

Aug. 30, 1949.

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2,480,404

PORTABLE THERMOELECTRIC GENERATOR

Filed Feb. 9, 1944

5 Sheets-Sheet 1

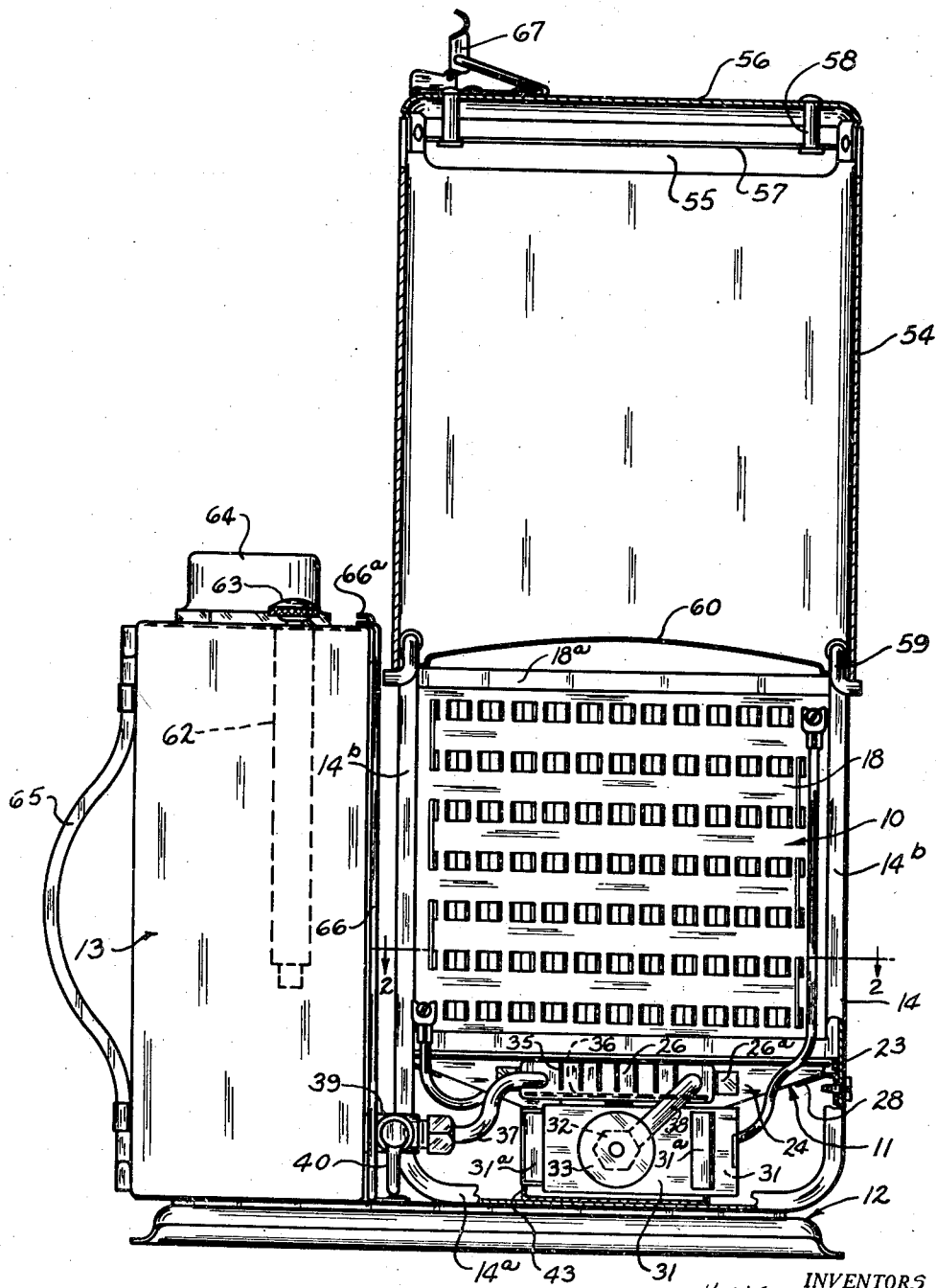


FIG. 1

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5 Sheets-Sheet 2

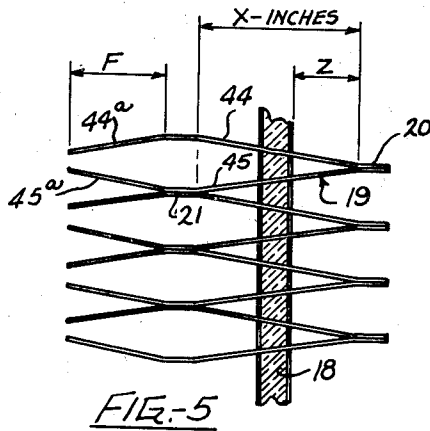


FIG. 5

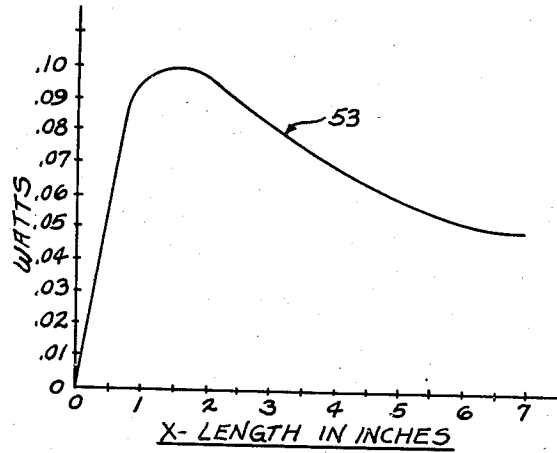


FIG. 6

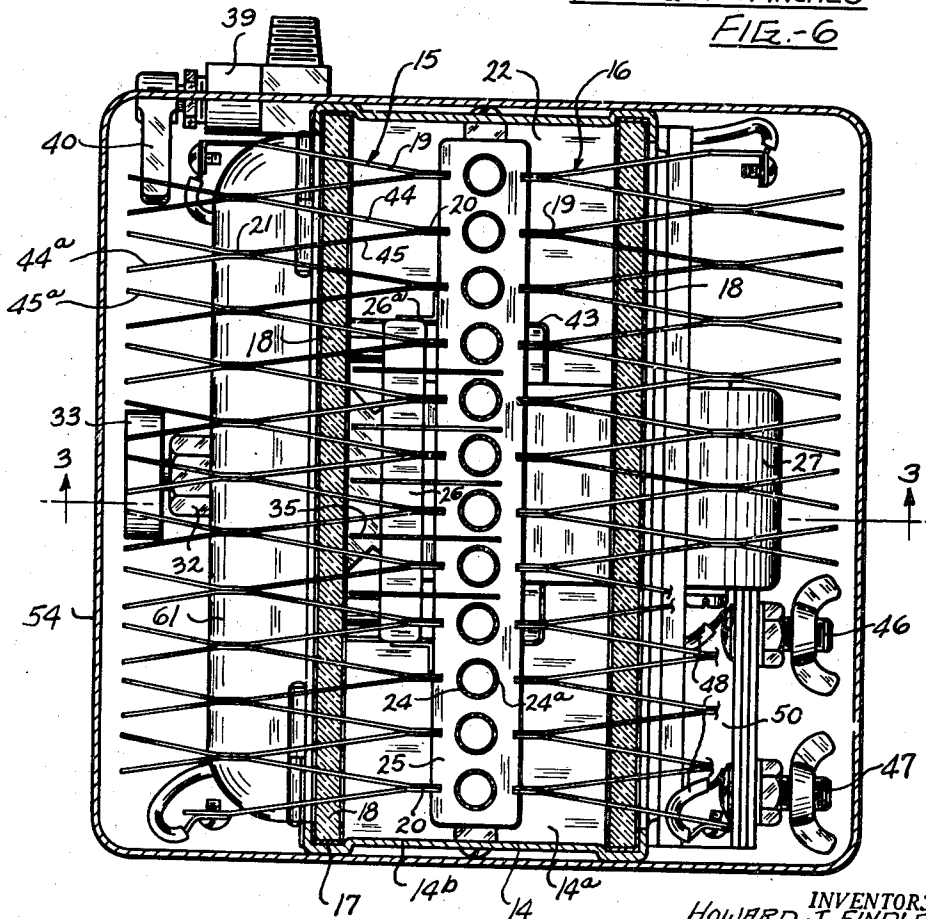


FIG. 2

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5 Sheets-Sheet 3

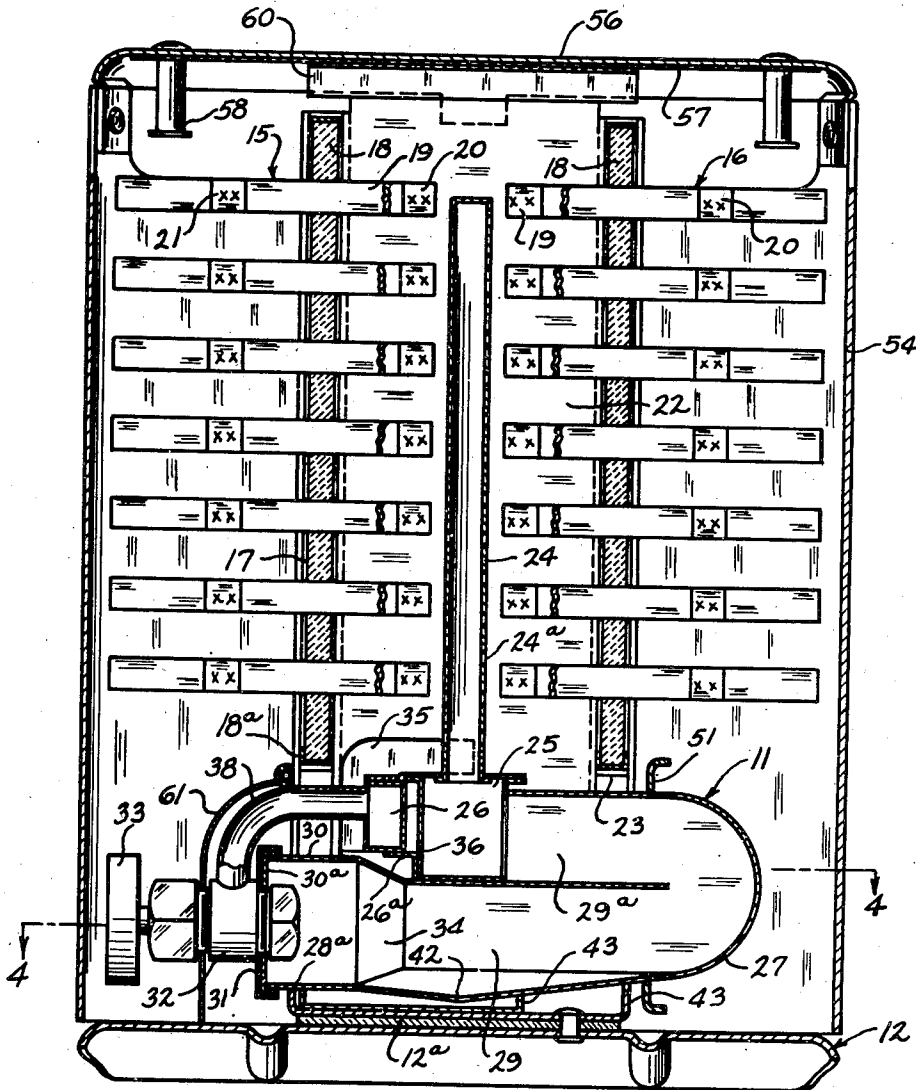


FIG. -3

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5 Sheets-Sheet 4

