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THERMOELECTRIC GENERATOR

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Fig. 1

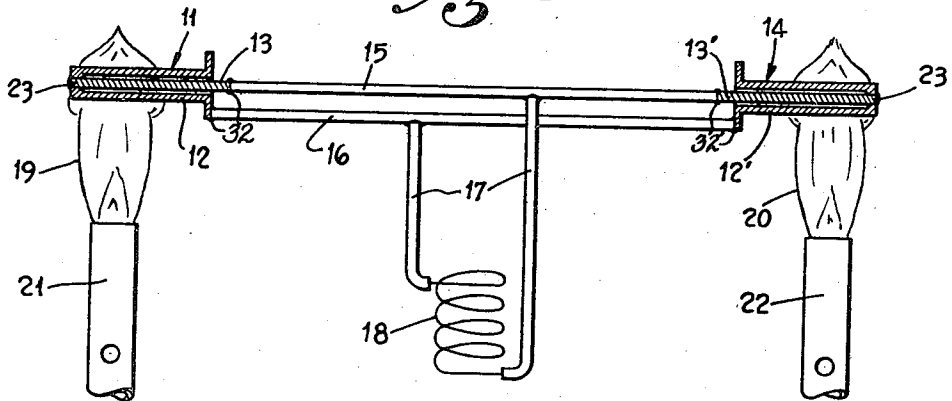


Fig. 2

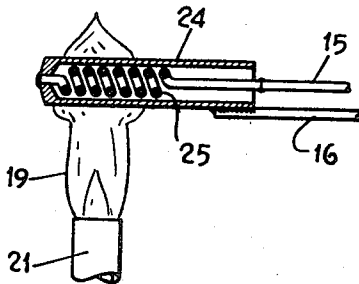


Fig. 3

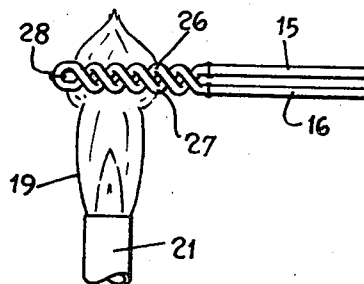
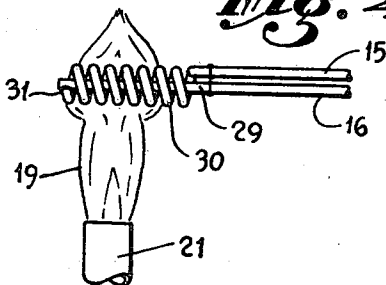


Fig. 4



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THERMOELECTRIC GENERATOR

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5 Claims. (Cl. 171-97)

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My present invention relates to thermoelectric generating systems and particularly to a system comprising a thermoelectric generating device which is influenced by two or more separate sources of heat.

In domestic heating systems employing fluid fuel it is common to provide a thermoelectric generating device, heated by the flame of the pilot burner for the main burner, for energizing an electromagnetic fuel-controlling valve either of the automatically-operated type, or of the "manual-reset" type wherein an electromagnet is employed to maintain the valve closure in open position only after it is first brought to that position by manual means; the valve being so arranged and biased that in the event of extinguishment of the pilot burner, and resultant cessation of generation of energy, the supply of fuel to the main burner is obstructed so that the danger of explosion when the pilot burner is relighted is prevented.

In large heating installations, and when burners of the sectional type are employed, it is necessary to provide a plurality of pilot burners; it then being essential that if any one of the pilot burners is extinguished the supply of fuel to its associated main burner should be stopped. If, as is customary, the main burners are supplied through a single valve, the thermoelectric generating device for energizing that valve must be influenced by the flames of all the pilot burners. However, due to the fact that the amount of electrical energy necessary to maintain an electromagnetic device in active condition is relatively small, the reduction of energy resulting from extinguishment of one of the pilot burners may not be sufficient to effect closing of the valve; and that is so even when only two pilot burners are employed and the amount of energy becomes one half of that normally available. It is therefore an object of this invention to eliminate such deficiency by providing a thermoelectric generating device, influenced by heat from a plurality of separate sources, whereby the amount of electrical energy supplied to a load is disproportionately reduced upon failure of any one of the sources.

