Nov. 14, 1950 S. K. MALEK 2,530,254

THERMOPILE CONSTRUCTION

Filed April 28, 1945

Fig. 1.

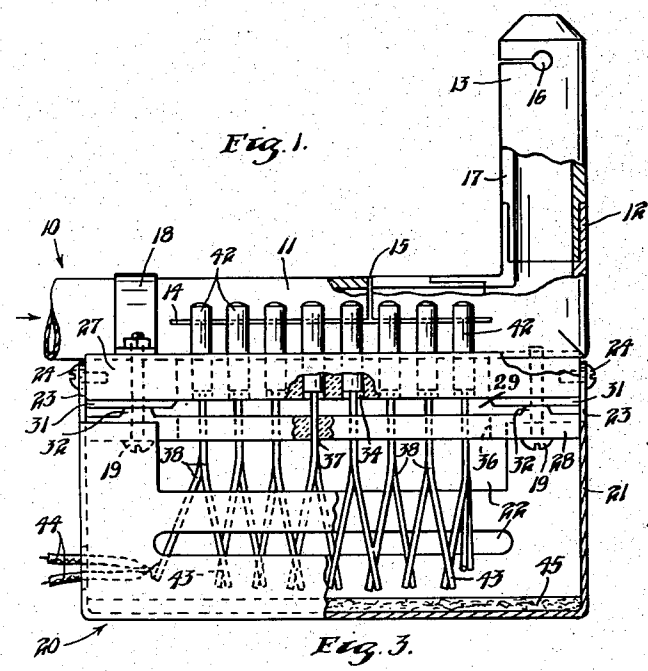


Fig. 2.

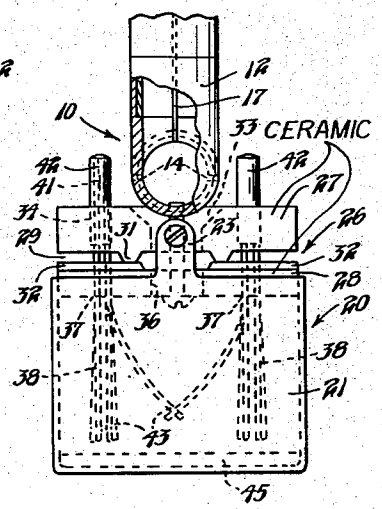


Fig. 3.

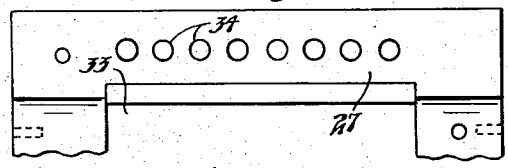


Fig. 4.

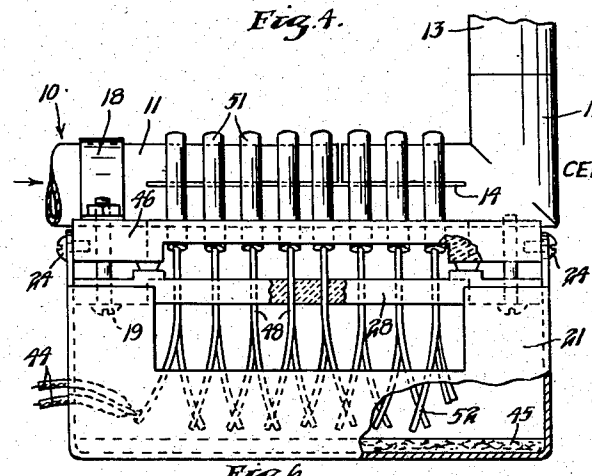


Fig. 5.

