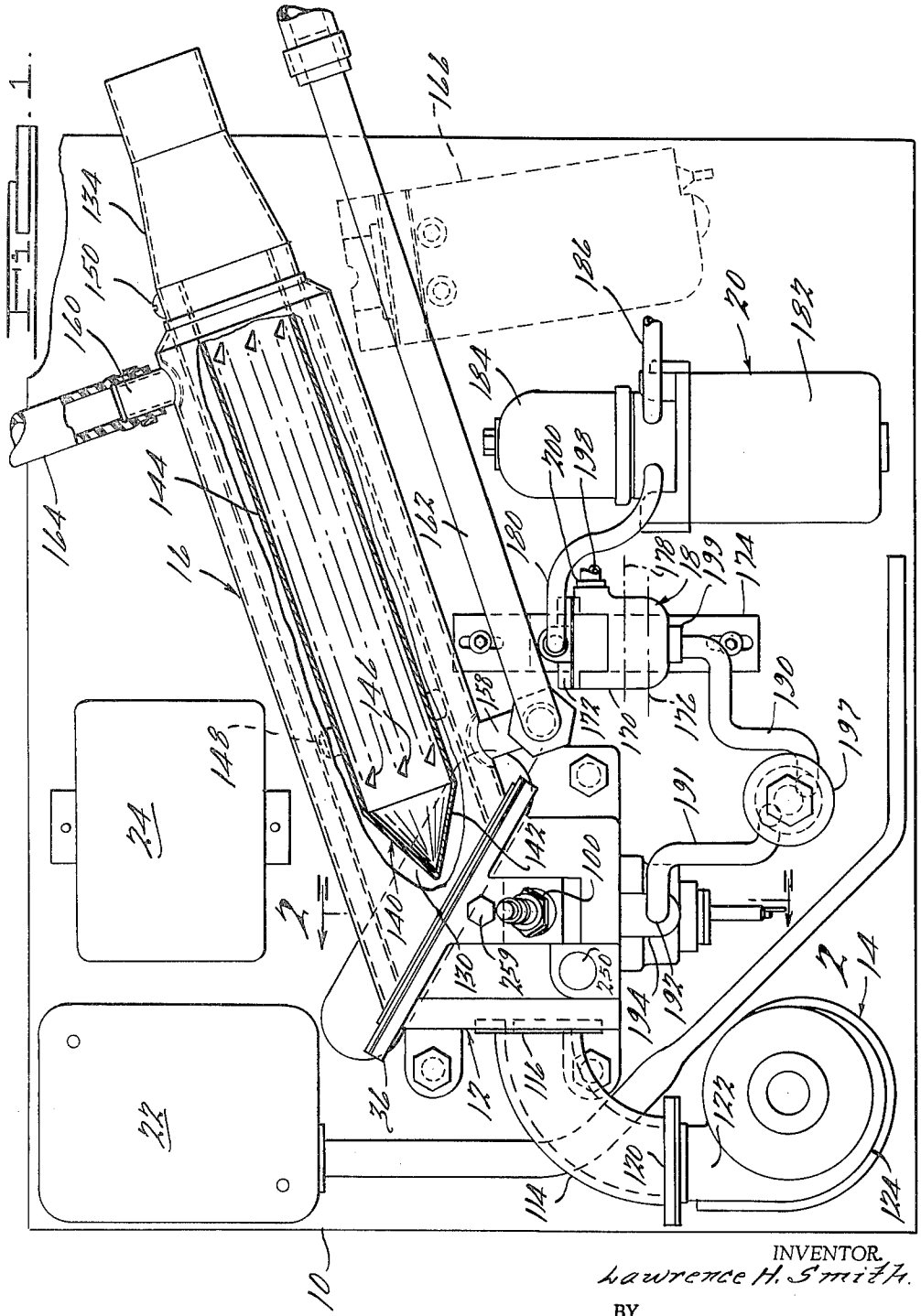
Feb. 15, 1966 L. H. SMITH 3,234,928

HEATER

Filed Jan. 13, 1964 3 Sheets-Sheet 1

Fig. 1.



