7 is at least partly pressed into the surfaces 3 and 5 that are being connected together. To facilitate handling, the particulate material is mixed with a carrier medium 8 having good heat conductive properties. The particulate material 7 which is formed, for example, of beryllium oxide, aluminum oxide, quartz or silicon carbide, is provided with as spherical a shape as possible in order to improve the flow properties of the intermediate layer sandwiched between the respective heat exchanger elements 4 of the Peltier block 1. River sand, for example, has this spherical shape. The spherical shape can be produced, however, by polishing or grinding in a ball mill, for example.

The carrier medium 8 is advantageously in liquid state at least when applied to the surfaces 3 and 5 that are to be connected together. The liquid carrier medium 8 advantageously has a viscosity of greater than 100 centistoke. Naturally, it is possible to produce a grain medium at least partly of silicone oil.

In certain cases, it is advantageous for the carrier medium to be formed of an elastic, yieldable and expandable plastic material which hardens after being applied to the surfaces 3 and 5, such as, for example, an artificial resin having a base of castor oil or ricinus oil — isocyanate. In order to improve further the thermal conductivity between the Peltier block and the heat exchanger elements, it may be advantageous to employ additional relatively smaller electrically insulating particles whose quantity and size is determined so that they fill the voids located between the particles of crystalline insulating material 7.

I claim:

1. Thermoelectric device comprising at least one Peltier block formed of a plurality of n and p-conductive semiconductor legs and metallic bridge members interconnecting said legs at opposite warm and cold sides of said Peltier block, heat exchanger means located respectively at said warm and said cold sides of said Peltier block and having a surface disposed adjacent a surface of the bridge members located at said warm and said cold sides respectively of said Peltier block, and an intermediate layer of solid insulating material and deformable medium for improving heat transfer sandwiched between said surfaces at said warm and said cold sides respectively of said Peltier block, said insulating material being in the form of crystalline particles having a grain diameter exceeding the sum of the roughness depths of the surfaces between which the respective intermediate layer is sandwiched, and a carrier medium mixed with said crystalline particles, said carrier medium being in liquid state at least when initially applied to said surfaces of said bridge members and both of said heat exchanger means.

2. Thermoelectric device according to claim 1, wherein said crystalline particles are formed of at least one metal oxide.

3. Thermoelectric device according to claim 2, wherein said metal oxide is selected from the group consisting of berryllium oxide, aluminum oxide and quartz.

4. Thermoelectric device according to claim 1, wherein said crystalline particles are formed of silicon carbide.

5. Thermoelectric device according to claim 1, wherein said crystalline particles comprise a multiplicity of substantially spherically shaped granules.

6. Thermoelectric device according to claim 1, wherein said carrier medium in said liquid state thereof has a viscosity of greater than 100 centistoke.

7. Thermoelectric device according to claim 1, wherein said carrier medium consists at least partly of silicone oil.

8. Thermoelectric device according to claim 1, wherein said carrier medium is formed at least partly of a hardening plastic material.

9. Thermoelectric device according to claim 8, wherein said plastic material is a synthetic resin having a base of ricinus oil.

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