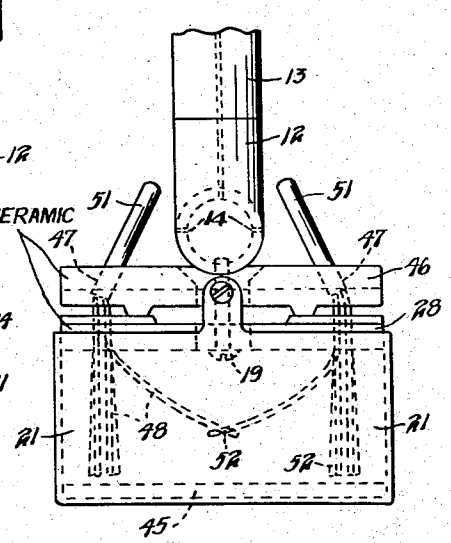
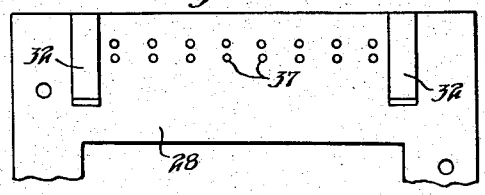


Fig. 6.



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THERMOPILE CONSTRUCTION

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Application April 28, 1945, Serial No. 590,836

10 Claims. (Cl. 136—4)

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This invention relates to an improved thermoelectric device which is especially adapted to be used in conjunction with a fluid fuel burner and has for one of its principal objects the provision of means for economically producing a highly efficient device adapted to be maintained in use over long periods of time without structural or functional impairment.

Another thermopile construction, similar to that in this application, is disclosed in my copending application, Serial No. 592,779, filed May 9, 1945.

Another object of advantage and importance resides in the provision of means for generating a relatively high E. M. F. per couple by maintaining a considerable temperature difference between the hot and cold junctions by protecting the cold junction from the effects of heat directed against the hot junction of the unit. Additionally, the improved device is formed and the cold junctions of the unit are so disposed that when the device is in operation a current of secondary air is drawn thereover.

The economical construction of an efficient thermopile has been attended with the problem of maintaining a substantial temperature gradient between the two ends or junctions of a relatively short piece of wire or rod forming the intermediate portions of each of the associated thermocouples. Various methods of reducing the heat conductance of the metal without increasing its electrical resistance have been more or less unsuccessfully tried. Thin and expanded portions for dissipating the heat of cold junctions causes cumbersome and enlarged units without producing the desired results. Porcelain and other dielectric members have also been interposed between the hot and cold junctions in an attempt to increase the temperature gradient therebetween and while these members retard in some measure, they do not prevent or greatly reduce the traveling of heat from the hot to the cold junction. Other structures have included the positioning of the cold junction within the supply line thus causing fuel to flow thereover. These structures while producing a relatively high temperature gradient between the junctions have the serious drawback of sharply curtailing the number of thermocouples that may be included in any single unit, or of unreasonably increasing the production cost of the device.

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In overcoming the objectionable features of the previous constructions and solving the problem of maintaining a considerable gradient between the hot and cold junctions of the thermopile without curtailing the number of thermocouples that may be included in a small compact unit, the present invention provides means for shielding the cold junction from heat and also providing means for limiting the conduction of heat through the shielding means.

A further object of advantage and importance is the provision of means for creating a flow of secondary air over the cold junction and upwardly through the apertured shielding means during operation of the device. The chimney effect caused by the flame used in heating the hot junction also tends to draw cooling air between the spaced sections of the shielding means and into the central aperture.

A still further object of importance is the provision of means for protecting the metal of the hot junction from oxidizing and disintegrating by reason of coming into contact with oxygen and the products of combustion of the thermopile flame when the device is in operation.

Additional objects of advantage and importance will become apparent as the following detailed description progresses, reference being had to the accompanying drawing wherein

Figure 1 is a side elevational view of a thermopile and pilot burner assembly which embodies the invention. Portions of the structure are broken away to show underlying parts.

Figure 2 is an end view of the structure shown in Figure 1, parts thereof being broken away.

Figure 3 is a top plan view of a fragmental portion of the upper shielding member of the device shown in Figure 1.

Figure 4 is a side elevational view of a slightly modified form of the invention, parts thereof being broken away.

Figure 5 is an end view of the structure shown in Figure 3.

Figure 6 is a top plan view of a fragmental portion of the lower shielding member of the structure shown in Figure 4.

