

Jan. 6, 1942.

P. L. DULANEY

2,269,337

THERMOELECTRIC GENERATOR AND BURNER THEREFOR

Filed Aug. 8, 1939

2 Sheets-Sheet 1

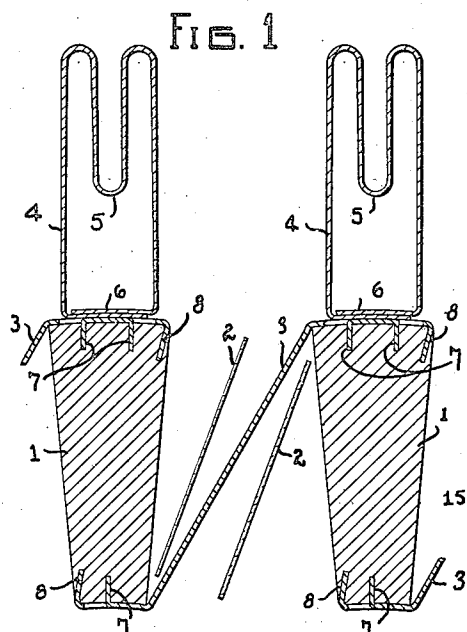


FIG. 2

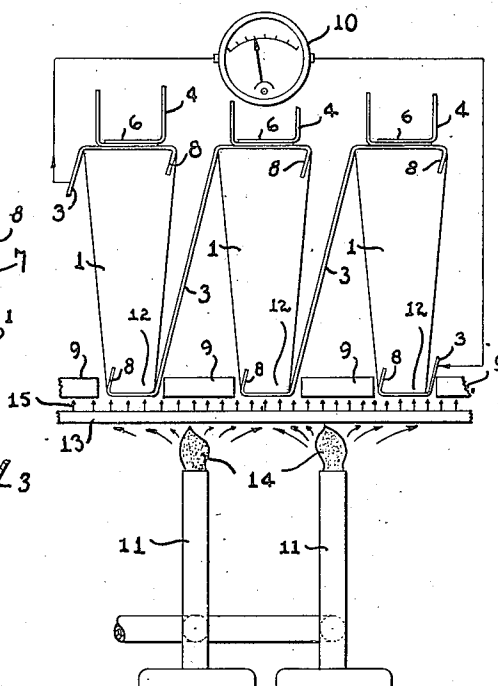


FIG. 4

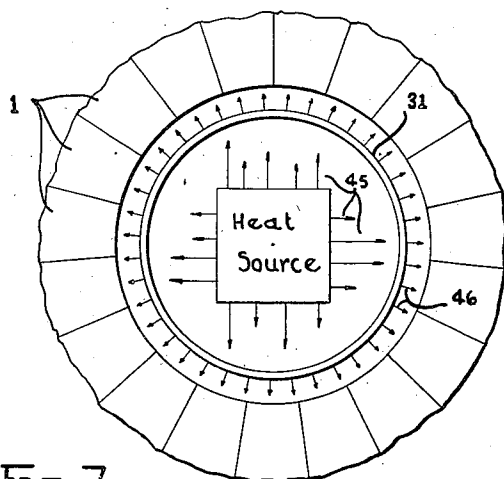


FIG. 7

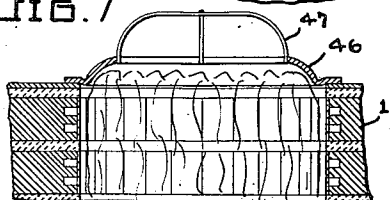
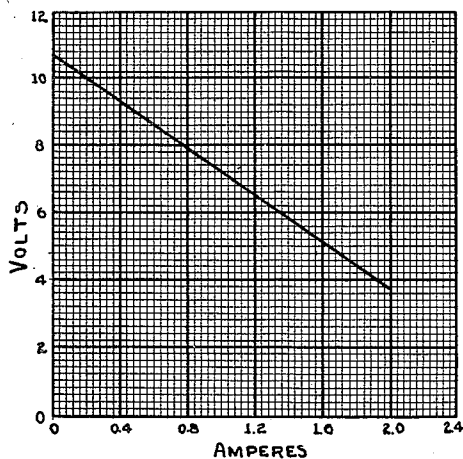


FIG. 3



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Jan. 6, 1942.

