

Sept. 10, 1946.

W. R. RAY

2,407,517

THERMOELECTRIC GENERATOR

Filed April 9, 1941

3 Sheets-Sheet 1

Fig. 1

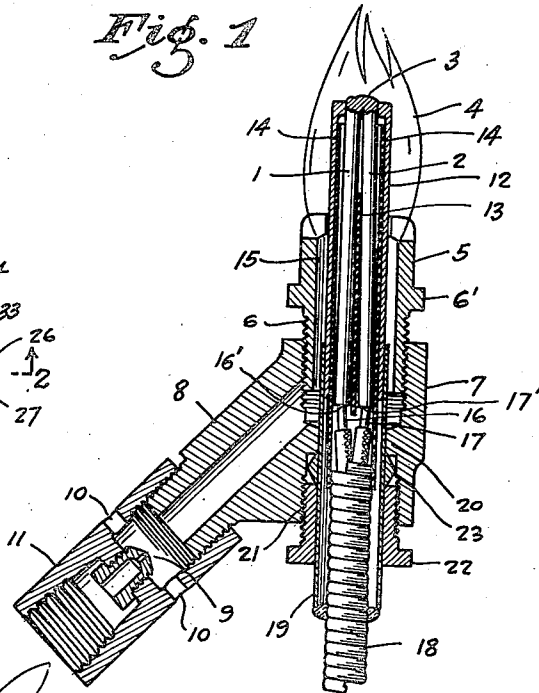


Fig. 5

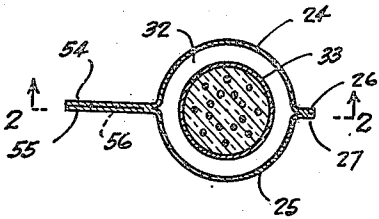


Fig. 2

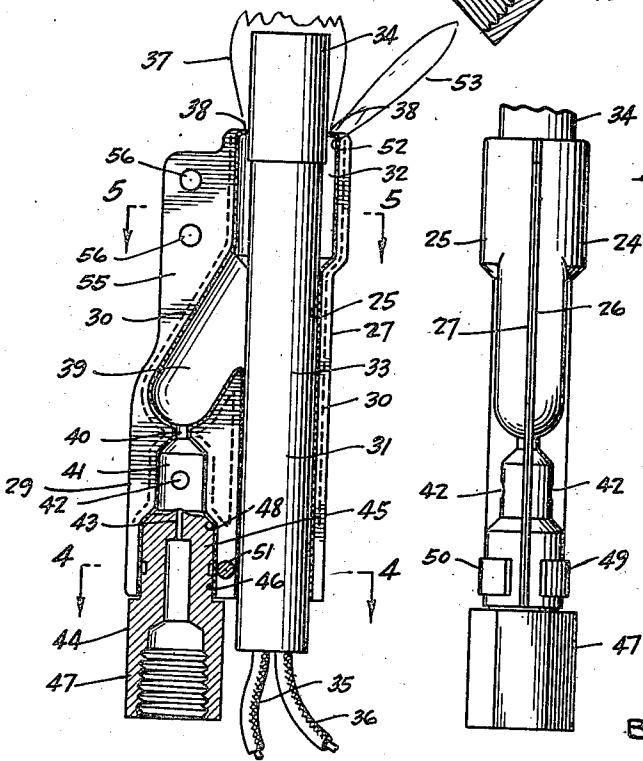


Fig. 3

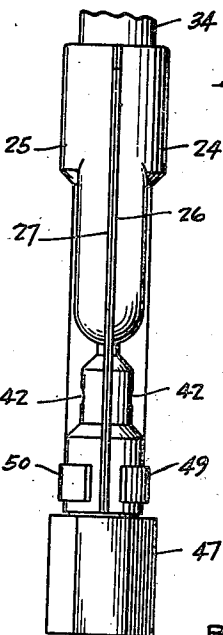
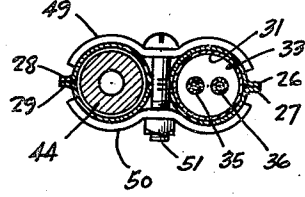