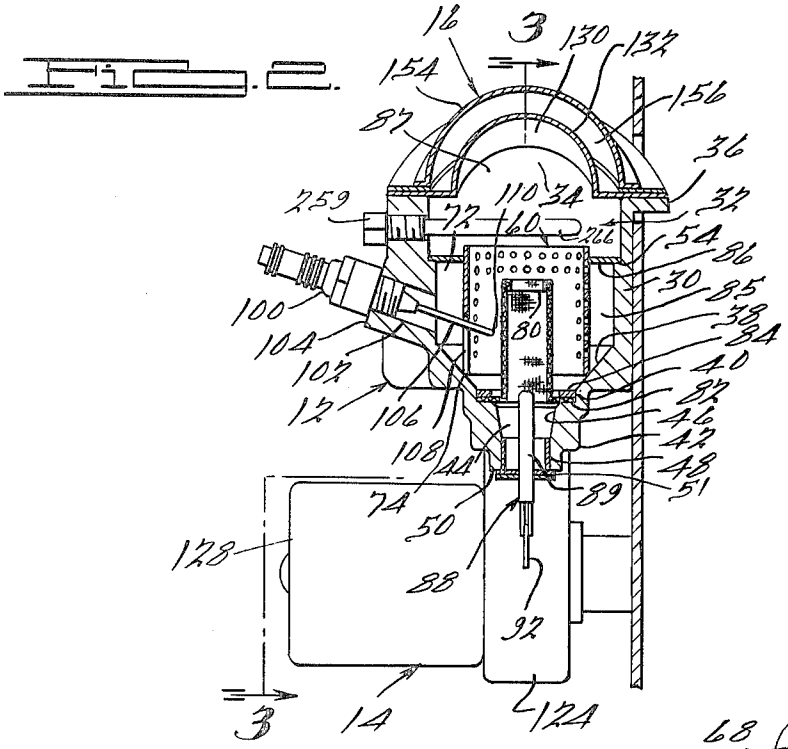

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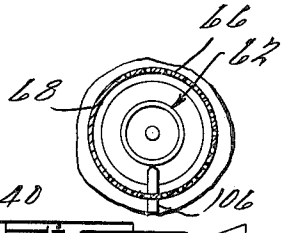
BY
Barnes, Dickey & Pierce
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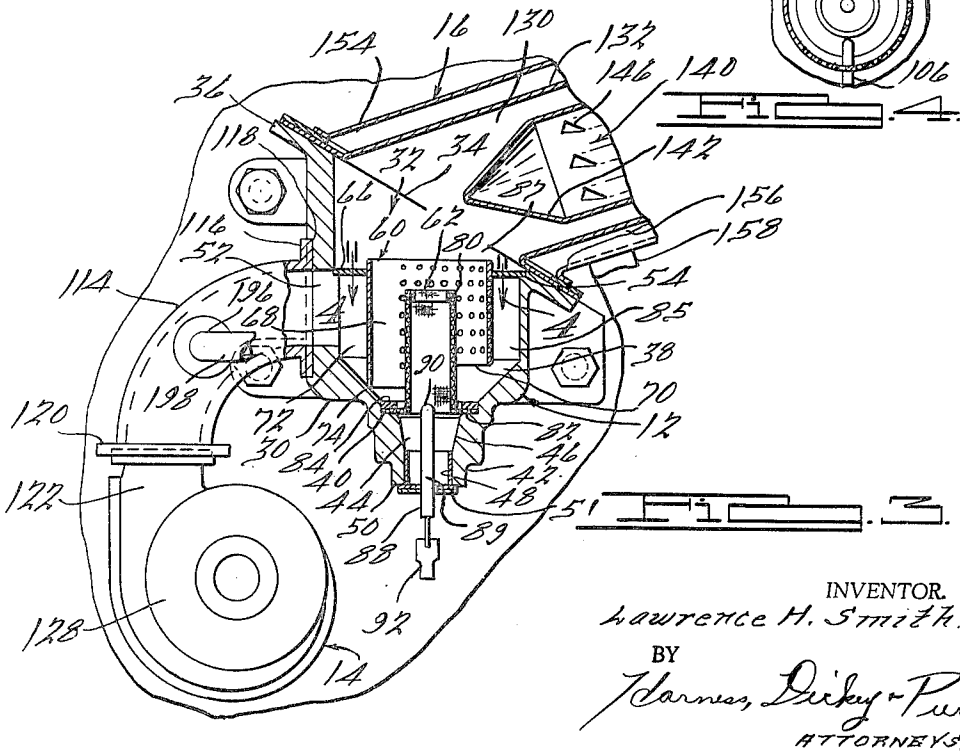
Feb. 15, 1966 L. H. SMITH 3,234,928

HEATER

Filed Jan. 13, 1964 3 Sheets-Sheet 2







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HEATER

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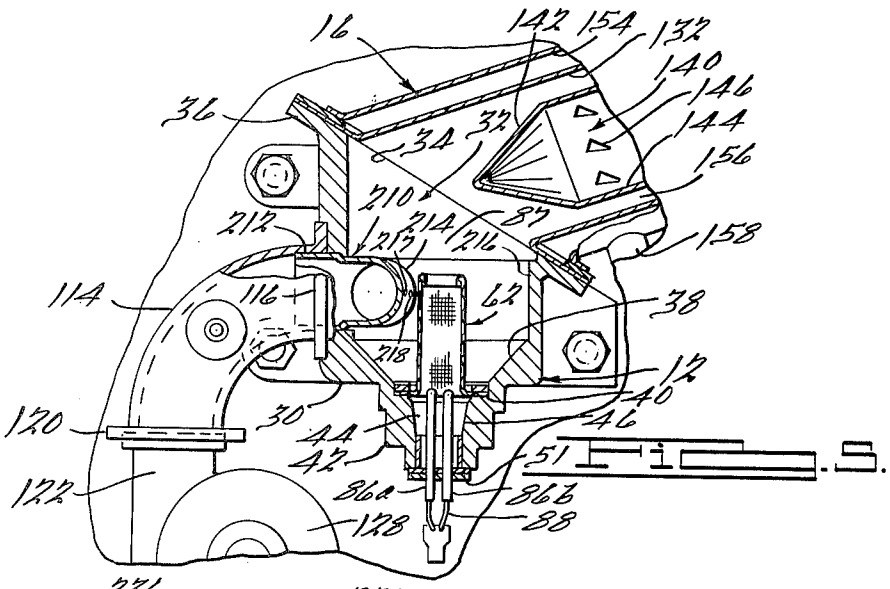



Fig. 5.

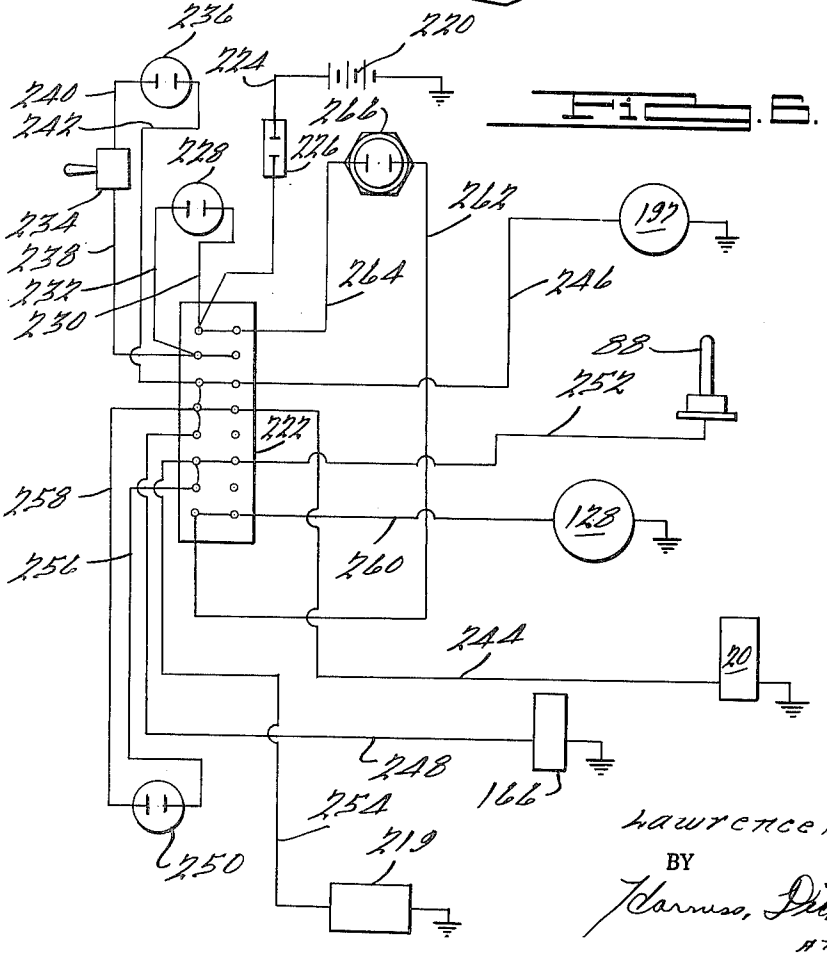



Fig. 6.