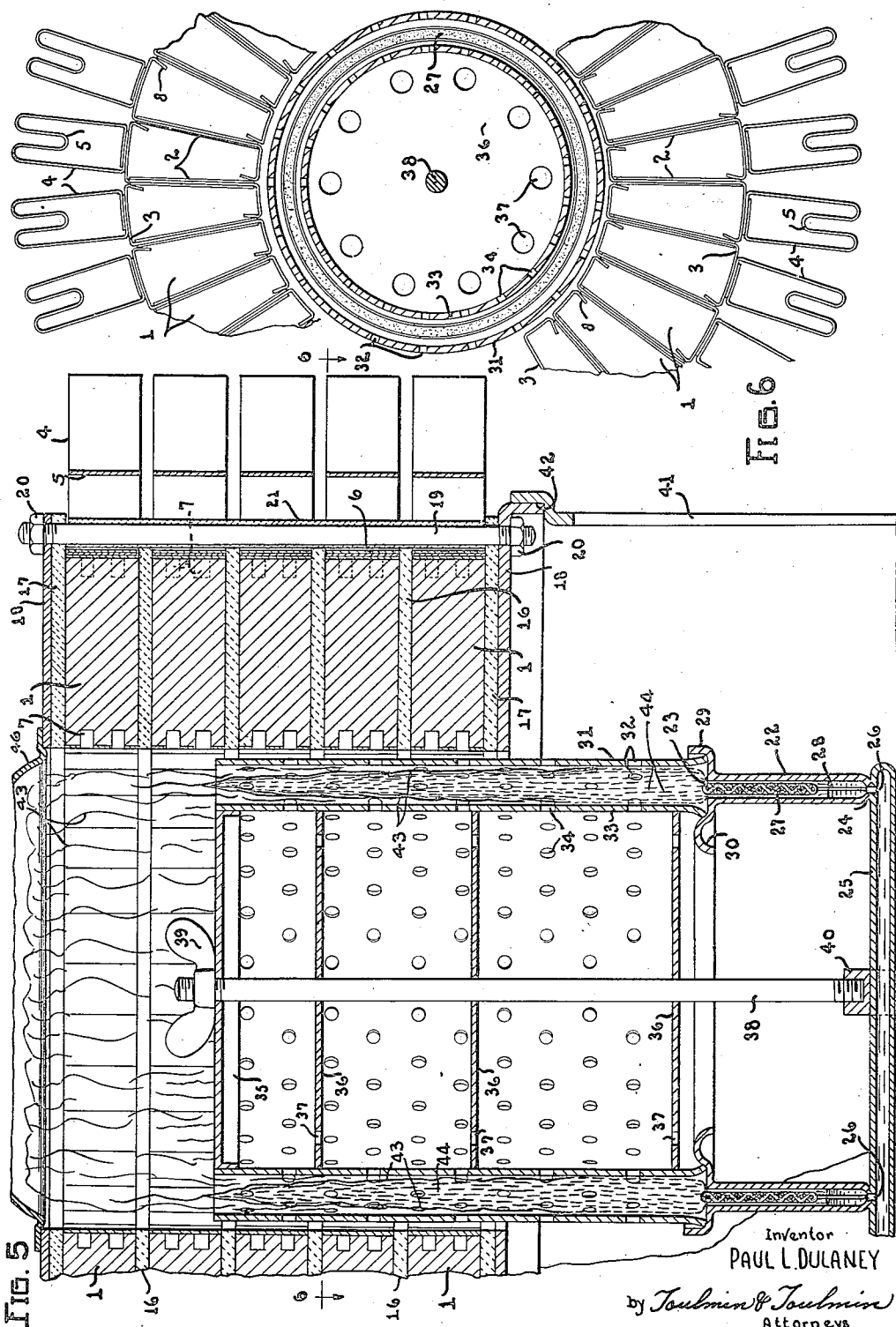
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THERMOELECTRIC GENERATOR AND BURNER THEREFOR

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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

2,269,337

THERMOELECTRIC GENERATOR AND
BURNER THEREFOR

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Application August 8, 1939, Serial No. 289,010

5 Claims. (Cl. 136-4)

The present invention relates to liquid fuel or oil burners and more particularly to those burners which are employed for the purpose of heating the hot junctions of thermoelectric generators.

