May 5, 1970 A. BIBER 3,510,238

TUBULAR UNIFORM TEMPERATURE HEAT SOURCE

Filed April 19, 1968

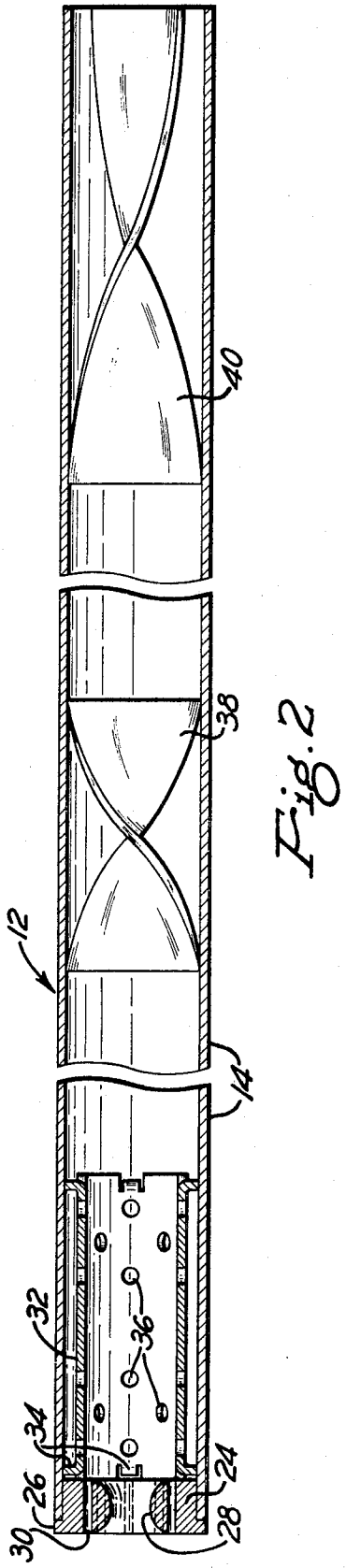


Fig. 2

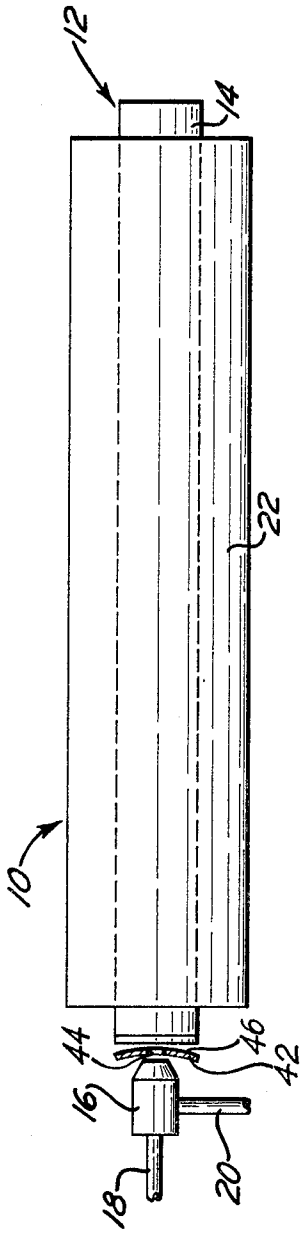


Fig. 1

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United States Patent Office 3,510,238 Patented May 5, 1970

3,510,238

TUBULAR UNIFORM TEMPERATURE HEAT SOURCE

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Filed Apr. 19, 1968, Ser. No. 722,690
Int. Cl. F23d 11/02
U.S. Cl. 431—116 12 Claims

ABSTRACT OF THE DISCLOSURE

A uniform temperature heat source utilizing liquid fuel comprising means to reduce the amount of heat imparted to the tubular housing by the combustion products adjacent the flame, and means to gradually increase the amount of heat imparted along the tubular housing away from the flame. The burner is particularly suited for use in thermoelectric generators.

This invention relates to the art of oil burners, and more particularly is concerned with a relatively small burner which is of generally tubular shape and which will produce a substantially uniform temperature along its outer wall.