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3,234,928

# HEATER

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22 Claims. (Cl. 123—142.5)

This invention relates generally to heating apparatus and more particularly to heating apparatus for use with internal combustion engines on vehicles such as trucks or tractors or other engine driven equipment.

The heating apparatus of the present invention is of the type which burns liquid fuel in a pot type burner and which is capable of burning various fuels such as gasoline on gasoline powered equipment and fuel oil on diesel powered equipment.

A general object of the present invention is to provide new and improved heater means capable of sustained automatic operation while burning gasoline or diesel fuel and producing a high heat output.

Another object of the present invention is to provide a heater means which, once started is self-sustaining and automatic, and which is reliable even under extremely adverse operating conditions and which is not subject to blowout by changes in ambient conditions such as, for example, changes in temperature and pressure or the like.

Still another object of the present invention is to provide a heater means which produces maximum heat output with minimum start up time.

A further object of the present invention is to provide heater means which are particularly effective in cold climates and under cold operating conditions.

To these ends, the subject heater means is provided with new and improved fire pot means, with new and improved burner means, with new and improved combustion air delivery means, with new and improved fuel delivery means, and with new and improved heat exchanger means, with new and improved control means, and with new and improved methods of operation. Furthermore, the aforementioned components of the heater means are arranged in combination in a new and improved manner providing exceptional results in comparison with prior art devices of the same general type.

Illustrative embodiments of the inventive principles are hereinafter described in detail by reference to the accompanying drawings in which:

FIGURE 1 is a side elevational view, with portions broken away and shown partly in section, of heater means embodying the inventive principles;

FIGURE 2 is a sectional view taken along the line 2—2 in FIGURE 1;

FIGURE 3 is a cross-sectional view taken along the line 3—3 in FIGURE 2;

FIGURE 4 is a reduced cross-sectional view taken along the line 4—4 in FIGURE 3;

FIGURE 5 is a partial side elevational view, partly in section, of an alternative embodiment of a portion of the apparatus shown in FIGURE 1; and

FIGURE 6 is a diagrammatic illustration of illustrative control circuitry for use with the apparatus shown in FIGURE 1.

Referring now to FIGURE 1, the subject heater apparatus is illustratively shown to be mounted on a plate 10 or other suitable frame. It will be understood that the apparatus may also be separately mounted on different portions of equipment with which it is to be associated. One of the features of the present invention is the provision of heater means which is compact and may be mounted in association with equipment powered by an internal combustion engine of one type or another within the engine compartment normally provided.



The main component parts of the heater system comprise a first pot assembly 12, a combustion air delivery means 14, and a combination heat exchanger and chimney assembly 16. In addition, suitable fuel supply means are provided which may include a float controlled fuel bowl assembly 18 directly connected to a source of fuel (not shown) or, alternatively, connected through a conventional fuel pump assembly 20 which is connected to the fuel supply. The electrical components of the heater control system may be mounted in suitable means 22, 24 adjacent the heater apparatus on the support 10.

Referring now to FIGS. 2, 3 and 5, the fire pot assembly 12, is shown to comprise a substantially annular casting 30 having a central annular cavity 32 provided with an outlet opening 34 at the upper end in an inclined flange portion 36. The bottom of the central cavity terminates in an inwardly tapered surface 38 which extends to a seat 40. An inwardly stepped depending projection 42 of reduced diameter extends from the bottom of the casting and provides a fuel reservoir 44 having a slightly tapered central surface 46 extending from the seat 40 and terminating in a passage 48 opening through a flat abutment surface 50. The passage 48 is closed by a resistance heating unit as hereinafter described and a gasket 51 interposed on the surface 50. The fire pot casting is further providen with an air inlet port 52 in its side wall above the tapered surface 38 and below a shoulder 54 adjacent the opening 34. In addition, certain other suitable openings are provided in the casting for reception of the fuel line, ignition means, thermostat means, and the like, which will be hereinafter described in detail.

Burner means are provided within the combustion chamber 32 and comprise, in one embodiment as shown in FIGS. 2 and 3, a combination air diffusing and shielding means 60, and wick means 62. The shield and diffuser means 60 is in the form of a tubular section having a large portion of its side wall perforated to permit flow of air inwardly therethrough. In the illustrative embodiment, the upper portion of the tube is perforated along its entire periphery and the bottom portion of the tube 60 is perforated only for approximately 240° so that a solid imperforate portion 68 of, for example, approximately 120° is located directly opposite the air inlet port to provide a shield or baffle causing the inlet air to separate into two flow paths extending around the tube to the foraminous portion. In order to equalize air flow through the diffuser, the bottom portion opposite the air inlet port is cut-away to provide a circumferentially extending opening 70 which may have a circumferential length of, for example, approximately 120°. The bottom of the tub 60 is supported on the inclined surface 38 of the fire pot casting by abutting engagement on its lower edge as indicated at 74. The wick means 62 may be formed from 16 mesh stainless steel hardware cloth or the like, the upper portion being turned inwardly to form a rim portion 80 terminating below the upper end of the shield and diffuser means 60. The bottom of the stainless steel wick is flattened ouwardly to form a flange 82 seated on the shoulder 40 and held in place by a suitable keeper ring 84.

A closed annular air inlet chamber 85 is formed between the diffuser and baffle means 60 by means of a plate 86 mounted on the seat 54 and extending radially inwardly to the side wall of the diffuser. A combustion chamber 87 is formed in the upper part of the pot.

