

Feb. 27, 1951

F. OKOLICSANYI

2,543,331

THERMOPILE

Filed Aug. 30, 1945

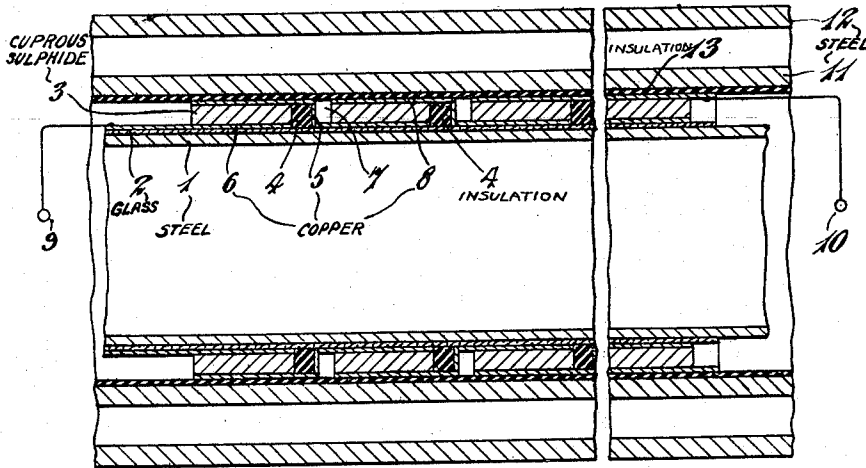


Fig. 1.

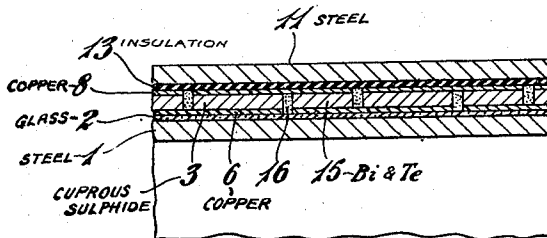


Fig. 2.

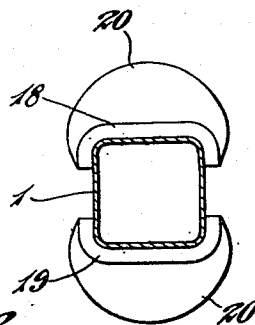


Fig. 3.

INVENTOR:  
FERENC OKOLICSANYI  
by Richardson, David and Vardon  
ATTY'S

## UNITED STATES PATENT OFFICE

2,543,331

## THERMOPILE

Ferenc Okolicsanyi, Hampstead, London,  
EnglandApplication August 30, 1945, Serial No. 613,544  
In Great Britain September 1, 1944

1 Claim. (Cl. 136—4)

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The present invention relates to thermopiles and has for its main object the provision of a thermopile capable of giving a current which can be employed to do useful work.

A further object of the invention is to provide a structure of a thermopile which is capable of transferring very large quantities of heat energy from the hot to the cold junctions and of converting this into electrical energy with a reasonable degree of efficiency. Hitherto, as far as is known, no proposal has been made for a thermopile capable of handling high input energies of the order of many kilowatts.

A still further object of the invention is to provide a thermopile which can utilize materials of high specific thermo-electric power and relatively high electrical resistance and yet yield a current of useful amperage.

According to the present invention such a thermopile comprises a central tube, alternating members of different thermo-electric powers surrounding said tube at least in part, an inner edge adjacent the tube and an outer edge remote from the tube, and electrically conducting surfaces arranged to connect the members electrically in series by their edges so that the thermo-electric current flows outwardly from the inner to the outer edges of one member, and inwardly from the outer to the inner edges of the next.

With such an arrangement, it becomes possible to employ members having a large effective cross-section at right angles to the electrical and thermal flow. Thus considerable heat energy can be handled without the whole device heating up to a more or less uniform temperature, and even when it is not desired to handle such large heat energies the structure has the advantage, for the same reason, that materials of high specific electrical resistance can be employed.

The invention may be put into practice in various ways, and some examples of the thermopiles constructed according to the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a longitudinal section of one form of thermopile;

Figure 2 shows a modified and preferred form of the thermopile shown in Figure 1;

Figure 3 shows a cross-section of a thermopile employing cooling fins.

Referring to Figure 1, a central tube 1 of steel, coated on its outer surface with a thin electrically insulating layer 2 (for example, glass or other vitreous material, sprayed on the outer surface) carries rings 3 of cuprous sulphide alternating

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with electrically insulating rings 4 of ceramic or refractory material carrying a sprayed coating 5 of copper on one face. Each ring 3 and layer 5 constitute a thermo-couple and are connected together by a coating 8 of copper. The various thermo-couples are separated, either by air spaces 7 as shown, but preferably by insulating rings occupying these air spaces, and are connected in series by further copper coatings 6, as shown. When heat is applied through the tube 1, the thermo-electric current will flow radially from the inner edge of the ring 3 to its outer edge, through the conducting layer 5, and then back from the outer edge of the layer 5 to its inner edge, and through the layer 6 to the next couple, and so on, and is taken off at the terminals 9, 10.