A burner of the character described is particularly useful in fabricating small, portable, thermoelectric generators. The use of such portable generators is described in a paper published by the American Society of Automotive Engineers, Paper No. 670452, dated May 15–19, 1967, by A. Bayne Neild. Generally, the heat source is surrounded by an elongated annular thermopile, and the temperature difference across the thermopile is utilized to produce electrical energy in the thermopile. The thermopile itself, and, in fact, use in thermoelectric generators itself, does not form a material part of the present invention, since the burner of the invention can be used in any application wherein a tubular uniform temperature heat source is required. For example, water or air heat exchangers, and heat treating and annealing furnaces, rolls for sheet metal processing, drying equipment, and bake ovens. The burner of the invention provides a radiant heat source without flame or combustion gases in the external heated area.

An object of the invention is to provide a burner of the character described which will be rugged and insensitive to orientation. In its use as a heat source for a portable thermoelectric generator, the burner must be able to operate, for example, in a military back pack to be carried by a soldier and thus be capable of operation in all attitudes, vertically, horizontally, and while in motion. Because of the self-contained nature of the burner of the invention, it will operate under all of these highly adverse conditions. It will be understood that some suitable means, such as a check valve or the like not shown, will be provided to prevent direct flow of fuel from the fuel source.

Another object of this invention is to provide a burner of the character described which shall be simple and economical to fabricate, positive and highly reliable in operation, able to spontaneously re-light itself if it should extinguish during operation, inexpensive, and practical and efficient to a high degree in use.

The above and other advantages of the invention will be pointed out or will become evident in the following detailed description and claims, and in the accompanying drawing also forming a part of the disclosure, in which: FIG. 1 is a side elevational view of the burner of the invention embodied in a thermoelectric generator;

and FIG. 2 is a cross-sectional side elevational view of the burner of the invention.

Referring now in detail to the drawing, **10** designates a thermoelectric generator embodying the burner **12** of the invention. Burner **12** comprises a burner housing tube **14** and a fuel nozzle **16**. The nozzle **16** will be selected to suit the fuel, and will usually include means to supply air under pressure and fuel under pressure or suction through the feed lines **18** and **20** from a fuel source and an air compressor, respectively, forming part of the thermoelectric generator, but not shown. For military use, it is desirable that nozzle **16** be able to burn any fuel available such as gasoline, diesel fuel, kerosene, jet and aviation fuel and the like.

Generator **10** comprises an outer housing **22** which is tubular and of a length slightly shorter than the overall length of housing tube **14**. The annular space between housing **22** and tube **14** is filled with a thermopile, not shown. The temperature difference between outside of housing **22** and the outside of tube **14** across the thermopile is the motive force which produces electricity in the thermopile. Generator **10** will also include suitable ignition means, not shown, in the form of spark electrodes, a glow plug, or other suitable means, which will be positioned at a suitable location. The positioning of the ignition means, and the ancillary ignition equipment required, does not form a material part of the present invention.

Referring now to FIG. 2, the burner **12** of the invention is shown in detail. Housing **14** comprises a straight length of plain tubing, formed of a suitable material that will resist the relatively high temperatures that burner **12** generates, uniformly, along the entire outside surface of tubing **14**. In the embodiment of the invention which has been successfully built, tubing **14** is about 13 inches in length, having an outside diameter of about 1¼ inches, an inside diameter of about one inch, and formed of a stainless steel based material known as Hastelloy, available from the Haynes Stellite Company. Other suitable materials include stainless steel.

In said successful embodiment, air was supplied under pressure from about 1 p.s.i.g. to about 2 p.s.i.g., and No. 2 fuel oil or kerosene was supplied at a rate of about .047 g.p.h. The average uniform temperature along the entire length of tube **14** was about 1200° F. with a heat output in the range of 6500 to 12,000 B.t.u./hr. The nozzle was of the air aspirating type, i.e., the air under pressure passing through the nozzle draws sufficient fuel into itself for proper combustion. Such nozzles are known, and any other suitable type of nozzle may be used.

In any burner where the flame is contained, the natural tendency is for the flame to create a hot spot or region of higher temperature adjacent the flame, with a decreasing temperature gradient away from the flame within the means housing the flame. The present invention provides a combination of means within the main housing **14** which mitigate this effect to spread the heat from the flame through the entire length of the housing **14** to thereby create a uniform temperature on the outside surface of housing **14**.