Fuel heating means are provided to heat and vaporize the fuel at the beginning of operation of the heater apparaus and comprises an electrical resistance heating device 88 in the form of a "Calrod" of the type manufactured by General Electric Co. An elongated upwardly extending igniter portion 89 terminates slightly above the

bottom of the wick 62 as indicated at 90. The fuel heating means is suitably secured in the end cap means 54 and further includes terminal means 92 adapted to be suitably electrically connected to control circuitry as hereinafter described in detail.

Referring now particularly to FIGURE 2, ignition means are provided for initiating a fire in the fire pot and comprise, in the illustrative embodiment, a conventional sparking device 100 mounted in a passage 102 and seated on a shoulder 104. The electrode 106 extends inwardly through the annular air chamber 85, a suitable opening 108 in the wall of the air diffuser means 60, and terminates at 110 closely adjacent the wick means 62 to which it discharges. The spark plug is suitably connected through a coil, which may be mounted at 24, to the control system as hereinafter described.

The forced air delivery means 14 comprises, in the illustrative embodiment, a power driven blower unit which is connected to the air inlet passage 52 by an elbow 114. A flange 116 on one end of the elbow is matingly received in a suitable recess 118 formed in the side of the fire pot casting and a flange 120 on the other end of the elbow is suitably abuttingly coupled to the outlet 122 of the blower housing 124. A suitable electric motor, or the like, 128 is provided to actuate the blower 124. Consequently, atmospheric air is delivered by the blower 124 through the elbow 114 to the passage 52 at a suitable rate dependent upon the blower capacity.

The combination chimney and heat exchanger means 16 is suitably connected to the inclined abutment provided by the flange 36 on the fire pot and extends upwardly at an angle of less than 45° in the illustrative embodiment. A central exhaust passage 130 is defined by an inner tubular member 132 which opens at its upper end to the atmosphere or which may be connected by a suitable coupling 134 to a flexible hose or other conduit (not shown) forming part of an exhaust system. A baffle means 140 is centrally mounted in the exhaust passage 130 to force the gas flow outwardly into heat transfer contact with the inner wall of the tube 132 and to minimize heat exchange between the exhaust gases and the tube. A conically shaped nose portion 142 is located adjacent the combustion chamber 87 and a tubular central portion 144, which may be suitably apertured as indicated at 146 to permit radial inward flow of gas resulting in pressure equalization and reduction in noise, is supported in closely spaced relationship with the tube 132 by suitable spacer means 148 provided along the length of the baffle as necessary. The end of the baffle is secured within the tube 132 in any suitable manner such as by radially inwardly extending fastener means 150 which may also be utilized to connect the coupling 134. Water jacket means are formed around the tube 132 and comprise a concentrically mounted tube member 154 providing an annular water chamber 156. Suitable inlet and outlet couplings 158, 160 extend through the outer tube 154 and are connected to suitable conduit means 162, 164 which in turn are connected to, for example, the cooling system of an internal combustion engine so that the water in the cooling system may be circulated through the chamber 156 around the tube 132 and heated thereby. If necessary or desirable, in some systems, a conventional water pump 166, FIG. 1, may be mounted on the frame 10 and connected to the inlet pipe 162 in a conventional manner.

The fuel supply means 18 comprises a reservoir 170, a conventional float controlled valve assembly 172 which maintains a predetermined fuel level in the reservoir. An adjustable bracket 174 supports the reservoir and valve assembly so that the position of the upper level of the fuel as indicated by lines 176 or 178 may be varied as necessary or desirable. An inlet line 180 is connected to the fuel reservoir through the float valve 172 and delivers fuel to the reservoir 170 in accordance with the open or closed position of the valve as determined by the float and the amount of fuel in the reservoir 170. The fuel inlet line 180 may be directly connected to a fuel source, such as the fuel system of an internal combustion engine with which the heater apparatus is associated, or it may be connected through its own fuel pump 182 and sediment bowl 184 to a suitable supply of fuel through a line 186. Fuel lines 190, 191 connect the bottom of the fuel reservoir 170 to the bottom of the fuel reservoir 44 in the lower portion of the fire pot by means of a passage 192 extending radially inwardly through a shoulder 194 integrally formed on the casting. A solenoid valve 197 controls flow of fuel by gravity from the fuel reservoir 170 to the fuel reservoir 44. The level of the fuel in the fuel reservoir 44 in the fire pot will be maintained, for example, at the level 176 or 178 determined by the float valve assembly 172. When it is necessary or desirable to change the level of the fuel as, for example, between the positions indicated by the lines 176 and 178, the fuel supply means 18 may be adjusted vertically by means of the adjustable bracket 174. In general, the level of the fuel in the reservoir 44 will be maintained above the heating means across the tapered portions 38 of the fire pot.

One of the main problems of prior art devices has been inconsistency of operation with a tendency to blow out the fire in the fire pot during self-sustaining operation. It has been previously found that some of the prior art devices, although working reasonably well under carefully controlled laboratory conditions, have been consistently unworkable for any sustained period in the field where conditions of use are constantly changing. In many operating environments, surrounding temperatures may vary between extremes of, for example, 30° or more above zero to 50° or more below zero. In addition, the internal pressure of the fire pot in the combustion chamber and directly above the fuel supply in the reservoir 44 is subject to considerable change depending, for example, on operating temperature in the fire pot, ambient temperature and pressure, and rate of flow of incoming air and exhaust gases.

It has been discovered that one of the primary problems in maintaining continuous self-sustaining operation is that of maintaining the proper fuel level in the fire pot and preventing, in extreme conditions, complete evacuation of the fuel reservoir 44 by reverse flow through the fuel delivery system and that extremely reliable operation of the subject heater apparatus can be obtained by the provision of pressure equalization means for the fuel supply means. In the illustrative embodiment, the pressure equalization means may be advantageously provided by connecting the space above the upper level of the fuel in the float reservoir 170 to the air supply means 14. A fitting 196, shown in FIG. 3, is connected to the air passage in the elbow 114 and a suitable conduit 198 connects the elbow to the space above the fuel in the reservoir 170 through a suitable connection 200 as shown in FIG. 1. Thus, the upper surface of the fuel in the reservoir 44 and the upper surface of the fuel in the reservoir 170 are both subjected to positive pressure. Surprisingly enough, the pressure applied through the conduit 198 to the surface of the fuel in the reservoir 170 is sufficiently related to the pressure exerted on the upper surface of the fuel in the reservoir 44 to prevent the fuel in reservoir 44 from being forced backwardly through the inlet lines 190, 191 into the reservoir 170 under any of the many diverse conditions of operation likely to be encountered in normal use.