Fig. 4



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Fig. 6

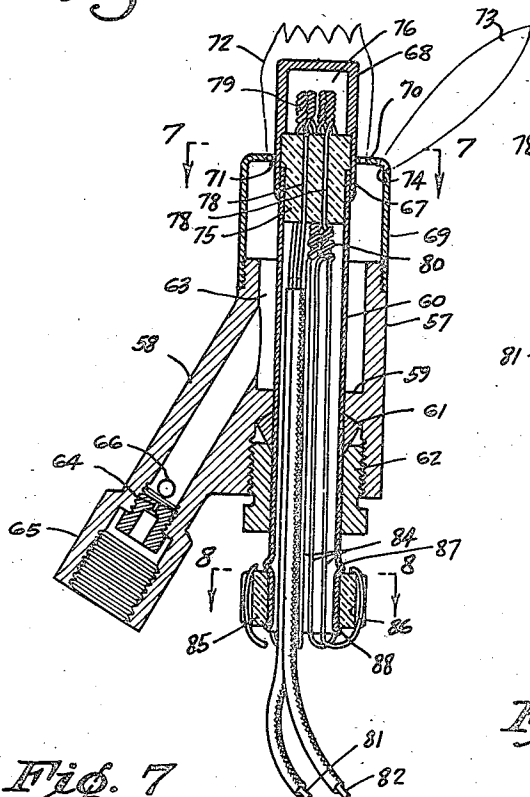


Fig. 7

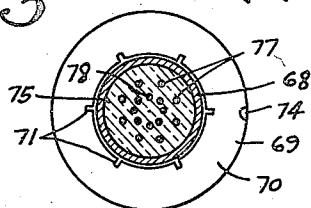


Fig. 8

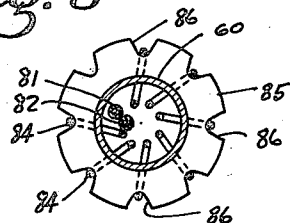


Fig. 9

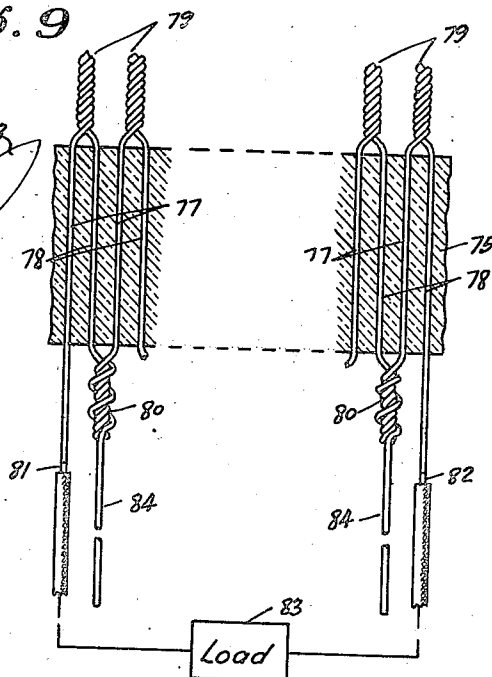
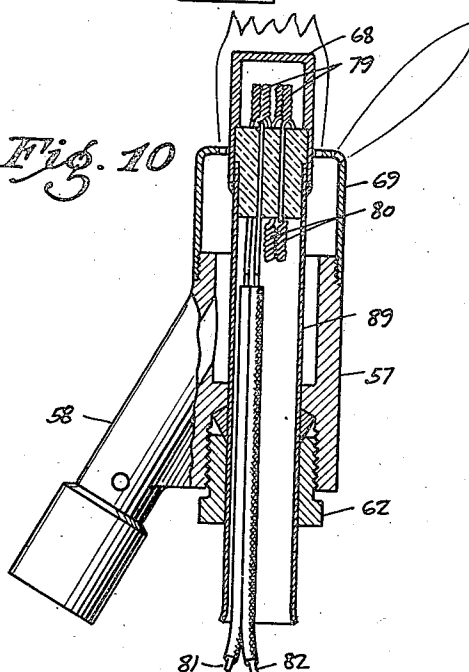