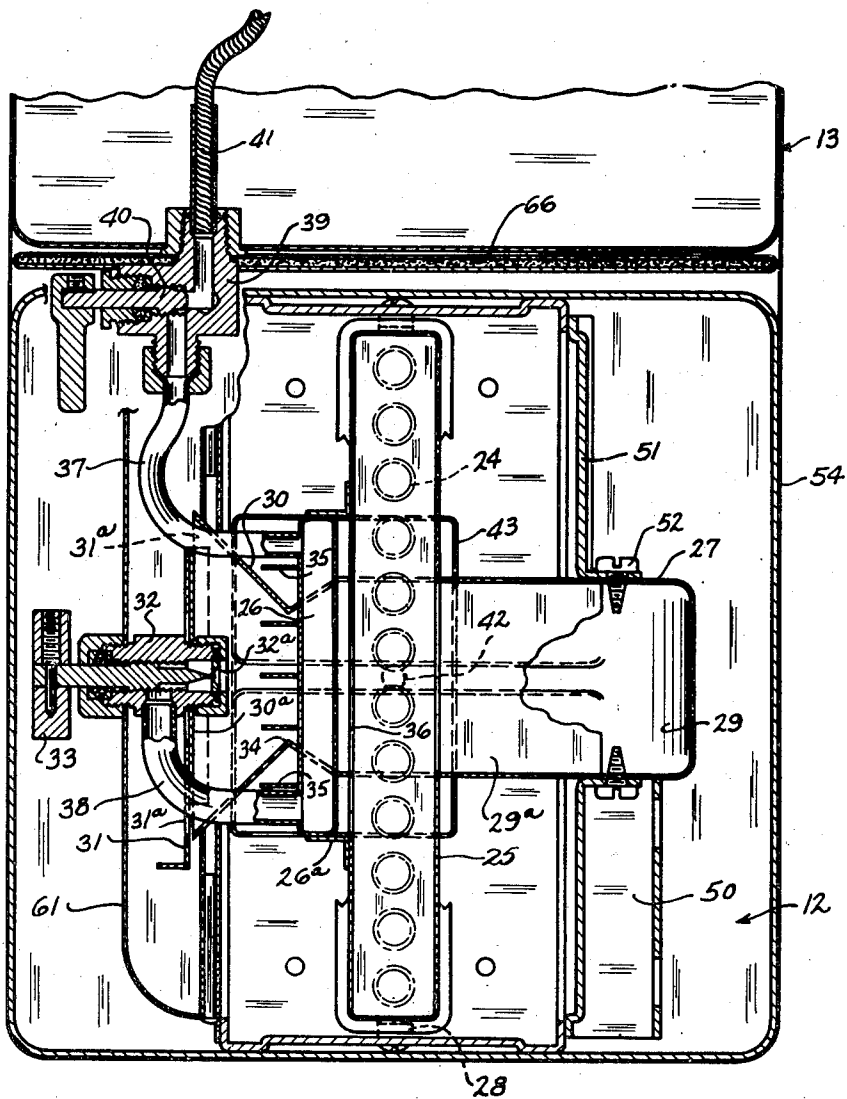


FIG-4

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5 Sheets-Sheet 5

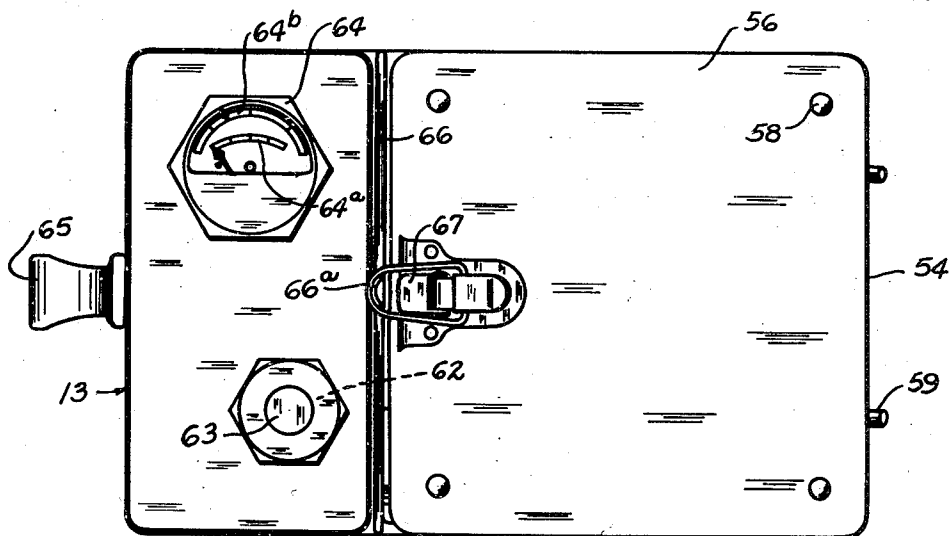


FIG. 8

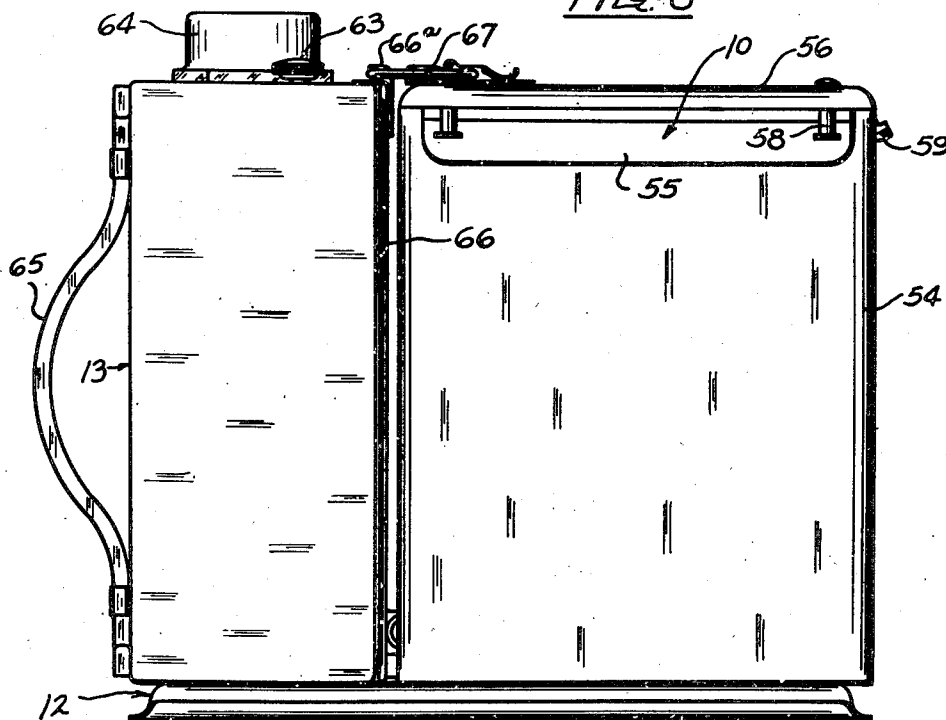


FIG. 7

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2,480,404

PORTABLE THERMOELECTRIC GENERATOR

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Application February 9, 1944, Serial No. 521,642

7 Claims. (Cl. 136-4)

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This invention relates to thermoelectric generators and aims to provide an improved device of this character which is safe, reliable and substantially silent in operation and which is compact and of light weight in relation to its electrical output.

Another object of this invention is to provide an improved thermoelectric generator which can be readily produced in the form of a self-contained unit embodying its own fuel supply and which is manually portable.

Still another object of the present invention is to provide an improved thermoelectric generator in which the thermocouples are arranged in opposed banks and a fuel burning means disposed between such banks directs the burning fuel against the thermocouple junctions.

The present invention also provides a novel form of thermopile which can be economically constructed and whose electrical output is high in relation to the weight and cost of such thermopile.

A further object of this invention is to provide an improved manually portable thermoelectric generator having a thermopile and fuel tank supported by the same base and in which the thermopile embodies spaced banks of thermocouples removably supported in upright relation with a fuel burning means disposed between such banks.