Surrounding the thermopile is an annular water jacket formed by concentric tubes 11, 12, an electrically insulating layer 13 being provided to prevent short-circuiting of the thermo-couples.

As mentioned above, the use of the insulating rings 4 coated with the copper layers 5 is necessitated by the low electrical resistance of copper compared with that of cuprous sulphide. It is preferred to employ, instead of copper, a material such as the alloy of bismuth and tellurium mentioned above, which has a high negative thermo-electric power. The electrical resistance of this material is of the same order as many materials having a high positive thermo-electric power, such as the intermetallic compound of bismuth and tellurium, so that a structure such as that shown in Figure 2 can be employed, in which the rings 15 of this alloy replace the copper coated insulating rings 4. The widths of the rings in the axial direction are so chosen that the electrical resistance to the thermo-electric current is substantially the same for the two rings of each thermo-couple, assuming a constant temperature difference throughout the length of the thermopile. Also, the rings 3 and 15 have a radial thickness less than their axial width. In actual practice a temperature gradient will exist along the central tube 1, and the width of the rings can be similarly graded so that the ratio of the thermo-electric voltage to the resistance is constant for each thermo-couple. The rings are separated by insulating discs 16 and the connections are made by coatings 6, 8, as in the previous example.

This structure may employ as the positive thermo-electric element, rings of molybdenum sulphide, which has a very high thermo-electric power, but normally has an extremely high electrical resistance. I have found, however, that if the material is subject to pressure in a direc-

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tion at right angles to the grain of the material (which has a flaky structure similar to graphite), the electrical resistance is substantially reduced. This fact can be taken advantage of by making the rings in such a way that the grain or layers of material run circumferentially and then shrinking the steel tube 11 over the structure so that pressure is exerted in the radial direction. The insulating layers 13 will be produced in this case by spraying glass over the conducting layers 8 prior to the shrinking operation.

The metals may, if desired, be sprayed in known manner on to the surface of the tube. Alternatively, the members surrounding the tube may be produced by the known powderised and sintering process since this will enable one to overcome the difficulties which arise when using brittle metals, metal alloys or metal compounds.

It will be understood that in Figures 1 and 2, the various parts are not drawn to scale, and, in particular, the various conducting and insulating layers are shown with exaggerated thickness for the sake of clarity. Also the steel tubes 1 and 11 should be as thin as possible consistent with mechanical rigidity.

Many modifications of the structure described above are possible and are within the scope of the invention. Figure 3, for example, shows a cross-section of thermopile which differs in that a central tube 1 of substantially square instead of circular cross-section is employed, and that instead of rings surrounding the tube, curved members, one of which is shown at 18, embracing only a part of the tube are employed. The various conducting and insulating layers are not shown, as the arrangement of them is substantially the same as in the previous example. An entirely separate thermopile is formed on the underside of the tube, one of the elements being

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shown at 19, and the two thermopiles can be connected in series or parallel as desired. Instead of water cooling, air cooling is employed, each member being provided with a cooling fin 20 for this purpose. As mentioned above such an arrangement can be used only for low power ratings; for high ratings forced circulation of water through the outer jacket by means of a pump is essential to remove the heat sufficiently rapidly, and a radiator of normal construction can be included in the cooling circuit.

I claim:

A thermopile comprising a central tube, alternately arranged flat rings of materials of different thermo-electric powers surrounding said tube and electrically insulated therefrom, said rings having a radial thickness less than their axial width, and electrically conducting layers arranged to connect the rings electrically in series by their edges so that the thermo-electric current flows outwardly from the inner to the outer edge of one ring and inwardly from the outer to the inner edge of the next.

FERENC OKOLICSANYI.

#### REFERENCES CITED

The following references are of record in the file of this patent:

#### UNITED STATES PATENTS

| Number    | Name               | Date          |
|-----------|--------------------|---------------|
| 775,187   | Lyons et al. _____ | Nov. 15, 1904 |
| 1,638,943 | Little _____       | Aug. 16, 1927 |

#### FOREIGN PATENTS

| Number  | Country             | Date          |
|---------|---------------------|---------------|
| 627,049 | France _____        | May 28, 1927  |
| 313,602 | Great Britain _____ | Aug. 28, 1930 |
| 742,364 | France _____        | Dec. 27, 1932 |