Fig. 10



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Fig. 11

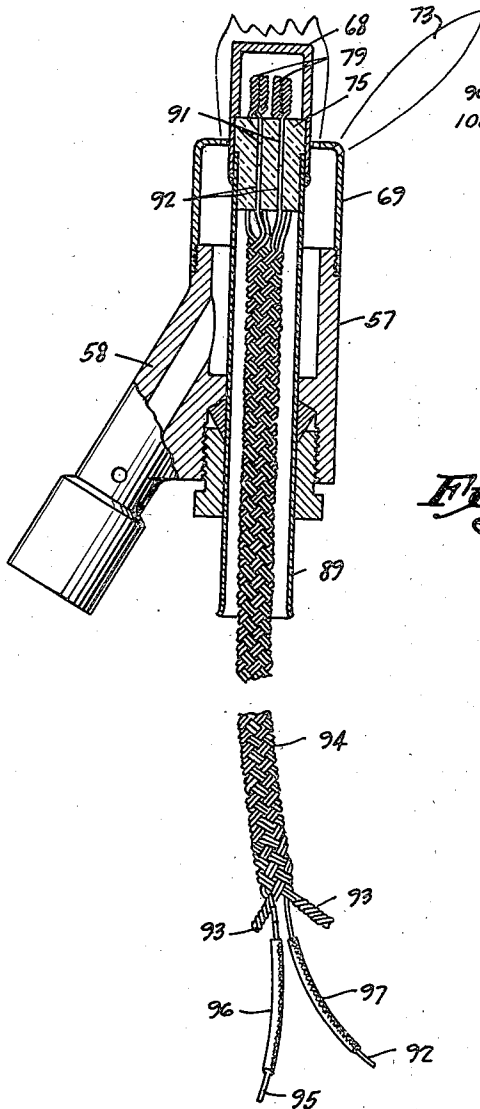
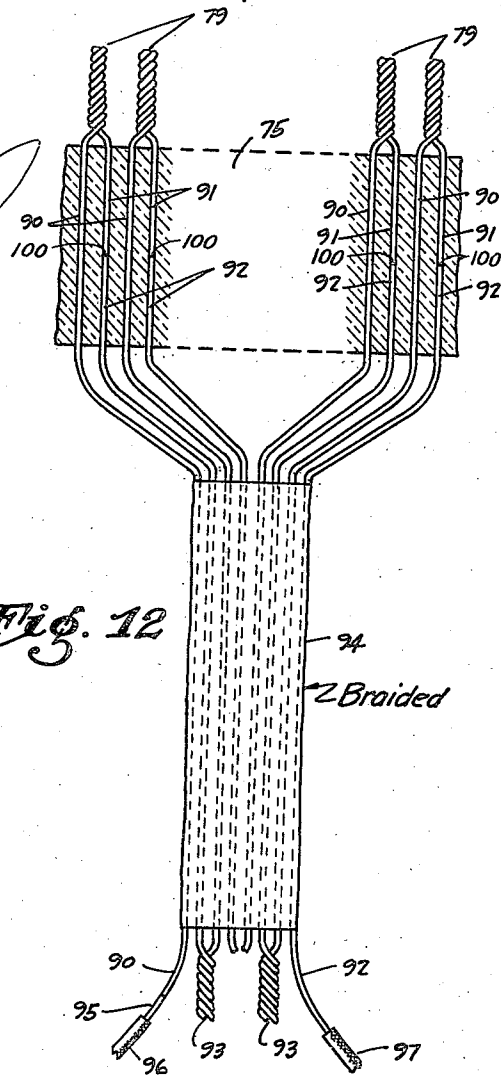


Fig. 12



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UNITED STATES PATENT OFFICE

2,407,517

THERMOELECTRIC GENERATOR

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Application April 9, 1941, Serial No. 387,591

9 Claims. (Cl. 136-4)

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This invention relates to thermoelectric generators; and particularly to generators that are adapted to be operated by the heat developed by combustion of a fuel, as for example, by a gas pilot burner.

Such thermoelectric generators may be used to provide electrical energy for the controlling functions of a fuel burner control system. The theory of operation of such generators is well understood and it is unnecessary to set it forth at length. Conductors made from thermoelectrically dissimilar metals (such as Chromel and Copel) are connected in alternate series arrangement; and if alternate junctions are heated as by a pilot burner flame, there is a consequent creation of electrical energy. The heated junctions are the "hot junctions"; and the unheated junctions are usually termed the "cold junctions." The amount of electrical energy developed is a function of the temperature differential between the hot and cold junctions.

