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2,519,785

THERMOPILE

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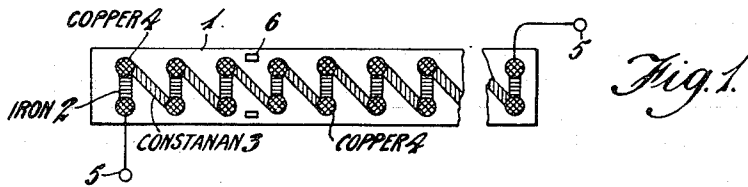


Fig. 1.

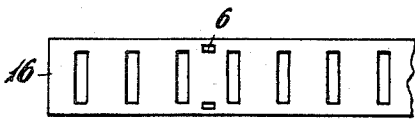


Fig. 2a.

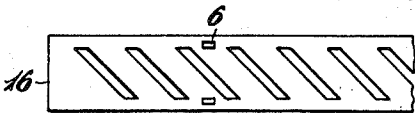


Fig. 2b.

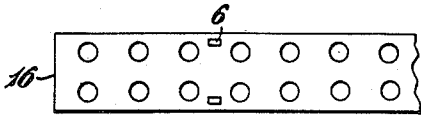


Fig. 2c.

Fig. 3b.

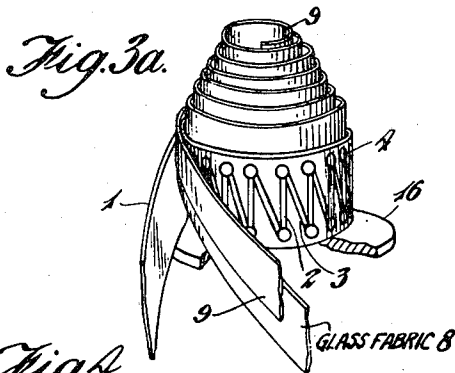


Fig. 3a.

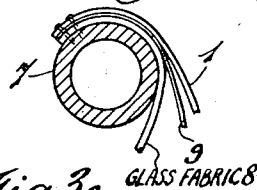


Fig. 3c.

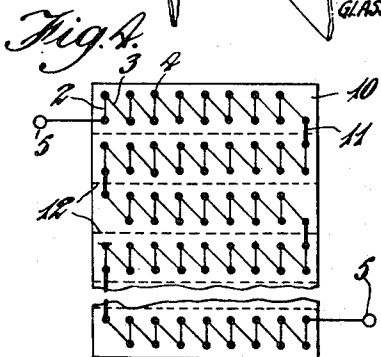


Fig. 4.

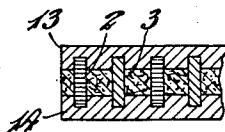


Fig. 5a.

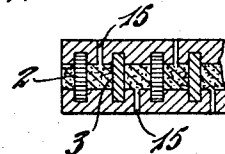


Fig. 5b.

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UNITED STATES PATENT OFFICE

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THERMOPILE

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5 Claims. (Cl. 136—4)

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This invention relates to thermopiles and has for its main object the provision of an improved thermopile which can be utilized to produce a current capable of doing useful work, in contradistinction to its normal function of acting as a pure temperature-measuring device.

A further object of this invention is to provide a method of constructing a thermopile which enables the provision of a very large number of thermo-couples to be achieved. Known methods of thermopile construction involving individually soldered joints are quite unsuitable for this purpose, since they do not enable mass-production of the articles to be effected; furthermore, the existence of thousands of soldered joints is a source of weakness, for a single bad joint will increase the electrical resistance of the whole device to a prohibitive extent.

According to this invention there is provided a thermopile comprising a flat block formed of layers of electrically insulating material whose surfaces are at right angles to the upper and lower faces of the block, and which carry on these surfaces a series of thermo-couples consisting of films of materials of different thermo-electric powers arranged alternately so that consecutive junctions lie alternately near the upper and lower edges of the layers.

Preferably these layers of electrically insulating material consist of consecutive turns of a tape wound into a flat spiral.

The preferred material of these layers consists of one of the known glass-type fabrics woven from vitreous fibres. In addition to having excellent electrical and thermal insulating properties and being able to withstand high temperatures, it is found that films deposited thereon by any of the well-known spraying processes, adhere firmly without any tendency to flake off such as is found to occur, for example, with cellophane. For very high temperatures asbestos may be used.

The method of depositing the films will depend upon the materials employed for the thermo-couples and to some extent upon the form in which they are commercially available. One of the well-known spraying processes is usually the most suitable, since these exist for dealing with metals either in wire or powder form. Alternative processes are painting, cathode sputtering, or pressing thin foils of metal into intimate contact with the insulating material. The spraying process has the advantage that by the use of suitable masks, the films can be deposited in the required pattern quickly and accurately.

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The choice of the pairs of materials for the thermo-couples will be governed by a large number of factors, and will depend not only on their thermo-electric powers, but also on the working temperature it is desired to employ, on their electrical conductivity which must not be too low and on the ease with which they can be handled in practice to produce the necessary thin films or foils. The following pairs of materials are quoted as examples, and it is obvious that many others exist.

1. Constantan and iron. These materials have the advantage of being able to withstand temperatures up to at least 1000° C. but show a rather low thermo-electric effect, namely 50 microvolts/° C.