The reference numeral 10 indicates generally a fuel supply line for a pilot burner through which fuel flows in the direction indicated by the arrow. The supply line comprises a horizontal portion 11 and a vertical portion 12 which terminate in a

pilot burner 13. Formed in opposed sides of the horizontal portion 11, as is clearly shown in the drawing, are fuel emitting slits 14. The slits 14 are connected by a runner type of slit 15 which extends over the upper portion of the supply line 11 as is best shown in Figure 1. The slit 15 is in turn connected to the outlet 16 of the pilot burner 13 by a runner type of slit 17. Accordingly, when the device is in operation a continuous flame extends from the slits 14 in the horizontal portion of the supply line 10 to the outlet 16 of the burner 13.

Secured to the supply line 10 by means of a bracket 18 and securing screws 19 is a thermopile unit indicated in its entirety by the reference numeral 20.

The screws 19 at the rear portion of the structure, only one of which is shown, engage the bracket 18 and the single screw 19 at the front is threaded into the supply line 10 as is best shown in Figure 1. The thermopile unit 20 comprises a substantially rectangular case 21 which may be conveniently formed of sheet metal or other suitable material. Portions of the side walls of the case 21 are cut away, as indicated by the reference numeral 22, to provide air passages into the interior of the case and also to reduce the thermal conductivity of the side walls. Formed on the upper edge of each end of the case 21 and extending thereabove is a securing ear 23. The securing ears 23 are located centrally of the upper edge, as best shown in Figure 2, and are apertured to receive screws 24.

Positioned within the upper portion of the case 21 and extending thereabove is a shielding unit indicated generally by the reference numeral 26. The shielding unit 26 comprises an upper member 27 and a lower member 28. The members 27 and 28 are preferably formed of a ceramic or other refractory material. Member 27 is provided with ribs 31 extending longitudinally along its lower surface, and member 28 is provided with ribs 32 extending transversely along its upper surface. In assembly, the ribs 31 and 32 form engaging surfaces for maintaining the main portions of the upper and lower surfaces of the members in spaced apart relation to provide an air passage 29 therebetween as best shown in Figure 1. The air passage 29 breaks the continuity of the material of which the unit 26 is formed and thus reduces heat conductivity therethrough. The upper and lower members are preferably maintained in associated positions by the screws 19.

The upper shielding member 27 is centrally apertured at 33 as is best shown by dotted lines in Figure 2. A row of perforations 34 are formed in the member 27 intermediate the central aperture and each outer edge. The perforations 34 extend through the member 27 as is best shown in Figure 1. A centrally disposed aperture 36 formed in the lower member 28 is adapted upon assembly to align with the central aperture 33 of the upper member 27. There is thus provided a passageway through the central portion of the shielding unit 26. Formed in the lower member 28 intermediate the central aperture and each outer edge thereof and in alignment with a row of perforations 34 in the upper member 27 is a double row of perforations indicated by the reference numeral 37. The purpose of the aligned perforations 34 and 37 will hereinafter be more fully explained.

The improved thermopile of this invention comprises a plurality of thermocouples each of which is constructed of a pair of wire or rod members

38 of materials having dissimilar thermoelectric characteristics. In the present structure, Copel and Chromel have been found to be satisfactory although other material may be employed. The wire or rod members 38 of each pair are joined at one end by twisting, welding, or the like, to provide a good electrical connection. The portions of the members so joined are hereinafter referred to as hot junctions 41.

It has been found in practice that hot junctions of thermocouples quickly deteriorate when exposed directly to a flame or the product of combustion therefrom. The metal oxidizes or burns away thus increasing the electrical resistance of the member. Thus, although the wires may be mechanically joined, the efficiency of the device will be greatly impaired. Accordingly, in the present structure, the hot junctions 41 are each encased in a protective cover 42, preferably of tubular flame resistant material, such as stainless steel or other suitable material, and the top ends thereof are sealed as by welding or the like. The bottom portions of the tubular covers 42 are inserted in the perforations 34 in the upper member 27 of the shielding unit 26, as is clearly shown in the drawing. The covers 42 thus function to protect the hot junctions from the products of combustion and also tend to prevent deterioration and oxidizing thereof by reason of their coming into direct contact with a thermopile flame.