In the Wiegand application Serial No. 288,408 filed August 4, 1939, and entitled "Thermoelectric generators," assigned to the same assignee as the present invention, there is disclosed and claimed an improved thermoelectric generator which employs a special alloy having the peculiar characteristics of generating thermocurrents of practical magnitude when subjected to easily obtainable temperatures. A complete disclosure of this alloy and the manner in which it operates will be given hereinafter.

It has been found in practice that, when the heat applied to the hot junction formed between the alloy and the connecting metal strip is obtained from the usual sources of heat, such as ordinary oil burners in which the flame actually contacts with the hot junction, the electrical output of the alloy is subject to considerable variation. It has further been found that, when a number of thermoelectric units formed of the alloy are connected in series and the flame of the heat source is permitted to contact directly with the hot junctions, the latter are not heated evenly, either over their respective surfaces or as between units. Thus, one unit is heated to a far greater degree than another unit, and the output of the generator is reduced accordingly.

The lack of control over the direct application of heat through permitting the flame to contact the hot junctions of the generator created a hazard to the generator of over-heating and seriously damaging the generator units. The alternative is to keep the average temperature so low—in avoiding uncontrolled over-heating—that the effective gradient could not be maintained.

In accordance with my invention, I have discovered that unusually good results are obtainable in connection with the thermoelectric generators when the hot junctions are subjected to radiant or indirect heat. In following out this discovery, I have also invented an improved burner by which these results are obtained. This burner has broad application to the heating field, although as stated hereinbefore, it is particularly well adapted to provide heat evenly to a large number of thermoelectric units.

Accordingly, the primary object of my invention is to provide an improved burner which depends on oil for fuel and radiates heat evenly

over a relatively large proportion of its heat-emitting surface; to provide an improved oil burner of cylindrical configuration which radiates heat at a uniform intensity in radial directions; to provide an oil burner which operates efficiently and is adapted to provide heat at exceedingly high temperatures even when using low grade oils.

The final and more specific object is to provide an improved burner which finds a particular adaptation to the art of thermoelectricity in that it furnishes heat of an indirect or radiant character for efficiently generating thermocurrents.

The invention will be better understood when reference is made to the following description and the accompanying drawings, in which—

Figure 1 is a cross sectional view of a pair of thermoelectric units, to which my improved burner finds particular adaptation.

Figure 2 is a diagram indicating the manner in which voltage is measured between three of the thermoelectric units when heated in accordance with the principles of my invention.

Figure 3 is a graph showing the electrical output actually obtained from 150 of the units shown in Figures 1 and 2 when connected in series and heated by my improved burner.

Figure 4 diagrammatically indicates the manner in which the improved burner operates to produce improved thermoelectric effects when the thermoelectric units are arranged in a cylindrical configuration.

Figure 5 shows a cross sectional view, partly in elevation of an improved thermoelectric generator as described in the Wiegand application referred to hereinbefore and employing the improved burner which forms the subject of the present invention.

Figure 6 is a fragmentary view, somewhat diminished, taken along line 6-6 in Figure 5 to show the plan view relation between the improved burner and the thermoelectric generator.

Figure 7 is a fragmentary view on a reduced scale of the upper portion of the thermoelectric generator and the improved burner.

Referring more particularly to Figures 1 and 2, numeral 1 designates a thermoelectric alloy cast in segmental form, arranged in rectilinear relation with the narrow end of each segment projecting in the same direction. It will be understood, in practice, that the units 1 are placed close together and are insulated from one another by means of a strip of mica, indicated at 2, placed between the segments. However, the

latter are electrically connected together by means of a metal strip 3 which is secured in any suitable manner to the outer surface of each segment and to the inner surface of the next adjacent segment. Thus, the segments are connected in series and currents generated therein by heat applied to the narrow end or hot junction can be taken off from the terminal strips 3.

It was pointed out in the Wiegand application referred to hereinbefore that the units 1 may be composed of an alloy of antimony and zinc with the antimony in the percentage of approximately 67% to 55% and the zinc approximately 33% to 45% by weight (assuming the alloy to be 100%) with five to ten ounces of dechlorinated salt per hundred pounds of antimony and a trace of arsenic. The strip 3 may be constituted of any suitable metal having a melting point higher than that of the alloy of the unit 1, but in order to withstand corrosion at high temperatures, a metal called "copel" is preferred for this purpose. Copel is somewhat similar to German silver and is constituted of approximately 46% nickel and 54% copper. The metal in strip form is readily procurable on the market.