Referring now to FIG. 5, alternative burner apparatus particularly adapted for use with diesel fuel oil or the like, is illustrated. The heater apparatus is identical to that previously disclosed except as hereinafter described

in detail. The output of the resistance heating means 88 is increased by utilizing a plurality of Calrods 86*a* and 86*b* to increase the heat available for vaporizing diesel fuel in the reservoir 44. Instead of the air passage and diffuser arrangement shown in FIG. 3, a special flow controlling nozzle means 210 is mounted in the inlet passage 52. A portion 212 of enlarged diameter is received in the end of the elbow 114 and the other end 214 is bent at substantially right angles to direct incoming combustion air onto the side wall 216 of the combustion chamber to form a swirling movement of air around the periphery of the side wall. The swirling action of the incoming combustion air agitates the surface of the fuel and washes raw fuel up onto the side wall of the fire pot. In this manner, total vaporization of the diesel fuel is greatly increased. Suitable ports 217, 218 may be provided in the nozzle to direct air radially inwardly.

Referring now to the circuit diagram shown in FIG. 6, ignition apparatus 219, including a coil 24 and an associated spark plug 100; the water pump 166, if one is provided; the fuel pump 20, if one is provided; the blower 128; fuel flow control valve solenoid 197; and the resistance heater 88 are connected to a source of energy 220 through a terminal block 222. A line 224 having a circuit breaker 226 connects the source to the terminal block. If desired, a timer circuit including timer 228 and lines 230, 232 may be connected in circuit in series with an on-off switch 234 and a main thermostat 236 by lines 238, 240 and 242. The normally closed main thermostat 236 is suitably mounted on the engine at the lower coolant line fitting, for example, and may be set to open as engine temperature increases at, for example, engine temperatures of approximately 80° F. to 90° F. The fuel pump 20, the fuel flow control valve solenoid 197, and the water pump 166 are directly connected to line 242 by lines 244, 246, 248. The ignition apparatus 219, including the spark plug 100 and the coil 24 and the resistance heating means 88 are connected in parallel to a thermostat 250 by lines 252, 254, 256, 258. Thermostat 250 is mounted on the fire pot as shown in FIGURE 1. In the illustrative embodiment, the thermostat contacts are normally closed at approximately 160° F. and are set to open when pot temperature reaches approximately 200° F. Blower motor 128 is directly connected to the source by lines 260, 262, 264 through a normally open probe type thermostat 266 mounted on the fire pot at 259 and extending into the combustion chamber 32 as shown in FIG. 2. The thermostat may be set to close, for example, at pot temperature of 160° F.

*Operation*

The fuel reservoir 44 in the pot is normally empty at the beginning of each operation as will be hereinafter explained in detail. At the beginning of each operation, the thermostats 236 and 250 are closed and thermostat 266 is open. When the ignition switch 234 is turned on, a circuit is completed from the source to the resistance heater 88, the fuel pump 20, and the solenoid 197. The resistance heater immediately heats up and the rate of heating is far greater with the fuel reservoir 44 empty than it would be if the fuel reservoir were full of cold fuel with the resistance heater immersed therein. The normal operating temperature of the resistance heater may be, for example, approximately 1700° F. The fuel pump is energized so that fuel is pumped to the reservoir 44 through line 180 to the bowl 170 when the float valve 172 is open. Since reservoir 44 is initially empty, fuel will immediately flow from the bowl 170 to the reservoir 44 through lines 190, 191 as soon as solenoid valve 197 is opened. As the fuel reaches the reservoir 44 and contacts the lower part of of the resistance heater, it is immediately vaporized and the ignition coil also being initially energized, a spark is immediately available to ignite the vaporized fuel as it rises through the wick 62. Fuel is transferred by gravity from bowl 170 to the reservoir 44 until the desired fuel level in the pot is obtained.

When the flame resulting from ignition contacts the probe type thermostat 266 and heats it to 200°, the contacts are closed to energize the blower motor. The thermostat 250 opens at a pot temperature of approximately 200° F. to turn off the ignition and the vaporizer. Thereafter, the fire is self-sustaining with the heat in the pot being sufficient to continually vaporize and ignite the fuel which is continuously supplied as needed by the float controlled valve assembly 172. It is contemplated that in normal operation, the pot temperature and the flame temperature will be, respectively, approximately 200° F. and 1750° F. with gasoline and approximately 450° F. and 1900° F. with oil.

The products of combustion are exhausted upwardly through the tube 132 wherein they are brought into intimate heat transfer engagement with the wall of the tube by means of the baffle 140. The conical lower end 142 of the baffle serves to guide the products of combustion outwardly onto the wall of the tube and the central tubular portion 144 of the baffle confines flow of most of the gaseous discharge to a path located closely circumjacent the tubular wall whereby maximum heat transfer is attained. Some of the gaseous discharge flows radially inwardly through the perforations 146 thereby equalizing pressure and reducing noise.

Water or the like of, for example, the cooling system of an internal combustion engine with which the heater apparatus is associated, is circulated through the annular cavity 156 around the outer surface of the tube 132 from the inlet 158 to the outlet 160. The water, or other coolant, is heated rapidly by the extremely high temperatures in the heat exchanger and serves to heat the associated internal combustion engine. It has been found that the present invention operates successfully to bring a given engine to the desired operating temperature in only approximately ¼ of the time required by prior art devices. In other words, the subject apparatus is surprisingly better in operation than prior art devices and has approximately four times more heating capability.

Tests of the subject apparatus at about −20° F. have shown that, at the start of operation with the reservoir 44 empty, the resistance heater will heat to vaporizing temperature in about 1 or 2 seconds. A flame will be established in about 5 seconds and approximately 25 seconds later the probe type thermostat reaches the temperature at which the blower is energized. The resistance heater and the ignition apparatus remain energized for a period of about 3 to 5 minutes until self-sustaining operating conditions are firmly established.

A feature of the present invention is the capability of burning oil such as diesel fuel in diesel equipment in extremely cold climates where temperatures are often far below zero. The only requirement under such adverse conditions for successful operation of the subject apparatus with diesel fuel is that the fuel have sufficient liquidity to flow to the heater apparatus. Tests have shown that the subject apparatus can be successfully operated even with partially frozen diesel fuel which may be described as slush.

