Sept. 16, 1947. A. RASPET 2,427,508

PROCESS FOR PRODUCING THERMOPILES

Filed May 3, 1945

Fig. 1.

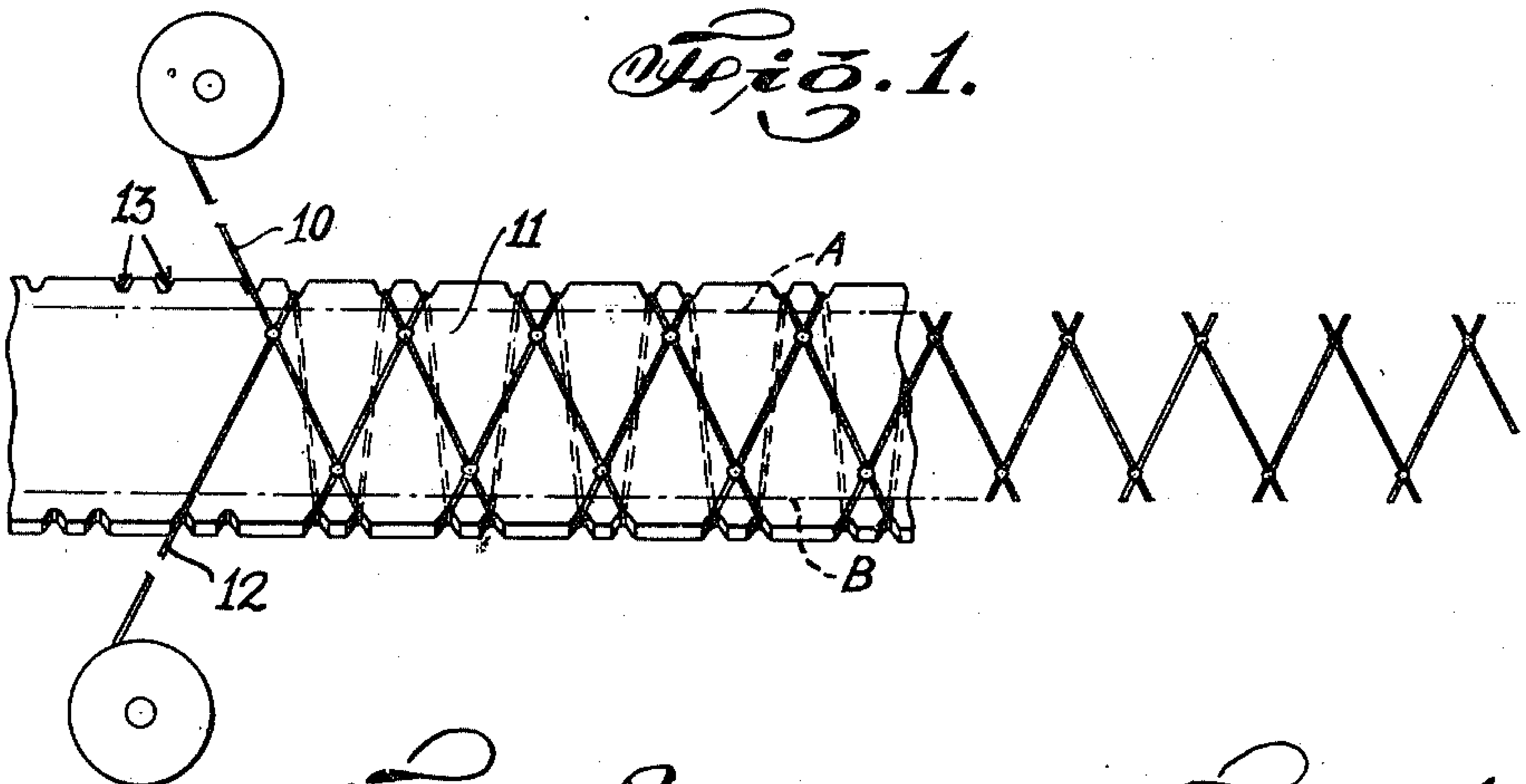


Fig. 2.

