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W. H. THORPE

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THERMOPILE AND METHOD OF MANUFACTURE

Filed Feb. 3, 1925

Fig. 1.

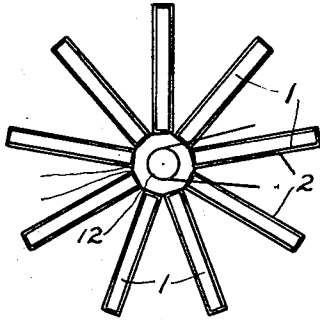


Fig. 2.

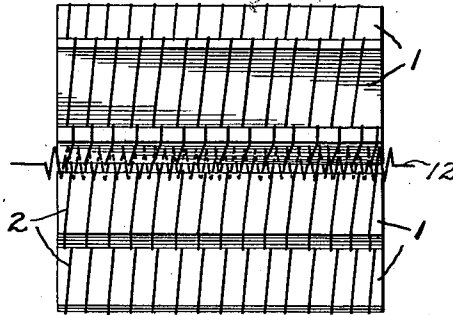


Fig. 3.

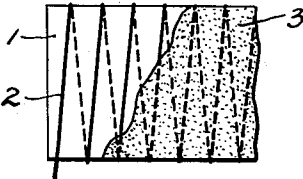


Fig. 5.

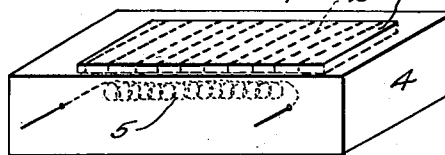


Fig. 4.



Fig. 6.

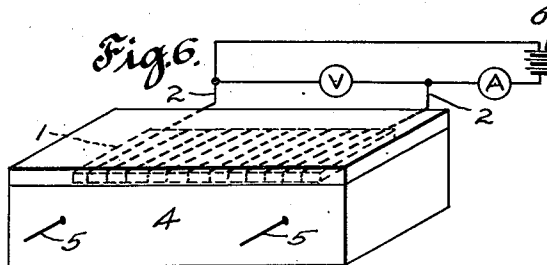


Fig. 8.

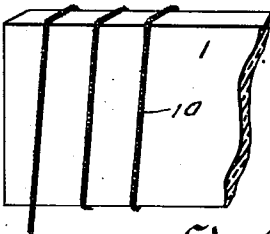


Fig. 7.

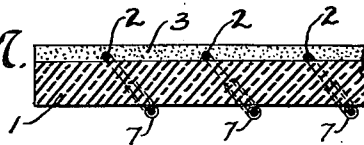


Fig. 9.

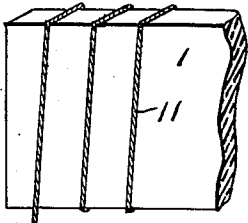
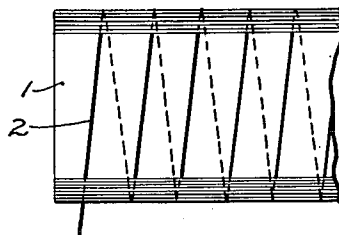


Fig. 10



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THERMOPILE AND METHOD OF MANUFACTURE.

Application filed February 3, 1925. Serial No. 6,516.

My invention relates to a thermopile, and particularly to a method of forming the joints of a thermopile, and the invention further consists in the article so formed.

It is a well known fact that, with practically any two different electrically conductive substances, when joined together, and the joint heated, a current will flow through the substances if the cool ends are connected. This fact has been taken advantage of heretofore in the manufacture of thermopiles, but, except for very special uses, it has been found that the cost of making satisfactory joints between the dissimilar electrically conductive substances or metals has been too high to make thermopiles commercially successful for general use, such as for use in connection with radio receiving apparatus.

It is an object of my invention, therefore, to provide a method for making a plurality of thermocouples, which method will permit of rapid production at exceedingly low cost.

It is a further object to provide a thermopile of compact form by means of which relatively high voltages can be attained.