To give specific examples, it has been found that, when the units 1 are formed of a segmental block having a width at the narrow end of approximately $\frac{3}{8}$ " and at the wide end of approximately $\frac{3}{4}$ " and a length of approximately $1\frac{7}{8}$ " and a thickness of approximately $\frac{5}{8}$ " by heating the hot junction end of the block to approximately 800° F. and cooling the opposite end to approximately 200° F., it is entirely possible to obtain a voltage of one-tenth of a volt between conductors 3.

It was brought out in the Wiegand application that, when thirty segments of this size were connected in series to form a cylindrical layer and five such layers were provided, all connected in series, electrical energy depicted by the chart (Figure 3) was readily obtainable. Thus, at one ampere, the voltage was approximately seven volts and at two amperes approximately four volts. It is apparent that this output is of a commercial magnitude and finds many uses in the electrical art, for example, the energization of the heater or filament of radio tubes, charging storage batteries, operating electrical devices, etc.

As shown in Figure 1, the end of the block opposite from the hot junction end is preferably cooled by means of a strip of copper 4 which is bent at the middle as indicated at 5 and is secured in any suitable manner to that portion of the copel strip 3 which abuts the wider end of the unit 1. The strip 5 may be of sufficient length to form a pair of legs, as indicated at 6, which overlap one another and can be spot-welded together and also to the upper flat portion of the copel strip. The latter may be secured to the unit in any suitable manner, for example, one or two vertically disposed tabs 7 provided at each end of the strip and cast into the alloy. In addition, the strip may be provided with a bent leg 8 which is also cast into the alloy. A mould may be provided and the strips 3 positioned at each end of the mould and the alloy poured into the mould at approximately 1350° F. and allowed to solidify. Thus, the heat-radiating fin 4 and the copel strip 3 are rigidly secured to the unit 1. It has been found that the strip 4 can, when properly designed, radiate sufficient heat to maintain the cold junction end of the unit at approximately 200° F. when the hot junction end is heated to approximately 800° F.

When the units are spread out, as indicated in Figure 2, instead of being arranged in an abutting relation, it may be desirable to provide between the lower ends of the units a metal heat baffle 9 to prevent the heat from striking the sides of each unit. As a result of numerous tests, it has been found that, when the source of heat strikes the hot junctions of each thermoelectric unit, deleterious effects are produced not only by way of a fluctuating voltage as measured by the voltmeter 10, depending upon the irregularity of the heating source, but the electrical load is not divided equally among all of the units, since one of the hot junctions may be heated to a higher temperature than another hot junction. Indeed, even parts of each hot junction may be heated to a greater or less degree than other parts of the same junction. It is entirely possible to heat limited portions of the alloy or the connecting strip to their respective melting temperatures without obtaining the maximum thermocurrent output from the unit.

In accordance with the present invention, I have discovered that unusually good results may be obtained by way of large thermocurrents and voltages and greater operating life of the alloy and the copel strips when the source of heat is not permitted to contact with the hot junction. There is, therefore, interposed between the Bunsen burners 11 and the hot junctions 12 of the units a metal heating plate 13 on which the flames 14 strike. The plate, therefore, becomes heated and serves to distribute its heat uniformly over all of the hot junctions 12 and over every part of each hot junction. Thus, the latter are subjected to radiant heat, as indicated by the uniformity of lengths of the arrows shown at 15. Notwithstanding the inter-position of the plate 13, it is entirely possible to heat the hot junctions 12 to any desired temperature less than the melting temperature of the alloy and to maintain such a temperature throughout the hot junctions.

It was pointed out hereinbefore that the thermoelectric generator may comprise thirty or more thermoelectric units in abutting relation and connected in series to form a circular layer. Any number of such layers may be connected in series to constitute the generator and, as illustrated, there are five such layers. The typical characteristic shown in Figure 3 gives a general indication as to the power output of such a generator when the units are subjected to a temperature gradient of approximately 600° F., although it will be understood that considerably greater power output may be obtained when this gradient is increased. The layers are separated from one another by an insulating plate 16 (Figure 5), preferably of asbestos, spun glass or mica and there is a similar plate 17 at the upper surface of the uppermost layer, also at the lower surface of the lowermost layer. On the outside of the plate 17, there is a metal plate 18. The plates 17 and 18 are of a diameter sufficiently large to accommodate four or more equidistantly spaced bolts 19 provided with nuts 20 which serve to clamp the two metal plates 18 and, therefore, to hold all of the thermoelectric layers and the individual units thereof rigidly in place. The bolts are insulated from the alloy by means of a lava tubing 21. The plates 16, 17, and 18, also the hot junctions of the thermoelectric units 1, when assembled, have the same inner diameter, thereby defining the interior surface of a cylinder.