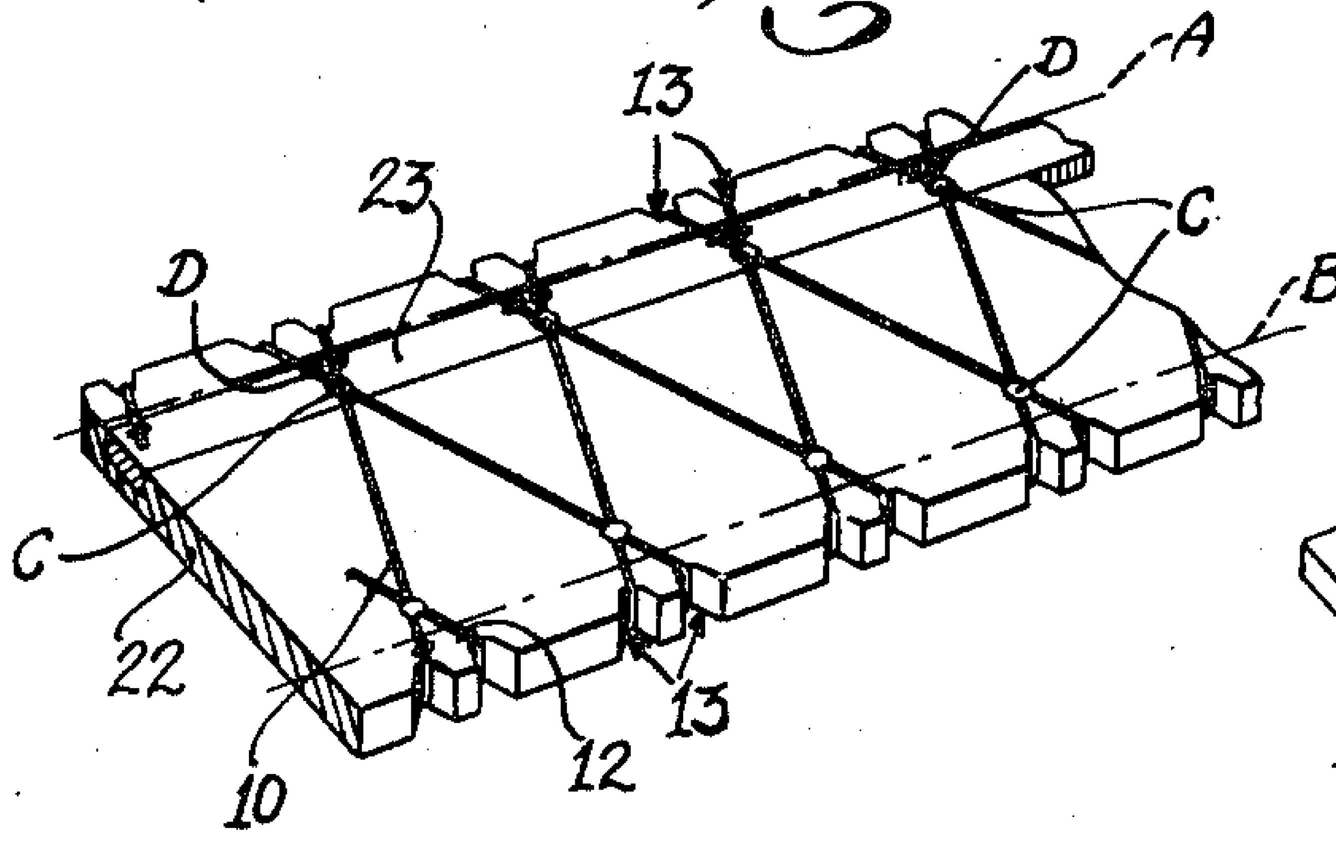


Fig. 4.