2. Bismuth and a bismuth-tin alloy containing 6 per cent of tin. These show a higher thermo-electric effect of 100 microvolts/° C. but can withstand temperatures up to 200° C. only.

3. A bismuth-tellurium alloy with the constituents in substantially equal proportions, and the intermetallic compound of bismuth and tellurium, Bi₂Te₃. These show a high thermo-electric effect of 250 microvolts/° C. and can withstand temperatures up to 550° C.

Preferred forms of thermopile according to the invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 shows an insulating tape carrying a series of thermo-couples;

Figures 2a-c show the masks employed in depositing the metal films on the tape;

Figures 3a-c show the method of forming a thermopile from the tape;

Figure 4 shows the use of a sheet of insulating material carrying a series of thermo-couples, and

Figures 5a-b show a tape with an alternative arrangement of metal films for the thermo-couples.

Referring to Figure 1, a long tape 1 of glass-fibre fabric carries on one surface a series of thermo-couples each consisting of a pair of sprayed films 2, 3 of two different metals, the films being arranged in zig-zag formation as shown, the junction points of each pair of films lying near one or other of the edges of the tape. To ensure good electrical contact each junction point is covered by a film 4 of copper or other good conductor. The films also serve, by virtue of their heat capacity, to preserve a more uniform temperature at the junctions. Output connections leading to terminals 5 are secured to each end of the series, so that the whole will con-

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stitute a thermopile. The various films are deposited on the tape by spraying with the aid of the apertured masks shown in Figures 2a-c. The masks are made of thin copper foil and are used in succession, the final spraying producing the copper films 4 with the aid of the mask shown in Figure 2c. The tape and the particular mask in use can be stretched on a frame, and holes 6 in the mask and tape can be used to obtain proper registration, or they may be wound off one drum past the spray on to the other if the tape is very long.

It is very desirable that the electrical resistance of the elements 2, 3 should be as nearly equal as possible and this can be achieved by a proper choice of the length, width and thickness of the two films.

The tape is then wound into a flat spiral on a former 7 as shown in Figures 3a and 3b. A second tape 8 of the same material is interwound with the first to provide the necessary electrical insulation. When air cooling is employed it is desirable to provide means to assist this, and for this purpose a tapering strip of copper foil 9 (Figure 3c) is interwound with the two strips, as shown.

Instead of using the second tape 8, the insulation of the thermo-couples can be achieved by coating the surface and edges of the tape with a very thin layer of a suitable heat-resisting enamel.

In Figure 4 a sheet 10 of glass-fibre fabric instead of a tape is employed, and after spraying through suitable masks the series of thermo-couples 2, 3, the copper films covering the junctions, and the copper films 11 connecting the ends of each row in series, the whole sheet is coated with a thin film of protective enamel and then folded along the dotted lines 12 to form a rectangular block.

An alternative arrangement of the films on the tape is shown in Figures 5a and 5b. Two broad bands 13, 14 of copper are sprayed along the edges of the tape and across the unoccupied central portion are alternate strips 2, 3 of the two materials, as shown in Figure 5a. Portions 15 of the copper bands are then removed as shown in Figure 5b. As a result there is formed a zig-zag chain of the materials. There is little or no temperature gradient in the areas of copper, which serve as heating and cooling fins. Both surfaces of the tape can be so treated and its subsequent treatment is the same as already described. Slits can be made in the portions of the tape at the points 15, or these portions of the tape entirely removed together with the copper, so that when the tape is in the final form of a spiral, the portions carrying the copper fins can be bent outwardly to increase the separation between the same.

When utilizing the thermopile care must be taken to ensure rapid and uniform transfer of heat to the hot junctions, and from the cold junctions. For heating, the thermopile can be mounted on a copper plate 16 (Figure 3a) which will be in close proximity to, yet electrically in-

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sulated from, the hot junctions. The copper plate is heated by any suitable means and serves to ensure a uniform distribution of heat.

For small electrical outputs, air cooling assisted by suitable cooling fins as already described, is adequate.

By heating the plate 16 with a conventional heater winding fed with A. C. or D. C. current, the device can be used for obtaining a smooth direct current from one of undesirable characteristics, for example, for supplying power to small radio receivers.

I claim:

1. A thermopile comprising a long electrically insulating tape wound into a spiral and carrying a series of thermo-couples consisting of films of materials of different thermo-electric powers arranged alternately so that consecutive junctions lie alternately near the lower and upper edges of the tape including means for air cooling said thermopile comprising a metallic ribbon interwound with said spiral and insulated from the thermocouples therein, said ribbon having areas extending longitudinally beyond said spiral for exposure to the surrounding atmosphere.

2. A thermopile comprising a long electrically insulating tape wound into a spiral and carrying a series of thermo-couples consisting of alternating strips of sprayed metals of different thermo-electric powers, the strips extending across the width of the tape in zig-zag formation including means for air cooling said thermopile comprising a metallic ribbon interwound with said spiral and insulated from the thermocouples therein, said ribbon having areas extending longitudinally beyond said spiral for exposure to the surrounding atmosphere.

3. A thermopile according to claim 1 wherein the electrically insulating material comprises a fabric woven from vitreous fibres.

4. A thermopile according to claim 1 wherein each junction is covered by a film of a good electrically conducting metal.

5. A thermopile according to claim 1 wherein a second tape of electrically insulating material is interwound therewith.

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