The lower portions of the dissimilar wires 38 of each thermocouple are threaded through the aligned double rows of perforations 37 in the lower member 28 of the shielding unit 26 and are thus spaced and insulated one from another. The ends of the wires 38 extend for a considerable distance below the lower member 28 and into the thermopile case 21. The lower ends of the wires are connected each to another of dissimilar material, as by welding or the like, in electrical series as is best shown in Figure 1. The ends so joined are hereinafter referred to as cold junctions 43. Electric conductors 44 may be suitably joined to the end junctions of the series connected thermocouples as shown in the drawing. Additionally, an insulating member 45 of asbestos or other suitable material may be positioned between the cold junctions and the bottom of the case 21.

Operation of the improved device is substantially as follows: when the pilot burner 13 is ignited, a runner flame extends along the slits 17 and 15 to ignite fuel emanating from the slits 14. The flame from the slits 14 is directed against the tubular covers 42 which thereupon become hot and a portion of the heat therefrom is transmitted to the hot junctions 41 encased therein. The shielding unit 26 functions to protect the lower portion of the series connected thermocouples from the effect of the thermopile flame. The combined thermopile, runner and pilot flames now tend to create a considerable updraft from the surface of the upper shielding member 27. This updraft is fed by free air passing through the apertures 22 in the case 21 and the air passage 29 between the upper member 27 and the lower member 28. This air flows upwardly through the central aligned apertures 36 and 33 after passing over the cold junctions and the intermediate portions of the thermocouples. This upward flow of air over the cold junctions and the intermediate portion of the thermopile greatly reduces the downward conductance of heat therethrough and thus tends to maintain a relatively high temperature gradient between the

cold and hot junctions. The upward flow of air over the cold junctions is continuous as long as the thermopile flame is burning. Additionally, the space 29 between the upper and lower members 27 and 28, respectively, breaks the continuity of the material and thus the path over which heat might be conducted to the lower portion of the unit. Although the upper member 27 gives off considerable heat the flow of air through the space 29 transfers a considerable portion of it away before it can be picked up by the lower member 28 and thus greatly reduces the conductance of heat through the shielding unit 26. The lower member 28 being thus protected from the heat of the flame tends to dissipate any heat which is conducted through or along the wires 38 of the thermocouples and thus prevents such heat from reaching the cold junctions.

A slightly modified form of the invention is shown in Figures 4 and 5. In the modified structure, the supply line 10, pilot burner 13, case 26 and lower member 28 of the shielding unit are substantially the same as the embodiment shown in Figures 1 and 2. These similar parts are therefore given the same reference numerals in Figures 4 and 5 and as they have been previously described the description need not be repeated here.

The upper member 46 of the shielding unit shown in Figures 4 and 5 is centrally apertured and is also provided with a plurality of aligned perforations 47 intermediate the central aperture and each side as is the upper member 27 of Figures 1 and 2. However, the perforations 47 in member 46 are disposed at an angle as is best shown in Figure 5. In all other respects, the body portion of the improved device is substantially the same in both embodiments. The modified embodiment comprises a plurality of thermocouples each of which consists of a pair of wire members 48 of materials having dissimilar thermoelectric characteristics. The upper ends of each pair of wires are joined to form hot junctions which are encased in tubular flame resistant members 51. The upper end of each flame resistance member 51 is sealed as by welding or the like to protect the junction from the flame and the lower ends thereof are inserted into the angularly disposed perforations 47. The lower portions of the thermocouple wire members 48 are threaded through aligned perforations in the lower member 28 and are then connected in electric series to provide cold junctions 52.