Suitable temperature differentials may be readily obtained by extending the conductor so as to form the cold junctions at a place where the burner flames have no appreciable influence on the temperature. Such an expedient however requires that quite long conductors be used. Since these conductors are made of material having relatively high resistance and are also quite expensive, it is highly desirable to secure the necessary temperature differential otherwise than by an extension of the conductors.

In a prior application, Serial No. 299,322, filed October 13, 1939, now Patent No. 2,340,899, dated February 2, 1944, for "Thermocouple structure," in the name of William R. Ray, there are disclosed several forms of thermoelectric generators that accomplish these important results; particularly by placing the cold junctions inside of the pilot burner tube where the cool stream of unignited fuel serves to absorb heat from the cold junction. This application is a continuation in part of the said prior application.

It is an object of this invention to provide a simple and compact thermoelectric generator of the kind that can be supported within a burner tube.

It is another object of this invention to make it possible to utilize a compact pre-assembled thermoelectric generator structure readily insertable into a burner tube; the assembly being such that the electrical connections are all adequately provided for without danger of any inadvertent short circuiting.

It is still another object of the invention to

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provide a compact pre-assembled unit of this character in which is incorporated cooling extensions joined to the cold junctions so as to absorb and transmit heat from the cold junctions. In this way the temperature differential between the hot and cold junctions is materially increased with attendant greater energy generation.

This invention possesses many other advantages, and has other objects which may be made more easily apparent from a consideration of several embodiments of the invention. For this purpose there are shown a few forms in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

In the drawings:

Figure 1 is an enlarged longitudinal section of a thermoelectric generator incorporating the invention;

Fig. 2 is a view similar to Fig. 1, of a modified form of the invention;

Fig. 3 is a side elevation of the structure illustrated in Fig. 2;

Figs. 4 and 5 are sectional views taken respectively on planes 4-4 and 5-5 of Fig. 2;

Fig. 6 is a view similar to Fig. 1 of a further modified form of the invention;

Figs. 7 and 8 are sectional views taken respectively along planes 7-7 and 8-8 of Fig. 1;

Fig. 9 is a diagrammatic development, showing the thermocouple conductors utilized in connection with the form of the invention illustrated in Fig. 6;

Fig. 10 is a view similar to Fig. 1 of a further modified form of the invention;

Fig. 11 is a view similar to Fig. 1 of a still further modified form of the invention; and

Fig. 12 is a diagrammatic development, showing the thermocouple conductors utilized in connection with the form of the invention illustrated in Fig. 11.

In general, the thermoelectric generator is so arranged that it may be readily inserted and supported within a fuel burner tube, such as a pilot burner tube. It is possible to utilize either a single pair of thermoelectric conductors, or a plurality of pairs of conductors, forming a series of alternate hot and cold junctions.

In the form shown in Fig. 1, a thermocouple employing a single hot junction is illustrated. In this form of the invention, the thermocouple con-

ductors 1 and 2 (of comparatively large cross section) are shown as joined as by being fused together at their upper ends 3 to form the hot junction. This hot junction is shown as enveloped by the flame 4 of a burner; and the thermocouple structure is shown as supported within the burner head 5.

The burner head 5 in this form is shown as having a lower threaded extension 6 threaded into the top of a base structure 7. A collar 6' may be provided around head 5 to facilitate turning the head 5 into the threads of base 7. This base 7 is a downwardly directed tubular extension or branch 8 for conducting a fuel mixture of gas and air to the open bottom of the head 5. This mixture is formed by the aid of the incoming gas passing through the nozzle aperture 9 and past the air inlet apertures 10, formed within a coupling member 11. One end of this member 11 is threaded into the end of branch 8; and the other end is adapted to accommodate an appropriate conduit leading from a source of fuel.

In the present instance the thermocouple conductors 1 and 2 are shown as enveloped by a metal jacket 12, as of stainless steel. The exposed hot junction 3 may be fused to the top of this jacket 12, so that there is a definite connection between the jacket 12 and the conductors. A layer of insulation 13, such as thin mica, may be interposed between the thermocouple conductors 1 and 2. Similarly a mica tube 14 may be inserted within the jacket 12 and may surround the thermocouple conductors 1 and 2, to ensure against any short circuiting of the conductors below the hot junction. The fuel mixture thus passes through an annular passage 15 formed between jacket 12 and head 5.