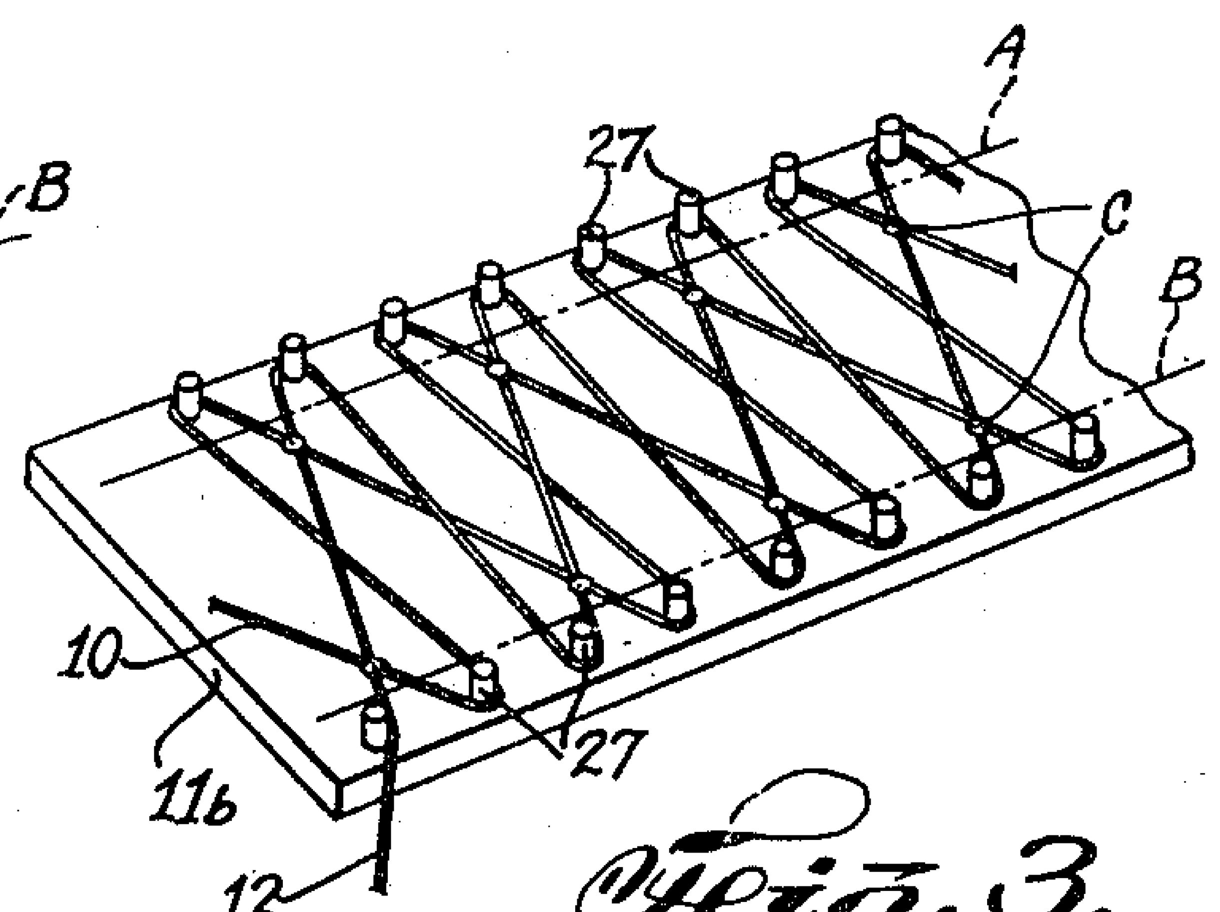


Fig. 3.