Other features of the present invention include the provision of the pressure equalization means which maintain the desired level of fuel in the fire pot regardless of changes in pressures within the fire pot. In this connection, the tapered surface 38 facilitates uniformity of vaporization of the fuel when the heater apparatus is subjected to continual variations in position relative to vertical due to movement of a vehicle on which it may be mounted. Furthermore, the tapered surface promotes the desired washing action which increases vaporization. The angle of inclination of the chimney relative to vertical facilitates mounting of the heater apparatus in the engine compartment of trucks or the like.

If for any reason the fire is extinguished, the aforedescribed cycle of operation will be repeated to the extent necessary to again obtain self-sustaining operation. Whenever pot temperature falls below 200° F., the thermostat **250** closes and the resistance heater **88** and the ignition apparatus are again energized. Thus the fuel will be heated and vaporized by the resistance heater and the vaporized fuel will be ignited by the spark plug until the fire is reestablished and pot temperature rises above 200° F.

Operation of the heater apparatus may be deliberately terminated by actuation of the switch **234** or automatically by opening of the engine thermostat **236** when the engine reaches a predetermined operating temperature of, for example, 80° F. When thermostat **236** is opened, the fuel pump **20** and the fuel flow control valve solenoid **197** are de-energized. The blower remains energized and the fire in the pot will continue to burn using the fuel remaining in the reservoir **44**. When all the fuel in the pot has been utilized, the fire is extinguished and the temperature of the probe type thermostat will be quickly reduced by delivery of relatively cold air through the pot by the blower which continues to operate. When the temperature has fallen from, for example, approximately 1900° F. to 160° F., the thermostat **266** will open and the blower will stop. The apparatus is then ready for another heating operation with the fuel reservoir **44** in the pot again empty to promote initial rapid heating of the resistance heater and instant vaporization of incoming fuel.

The inventive principles have been hereinbefore described with reference to illustrative embodiments thereof which are subject to modification or change, in many respects, without departing from the proper scope of the appended claims intended to cover, protect and secure the invention for the applicant in the broadest possible manner consistent with the extent of the applicant's contribution to this art as determined by the status of the prior art.

What is claimed is:

**1.** Heater apparatus comprising fire pot means in which a continuous self-sustaining fire is adapted to be maintained, fuel supply means for delivering fuel to said fire pot means for vaporization therein to sustain the fire, forced air supply means connected to said fire pot means, chimney means connected to said fire pot means, passage means connecting said forced air supply means to said fire pot means and said chimney means to said fire pot means and providing a passage from said forced air supply means to said chimney means through said fire pot, pressure equalization means connecting said forced air supply means to said fuel supply means, said fire pot means is adapted to burn gasoline or the like and comprises a central cylindrical cavity, cylindrical air diffuser means mounted in said cavity and defining an annular air inlet chamber with said central cavity, a portion of said air diffuser means opposite the portion of said passage means connecting said forced air supply means to said fire pot means forming an imperforate shield dividing air flow into a plurality of flow paths and the other portions of said diffuser means being perforate to permit flow of air radially inwardly therethrough, a fuel reservoir provided in the bottom of said fire pot means, cylindrical wick means extending upwardly from said fuel reservoir and defining a central annular passage for vaporized fuel and being spaced from said air diffuser means and defining an annular upwardly extending air passage therewith, and combustion chamber means provided above said wick means and interconnecting the annular air passage and the annular vaporized fuel passage.

**2.** The invention as defined in claim **1** and wherein said fire pot means is adapted to burn fuel oil or the like and comprises a central cylindrical cavity having an annular side wall, a fuel reservoir provided at the bottom of said fire pot means, cylindrical wick means extending upwardly from said fuel reservoir, combustion chamber means provided above said fuel reservoir and around said wick means, and inlet air nozzle means having an opening facing the side wall of said central cylindrical cavity and directing flow of air from said forced air supply means radially onto the inner wall of said fire pot means to establish a whirling flow of air and a splashing action in the fuel in said fuel reservoir causing movement of the fuel onto the annular side wall of the fire pot means to increase the rate of fuel vaporization.

**3.** The invention as defined in claim **2** and having a conical surface connecting the inner wall of said combustion chamber means and said fuel reservoir, and fuel level control means to maintain the level of fuel at a height extending across said conical surface.

**4.** An auxiliary heater, for use in a vehicle or the like of the type having a liquid cooled engine, comprising burner means including a fluid fuel reservoir located in the bottom of said burner means and communicating directly with said burner means, a combustion chamber formed in said burner means directly above said fuel reservoir, a tapered surface forming part of said fuel reservoir and connecting said fluid fuel reservoir and said combustion chamber, fuel delivery means to deliver fuel to said fuel reservoir from a remote source, fuel level control means to maintain the level of fuel in said fuel reservoir at a height whereat the upper surface of the fuel in said fluid fuel reservoir extends across said tapered surface, heat exchanger means having a gas passage connected to said combustion chamber, and air delivery means connected to said combustion chamber to deliver air into said combustion chamber and through said gas passage.

**5.** The invention as defined in claim **4** and having pressure equalization means connected between said air delivery means and said fuel delivery means to maintain a constant fuel supply condition.

**6.** Heater apparatus, for association with an internal combustion engine or the like having a liquid cooling system and a source of liquid fuel such as gasoline or oil, comprising: mounting means for mounting said heater apparatus on or near said internal combustion engine; fire pot means for maintaining a self-sustaining fire by burning said liquid fuel and comprising a substantially annular central chamber extending vertically upwardly from a fuel chamber of reduced diameter at the bottom of said fire pot means and terminating in an exhaust opening formed in an inclined flange portion at the top of said fire pot means, a tapered upwardly outwardly extending substantially conical surface formed on said fire pot means and connecting said central chamber and said fuel chamber, burner means mounted in said fire pot means and comprising wick means seated on said fire pot means adjacent said fuel chamber and extending upwardly therefrom and terminating substantially centrally in said central chamber, air diffuser means surroundingly mounted about said wick means in spaced relationship thereto and being seated at the bottom on said tapered surface of said fire pot means to define an annular mixing chamber for air and fuel vapor and extending upwardly from said tapered surface in spaced relationship to said fire pot means to define an annular air inlet chamber, baffle means extending transversely between said fire pot means and said air diffuser means to confine flow of air to a path through said air diffuser means; fuel supply means connected to said source and said fuel chamber to deliver a supply of liquid fuel thereto; fuel flow control means to control the flow of fuel to said fuel chamber and to limit the amount of fuel provided in said fuel chamber; resistance heating means mounted in said fuel chamber to heat and vaporize the liquid fuel contained therein; selectively operable ignition means mounted on said fire pot means and extending into said annular mixing chamber, electrical means to energize said resistance heating means and said ignition means to vaporize the liquid fuel and to ignite the air-vapor mixture at the start of operation; forced air circulating means connected to said air inlet chamber to continuously force a quantity of air into said air inlet chamber and through said air diffuser means into said mixing