The lower ends of the thermocouple conductors are shown as fused or otherwise attached respectively to the twin conductors or leads 16 and 17 of armored cable 18. These joints form the cold junctions 16' and 17'. This armored cable 18 is shown as extending through the thin metal sleeve 19, which may be of brass, brazed to the bottom of the jacket 12. The metallic sheath of cable 18 may be joined as by welding, soldering or brazing, to the interior of the tube 19. The cold junctions are shown in this instance as encompassed within the tube or sleeve 19. This tube is cooled by the cold fuel stream and there is transfer of heat from the cold junctions through this tube and into the fuel stream.

The tubular member 19 is arranged to pass downwardly through the base 7 and past the apertured flange 20 located within the base 7. The tube 19 fits snugly within this aperture, to aid in rendering the structure air tight. The tube 19 also passes beyond the lower extremity of a threaded aperture 21, in the bottom of base 7. This threaded aperture is provided for the accommodation of a hollow threaded sealing plug 22 which fits snugly around the tube 19. The inner extremity of the plug 22 is arranged to engage a tapered collar 23 disposed around the tube 19 and made of deformable material, to form a seal around the tube. The upper edge of the collar 23 fits against the lower surface of the flange 20.

In this form of the invention, the cool mixture of fuel and air passes through the extension 8 into the head 5, and past the metal sheath 12. The cold junctions 16' and 17' transmit heat to the tube 19, which is cooled by the passage of the stream of fuel mixture around the sheath 12.

The pilot burner tube structure of Fig. 1 illus-

trates but one form that such a structure may take. It may be formed relatively inexpensively by the aid of sheet metal parts that may be joined together by welding. Such an arrangement is illustrated in Figs. 2, 3, 4 and 5.

In this form there are provided casing halves or shells 24 and 25. These halves are shown as being provided with contacting flanges 26, 27 and 28, 29 (see particularly Figs. 4 and 5). By the aid of these flanges the halves may be joined together as by stitch welding, indicated in general by the dotted lines 30 of Fig. 2.

The right hand portions of the casing 24 and 25 have depressions or channels defining a tubular passageway 31 extending entirely through the structure. This passageway 31 has an upper enlarged portion 32. Located within the passageway 31 is the metallic sheath 33 of a thermoelectric generator structure. This sheath is shown as capped by a metal cap member 34 extending upwardly beyond the enlarged portion 32 of the burner tube. The leads 35 and 36 for the thermocouple structure extend into the sheath 33. Both the sheath 33 and the cap 34 are preferably made from non-corrosive material such as stainless steel. The cap 34 furthermore encloses the hot thermocouple junctions.

The cap 34 is arranged to be heated by a flame 37 (Fig. 2). Fuel for this flames is provided by the aid of a plurality of jet passageways 38 formed by the aid of slots in the top flange of the tubular portion 31. These slots together with the exterior cylindrical surface of the cap 34 form a series of jet apertures through which a combustible mixture may pass to form the flame 37. This flame 37 encompasses the cap 34 and heats it for raising the temperature of the hot junctions enclosed within this cap 34. The slots 38 may be uniformly spaced about the burner, for example as illustrated by slots 71 of Fig. 7.

The fuel mixture is passed into the enlarged portion 32 from the branch passageway 39 formed by channels or depressions in the casing shells 24, 25. This branch passageway further communicates as through a restricted opening 40, with a chamber 41. This chamber 41 is in communication with the air as by the aid of one or more radial apertures 42. The chamber 41 which forms the mixing chamber is also in communication with a source of gaseous fuel. This is accomplished by the aid of a nozzle opening 43 formed in a coupling member 44. This coupling member 44 has a cylindrical upper portion 45 telescoped within the tubular passage 46 formed in the casing 24-25. It is also provided with an appropriate internally threaded extension 47 by the aid of which a fuel conduit may be attached to the coupling member 44. This extension 47 is shown as having an external hexagonal surface. As shown most clearly in Fig. 2, the upper end of the coupling member 44 may be tapered to seat against the shoulder 48 formed beneath the mixing chamber 41.

The fuel passes upwardly through the coupling member 44 and through the nozzle opening 43 into the mixing chamber 41. Air is drawn in through apertures 42 into this mixing chamber and the combustible mixture then passes upwardly into the passageway 39 and thence the fuel mixture proceeds upwardly around the upper portion of the sheath 33 into the enlarged portion 32 of the tubular structure 31. The fuel finally

passes through the jet openings 38 and burns as indicated by the flame 37.