As is best shown in Figure 5, the two rows of angularly disposed hot junctions are inclined toward each other and so that upon association with a burner, as illustrated, they are in a position to maintain contact with the flame during considerable fluctuations thereof. In thermopile construction, it is well known that the E. M. F. generated per couple is in ratio to the temperature gradient maintained between the hot and cold junctions. It is also well known that if the hot junction is positioned sufficiently close to the burner to maintain a heating contact therewith when the flame is low, it is too close for a high flame and as a result may become increasingly inefficient. It is also true that if the junction is positioned to efficiently operate on a high flame, it will be too far away for a low flame. The flame from a horizontal burner of the kind here shown is maintained on a horizontal plane when the fuel supply pressure is relatively high, but as the pressure drops, the flame turns upwardly in an angular direction and this angle increases in proportion to the drop in pressure. Consequently, a vertically disposed hot junction suitably positioned for a high or medium flame would be entirely out of contact with a high angle flame during low pressure periods. As a result of such conditions, the temperatures of the hot and cold junctions would move toward equalization and the E. M. F. generated by the device would drop off. The present invention overcomes such undesirable features by so arranging the hot junction relative to the burner that variation in the pressure of the fuel supply which tends to result in an unsteady or high angle flame causes no appreciable difference in the E. M. F. generated by the improved structure.

A higher E. M. F. is obtained from the thermopile of Figures 4 and 5 than is obtained from the thermopile of Figures 1 and 2, because of the angular relationship of the casings 51 with respect to the axis of the flame jet. Due to said angular relationship, part of the normally rising flame is deflected downwardly and in the direction of the cold junctions, causing a greater surface of the casings to be licked by the flame than would be licked except for said angular relationship and, therefore, a larger amount of the flame's heat to be absorbed therefrom than is absorbed by the Figure 1 arrangement. By deflecting the flame downwardly with the arrangement of Figures 4 and 5, rather than lowering the flame orifices 14 in the device of Figures 1 and 2, the hottest portion (tip of the center cone) of a flame can remain near the hot junction and substantially only the outer, less hot, portion will provide the extra flame contact with the thermopile to add heat to the hot junction. This tends to keep the cold junction cooler than would the lowering of the entire flame, effected by the lowering of orifices 14 in Figures 1 and 2.

From the foregoing, it will be apparent that the present structure provides means for maintaining a considerable temperature gradient between the hot and cold junctions, also provides means for disseminating heat being conducted through the metal of the couples toward the cold junctions thereof and provides means for conveying the disseminated heat toward the heat source. The present structure also tends to eliminate the conductance of heat through the shielding unit interposed between the flame and the cold junctions of the device.

It will be further apparent from the foregoing that herein is provided a highly efficient and compact unit which is economical to use, exceptionally long lived, and which may be readily installed. It will also be apparent that numerous changes in construction and design may be made from the illustrated embodiments here shown without departing from the spirit or scope of the invention. Accordingly, the patent granted hereon is not to be limited to the precise embodiments here shown nor in any other manner except as may be necessitated by the terminology of the appended claims.

I claim as my invention:

1. In a thermopile, a plurality of thermocouples arranged in spaced parallel rows and electrically connected in series, a cap of flame resistant material positioned over the hot junction of each thermocouple, a sectional base through which said thermocouples extend positioned intermediate the hot and cold junctions thereof, said sectional base comprising a plurality of

spaced refractory members, the lower portions of said caps being imbedded in the upper refractory member of said sectional base, and an aperture formed in the central portion of each refractory member, said apertures being disposed in alignment to provide an air passage therethrough, whereby air may pass between the spaced refractory members and through said apertures.

2. In a thermoelectric device, a plurality of thermocouples electrically connected in series, said thermocouples comprising hot and cold junctions joined by metal members of dissimilar material, a protective cap positioned over each of said hot junctions, a shielding member positioned on said metal members intermediate said hot and cold junctions, said shielding member being perforated to receive and maintain said metal members in aligned spaced relation, a second shielding member positioned above and spaced from said first named spacing member, said second shielding member being perforated to receive and maintain said capped hot junctions in spaced relation, and a draft passage formed in each shielding member closely adjacent the perforations therein, whereby air may pass along said shielding members and through said draft passages.