For heating the inner surface of the hot junctions of the thermoelectric generator, there is provided a double-walled burner improved in accordance with my invention. This burner is constituted essentially of an enclosure 22 termed an "oil bowl" and having a U-shaped cross section, i. e., open at the top as indicated at 23, and closed at the bottom as indicated at 24. The bowl is supported on a conduit or pipe 25 which leads to an oil reservoir (not shown). The interior of the pipe 25 communicates with the interior of the oil bowl 22 at two diametral positions illustrated by the openings 26. A cylindrical lighting ring 27 of interwoven asbestos strands is contained within the bowl 22 and supported from the closed end 24 thereof by means of a wire truss 28. This truss preferably made in the form of loops stapled to the lower end of the lighting ring rests on the lower or closed end of the oil bowl. The lighting ring 27 has a length as measured in the vertical direction of the figure considerably shorter than the length of the bowl 22 and the upper end extends just beyond the annular opening 23.

The outer wall of the bowl 22 terminates in a flange 29 and the inner wall terminates in an inwardly extending rolled flange 30. There is an apertured cylinder 31 loosely resting on the flange 29 and, therefore, removable in order to apply an igniting torch to the upper or lighting edge of the ring 27. The apertures in the cylinder 31 are indicated at 32. The cylinder extends to a height preferably just above the third layer of the thermoelectric units.

There is an inner cylinder 33 having apertures 34 and arranged concentrically with the outer cylinder 31. The inner cylinder rests on the flange 30, to which it may be secured. The upper end of the cylinder 33 is closed by a top piece 35 welded or otherwise secured to the cylinder. The latter is also provided with three or more transversely extending partitions 36 having openings 37, arranged in a circular path, as can be seen more clearly in Figure 6. The inner cylinder 33 is pressed against the flange 30 by means of a threaded bolt 38 provided with a wing nut 39. The bolt is secured at the end opposite from the nut to a lug 40 which may be welded to the conduit 25. The pipe or conduit 25 may pass through a hand-operated valve (not shown) of any suitable type, to a reservoir (not shown), containing a hydrocarbon fuel such as kerosene. Thus, oil is fed from the reservoir and controlled by the valve to the openings 26.

Prior to the lighting of the burner, the oil fills the annular space between the lighting ring and the bottom of the oil bowl 22, the level of the oil reaching a position $\frac{3}{8}$ " to 1" up from the lower surface of the lighting ring. After the ring 27 has been lighted by removing the outer cylinder 31 and applying a torch, the level of the oil automatically drops, provided the oil valve has the proper setting, to a position just below the lighting ring, as is indicated in Figure 5. The supply of oil is controlled in such a manner that the zone of greatest combustion is positioned fairly low in the annular space between the cylinders 31, 34. Thus, the flame is kept relatively low and the burner is operated at less than its maximum capacity.

However, the flame will extend upwardly between the walls 31, 33 to a distance practically as high as the upper surface of the upper layer of the generator.

The oxygen for combustion is obtained from

the air which passes through a number of openings 41 positioned about a cylinder, on which the bottom plate 18 rests, as indicated at 42. This air flows through the openings 32 in the cylinder 31 and also through the openings under the bowl 22, passing upwardly through each of the openings 37 and into the inter-cylinder space through the openings 34. A draft or chimney effect introduced by the openings 41, 32, 37 and 34 is such as to cause the flame to emerge at the upper end of the burner as an annular jet, following the original direction and, therefore, spaced from the inner surfaces of the thermoelectric units 1.

In order to insure that the upper end of the flame does not tend to strike the thermoelectric units directly, it may be desirable to provide a so-called outlet ring 46 placed above the burner and supported on the plate 18 in order to retard and direct the products of combustion. This ring carries a wire safety guard 47. The ring, therefore, controls the amount and distribution of radiant heat reaching the two upper layers in the same manner as the vertical position of the outer cylinder 32 with respect to the three lower layers controls the distribution of radiant heat transferred to the lower layers.