Referring now in detail to FIG. 2, tube **14** is provided with a front end member **24**, which fits within the inlet end of main housing **14** and is secured thereto by any suitable means such as the abutting shoulder **26**, set screws, welding or the like. End member **24** is formed with a venturi orifice **28** of reduced diameter. In the embodiment of the invention which has been successfully built, the reduced venturi diameter was about $^{13}/_{32}$ of an inch. As shown in FIG. 1, the nozzle is positioned in spaced relation and in axial alignment with venturi opening **28**. The gap permits entry of ambient or secondary

air and may be on the order of about ¼ to about ⅜ of an inch, dependent upon a combination of factors such as the angle of spray from nozzle **16**, flow rate, heat rate, and other factors well known to those skilled in this art. End member **24** is formed with a plurality of longitudinal secondary air openings **30**, the operation of which will appear below. In the successfully built embodiment of the invention, eight openings **30** each of a diameter of about 1/16 of an inch located on an imaginary circle having a diameter of about 9/16 inch were provided in end member **24**.

Means are provided to prevent the creation of a "hot spot" at the inlet end of housing **14**. To this end, a combustion chamber sleeve **32** is provided with its front end in abutting relation to the rear surface of end member **24**. The inside diameter of sleeve **32** is larger than the imaginary diameter on which openings **30** are located plus the diameter of one of said openings, so that said openings will communicate atmosphere to the inside of sleeve **32**. The outside diameter of sleeve **32** is smaller than the inside diameter of main housing **14** so that a longitudinal annular space is created between the sleeve **32** and the housing **14**. In the successfully built embodiment of the invention, the outside diameter of sleeve **32** was about 13/16 of an inch. Means are provided to hold sleeve **32** centralized within housing **14**. To this end, each end of the sleeve is formed with a plurality of upstanding lugs **34**, the outer ends of which abut the inside of the main housing **14**. Sleeve **32** is reversible, and each end is provided with a plurality of openings **36**, which provide a recirculation of hot gases, as will appear in more detail below. The sleeve **32** is held in place within the tube **14** by welding to end member **24**.

Means are provided to increase the residence time of the hot combustion gases at selected, spaced positions along the length of housing **14** to achieve the desirable uniform external temperature as described above. To this end, a first space of predetermined length separates the outlet end of the combustion sleeve **32** from a first restricting means **38**, and a second shorter space separates restrictor **38** from a second, longer restrictor **40**. Restrictor **38** is in the form of a flat strip of a suitable metal, such as stainless steel or Hastelloy, to which has been imparted a 180° twist. Restrictor **40** is similar to restrictor **38** except that it is substantially longer and has a twist slightly less than 180° imparted to it, and is placed in the main housing **14** so that the direction of twist is opposite to the direction of twist of restrictor **38**. The space between sleeve **32** and restrictor **38** is substantially longer than the space between the restrictors because said first mentioned space contains gases that are at a temperature very close to the temperature at which it is desired to maintain housing **14**. The first restrictor **38** is relatively short because residence time of the gases need not be increased a great deal, relatively, to permit said gases to bring the housing to the desired uniform temperature. The space between the restrictors is relatively short because the gases here have given up a relatively large portion of the heat they contain. Restrictor **40** is twisted oppositely to restrictor **38** to increase the residence time of the combustion gases in the space between the restrictors. Restrictor **40** is relatively long and extends all the way to the exit end of the housing **14** because the gases here are relatively cool by the time they arrive at the exit end and residence time must be increased substantially to bring the adjacent portion of housing **14** to the desired uniform temperature. Restrictor **40** is twisted less than 180° because excess restriction will cause the flame to flash back to the nozzle. The restrictors are preferably held in place by spot welding for vertical or in motion operation, friction fit for horizontal stationary operation, or the like easily disassembled means since it may be desirable to move them for changes in the nozzle, fuel, flow rate, heat rate, or the like.

By way of example, the following lengths and distances were incorporated in the successfully built embodiment of the invention:

Element:	Length (inches)
Front end member **24**	⅜
Sleeve **32**	2¼
First space	3
Restrictor **38**	2
Second space	1⅞
Restrictor **40**	3½
Total length	13

Operation

A finely divided pressurized mist of fuel and air is supplied from nozzle **16** through the gap between the nozzle and the inlet end of housing **14** and through the venturi throat **28**. The motion of the fuel and air mixture through the gap draws secondary air into itself from the gap. The motion of the fuel and increased air mixture through the venturi throat draws still additional secondary air into itself through the row of openings **30** in the end member **24**. Combustion is initiated by any suitable ignition means, not shown, and the flame front is located at some position inwardly of the end member **24** and within the combustion sleeve **32**. Recirculation hot gases will be drawn through the annular space between the sleeve **32** and the tube **14**, which layer of combustion gases serves to insulate the adjacent regions of tubing **14** from the higher temperature of the flame itself. The combustion gases proceed through the tubing **14**, are slowed down to a relatively small extent by the first restrictor **38**, are slowed in their passage through the space between the restrictors by the reversal of twist existing between the restrictors, and are still further slowed by second restrictor **40** for a relatively longer period of time. Thus, a relatively uniform temperature is achieved over the entire length of the main tubing **14**, including the region adjacent end member **24** to which heat is supplied by conduction through the metal parts in that region.