Yet another object of the invention is to provide an improved thermoelectric generator of this character, in which the heating of the thermocouple junctions is accomplished substantially without clogging of the burner openings.

The invention can be further briefly summarized as consisting in certain novel combinations and arrangements of parts hereinafter described and particularly set out in the appended claims.

In the accompanying sheets of drawings,

Fig. 1 is a side elevation of a thermoelectric generator constructed according to the present invention, the generator being shown with portions thereof broken away and with the housing in its open position;

Fig. 2 is a sectional plan view taken through the thermopile substantially as indicated by section line 2-2 of Fig. 1;

Fig. 3 is a vertical sectional view taken through the thermopile and fuel burning means substantially as indicated by section line 3-3 of Fig. 2, the device being shown with the housing in its closed position;

Fig. 4 is another sectional plan view taken through the device below the thermopile and sub-

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stantially as indicated by section line 4-4 of Fig. 3;

Fig. 5 is a partial sectional plan view taken through one of the banks of thermocouples to further illustrate the construction of the thermopile;

Fig. 6 is a diagram illustrating the electrical output of one thermocouple in relation to certain dimensional values thereof;

Fig. 7 is an external side view of the thermoelectric generator showing the same with the housing in its closed position; and

Fig. 8 is an external plan view of the device.

Further reference will now be made to the drawings in connection with the following detailed description of the present embodiment of our improved thermoelectric generator. It should be understood, however, that the invention is susceptible of various other embodiments than the one here shown.

As shown in the drawings, the improved thermoelectric generator comprises in general a thermopile 10 provided with a fuel burning means 11 and mounted on a base 12. The device also includes a tank 13 mounted on the base 12 adjacent the thermopile 10 and adapted to contain a supply of suitable fuel such as gasoline. The base 12 may be a dished and ribbed rectangular plate in the form of a sheet metal stamping and which provides a support upon which the device stands or rests. The base 12 has a ventilated space therebelow by reason of the fact that the recess provided by the dished shape is in the underside of the base and the downwardly bent portions at the edges of the dished shape are so formed as to provide an opening from atmosphere into the recess along one or more sides.

The thermopile 10 comprises a frame 14 and a pair of laterally spaced upright thermocouple banks 15 and 16. The frame 14 is here shown in the form of a U-shaped member having its transverse section 14a riveted or otherwise attached to the base 12 with a layer 12a of asbestos or the like therebetween. The parallel legs 14b extend in upright relation above the base and each leg has a pair of substantially parallel vertical grooves 17 therein. The thermocouple banks 15 and 16 each comprise a wall or panel 18 formed of electrically-insulating heat-resistant material such as ceramic or any other suitable substance, and a plurality of vertically spaced laterally extending rows of thermocouples 19 supported by such wall. The thermocouples 19 can be mounted in preformed openings provided in the panels 18

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or can be molded into the panels during the forming or casting of the latter.

The walls 18 are removably received in the grooves 17 of the upright legs 14b of the frame 14. As will be explained more in detail hereinafter, the thermocouples 19 are of a length to extend through the wall 18 with their hot junctions 20 located on one side of such wall and their cold junctions 21 on the opposite side. The walls 18 are held by the grooves 17 in substantially parallel upright relation so as to provide therebetween a combustion chamber 22 with the hot junctions 20 of the thermocouple banks 15 and 16 extending into such chamber and located substantially directly opposite each other.

The walls 18 may be formed either as a single slab of electrically-insulating material or may be composed of a plurality of assembled sections and are preferably provided with a reinforcing marginal rim 18a. The thermocouple banks 15 and 16 are spaced above the base 12 and are supported in the frame 14 at the desired height above the base by engagement of the lower edges of the walls 18 with lugs or stops 23 provided in the grooves 17. The spacing of the lower edges of the walls 18 above the base 12 permits combustion air to flow laterally and upwardly into the combustion chamber 22.

The fuel burning means 11 comprises a fuel vaporizing, mixing and distributing means located beneath the thermopile 10 and a plurality of burner tubes 24 extending upwardly in the combustion chamber 22 between the thermocouple banks 15 and 16. The fuel distributing means comprises an elongated hollow member or box 25 located between the spaced walls 18 of the thermocouple banks and substantially coextensive therewith. The burner tubes 24 are mounted on the box 25 so that these tubes will be disposed in a laterally extending row or series with one such burner tube located directly between each pair of opposed hot thermocouple junctions 20. The upper ends of the burner tubes 24 are closed and their lower ends communicate with the box 25 to receive fuel mixture therefrom. The burner tubes are provided with spaced openings 24a for directing burning fuel against the hot thermocouple junctions 20.

The fuel vaporizing means comprises an elongated hollow member or vaporizer 26 located adjacent to, and extending parallel with, the distributing box 24. The fuel and air mixing means comprises an elongated mixing tube 27 which extends in transverse relation to the distributing box 25 and the walls 18 of the thermocouple banks. As will be presently explained more in detail, the delivery end of the mixing tube 27 is connected with the distributing box 25 and its receiving end is connected with the vaporizer 26. The fuel burning means 11 is supported by engagement of the ends of the distributing box 25 with the clips 28 of the frame 14 and by engagement of the outer end of the mixing tube 27 with the frame as indicated at 28a in Fig. 3.