It is a further object to provide a thermopile in which the electrically conductive substances constituting the various thermocouples will not be likely to warp out of shape. Other minor objects will be apparent as the specification proceeds.

The method will be described in connection with the manufacture of a thermopile according to my invention.

In the drawings, which show for illustrative purposes only, a preferred form of thermopile and certain apparatus used in the production thereof to describe the method:

Fig. 1 is an end view of a completed thermopile;

Fig. 2 is a side view of the thermopile shown in Fig. 1;

Fig. 3 is a fragmentary partially diagrammatic view of a portion of a thermopile;

Fig. 4 is a central sectional view of the parts shown in Fig. 3;

Fig. 5 is a partially diagrammatic view illustrating one step in my improved process;

Fig. 6 is a view similar to Fig. 5 but amplified by the addition of certain parts;

Fig. 7 is a relatively enlarged fragmentary view of a portion of my improved thermopile;

Fig. 8 is a fragmentary perspective view of a slightly modified form of thermopile;

Fig. 9 is a view similar to Fig. 8 but illustrating a further modification.

Fig. 10 is a partially diagrammatic view of a portion of a thermopile to illustrate how the joints between dissimilar substances may be enclosed in a protective covering.

In carrying out my improved process for producing the improved form of thermopile, I preferably employ a relatively thin plate or sheet of electrically non-conducting material 1, such as mica or sheet asbestos. Upon this plate I wind a plurality of turns of wire 2, with the turns suitably spaced apart. While I mention wire, I wish to use that term in a broad sense to include a tape, ribbon or other form of strip. I may next coat the wire on one side of the sheet and in fact I may coat the entire one side of the sheet with a protective covering 3, such as cement, or the like, so that in subsequent steps in the process that portion of the wire which is coated with cement will not be affected. Such a coated sheet is clearly shown in Figs. 3, 4, and 7.

The exposed portion of the wire may now be subjected to treatment so as to form thereon a different electrically conductive substance. One method of accomplishing this result is to place the sheet 1 in a suitable retort 4 which may be heated by any suitable means such as an electrical resistance unit 5. I then form in, or conduct a gas or other substance into, the retort so as to act on the exposed portions of the wire turns; for example, if the wire 2 is formed of copper I may introduce sulfur into the retort 4 and due to the heat, the sulfur vaporizes, or in the presence of air, may partially ignite and the vapors will act upon the exposed portions of the wire and form copper sulfid. The copper for this step of the process should be maintained at a dull red heat. During this procedure, the wire 2 on the sheet may be connected with a source of current 6 and an ammeter and voltmeter placed in the circuit. By reading the ammeter and voltmeter I am enabled to check the process of copper sulfid formation and stop the process at the proper point. In order to prevent any sulfur vapors being subsequently given off when the thermopile is being used, I next prefer to continue the heating of the treated wire out of the presence of the sulfur vapors and preferably out of the presence of oxygen. For this purpose the retort may be made air-tight or some

inert gas may be introduced therethrough so that in the continued heating of copper sulfid there will be no injury thereto. I may also, during this subsequent heating, place a few sheets of copper in the retort so that any sulfur vapors given off may be taken up by these copper sheets.

It will thus be seen that after this process has been completed there are provided a number of turns of wire on the sheet, the wire at one side being now at least partially formed of a different electrically conductive substance than that on the other side. The joints between these two different substances will be formed without the necessity of soldering or brazing or otherwise mechanically connecting the substances, and by the method just described, a joint will be secured, which is better than can ordinarily be secured by any mechanical method with which I am familiar.

It is not necessary, of course, for me to use copper wire and act upon the same with sulfur for other metals may be used and reagents other than sulfur may be employed, the essential thing being to secure two dissimilar electrically conductive substances joined together.

As an alternative method for producing the two different metals joined together, I may treat one side of the sheet so as to remove a portion of the material constituting the turns at that side of the sheet and then deposit or form thereon a different substance, for example, I may immerse the turns at one side of the sheet 1 in a bath which will dissolve a portion of the material, or I may remove a portion of it by passing a current through a bath in the proper direction so as to remove a part of the wire. I may then again immerse the sheet in a different bath and by the well known electroplating process deposit a coating of the proper thickness of another metal on the exposed side of the wire. During this alternative process I may, if desired, have the wire on one side of the sheet coated with cement or otherwise, as heretofore described.