Provisions are made to ensure against leakage of fuel past the sheath 33 or downwardly past the coupling member 44. For this purpose the coupling member 44 and the sheath 33 are quite tightly enclosed within the walls of the casing shells 24 and 25. In addition, a clamping arrangement may be provided adjacent the lower end of the structure. This may take the form of a pair of strap members 49, 50 (Figs. 3 and 4). These strap member are appropriately curved to encompass the external cylindrical surfaces of the casing members 24, 25. They are urged into clamping position as by the aid of a screw 51 passing through the members 49-50, as well as between the tubular portions 46 and 31 of the casing member.

The flame 37 is utilized primarily for supplying heat to the thermoelectric generator. The burner may also be utilized as a pilot burner as by providing an aperture 52 communicating with the upper enlarged portion 32 of the tube 31. The pilot flame 53 is shown as issuing therefrom.

Furthermore, in order to provide a convenient supporting means for the complete thermoelectric generator structure, the casing halves 24 and 25 may be extended at the left hand side to form the contacting flat portions 54 and 55 (Figs. 2 and 5). These contacting portions may be welded together and may be provided with one or more apertures 56. By the aid of these apertures the structure may be appropriately fastened to a stationary support.

The thermoelectric generator enclosed within the sheath 33 of the cap 34 may take any of several forms. These forms will be described hereinafter in connection with other modifications of the burner tube structure.

In the modification illustrated in Figs. 6, 7, 8 and 9, a burner tube 57 is shown having an integrally formed fuel mixture conduit 58. This burner tube 57 is open at the top and bottom. It has an intermediate flange 59 through which the sheath 60 of the thermoelectric generator passes. This sheath 60 extends completely through the tube 57. It is held in fluid tight sealed relation with respect to the flange 59 as by the aid of the metal packing ring 61. This may be made of deformable material to form a tight seal around the exterior of the sheath 60. The deformation may be accomplished by the aid of a hollow threaded sealing plug 62.

The deformable collar 61 has an internal cylindrical surface closely contacting the sheath 60 and is urged against the sheath 60 by the cooperation of the tapering contacting surface of the threaded plug 62 and the collar 61.

The fuel mixture supplied through the conduit 58 is passed into the annular space 63 around the sheath 60. The fuel is passed into the conduit 58 through the nozzle member 64 located in the coupling extension 65 of the conduit 58. Radial air apertures 66 extend into the conduit 58 for forming the fuel mixture.

The sheath 60 telescopes within the depending skirt portion 67 of a metal cap 68. This metal cap 68 encloses the hot junctions of the thermoelectric generator constructed in a manner to be hereinafter described.

The upper end of the tubular member 57 is threaded for the accommodation of a hollow jet forming metallic member 69. This metallic member has an upper flange 70 through which the

cap 68 extends. This flange as shown most clearly in Fig. 7 may be provided with a series of radial slots 71 to form jet openings in cooperation with the external cylindrical surface of the cap 68. A burner flame 72 issues from these jet openings 71 and encompasses and heats the cap 68.

The flame 72 is used primarily to provide heat for the generation of electrical energy. A pilot flame 73 may be provided for and may issue from an aperture 74 formed in the hollow metallic member 69.

A refractory insulation member 75 serves as a support for the thermoelectric conductors and is shown as telescoping within the top of the sheath 60. This insulation member 75 (which may conveniently be made of porcelain) has an enlarged head to form a shoulder against which the top end of the tubular sheath 60 may abut. Similarly, the upper surface of the insulation member 75 is in contact with the shoulder of cap 68 formed between the skirt 67 of the cap and the upper portion of the cap. In this way upon proper fusion of the cap 68 into the sheath 60, the insulation support 75 is firmly secured in place near the top of the metal casing.

A space 76 is enclosed by the cap 68 in conjunction with the top surface of the support 75. The pairs of thermoelectric conductors 77-78, etc., pass through apertures in the support 75. One series of conductors 77 form an outer annular arrangement, around the other series of conductors 78 which form an inner annular arrangement. The pairs of conductors 77-78 are joined together to form a twisted connection illustrated at 79 (Figs. 6 and 9). These twisted ends form the hot junctions. Heat is supplied to them by radiation from the heated cap 68.