In Figure 5, the flame is indicated by the curved lines 43 which, as will be noted, extend a considerable distance beyond the top piece 35. Figure 7 shows the manner in which the outlet ring 46 operates to converge the flame inwardly at a position above the uppermost thermoelectric layer, thereby directing the flame away from this layer but permitting the radiant heat to reach the latter. The vertical dotted lines 44 shown in Figure 5 indicate the direction taken by the kerosene vapor on leaving the oil bowl and passing upwardly through the narrow annular spaces between the lighting ring and the bowl. It will be noted that the lines 44 extend for considerable distance upwardly from the top edge 23 of the lighting ring, indicating that the flame does not extend as far down as the lighting ring.

The ample and constant supply of oil in the burner bowl to the proper level, combined with the proper heating of the lower walls of the combustion chamber and the upper walls of the oil bowl combine to supply a uniform supply of oil vapor into the combustion chamber. The annular space at the bottom of the bowl containing free oil which makes possible a constant and ample evaporation of oil taken up by capillary action of the ring and the cooler walls of the bowl because of this constant evaporation, prevent the permanent deposits of carbon on the ring which formerly occurred. The coating of the ring with baked on free carbon or asphaltum residue, is thus eliminated.

The feature of spacing the lighting ring from the bottom of the oil bowl 22 by means of the truss 28 is described and claimed in the Dulaney application Serial No. 289,011, filed August 8, 1939, and entitled "Lighting rings for wickless burners."

In order to assure that the flame within the burner is of uniform intensity over the entire height of the thermoelectric units, the spacing and size of the openings 37, also the distances between the partitions 36, and between the top piece 35 and the upper partition 36, are so determined, preferably by experiment, as to provide the proper gradation of air through the openings 34. Thus, the supply of oxygen is regulated at the different levels of the burner, as represented by the openings 34 to provide a flame of uniform

intensity throughout the length of the burner, which in turn causes an even application of heat to the interior surface of the thermoelectric generator. The narrow annular space between the wall 31 and the interior surface of the thermoelectric generator also constitutes an air flue in that it regulates or controls the amount of air and, therefore, oxygen passing through the openings 32 at the different levels throughout the burner. This flue space is, therefore, preferably accurately determined by experiment and depends on the size of the burner, the size of the openings 32, the annular width of the combustion chamber and other factors.

The outer wall 31, in addition to constituting a part of the combustion chamber, also serves to prevent the flame from actually impinging on the thermoelectric units and tends to smooth out still further any slight irregularity in the flame within the burner. It is conceivable that, in the absence of the wall 31, the flame may have such an irregular character as to radiate heat in different amounts in the radial directions, as indicated by the arrowed lines 45 of different lengths, shown in Figure 4. However, the presence of the wall 31 assists in causing the radiation of heat uniformly in the radial direction, as indicated by the arrowed lines 46 (Figure 4) of equal lengths. Thus, the hot junctions of the thermoelectric units are subjected to heat of uniform intensity, not only as between junctions, but also over every portion of each junction. It is apparent that the voltage generated under these conditions is of an optimum value and is much more constant than if the flame were permitted to strike the units.

In the absence of wall 31, it would be impossible to sustain a flame reaching upward along the generator wall as introduction of air throughout the entire height of the flame is necessary from both inside and outside the annular combustion chamber. With air introduced only from the inside, the outer surface-generator face would be coated with carbon and the flame would sink to the base of the combustion chamber, where a small portion of air could be had from the outside below the generator wall. The wall 31 is an essential to all wickless burners and particularly to this one where a uniform heat is desired throughout the entire height of the combustion chamber.

In addition, the uniformity of the radiated heat permits the hot junctions to be heated up to their maximum temperature without the danger of localized melting or otherwise deleteriously affecting any portion of the junctions. Notwithstanding drafts or other irregularities of the air travel through the openings 41, the voltage remains substantially constant under load for any given current output, this result being directly attributable to the uniformity of heat radiation and distribution by the wall 31, as indicated by the arrowed lines 46 of equal length in Figure 4.