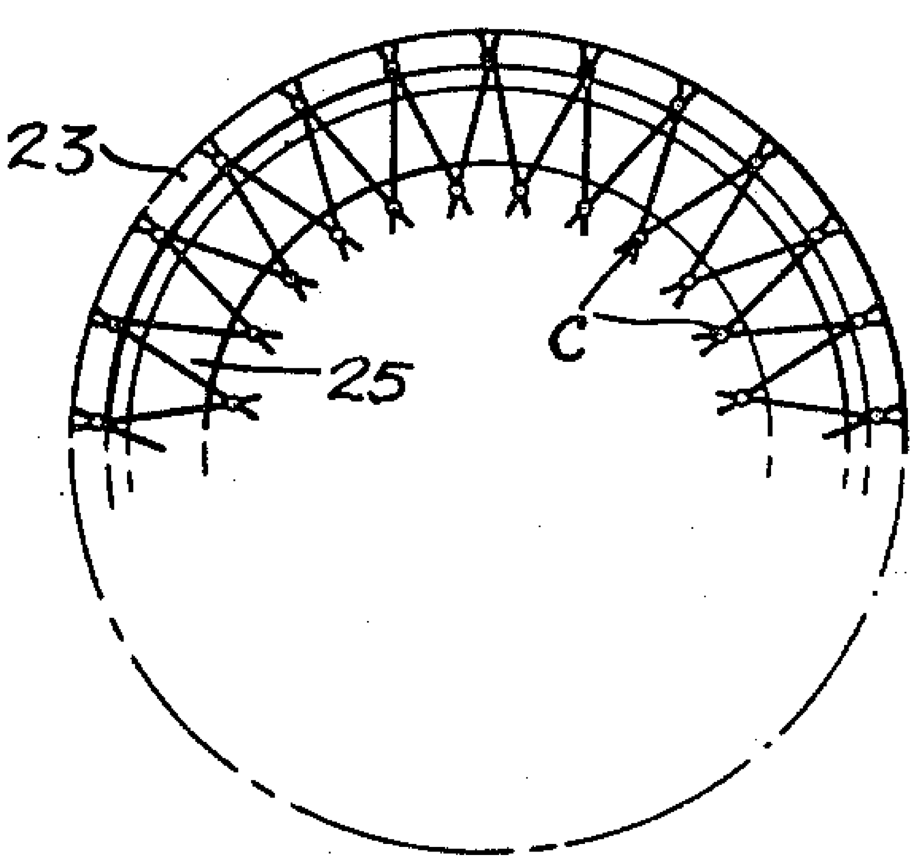
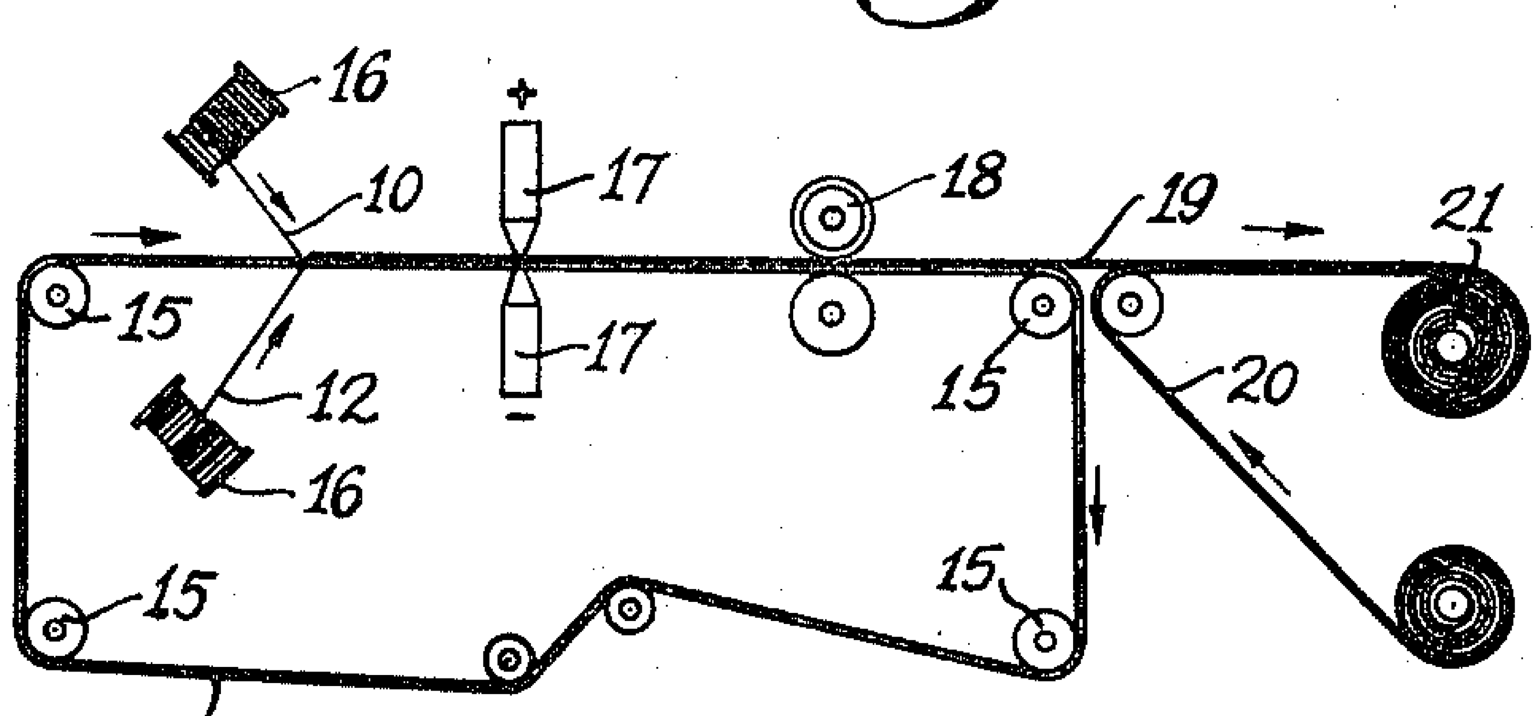