In the present instance the cold junctions are formed beneath the support 75 as by joining the alternate conductors as indicated by the twisted wires 80. Conductors 77 and 78 may be respectively of Chromel and Copel. As shown most clearly in Fig. 9, the thermocouples are thus joined in series relation. The end conductors may be connected as by the copper leads 81 and 82 to a load 83. This load 83 may be an electromagnet or a relay or the like, as for controlling the supply of fuel to a main burner, or the generated electricity may be utilized for any other desired controlling function.

The hot junctions 79 being supported above the refractory support 75 do not materially affect the cold junctions 80 disposed below the refractory support 75. Furthermore, due to the flow of the cool fuel mixture past the sheath 60 the transfer of heat to the cold junctions 80 is very materially retarded. Although the thermoelectric conductors 77 and 78 are quite short, the temperature differential between the hot and cold junctions is ample to provide the desired electrical energy.

However, in order further to ensure that the cold junctions 80 will be maintained at a proper low temperature, heat dissipating or radiating metal extensions 84 may be joined to the cold junctions 80. These extensions may be of copper wire. They serve to transfer heat from the cold junctions to the circumambient atmosphere that is in communication with the lower end of the sheath 60. The ends of these heat radiators 84 may be conveniently disposed around a refractory or insulation ring 85. This ring 85 is telescoped over the lower end of the sheath 60. It may be provided with a plurality of notches 86 as illus-

trated in Fig. 8. The extensions 84 pass downwardly and out of the open end of the sheath 60. They may then be turned upwardly to be accommodated within the notches 86. The ring 85 may be held in place against axial movement 5 on the sheath 60 as by the aid of the upset portion 87 formed on the sheath 60 and the outwardly turned flange 88 at the end of the sheath 60.

The interior of the sheath 60 being hollow and 10 in communication with the outside air, the cooling of the cold junctions 89 is rendered very effective. The radiating surfaces of the heat conductors 84 being exposed to the external air also assist to maintain the temperature of the cold 15 junctions at a suitable low value.

It is not always essential to utilize the heat radiating elements 84. In the form of the invention illustrated in Fig. 10 these conductors are omitted, as well as the ring 85. The sheath 20 89 in this case simply extends downwardly past the hollow threaded clamping member 62. The cold junctions 89 and the hot junctions 79 are arranged as before.

In the form of the invention illustrated in 25 Figs 11 and 12, the cooling effect of the cold junctions is secured otherwise than by the aid of any supplemental radiating conductors. In this case the pairs of thermoelectric conductors are designated by the reference characters 90 and 91 30 extending through the refractory insulation support 75. The conductors 90 may be made of Copel, and extend for a considerable distance beyond the sheath 89. The conductors 91, however, are short and may be made of Chromel. These conductors are within the support 75 and 35 may be joined as by copper leads 92 to form the cold junctions 93. By using these copper leads 92 as extensions of the Chromel conductors, the resistance of these Chromel conductors is kept 40 within reasonable limits. Since the resistance of Chromel is quite high, the shortening of the Chromel conductors thus rendered possible is quite important.

Since the thermoelectric characteristics of some 45 types of Chromel and copper are somewhat similar, the joints 100 between the conductors 92 and the Chromel conductors 91 have little effect upon the generation of electricity. The true cold junctions are formed between copper leads 92 and the Copel leads 90. In order to ensure effective cooling 50 of these cold junctions they may be disposed in a braided fashion illustrated in general by the reference character 94 within and beyond the sheath 89. In order to prevent inadvertently short circuiting of any element of the thermoelectric generator, the conductors 90 and leads 55 92 may be covered prior to the braiding operation with a thin layer of insulation, such as an enamel layer.

The thermocouple conductors being arranged in series, one of the Copel conductors 90 may form a terminal for the generator. A copper lead 95 may be connected to the end of this terminal conductor. The other terminal conductor is 60 formed by the end copper conductor 92. These leads may be covered with appropriate insulation, such as indicated by the braided sleeves 96 and 97.

As in the forms disclosed in Figs. 6 and 10, the interior of the sheath 89 is open to the atmosphere. It is also subjected to the flow of the cool fuel mixture passing through the conduit 58. Accordingly the cold junctions are maintained at a suitably low temperature.