Fig. 7 indicates a sheet with the wire wound thereon and after the two different electrically conductive substances have been formed. It will be clear that the wire 2 coiled about the sheet is protected on one side by the cement 3, which cement in this instance has also been extended so as to protect about half of the coil at the bottom of the sheet. 7 indicates the coating of the electrically conductive substance which is on the exposed side of the wire 1. If desired, the cement, after serving its purpose as a protective covering may be removed.

The joints between the different electrically conductive substances may sometimes become damaged in use, either due to the

heat to which they are subjected or other causes, and I propose, in a measure, to protect these joints. For that purpose then I may immerse the coils, after treatment as above described, in an electroplating bath to a depth, for example, indicated by the shaded portion in Fig. 10. A thin protective coating may then be deposited upon the joints in the usual way, which covering will protect the joints against damage.

I have found that while treating the exposed portion of the wire by my process, there may be more or less distortion of the wire and to overcome this objection, I may first form the wire into a coil 10, as indicated more particularly in Fig. 8, which coil may be more or less extended and therefore resilient. With such a construction, any expansion or contraction of the wire or the plate 1 would be taken up by the coils.

Instead of forming the wire as indicated in Fig. 8, I may use a number of wires twisted or otherwise twined together as indicated in Fig. 9. Such a wire will serve the purpose of, in a large measure, preventing distortion due to heat or other treatment.

Now, depending upon what voltage is desired, I may connect the coils of two or more of the plates 1, so as to form a thermopile. In the preferred form I arrange a plurality of units as indicated in Fig. 1, with edges adjacent each other. It will, of course, be apparent that the turns of the wires adjacent the center as viewed in Fig. 1 will constitute the joints between two dissimilar electrically conductive substances. 12 indicates any suitable means for heating the joints. In the specific form shown, I have employed an electrical resistance unit for such purpose of heating the joints. It is, of course, to be understood that one series of coils on a base 1 may be used alone as a unit, or any number may be combined and connected together either in series or in multiple for securing whatever result may be desired.

By my method I secure very cheap and rapid production in making the joints between dissimilar electrically conductive substances, and the joints are exceedingly good both from an electrical and a mechanical viewpoint.

While the invention has been described in some detail, I do not wish to be limited to the specific methods described, nor to the articles shown, since changes in both may be made within the scope of the invention as defined in the appended claims.

I claim:

1. The method of forming a thermopile which includes forming a plurality of turns of wire, protecting a portion of the wire constituting the turns and then subjecting the exposed portion of said wire to a reagent

which will combine with the material of the wire to form a different electrically conductive substance whereby two different electrically conductive substances are joined
5 to each other.

2. The method of forming a thermopile which includes forming a plurality of turns of wire and protecting a portion of the wire constituting the turns, heating the exposed
10 portions of the wire and exposing the same to a reagent which will combine with the material of the wire to form a different electrically conductive substance.

3. As an article of manufacture, a thermopile including a plurality of turns of
15 metal wire, a portion of each turn being at least partially formed of a different electrically conductive substance and comprising a compound derived from the remainder of
20 said turn, the joint between said two different electrically conductive substances being coated with a thin protective covering.

4. As an article of manufacture, a plurality of turns of metal wire connected together, a portion of each turn being of a
25 different electrically conductive substance and comprising a compound derived from the remainder of each said turn, a plurality of said plurality of turns being electrically
30 connected together, heating means for the joints of said turns constituting the different electrically conductive substances.

5. As an article of manufacture, a thermopile including a plurality of turns of wire, a portion of each turn comprising a metal
35 in substantially pure form, the remainder of each turn comprising a compound of said metal of which the wire is made having
40 different electrical conductivity from the pure metal, the joint between said two different electrically conductive substances being coated with a thin protective covering.

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