Fig. 5.



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Patented Sept. 16, 1947 2,427,508

UNITED STATES PATENT OFFICE

2,427,508

PROCESS FOR PRODUCING THERMOPILES

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Application May 3, 1945, Serial No. 591,722

6 Claims. (Cl. 140—71)

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This invention relates in general to an apparatus for measuring temperatures and in particular to a process for producing a thermopile adapted for use in the measurement of heat flow, radiation and stellar temperatures, and to correlated improvements designed to enhance the sensitivity and utility of such apparatus.

A simple thermocouple is formed with two wires of dissimilar metals having two junctions, such, for example, as copper and an iron constantan alloy. When one of the junctions is kept at a temperature above that of the other, there is a voltage generated at the junctions as a result of the temperature difference. It is possible to make this voltage directly proportional to the temperature difference and the constant of proportionality is the thermoelectric power of the particular metals of the thermojunction. Such a simple system has a very low sensitivity and is of no value for measuring small temperature gradients. Of course, the small voltage generated in the single closed circuit comprising two junctions can be amplified by means of electron tubes, but this increases the complexity of the electric circuits, introduces variables, and increases the weight and bulk of the instrument. Another method of increasing the voltage is to increase the number of thermojunctions by using a multiplicity of separate wires, each having one junction. This means that there are a large number of connections to be made and such a circuit has the disadvantage of increased resistance as a result of the increased length of wire which has to be employed. Moreover, such circuits comprising long wires and single junctions have a high lag, that is, they do not respond promptly to small changes in temperature.

The chief disadvantage in the use of multi-junction thermopiles is the difficulty of manufacture of such devices. For accuracy and uniformity of performance, it is essential that the length of the wires between the several junctions be substantially identical. It is also advisable that the junctions be uniform in area. Heretofore, multi-junction thermopiles have been produced exclusively by hand, being built up wire by wire, and the individual junctions spot welded in sequence. For high sensitivity it is necessary to use extremely fine wires. Accordingly, it has been necessary to carry out such prior manufacture under a magnifying glass which adds greatly to the eye strain and fatigue of the operator.

Therefore, it is a general object of the present invention to provide a simple and rapid process for the production of multi-junction thermopiles of high uniformity, both in physical characteristics and thermoelectric function.

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It is another object of the present invention to provide a process for producing a thermoelectric gradiometer which will be characterized by high sensitivity, maximum deflection, low internal resistance and a low thermoelectric lag.

It is another object to produce thermopiles without the necessity of working under a magnifying glass.

According to the present invention, there is provided a process for producing thermocouples in a uniform and rapid manner by lapping two continuous wires formed of dissimilar metals in an opposite direction on a mandrel in such a manner that the wires cross each other twice, joining said wires together at their points of crossing, severing the lapped structure thus produced along a line between the junctions, thereby forming a thermopile having a multiplicity of junctions arranged in series.