What is claimed is:

1. In combination, a burner tube having open ends, a thermoelectric generator structure having an external sheath and disposed in said tube so that one end of the sheath extends beyond the tube and defines with said end, one or more burner jets arranged around said extending end, an annular clamping ring disposed around the sheath adjacent the other end of said tube, and in contact with the tube, to close the space between the interior of the tube and the exterior of the sheath, and thereby serving to seal and support said sheath within the tube, and means for passing a fuel mixture into the tube.

2. In combination, a burner structure having a fuel jet burner head as well as an extension for conducting a stream of a mixture of fuel and air to the base of said burner head, a thermocouple structure supported in the burner head and extending past the base, said thermocouple structure including a pair of conductors of dissimilar metals forming a hot junction exposed in the flame beyond the burner head, said thermocouple structure, also including a metallic sheath 25 disposed around said conductors, and clamping means, surrounding said metallic sheath, supported within the burner structure, and operable from the exterior of said burner structure closing the space between the burner head and the sheath, and compressible to grip said sheath.

3. In combination, a pair of sheet metal shells having contacting flanges by the aid of which they may be joined, said shells having recesses forming a burner tube as well as a passage for a fuel mixture into the tube, said flanges having an extended area at a place to form a convenient means for fastening the assembled shells to a support, said burner tube thus formed having open ends, said shells having provisions for accommodating an end of a fuel supply conduit in operative relation to said passage, and a thermoelectric generator structure having an external sheath extending through the tube, and defining with one end of the tube, one or more 45 burner jet openings.

4. In combination, a burner tube having open ends, a thermoelectric generator structure extending in said tube, comprising an insulation support, thermoelectric conductors passing 50 through the support, forming on one side of the support, one or more hot junctions, a metal cap defining with said support a space enclosing the hot junctions, said cap being within the influence of the burner flame, and a tubular metallic member carried by said cap to form a sheath, and extending on the other side of said support leads for the thermoelectric generator structure extending into the tubular member; and means surrounding said tubular member for supporting 55 said tubular member in fluid tight manner in the burner tube, and sealing one end of said tube.

5. In combination, a burner tube having open ends, a thermoelectric generator structure extending in said tube, comprising an insulation support, thermoelectric conductors passing through the support, forming on one side of the support, one or more hot junctions, and forming on the other side of the support, one or more cold junctions, and a metal sheath structure enclosing the 70 burner tube; and means surrounding said sheath structure for supporting said sheath structure in fluid tight manner in the burner tube, and sealing one end of said tube.

75 6. In combination, a burner tube having open

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ends, a thermoelectric generator structure extending in said tube, comprising a metallic sheath structure, thermoelectric conductors within said sheath structure and forming one or more hot and cold junctions, heat conducting extensions joined respectively to at least some of the cold junctions and extending out of that end of the sheath structure remote from the hot junction end, and means co-operating with the said structure for sealing one end of the tube.

7. In combination, a burner tube having open ends, a thermoelectric generator structure extending in said tube, comprising a metallic sheath structure, thermoelectric conductors within said sheath structure and forming one or more hot and cold junctions, heat conducting extensions joined respectively to at least some of the cold junctions and extending out of that end of the sheath structure remote from the hot junction end, an insulation ring carried by said end of the sheath structure and on which ring said extensions are looped, and means co-operating with the said structure for sealing one end of the tube.

8. In combination, a burner tube having open ends, a thermoelectric generator structure extending in said tube, comprising a metallic sheath

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structure, thermoelectric conductors within said sheath structure and forming one or more hot and cold junctions, an insulation support through which the conductors pass, and within said sheath structure, those parts of said conductors extending on that side of the support where the cold junctions are formed, being elongated and mechanically intertwined, and means co-operating with the said structure for sealing one end of the tube.

9. In a thermoelectric generator structure, an insulation support, thermoelectric conductors passing through the support, forming on one side of the support, one or more hot junctions, and forming on the other side of the support one or more cold junctions, a metal cap defining with said support, an enclosure for said hot junctions, and a tubular metallic member surrounding said support and cooperating with said cap to form an elongated sheath, heat conducting extensions connected respectively to at least some of the cold junctions and located within the sheath, and an insulation ring carried by the end of the sheath, and around which ring said extensions are looped.

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