chamber and to force the products of combustion upwardly through said central chamber and outwardly through said outlet port during continuous self-sustaining operation of the heater apparatus, and temperature responsive control means to terminate operation of said ignition means and said resistance heating means after a predetermined operating temperature has been reached sufficient to thereafter sustain continuous operation of said heater means.

7. The invention as defined in claim 6 and wherein said air diffuser means comprises a substantially cylindrical sleeve, passage means extending transversely through said fire pot means and connecting said air inlet chamber to said forced air circulating means, a portion of said cylindrical sleeve opposite said passage means being imperforate and dividing air flow into at least two paths extending circumjacent said sleeve, and the other portions of said sleeve being perforate and directing air flow radially inwardly from said air inlet chamber to said mixing chamber.

8. The invention as defined in claim 7 and having circumferentially extending slot means formed along the bottom of said air diffuser means opposite said imperforate portion to increase uniformity of air flow into said mixing chamber.

9. The invention as defined in claim 6 and having pressure equalization means connected to said fuel supply means beyond said fuel chamber to prevent forces applied to the surface of the fuel in said fuel chamber from forcing the fuel rearwardly through said fuel supply means.

10. The invention as defined in claim 9 and wherein said pressure equalization means comprises an air passage of reduced diameter connected at one end to said passage means and at the other end to said fuel supply means.

11. The invention as defined in claim 6 and having heat exchanger means mounted on the inclined flange of said fire pot means and comprising an inner tubular member defining an exhaust passage, an outer tubular member mounted in spaced relationship with said inner tubular member and defining a closed annular coolant chamber therewith, and coolant inlet and outlet means connecting said annular coolant chamber to the engine coolant system to circulate coolant through said annular coolant chamber around said exhaust passage.

12. The invention as defined in claim 11 and having baffle means mounted in said exhaust passage comprising a tubular member having a conical lower end portion and a cylindrical central portion mounted in spaced relationship with said inner tubular member and defining an annular exhaust gas passage confining gas flow to an area closely adjacent the inner tubular member and maximizing heat transfer from said exhaust gases to the coolant circulating in said coolant chamber.

13. Heater apparatus, for heating the coolant in the cooling system of an internal combustion engine and for burning fuel of the type used by the engine, comprising: fire pot means having an elongated cylindrical central combustion chamber, support means mounting said fire pot means adjacent the internal combustion engine in a vertical position with said elongated cylindrical combustion chamber extending vertically, combination chimney and heat exchanger means mounted on the top of said fire pot means, mounting means supporting said combination chimney and heat exchanger means at an upwardly extending angle of inclination approximately equal to 45° or less from horizontal, and engine coolant conduit means connecting the heat exchanger portion of said combination chimney and heat exchanger to the cooling system of the internal combustion engine.

14. The invention as defined in claim 13 and wherein said mounting means comprises an inclined abutment surface formed on the upper end of said fire pot means and a mating inclined abutment surface formed on the lower end of said combination chimney and heat exchanger means.

15. Heater apparatus, for heating coolant of a cooling system of an internal combustion engine and for burning the fuel provided for and utilized by the engine, comprising a fire pot having an elongated cylindrical combustion chamber, mounting means supporting said fire pot in a vertical position with the longitudinal axis of said elongated cylindrical combustion chamber extending vertically, and combination chimney and heat exchanger means mounted at the top of said fire pot and extending at an angle of inclination such that the vertical rise thereof is substantially smaller than the horizontal extent thereof whereby maximum heat exchange is obtained with minimum vertical displacement so that the heater apparatus may be mounted alongside an internal combustion engine in an existing compartment provided therefor.

16. The method of starting operation of heater apparatus of the continuous self-sustaining type, said heater apparatus comprising fire pot means having a central combustion chamber, a fuel chamber at the bottom of said fire pot means, electrical resistance heating means mounted in said fuel chamber for heating and vaporizing fuel therein, fuel flow control means for controlling flow of fuel to said fuel chamber from a fuel supply, and forced air circulating means for delivering air under pressure to said combustion chamber, the steps comprising maintaining a body of liquid fuel in said fuel chamber during operation of said heater apparatus, terminating operation of said heater apparatus by stopping the supply of fuel to said fuel chamber and continuing burning of fuel in the fire pot until the fire is self-extinguished by lack of fuel in said fuel chamber creating a dry condition in the fuel chamber, preventing the delivery of additional fuel to said fuel chamber until subsequent operation of the heater apparatus is desired, maintaining said fuel chamber dry at the beginning of each subsequent heater operation until said electrical resistance heating means has been energized and has reached a temperature at which fuel in contact therewith will be vaporized, and thereafter filling said fuel chamber with fuel for continuous self-sustaining operation of said heater apparatus.

17. The method of operating heater apparatus of the self-sustaining type, said heater apparatus comprising fire pot means having a central combustion chamber, a fuel chamber at the bottom of said fire pot means, electrical resistance heating means mounted in said fuel chamber for heating and vaporizing fuel therein, fuel flow control means for controlling flow of fuel to said fuel chamber from a fuel supply, ignition means for igniting the vaporized fuel, and forced air circulating means for delivering air under pressure to said combustion chamber: comprising the steps of, initiating operation without fuel in said fuel chamber by energizing said heater means and said ignition means at the start of a heating operation, thereafter delivering fuel to said fuel chamber and immediately vaporizing said fuel by contact with said heating means to form an air-fuel vapor mixture in said combustion chamber subject to immediate ignition by said ignition means to create a fire in said fire pot means, raising the level of fuel in said fuel chamber until a predetermined maximum level is attained, starting said forced air circulating means after a predetermined temperature is attained in said fire pot means, de-energizing said electrical resistance heating means and said ignition means after a predetermined temperature is reached sufficient to maintain the fire in the fire pot means on a self-sustained basis, stopping self-sustained operation by de-energizing said fuel flow control means to stop delivery of fuel to said fuel chamber, and continuing operation of said forced air circulating means until the fuel in the fuel chamber has been consumed and the fire is extinguished and sufficient air is delivered to said fire pot means to reduce the temperature of said fire pot means to a predetermined low value.