Each of the elements shown in FIG. 2 contributes its portion alone and in combination with the other elements to achieve the uniform temperature along the outside of the main housing **14**. Experiments have shown this to be so. With restrictor **40** removed, the temperature in the region of restrictor **38** increases, and the temperature at the exit and decreases. With restrictor **38** moved closer to sleeve **32**, the front end of the burner is much hotter than the exit end of the burner. If the sleeve **32** is omitted, the front end of the burner becomes considerably hotter at the expense of the remaining portions of the burner. When the tubular sleeve **32** was moved closer to restrictor **38**, a cooler region was created between end member **24** and the sleeve, while the area immediately adjacent the sleeve experienced an increased temperature. When the holes **36** in the sleeve **32** were plugged, ignition occurred in the region of restrictor **38**. With restrictor **38** removed, the entrance end was very much colder than the remaining portions, and ignition was difficult to achieve. Thus, it can be seen that in addition to increasing the residence time of the gases when they pass over it, restrictor **38** helps in locating the flame front inside of the sleeve **32**.

As mentioned above, the burner of the invention may be used with virtually any fuel within the ability of the nozzle. However, when burning certain highly volatile fuels, such as gasoline, a vapor lock problem in the nozzle may occur. Because the nozzle **16** is in closely spaced relation to the inlet end of the burner **12**, the heat from the burner may cause such highly volatile fuels to vaporize prematurely in the nozzle, thus disrupting normal fuel flow.

Referring again to FIG. 1, heat shield means 42 may be interposed between the nozzle and the inlet end of the burner when using such fuels, if required. Shield 42 may take any convenient form, and for example purposes is shown as a curved metal disc formed with an opening 44 to permit passage of the spray from the nozzle therethrough. Shield 42 may be mounted on the nozzle and/or the supply pipes 18 and 20 or other part of the apparatus with the use of heat insulating means, all not shown but in a manner known to those skilled in this art, so that the shield will not heat the portion of the apparatus on which it is mounted by conduction. The convex surface 46 of the shield preferably faces the burner and is provided with a heat reflective finish, such as bright chromium plating, to maximize the amount of heat directed away from the nozzle.

While the invention has been described in detail above, it is to be understood that this detailed description is by way of example only, and the protection granted is to be limited only within the spirit of the invention and the scope of the following claims.

I claim:

1. A burner comprising an elongated hollow housing adapted to produce a uniform temperature over the length of the housing, said housing being imperforate over its length and comprising an inlet end and an outlet end, means to form a constricted opening at the inlet end of said housing, means to supply a combustible mixture through said constricted opening, means to supply secondary air for combustion to said combustible mixture after said combustible mixture has passed through said constricted opening, flame containing means within said housing extending from said opening forming means a predetermined distance towards said outlet end, said flame containing means comprising means to supply a portion of the products of combustion to the annular space between the inside of said housing and the outside of said flame containing means, and combustion products restricting means in said housing in spaced relation to said outlet end and to said flame containing means.

2. The combination of claim 1, said combustible mixture supplying means comprising a fuel nozzle, means to position and fuel nozzle in spaced relation to said constricted opening, whereby the velocity of said combustible mixture issuing from said fuel nozzle will draw air into itself from the gap between said fuel nozzle and said inlet end of said housing.

3. The combination of claim 1, said constricting opening forming means comprising an end member seated within the inlet end of said housing, said end member being of generally toroidal configuration and formed with a curved innermost radial surface, whereby said constricted opening comprises a venturi opening.

4. The combinaion of claim 1, said flame containing means comprising a sleeve having a diameter a predetermined amount less than the inside diameter of said housing, and said sleeve comprising means to hold said sleeve in concentric relation to said housing.

5. The combination of claim 4, said concentric holding means comprising a plurality of upstanding lugs formed on the ends of said sleeve, the end edges of said lugs being adapted to tightly fit within the inside diameter of said housing.