Other objects and advantages of the invention will be found in the description, the drawing and the claims; and, for full understanding of the invention, reference is to be had to the following detailed description and accompanying drawing, wherein:

Figure 1 is a sectional view of a thermoelectric generating device embodying the present invention; and

Figures 2, 3 and 4 are views of modified forms of thermocouples adapted for use in thermoelectric generating devices constructed according to the invention.

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Referring first to Fig. 1 of the drawing, the numeral 11 indicates a thermocouple comprising a tubular element 12 within which is a rod-like element 13 which is welded or fused to the outer end of element 12 to form the "hot" junction 23 of the thermocouple. Indicated at 14 is another thermocouple which is identical in construction with thermocouple 11, the elements of thermocouple 14 therefore having been assigned the same numerals with a prime mark added. Connecting thermocouples 11 and 14 in parallel, to form a complete thermoelectric generating device, is a pair of conductors 15 and 16 of low-resistivity metal such as copper. The effective "cold" junction of each thermocouple is at the points (indicated by the numerals 32 and 32') where its elements 12-13 join the conductors 15-16. The thermoelectric generating device is shown connected by another pair of conductors 17 to an electrical load 18 which may be the coil of an electromagnetic valve or relay. The thermocouples are arranged for heating by the flames 19 and 20 of a pair of gas burners 21 and 22, the size of the thermocouples being such that a substantial or major portion of the thermocouple elements adjacent the hot junctions thereof are heated by the flames.

The dissimilar elements of thermocouples, of the type employed in connection with heating apparatus, are usually constructed of the alloys "Chromel" and "Copel" or their equivalents since the thermoelectric power of such alloys, in combination, is the highest of present-known materials capable of continuously withstanding the heat of a gas flame. The change of electrical resistance of such a thermocouple upon heating or cooling is very small since the temperature coefficient of resistivity of "Chromel" is of the order of $+0.0001$ per $^{\circ}\text{C}$. and that of "Copel" substantially zero. Hence, if the thermocouples of Fig. 1 were constructed of these alloys, the voltage across the load 18 would become one half the normal voltage if one of the flames 19-20 were extinguished.

According to this invention, the decrease of voltage across the load upon deenergization of one of the parallel thermocouples is augmented by forming at least one of the elements 12-13 of a material having a high positive temperature coefficient of resistivity. For example, the element 13 may be of nickel and element 12 of "Chromel" or some other material which is thermoelectrically dissimilar to nickel in a high degree. The temperature coefficient of nickel has an average value of $+0.005$ per $^{\circ}\text{C}$. so that a nickel element having a resistance of, say, 1 ohm at 20°C . will have a resistance of approximately 3 ohms at 420°C . and 4 ohms at 620°C . Therefore, if one of the flames is extinguished, the resistance of the cold thermocouple will be considerably less than that of the

hot one so that the cold thermocouple forms a relatively low-resistance shunt across the higher-resistance hot thermocouple, and the voltage across the load is reduced to considerably less than one half the normal voltage.

If one of the elements of the thermocouple is of a material having a low temperature coefficient, the resistance of that element is made small by increasing its cross-sectional area with respect to that of the high-temperature-coefficient element so that even if the resistivity of the material of the low-temperature-coefficient element is high (as it is of "Chromel") there will be a considerable overall change of resistance of the thermocouple with change of temperature. As shown in Fig. 1, the cross-sectional area of the tubular "Chromel" element 12 is approximately eight times that of the nickel element 13. To further enhance the change of resistance, a substantial or major portion (beyond the hot junctions 23-23') of each thermocouple is subjected to the flame, as illustrated.

In order to obtain maximum transfer of power to the load, the resistance of the same is made substantially equal to the resistance of the thermocouples in parallel, and when heated. For example, if the "hot" resistance of thermocouple 11 is 4 ohms and that of thermocouple 14 likewise 4 ohms, the resistance of the load should be approximately 2 ohms. (Obviously, the resistance of each thermocouple should be substantially the same.) The resistance of the load may advantageously be slightly greater than that of the parallel thermocouples since, as can readily be verified by calculation, there is then maximum change of resistance with change of temperature. However, the mismatch of resistance should not be great because of the overall loss of power which results.