In one embodiment the two wires are wound spirally about a suitable mandrel in such a manner that they overlap on one side of the mandrel but do not overlap on the other side, and after the wires are joined at their points of crossing they are then severed on that side of the mandrel where the wires are not overlapped, thus forming a thermopile having a multiplicity of junctions arranged in series. In another embodiment the wires are overlapped by lacing them from side to side on one side of a suitable mandrel, as will be hereinafter described.

The joining of the wire may be effected by soldering or by fusion as by spot welding.

For a more complete understanding of the nature and objects of the invention, reference should be had to the accompanying drawing in which:

Fig. 1 is a top plan view of a suitable means for carrying out one embodiment of the process of the invention;

Fig. 2 is a perspective view of another embodiment of a suitable apparatus for carrying out the process.

Fig. 3 is a diagrammatical side elevation of suitable apparatus for carrying out the process in a continuous and automatic manner.

Fig. 4 is a top plan view of one embodiment of suitable means for carrying out a second embodiment of the step of associating the wires together in the process;

Fig. 5 is a top plan view of one embodiment of a thermopile produced according to the process of the invention.

In the construction of the thermopiles, any dissimilar wires may be employed. In the following table there are listed a few thermojunctions and their thermoelectric power:

	Microvolts/degrees C.
Copper-nickel	22
Copper constantan	40
Iron constantan	55
Chromel constantan	65
Chromel X-Copel	75
Bismuth antimony	115

In the now preferred embodiment of the invention, there is employed chromel-constantan junctions because chromel has about 1/40 the thermal conductivity of copper and such thermocouples have E. M. F. of about 65 microvolts per degree C. as compared to 40 microvolts per degree C. for a copper-constantan junction. In general, the smaller the wire and the better the contact of the cojunction, the lower the lag.

It is immaterial in the device of the present invention what shape or configuration is given to the series of multiple thermojunctions. For example, the thermojunctions may be connected in series and arranged in a common plane and in a straight line as shown in Fig. 3. Alternatively, they may be in a common plane but disposed so that the outer junctions describe a circle while the alternate junctions lie along a smaller circle in the interior as shown in Fig. 5. More particularly, when the device is to be used for measuring radiation temperatures, it is even possible to position one set of the alternate junctions so that they are closely spaced around a common point. Generally speaking, it is desirable to have one set of alternate junctions arranged so that they can be exposed to an atmosphere, the temperature of which is to be measured, while the other junctions are insulated from such atmosphere and are also in good contact with a cooling means or a block of metal having a high specific heat.

The insulating material may be any suitable material of low thermal conductivity, such, for example, as glass wool, sponge rubber, asbestos, balsa wood, paper, foamed synthetic resins or other cellular, porous or fibrous material.

Referring to Fig. 1, a chromel wire 10 is wound in a spiral manner in one direction around an elongated mandrel 11 and a second wire 12 is wound in the opposite direction around the mandrel 11. In that embodiment shown in Fig. 1, the mandrel has a rectangular cross-section and the wires are wound in such a manner that they cross only on one side of the mandrel, there being no crossings of the wire on the underside of the mandrel as shown in Fig. 1. Since the length of the wires between each junction should be substantially identical, it is preferable to provide the mandrel with a series of notches 13 along the edges, the notches being spaced to force the wires to cross as desired. For purposes of illustration, the notches are shown on the mandrel in Fig. 1 as substantially spaced apart, but it is to be understood that the notches can be positioned quite close to each other. Using a mandrel and the method of wiring as shown in Fig. 1, it is quite apparent that the winding of the wires about the mandrel can be performed automatically.

In Fig. 4 there is illustrated another embodiment of a suitable mandrel 11*b* which is provided with two rows of similar vertical pegs 27 adjacent each longitudinal edge of the mandrel. The wire 10 is then lapped around mandrel pegs on each side while the second wire 12 is lapped about the other alternate pegs so that the wires cross at the points C. After fusion of the junction at the points C, the wires are then cut along the lines indicated by the broken lines A and B. The product is similar to that produced with the apparatus of Figures 1 and 2.