6. The combination of claim 1, said restricting means comprising a first twisted member extending a predetermined distance into said housing from said outlet end and a second twisted member in spaced relation to said first twisted member positioned mediately the ends of said housing.

7. The combination of claim 6, said first twisted member being twisted in a direction opposite to the direction of twist of said second twisted member.

8. The combination of claim 6, said first twisted member having a length greater than the length of said second twisted member.

9. The combination of claim 2, and heat shield means interposed between said nozzle and said inlet end of said burner.

10. A burner comprising an elongated hollow housing adapted to produce a uniform temperature over the length of the housing, said housing comprising an inlet end and an outlet end, means to form a constricted opening at the inlet end of said housing, means to supply a combustible mixture through said constricted opening, means to supply secondary air for combustion to said combustible mixture after said combustible mixture has passed through said constricted opening, flame containing means within said housing extending from said opening forming means a predetermined distance towards said outlet end, said flame containing means comprising means to supply a portion of the products of combustion to the annular space between the inside of said housing and the outside of said flame containing means, combustion products restricting means in said housing in spaced relation to said outlet end and to said flame containing means, said constricting opening forming means comprising an end member seated within the inlet end of said housing, said end member being of generally toroidal configuration and formed with a curved innermost radial surface, whereby said constricted opening comprises a venturi opening, said flame containing means comprising a sleeve having a diameter a predetermined amount less than the inside diameter of said housing, said sleeve comprising means to hold said sleeve in concentric relation to said housing, said secondary air supply means comprising a plurality of longitudinal openings formed in said end member with the outlet ends of said longitudinal openings positioned on a diameter less than the inside diameter of said sleeve, whereby the velocity of said combustible mixture through said venturi will draw additional air for combustion through said longitudinal openings into said combustible mixture within said sleeve.

11. A burner comprising an elongated hollow housing adapted to produce a uniform temperature over the length of the housing, said housing comprising an inlet end and an outlet end, means to form a constricted opening at the inlet end of said housing, means to supply a combustible mixture through said constricted opening, means to supply secondary air for combustion to said combustible mixture after said combustible mixture has passed through said constricted opening, flame containing means within said housing extending from said opening forming means a predetermined distance towards said outlet end, said flame containing means comprising means to supply a portion of the products of combustion to the annular space between the inside of said housing and the outside of said flame containing means, combustion products restricting means in said housing in spaced relation to said outlet end and to said flame containing means, said flame containing means comprising a sleeve having a diameter a predetermined amount less than the inside diameter of said housing, said sleeve comprising means to hold said sleeve in concentric relation to said housing, said means to supply a portion of the combustion products to the annular space between said sleeve and said housing comprising a first plurality of openings formed in spaced relation to the outlet end of said sleeve, and a second plurality of openings formed in spaced relation to the inlet end of said sleeve, both of said pluralities of openings communicating said annular space with the space within said sleeve.

12. A burner comprising an elongated hollow housing adapted to produce a uniform temperature over the length of the housing, said housing comprising an inlet end and an outlet end, means to form a constricted opening at the inlet end of said housing, means to supply a combustible mixture through said constricted opening, means to supply secondary air for combustion to said combustible mixture after said combustible mixture has passed through said constricted opening, flame containing means within said

housing extending from said opening forming means a predetermined distance towards said outlet end, said flame containing means comprising means to supply a portion of the products of combustion to the annular space between the inside of said housing and the outside of said flame containing means, combustion products restricting means in said housing in spaced relation to said outlet end and to said flame containing means, said combustible mixture supplying means comprising a fuel nozzle, means to position said fuel nozzle in spaced relation to said constricted opening, whereby the velocity of said combustible mixture issuing from said fuel nozzle will draw air into itself from the gap between said fuel nozzle and said inlet end of said housing, and heat shield means interposed between said nozzle and said inlet end of said burner, said heat shield means comprising a curved plate having its convex side facing said inlet end of said burner and provided

with a heat reflective coating on the outer surface of said convex side.

References Cited

UNITED STATES PATENTS

166,180	8/1875	Bailey.	
1,975,033	9/1934	Wolff	431—9 XR
2,368,179	1/1945	Turpin	431—347
2,560,275	7/1951	Clark	110—970
2,918,117	12/1959	Griffin	431—116
3,238,990	3/1966	Linde et al.	431—116

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U.S. Cl. X.R.

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