The mixing tube 27 has a passage 29 therein which includes a reversely extending portion 29a leading into the distributing box 25. The outer end of the mixing tube 27 is provided with a flared portion 30 (see Fig. 4) having a partial front wall 30a and a slidable air inlet shutter 31 extending thereacross and controlling the air inlet openings 31a. A vapor control valve 32 is supported at the outer end of the mixing tube 27 by the wall 30a thereof so as to direct a stream of vaporized fuel from the nozzle 32a into the mixing

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tube. The vapor valve 32 is controlled by a knob 33. The mixing tube has a constricted portion or throat 34 located at the inner end of the flared section 30 and the stream of vapor passing through such throat causes air to be drawn into the mixing tube through the inlet openings 31a. The air and vaporized fuel form a combustible mixture which passes into the distributing box 25 and is supplied by the latter to the burner tubes 24.

The vaporizer 26 is a hollow member which, as mentioned above, extends along the distributing box 25 for a portion of the length of the latter. The vaporizer is attached to the distributing box 25 by supporting clips 26a and is adapted to be heated by heat conducted thereto from the burner tubes 24 through the heat conducting fins 35 and also by a flame directed thereagainst from a burner slot 36 formed in the adjacent wall of the distributing box 25. In the event that the flame which is directed against the vaporizer by the burner slot 36 becomes extinguished, heat will still be supplied to the vaporizer by the conducting fins 35.

One end of the vaporizer 26 is connected with the fuel tank 13 by a fuel supply pipe 37 and its other end is connected with the valve 32 by the vapor delivery pipe 38. The liquid fuel which is supplied through the pipe 37 is converted into vapor in the vaporizer 26 and is delivered therefrom to the valve 32 through the pipe 38. The fuel supply pipe 37 is connected with the tank 13 by means of a fitting 39 which contains a shut-off valve 40. The liquid fuel flowing from the tank 13 through the fitting 31 is filtered by passage through the wick 41.

When the thermoelectric generator is to be placed in operation the valves 40 and 32 are opened and a small quantity of liquid fuel is permitted to flow into the mixing tube 27 from which it drains through the hole 42 and collects in the priming pan 43. The control valve 32 and the air inlet shutter 31 are then closed and the fuel in the pan 43 is ignited. The burning of the fuel in the pan 43 initially heats the various parts of the fuel burning means 11 and when the priming charge has been nearly consumed the control valve 32 is opened so that fuel will be discharged from the nozzle 32a and will be ignited by the priming charge. Shortly thereafter the air inlet shutter 31 is opened to the desired extent. The fuel and air mixture is supplied to the burner tubes 24 and issues from the openings 24a thereof as a silently burning sustained flame.

Reverting now to the thermocouple banks 15 and 16 it will be seen from Figs. 2 and 5 that each thermocouple 19 comprises a pair of substantially coextensive contiguous strips 44 and 45 which are made of dissimilar metals. One of the strips is made of an electro-positive metal such as Chromel and the other strip is made of an electro-negative metal such as constantan. The pairs of strips 44 and 45 extend in divergent-convergent relation to each other and have their inner ends joined together, as by spot welding, to form the hot thermocouple junctions 20. The adjacent pairs of strips are joined to each other at an intermediate point, as by spot welding, to form the cold thermocouple junctions 21. Both of the strips 44 and 45 are extended outwardly beyond the cold thermocouple junctions 21 to form cooling fins 44a and 45a.

The thermocouples of the banks 15 and 16 are electrically connected in series with each other and are connected with a pair of terminals 46

and 47 by suitable conductors 48. The terminals 46 and 47 may be supported by a bracket 50 which is formed as an integral part of a plate 51, the latter being connected with the mixing tube 27 by the screws 52.

We have found that the dimensional values for the thermocouples 19 are more or less critical as will now be described in connection with Figs. 5 and 6. For best results and maximum electrical output the inner ends of the thermocouples should project from the wall 18 so that the strip portions designated by the dimensional line Z, and which are heated simultaneously with the hot junctions 20, will be not less than one half inch, and not more than one inch, in length. The length of the strips measured between their thermocouple junctions 20 and 21 and represented by the dimensional line X, should be not less than one inch and not more than two and one half inches. The cooling fins formed by the strip extensions 44a and 45a and designated by the dimensional line F should be not materially less than one half inch, and not more than one inch, in length.

In Fig. 6 we have plotted the electrical output of one of the thermocouples 19 in watts for variations in the dimensional length X of the strips 44 and 45 in inches. The resulting curve 53 shows that the dimensional length X is more or less critical and that maximum electrical output is obtained when this length is about one and one half inches. As indicated by the curve 53 the output falls off rapidly when this length is made less than one inch and falls off somewhat less rapidly when this length is increased beyond two inches. In the thermoelectric generator shown in the drawings, the strips 44 and 45 are approximately one fourth of an inch wide and approximately one thirty-second of an inch thick although the above described lengths hold true for strips of other widths and thicknesses.