For example, referring to Fig. 5, the thermopiles of the present invention may be produced entirely automatically by utilizing as the mandrel 11 an endless flexible metal band 11*a* provided with notches along the side as desired and adapted to be moved continuously about the supporting rollers 15 in the direction of the arrow. At one point the wires 10 and 12 are wound in opposite directions about the moving mandrel from the spools 16 by conventional means. The band carrying the spirally wound wires then passes through the spot welding jaws 17, a pair of such jaws being positioned on each side of the band so that the wires are welded together at their points of crossing. The downward movement of the spot welding electrode 17 is synchronized with the notches 13 on the band 11A so that the weld is made precisely at the point where the wires cross and at nowhere else. From the weld electrode 17 the metal band 11A carrying the welded wires passes beneath a pair of cutters in the form of a circular blade 18 which severs the wires along the lines A and B on the outside of the welded joints. The multi-unit thermopile 19 thus produced is now free of the band 11A and is carried by the auxiliary sheet 20 of flexible material and is wound in interleaved relation into a roll 21. Accordingly, it is noted that the process of the present invention is adapted for producing multi-joint thermopiles in continuous step form in which the joints are connected in series. The length of the thermopile is only limited by the length of the wires unwound from the reels 16.

It is noted that the thermopile produced by the process illustrated in Fig. 5 is not attached to a support. In some cases, particularly when it is desired to produce circular thermopiles or thermopiles in which one set of junctions are positioned about a common point, it is desirable to have the thermopile temporarily fixed to a support. For this purpose, a divisible mandrel of the type shown in Fig. 2 is employed. In this case the mandrel 11 comprises a large longitudinal section 22 and having an elongate groove holding a narrow longitudinal section 23 which is separable therefrom. The edges of the section 22 are provided with notches 13 along the edges as shown and the wires 10 and 12 are wound in the same manner as shown in Fig. 1. However, in addition to the welding of the wires at their points of crossing C, the wires are also welded at the points D to the narrow section 23. The wires are then cut along the lines A and B. After the wires are cut, it will be noted that the thermopile, instead of being free as shown in Fig. 3, is attached to the strip 23 which acts as a support. If this strip is made of a bendable metal, such as lead, copper or soft alloy, the strip 23 may be curved or shaped in any desired manner, as, for example, by forming into a circle as shown in Fig. 5. Thus, in producing a circular thermopile, the strip 23 is curved about a suitable cylindrical mandrel whereupon the inner junctions C are pushed closer together in the center. A permanent circular non-conducting support 25 such as a strip of paper is now glued to the thermopiles between the junctions C as shown in Fig. 5.

The present process provides a method for making multi-joint thermopiles having junctions connected in series in a continuous and preferably automatic manner without the necessity of working over a magnifying glass. Thus the process eliminates the errors of human judgment in assembling thermopiles. Moreover, the present process produces multi-junction thermopiles which are absolutely uniform and therefore of uniform electrical characteristics. This is not possible with prior methods of making these devices by hand.

The multi-joint thermopile disclosed herein is claimed in my co-opending application Serial No. 704,214, filed October 18, 1946.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A process for producing thermopiles having a multiplicity of uniform thermocouples comprising lapping two continuous wires formed of dissimilar metals in opposite directions so that the wires cross each other twice, joining said wires together at their points of crossing, and severing the lapped structure thus produced along a line between the junctions, thereby forming a thermopile having a multiplicity of junctions connected in series.

2. A process according to claim 1 in which the wires are lapped by winding them spirally in opposite directions around a common center.

3. A process according to claim 1 in which the wires are lapped by lacing them in opposite directions in a common plane.

4. A process for the continuous production of thermopiles comprising a multiplicity of uniform junctions comprising moving an elongate supporting member, continuously winding two wires in opposite directions about said member while it is moving in such a manner that the wires cross each other twice on at least one side of said support, joining said wires together at their points of crossing while on said support, severing said wires along a line parallel to the direction of movement of said support and along a line between said junctions, thereby forming a thermopile having a multiplicity of junctions connected in series, and removing said structure from said support.

5. A process according to claim 4 in which the support is an endless band.

6. A process according to claim 4 in which the thermopile is passed from said support and wound in interleaved relation with a secondary flexible support.

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