The electrical device, represented by the load 18, is so constructed that it is necessary for both thermocouples to be heated in order for the device to operate; i. e., for it to "pull-in" if it is an automatic valve or relay, or to "hold-in" if it is of the "manual-reset" type. Upon extinction of one of the flames, "drop-out" of the device is assured by the substantial reduction of power due to the decrease of resistance of the unheated thermocouple.

Combinations of materials, in addition to that mentioned above, suitable for construction of the thermocouples are, for example: nickel against iron or nickel against copper, in which combinations both of the materials have high temperature coefficients; or iron against "Copel," which combination has a high thermoelectric power.

In Figs. 2, 3 and 4 there are illustrated various forms of thermocouples especially adapted for use in the system of Fig. 1, but obviously capable of other uses.

The thermocouple of Fig. 2 is similar to those of Fig. 1 and comprises a tubular element 24, conveniently of "Chromel," within which is a coiled element 25, conveniently of nickel. By this arrangement the effective length of the nickel element is increased so that there is a greater change of thermocouple resistance with change of temperature.

In Fig. 3, the thermocouple elements 26 and 27 form an interlaced double coil, the convolutions of which are spaced from each other. The flame is arranged to heat a substantial portion of the elements beyond the hot junction 28 thereof, and since both elements are subjected directly to the flame the change of resistance of the ther-

mocouple upon heating or cooling is relatively great.

The thermocouple of Fig. 4 comprises a straight element 29 around which, and in spaced relation thereto except at the junction 31, is an open coil 30 which forms the other element of the thermocouple. This arrangement, generally similar to that of Fig. 3, is particularly suitable when the materials chosen are nickel and "Chromel," or the like, since by employing nickel for the coil 30 the resistance and exposure to the flame of that element is increased; the short straight element 29 then being of "Chromel," its undesirable resistance is reduced to a minimum.

The embodiments of the invention herein shown and described are obviously susceptible of modification without departing from the spirit of the invention, and I intend therefore to be limited only by the scope of the appended claims.

I claim as my invention:

1. In combination: a thermoelectric generating device comprising a pair of thermocouples connected in parallel, each of said thermocouples comprising a pair of dissimilar elements, at least one element of each of said pairs of elements being of material having a high positive temperature coefficient of resistivity, a separate source of heat for each of said thermocouples, and an electrical load energized by said thermoelectric generating device.

2. In combination: a thermoelectric generating device comprising a pair of like thermocouples connected in parallel, each of said thermocouples comprising a pair of dissimilar elements, at least one element of each of said pairs of elements being of material having a high positive temperature coefficient of resistivity, a separate source of heat for each of said thermocouples, and an electrical load energized by said thermoelectric generating device, the resistance of said generating device when in normal operation being substantially the same as that of said load.

3. In combination: a thermoelectric generating device comprising a pair of like thermocouples connected in parallel, each of said thermocouples comprising a pair of dissimilar elements, one element of each of said pairs of elements being of material having a high positive temperature coefficient of resistivity, said one element being so constructed and arranged that its resistance is high with respect to that of the other of the elements when the thermocouple is heated, a separate source of heat for each of said thermocouples, and an electrical load energized by said thermoelectric generating device, the resistance of said load being at least as great as that of said generating device when the same is in normal operation.

4. In combination: a thermoelectric generating device comprising a pair of like thermocouples, a pair of conductors of low resistance connecting said thermocouples in parallel, each of said thermocouples comprising a pair of dissimilar elements, at least one element of each of said pairs of elements being of material having a high positive temperature coefficient of resistivity, a separate source of heat for each of said thermocouples and arranged to influence a major portion of said elements, and an electrical load connected to said conductors, the resistance of said thermocouples in parallel being substantially the same as that of said load when the generating device is in normal operation.

5. In combination: a thermoelectric generating device comprising a pair of like thermocouples, a

pair of conductors of low resistance connecting said thermocouples in parallel, each of said thermocouples comprising a pair of dissimilar elements, one element of each of said pairs of elements being of material having a high positive temperature coefficient of resistivity, said one element being so constructed and arranged that its resistance is high with respect to that of the other of the elements when the thermocouple is heated, a separate source of heat for each of said thermocouples and arranged to influence a major portion of said elements, and an electrical load connected to said conductors, the resistance of said thermocouples in parallel being substantially the same as that of said load when the generating device is in normal operation.

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