It has been pointed out that the openings 37, 34 and 32 together with the air flue effects all tend to cause the flame within the burner to burn uniformly. This uniformity of combustion is not reduced in any appreciable degree, even when the supply of oil is restricted to such a point that the zone of the greatest combustion within the burner is held low. Thus, the improved burner has a wide variation of oil control and, in the case of a constant load such as the thermoelectric generator, can be efficiently run at an economical rate of oil consumption without giving

off odoriferous fumes or producing any irregularity in the flame. Its economy of operation is so marked that, in the case of the thermoelectric generator referred to hereinbefore and producing the energy shown in chart form in Figure 3, a gallon of ordinary gasoline will last the burner from twenty-six to thirty hours, raising the temperature of the generator hot junctions to the required amount with less than .04 gallon per hour.

While I have explained my invention more particularly in connection with the improved thermoelectric generator which forms the subject of the Wiegand application referred to hereinbefore, it is to be understood that the invention is not limited to this particular application. Indeed, the improved burner finds utility in any case where a heat source of uniform intensity is required, and in which the burner is operated with a low flame and, therefore, at less than its maximum capacity with consequent optimum economy. The improved burner makes a valuable contribution to a laboratory requiring a heat source of even temperature, wherein the only fuel or energy available is oil. The burner may also be used in household furnaces and stoves, where economy of operation is required and complete absence from fumes and disagreeable odors.

It will be understood that I desire to comprehend within my invention such modifications as come within the scope of the claims.

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

1. In combination, a generator of electromotive force comprising a plurality of thermoelectric units electrically connected together to form a layer with the hot junctions adjacently positioned, said generator consisting of a plurality of said layers stacked on one another, and means including a double-walled oil burner to form a combustion chamber, said walls enclosing the flame for heating the hot junctions uniformly and extending over only a portion of the hot junctions, all parts of the burner being spaced from the hot junctions, and means including a draft-directing ring secured to said generator for directing the flame away from the remainder of the hot junctions or in heat-radiating relation therewith.

2. In combination, a generator of electromotive force comprising a plurality of thermoelectric units electrically connected together to form a layer with the hot junctions adjacently positioned, said generator consisting of a plurality of layers stacked on one another, and means including an oil burner for heating the hot junctions uniformly, said burner including an oil flame contained between a pair of concentrically arranged cylinders contained within said layers, said cylinders extending over only a portion of the inner surface of said layers, and a cup-shaped element secured to the upper portion of the generator and mounted over said flame for directing the flame away from the upper layers of the stack but permitting the flame to remain in heat-radiating relation therewith.

3. In combination, a generator of electromotive force comprising a plurality of thermoelectric units electrically connected together to form a layer with the hot junctions adjacently positioned, said generator consisting of a plurality of layers stacked on one another, and means including an oil burner for heating the hot junctions

tions uniformly, said burner comprising an oil flame positioned near one of the layers, and means for preventing the flames from contacting any of the hot junctions, said last-mentioned means including a double-walled perforated combustion chamber which extends over a portion of the hot junctions, said last-mentioned means also including a draft-directing ring secured to the upper portion of said generator for directing the flame away from the remainder of the hot junctions but permitting the flame to remain in heat-radiating relation therewith.

4. In combination, a generator of electromotive force comprising a plurality of thermoelectric units of segmental configuration and electrically connected together to form a cylindrical layer with the hot junctions positioned around the inner diameter of the cylinder, a plurality of said layers stacked one on the other to form an elongated cylinder and electrical connections between the layers, means contained within the cylinder for heating the hot junctions uniformly, said means comprising an oil burner having an annular flame positioned near one of the layers,

and means for preventing the flame from contacting any of the hot junctions, said last-mentioned means including a double-walled perforated combustion chamber of cylindrical configuration which extends over a portion of the hot junctions, said last-mentioned means also including a draft-directing ring secured to the generator for directing the flame away from the remainder of the hot junctions but permitting the flame to remain in heat-radiating relation therewith.

5. In combination, a generator of electromotive force comprising a plurality of thermoelectric units electrically connected together to form a layer with the hot junctions adjacently positioned, said generator consisting of a plurality of said layers stacked on one another, and means including a double-walled oil burner to form a combustion chamber, said walls enclosing the flame for heating the hot junctions uniformly and extending over only a portion of the hot junctions and all parts of which are spaced from the hot junctions.

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