In our improved thermoelectric generator important advantages are obtained when the burner tubes 24 are made of stainless steel. When these tubes are made of stainless steel corrosion thereof is retarded or eliminated and a relatively high operating temperature is obtained for the tubes because of the relatively low heat conductivity of stainless steel. This high operating temperature causes the lead usually present in gasoline to be completely burned up, thus preventing the lead from forming a deposit which would otherwise clog the openings 24a of the burner tubes.

It is also important that the walls of the burner tubes 24 be of a thickness not less than one thirty-second of an inch and that the openings 24a be not greater than five sixty-fourths of an inch in diameter. When the walls of the tubes are one thirty-second of an inch or greater in thickness and the openings 24a are five sixty-fourths of an inch or less in diameter, the fuel mixture supplied to the tubes will burn efficiently and silently with a sustained external flame which is projected laterally into direct contact with the exposed inner ends of thermocouples 19. If the walls of the burner tubes are made thinner than one thirty-second of an inch or if the openings are greater than five sixty-fourths of an inch in diameter, the fuel mixture ignites and burns within the tubes instead of in the form of a sustained external flame. Such burning of the fuel mixture within the tubes 24 is undesirable because the thermocouple junctions 20 will not be properly heated.

For enclosing and shielding the thermopile 10 and the fuel burning means 11 we provide the device with a housing 54 which is shown in Fig. 3 in its closed position but which is adapted to be lifted and retained in an open position as shown in Fig. 1. When in its open position, the housing 54 extends above the thermopile 10 as a stack or flue which shields the burner flames from drafts and its lower end forms an intake above the hot and cold junctions. The side walls of the housing are provided with gas discharge openings 55 which are located adjacent the top wall 56.

Overheating of the top wall 56 is prevented by a baffle plate 57 which is suspended from such top wall by the rivets 58. The baffle plate 57 is movable on the rivets 58 to a position adjacent the top wall 56 when the housing is lowered to its closed position, as shown in Fig. 3. The housing 54 is releasably held in its elevated position by means of latches 59 which are pivotally mounted in the frame 14 and are adapted to be swung inwardly to permit the housing to be lowered.

As shown in Fig. 1, the upper end of the thermopile 10 is provided with a bowed cover strip 60 which is supported at its ends by engagement with the upright legs 14b of the frame 14. The cover strip 60 is of a width corresponding substantially with the space between the walls 18 of the thermocouple banks and forms a baffle or shield which retards the flow of heated gases upwardly from between the combustion chamber 22. When the housing 54 is lowered, the strip 60 engages the baffle plate 57 and lifts the latter upwardly against the top wall 56. When it is not necessary or desirable to shield the flames produced by the burner tubes 24, the cover 54 can be completely removed from the device.

As shown in Figs. 3 and 4 a hinged cover or curved baffle 61 may be provided in front of the air intake shutter 31. This cover has an appropriate slot or opening therein which accommodates the vapor control valve 32. This cover can be swung upwardly to afford access to the mixing tube 27 for inspection or for adjusting the shutter 31.

The fuel tank 13 which is mounted on the base 12 as mentioned, extends in an upright relation adjacent the thermopile 10 and is of substantially the same height as the housing 54 when the latter is in its closed position. An air pump 62, located in the tank and having an operating knob 63, creates pressure in the tank for forcing fuel through the pipe 37 to the vaporizer 26. The tank may also be provided with a fitting 64 containing a fuel gauge 64a and a pressure gauge 64b. A suitable carrying means such as the handle 65 is provided on a side wall of the tank 13 so that the device can be manually carried in a conveniently balanced condition. To retard the transfer of heat from the thermopile 10 to the tank 13 a heat-insulated shield or plate 66 is located therebetween. A suitable latch 67 is provided on the upper end of the housing 54 and cooperates with a projection 66a of the shield 66 for retaining the housing 54 in its closed position.

In the operation of our thermoelectric generator the inner ends of the thermocouples 19 are heated by the flames from the burner tubes 24 and the outer ends of the thermocouples are simultaneously cooled by the atmosphere. The temperature differential thus maintained causes electric current to be generated in the thermocouples. This electric current becomes available at the terminals 46 and 47 and can be used

for operating a radio apparatus or any other desired purposes.

From the foregoing description and the accompanying drawing it will now be readily understood that we have provided an improved thermoelectric generator which can be manufactured as a self-contained manually portable unit and which is safe, reliable and substantially silent in operation.

While we have illustrated and described our improved thermoelectric generator in considerable detail it will be understood, of course, that we do not wish to be correspondingly limited but regard our invention as including all changes and modifications coming within the scope of the appended claims.