3. In a thermoelectric device comprising, a plurality of upwardly extending thermocouples having hot and cold junctions, said hot and cold junctions being the terminals of a plurality of wires of dissimilar materials alternately joined one to another, each of said hot junctions being provided with a protective cap, a centrally and vertically apertured plate, a row of spaced perforations intermediate the central aperture and each side of said plate, said perforations being adapted to receive and maintain said capped hot junctions in aligned spaced relation, a second centrally and vertically apertured plate, a double row of perforations intermediate the central aperture and each side of said plate, said perforations being adapted to receive and maintain the wires forming the intermediate portion of the device in spaced relation, means for maintaining said plates substantially horizontally disposed and in spaced parallel relation, and an apertured case positioned beneath said second plate, said central apertures, the space on both sides of said second plate and the apertures in said case providing passages for the circulation of air through said device to a point adjacent said hot junctions.

4. In a thermoelectric device adapted to be used in conjunction with a laterally extending burner flame, a plurality of thermocouples having hot and cold junctions, said hot junctions being angularly disposed to the axis of said flame with all of the hot junction ends of the thermocouples extending upwardly and inwardly toward the burner flame to maintain a relatively constant temperature during raising and lowering fluctuations of said burner flame, and means interposed between the hot and cold junctions for shielding said cold junctions from the heat of said flame, said means comprising a plurality of vertically apertured and horizontally arranged plates for causing a current of air to pass over the cold junctions of said thermocouples and through said plurality of plates.

5. In a thermoelectric device adapted to be used in conjunction with a source of heat generated by a generally horizontal jet of flame, said thermoelectric device having high and low temperature portions embodying hot and cold junctions, respectively, said high temperature portion thereof being disposed at an angle to the axis of said jet and extending upwardly and inwardly toward the burner flame to maintain a relatively constant temperature during raising and lowering fluctuations of said flame, means interposed between the hot and cold junctions for shielding the cold junctions from the heat of said generating source, and means for causing a current of air to pass over the cold junctions of said thermoelectric generator.

6. In combination, a burner having a horizontal portion and a final vertical portion, an opening in said vertical portion to provide a main flame, a burner slot extending along said horizontal portion and communicating with said opening by means of runner slits, a thermoelectric generator disposed with a portion thereof closely adjacent said burner, and a plurality of refractory shielding plates through which said thermoelectric generator extends positioned beneath said burner, said plates being spaced one from another to provide for the passage of air therebetween.

7. In combination, a burner having a horizontal portion and a final vertical portion, an opening in said vertical portion to provide for a main flame and a plurality of longitudinal oppositely disposed burner slots extending along said horizontal portion and communicating with said opening by means of runner slits, and a thermopile having a plurality of connected thermocouples extending vertically on opposite sides of said horizontal portion with their hot junctions adjacent said slots so as to be exposed to flames therefrom.

8. In combination, a burner having a horizontal portion and a final vertical portion, an opening in said vertical portion to provide for a main flame and a plurality of longitudinal oppositely disposed burner slots extending along said horizontal portion and communicating with said opening by means of runner slits, and a thermopile having a plurality of connected thermocouples extending vertically on opposite sides of said horizontal portion with their hot junctions adjacent said slots so as to be exposed to flames therefrom and with their cold junctions below said horizontal portion.

9. In combination, a burner having a horizontal portion and a final vertical portion, an opening in said vertical portion to provide for a main flame and a longitudinal burner slot extending along said horizontal portion and communicating with said opening by means of a runner flame slit, a thermopile having a plurality of connected thermocouples extending vertically adjacent said horizontal portion with their hot junctions adjacent said slot and with their cold junctions disposed beneath said horizontal portion, and a refractory plate between said burner and said cold junction.

10. In combination with a heating unit having an orifice for directing a heating medium in a generally horizontal direction, a thermocouple having a lower cold junction and an upper hot junction, a casing enclosing said hot junction having a surface portion extending downwardly from said hot junction and outwardly from said orifice at an obtuse angle to the axis of said orifice so as to deflect at least a portion of said heating medium from said orifice inwardly and downwardly over a lower part of said casing surface portion.

SIDNEY K. MALEK.

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