18. In heater apparatus, for heating coolant in the cooling system of an internal combustion engine and for burning fuel provided for the engine, comprising fire pot means

having a combustion chamber and a fuel chamber, electrical resistance heating means mounted in said fuel chamber to heat and vaporize fuel during initiation of heater operation, spark discharge ignition means mounted in said combustion chamber to ignite the fuel vapor during initiation of heater operation, fuel delivery means for delivering a predetermined amount of fuel to said fuel chamber during ignition and for maintaining a predetermined fuel level in said fuel chamber during self-sustaining operation, exhaust gas operated heat exchanger means connected to said fire pot means, coolant passage means connecting said heat exchanger means to the cooling system of the engine, forced air circulating means connected to said fire pot means to deliver combustion air to said combustion chamber and force exhaust gases through said heat exchanger means, first thermostatic control means associated with said engine and having an on circuit condition during predetermined low engine conditions and an off circuit condition during predetermined high engine temperature conditions, a second thermostatic control means associated with said pot means and having an on circuit condition dependent on pot temperature being below a predetermined temperature and an off condition above said predetermined temperature, a third thermostatic control means associated with said pot means and having an on condition dependent on pot temperature being above a predetermined temperature and an off condition below said temperature, circuit means for controlling said heater apparatus including said first and second and third thermostatic control means and an electrical source such as a battery associated with said engine, an on-off switch connected in said circuitry, said forced air circulation means including motor means connected in circuit with said electrical source in series with said third thermostatic control means, said resistance heating means and said ignition means being connected in circuit in parallel through said first and second thermostatic control means and said switch means to said source, and said fuel delivery means including a solenoid operated control valve connected in circuit with the source through said switch and said first thermostatic control means.

**19.** Heater apparatus comprising fire pot means in which a continuous self-sustaining fire is adapted to be maintained, heater apparatus comprising fire pot means having a central cavity, air diffuser means mounted in said central cavity and defining an air inlet chamber, fuel reservoir means provided in the bottom of said fire pot means, fuel supply means for delivering fuel to said fire pot means for vaporization therein to sustain the fire, forced air supply means connected to said fire pot means, chimney means connected to said fire pot means, passage means connecting said forced air supply means to said fire pot means and connecting said chimney means to said fire pot means and providing a passage from said forced air supply means to said chimney means through said air diffuser means, shield means for said air diffuser means located opposite the portion of said passage means connecting said forced air supply means to said fire pot means and forming an imperforate shield dividing air flow into a plurality of flow paths, portions of said diffuser being perforate to permit flow of air radially inwardly therethrough along said plurality of flow paths, wick means extending upwardly from said fuel reservoir means and defining a passage for vaporized fuel and being spaced from said air diffuser means and defining an upwardly extending air passage therewith, and combustion chamber means provided above said wick means and interconnecting the air passage and the vaporized fuel passage.

**20.** Heater apparatus comprising fire pot means having a central cavity defined by vertically extending side wall portions, a fuel reservoir provided at the bottom of said fire pot means, wick means extending upwardly from said fuel reservoir, combustion chamber means provided above said fuel reservoir and around said wick means, fuel supply means for delivering fuel to said fire pot means for vaporization therein to sustain the fire, forced air supply means connected to said fire pot means, chimney means connected to said fire pot means, passage means connecting said forced air supply means to said chimney means through said fire pot means, and inlet nozzle means having an opening facing the vertically extending wall portions of said central cavity and directing flow of air from said forced air supply means onto the wall portions to establish a whirling flow of air and a splashing action in the fuel in said fuel reservoir causing movement of the fuel onto the side wall portion of the fire pot means to increase the rate of fuel vaporization.

**21.** The invention as defined in claim **20** and having an inclined wall surface connecting the combustion chamber means and the fuel reservoir, and fuel level control means to maintain the level of fuel in the fuel reservoir during sustained operation of said heater apparatus at a height extending across said inclined surface.

**22.** Heater apparatus for association with an internal combustion engine or the like having a liquid cooling system and a source of liquid fuel such as gasoline or oil, comprising: mounting means for mounting said heater apparatus on or near said internal combustion engine; fire pot means for maintaining a self-sustaining fire by burning said liquid fuel and comprising a central chamber extending vertically upwardly from a fuel chamber at the bottom of said fire pot means and terminating in an exhaust opening at the top of said fire pot means, an inclined surface formed on said fire pot means and connecting said central chamber and said fuel chamber, burner means mounted in said fire pot means and comprising wick means extending upwardly therein and terminating within said central chamber, air diffuser means surroundingly mounted about said wick means in spaced relationship to define a mixing chamber for air and fuel vapor and extending upwardly in spaced relationship to said fire pot means to define an air inlet chamber, baffle means extending between said fire pot means and said air diffuser means to define an air flow path through said air diffuser means; fuel supply means connected to said source and said fuel chamber to deliver a supply of liquid fuel thereto; fuel flow control means to control the flow of fuel to said fuel chamber and to limit the amount of fuel provided in said fuel chamber; heating means mounted in said fuel chamber to heat and vaporize the liquid fuel contained therein; ignition means mounted on said fire pot means and extending into said mixing chamber; electrical means to energize said heating means and said ignition means to vaporize the liquid fuel and to ignite the air-vapor mixture at the start of operation; air circulating means connected to said air inlet chamber to continuously circulate air through said air inlet chamber and said air diffuser means and said mixing chamber during continuous self-sustaining operation of the heater apparatus; and control means to terminate operation of said ignition means and said heating means after a predetermined operating temperature has been reached sufficient to thereafter sustain continuous operation of said heater means.

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