Having thus described our invention, we claim:

1. In a thermoelectric generator, a pair of opposed substantially flat walls, thermocouples supported by said walls and having their hot junctions exposed on one side of the walls and their cold junctions exposed on the other side of the walls, said hot junctions being on the sides of said walls which are adjacent each other and being distributed in spaced relation on said walls so as to lie substantially in vertical and horizontal rows, fuel burning means disposed between said walls and substantially coextensive therewith and operable to direct burning fuel against said hot junctions, a housing disposed around said walls and thermocouples and having a bottom opening, said housing being liftable to an open position to expose said cold junctions to atmosphere, and means for releasably retaining said housing in said open position.

2. A manually portable thermoelectric generator comprising, a single unitary base, a thermopile connected with said base and extending thereabove, fuel burning means operable to supply heat to said thermopile, a fuel tank connected with said base and extending in upright relation beside the thermopile, means for supplying fuel from the tank to said fuel burning means, a housing having a closed position surrounding the thermopile, said housing having a bottom opening and being liftable to an open position to expose said thermopile to atmosphere, and means for retaining said housing in said open position, said tank extending above said base for substantially the same distance as said housing when the latter is in its closed position.

3. A manually portable thermoelectric generator comprising, a single unitary base, a thermopile connected with said base and extending thereabove, fuel burning means operable to supply heat to said thermopile, a fuel tank connected with said base and extending in upright relation beside the thermopile, means for supplying fuel from the tank to said fuel burning means, a housing having a closed position surrounding the thermopile, said housing having a bottom opening and being liftable to an open position to expose said thermopile to atmosphere, means for retaining said housing in said open position, said tank extending above said base for substantially the same distance as said housing when the latter is in its closed position, and carrying means connected with said tank.

4. In a thermoelectric generator, a base, an upright frame connected with said base, a thermopile comprising laterally elongated substantially flat upright slabs of electrically-insulating material held in opposed spaced relation by said frame and banks of thermocouples supported by said slabs with their hot junctions projecting

from the adjacent faces of said slabs, said hot junctions being distributed over said slabs so as to lie in substantially vertical and horizontal rows, and a laterally elongated row of upright burner tubes between said banks of thermocouples and having openings for directing burning fuel against said hot junctions, the spacing of said slabs being such as to locate the hot junctions of one bank in relatively closely spaced relation to the hot junctions of the other bank for effective heating of the hot junctions of both banks by said row of burner tubes, said frame having pairs of opposed grooves therein in which the ends of said slabs are slidably engaged for removably mounting said slabs in said opposed relation.

5. A thermoelectric generator comprising two substantially parallel, vertically disposed, end plates; each plate provided with a pair of vertically disposed channels, the two channels of one plate respectively facing the two channels of the second plate; two substantially parallel, vertically disposed, slabs of fire-resistant and heat-resistant material, removably positioned between said plates, each slab extending into two of said facing channels; a plurality of thermocouples extending through each of said slabs, the hot junctions of the thermocouples of the respective slabs extending toward each other and the cold junctions thereof extending away from each other; cooling fins secured to the cold junctions and extending outwardly beyond said cold junctions; means to heat said hot junctions; and each slab with its thermocouples being individually removable as a unit.

6. A thermoelectric generator comprising two substantially parallel, vertically disposed, end plates; each plate provided with a pair of vertically disposed channels, the two channels of one plate respectively facing the two channels of the second plate; two substantially parallel, vertically disposed, slabs of fire-resistant and heat-resistant material, removably positioned between said plates, each slab extending into two of said facing channels; a plurality of thermocouples extending through each of said slabs, the hot junctions of the thermocouples of the respective slabs extending toward each other and the cold junctions thereof extending away from each other; cooling fins secured to the cold junctions and extending outwardly beyond said cold junctions; means to heat said hot junctions; each slab with its thermocouples being individually removable as a unit; a chimney adapted to conduct combustion gases from the heating means and to cause cooling air to flow over said cold junctions; and means for sustaining said chimney in an operative position above both the hot and cold junctions.

7. A thermoelectric generator comprising a base of sheet metal bent downwardly at portions of its periphery to form a ventilated space below it; a fuel unit and a thermoelectric unit sustained upon said base; a shield interposed between said fuel and thermoelectric units; the thermoelectric unit including a pair of spaced, mutually parallel, vertically disposed, end plates, provided with two pairs of opposed, vertically disposed, channels; chimney supports secured to the upper ends of said end plates; a heater unit secured to the base intermediate the said end plates, said heater unit being provided with a plurality of upwardly extending burner tubes; a pair of thermocouple banks extending between the two end plates aforesaid and into the oppos-

ing channels aforesaid, so as to form a substantially rectangular chamber between the two end plates and the two banks; means to allow ready removal of one or both of said banks; each of said banks including a flat rectangular slab of refractory material; thermocouples extending through said slabs and embedded therein for part of their length; hot thermocouple junctions disposed within the chamber aforementioned; cold thermocouple junctions disposed outside the chamber aforementioned; cooling fins on said cold junctions; a chimney surrounding said thermopile and being positionable upon the said chimney supports so as to provide an intake above both the hot and cold junctions aforementioned.

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