March 16, 1965 R. H. HUNTER ETAL 3,173,467

THERMOSTATICALLY CONTROLLED MULTIPLE FUEL BURNER

Filed Sept. 4, 1959 4 Sheets-Sheet 1

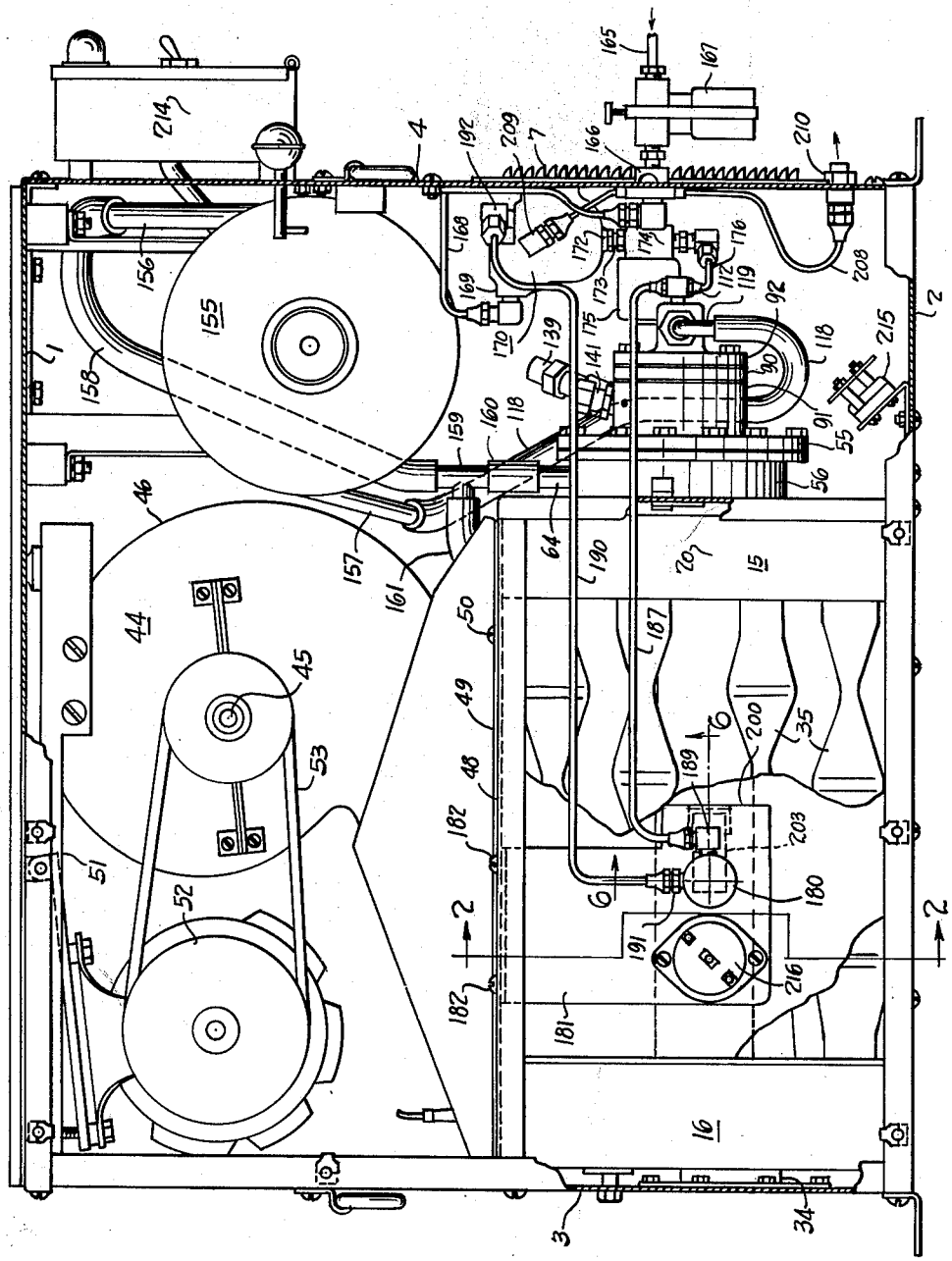


FIG. 1

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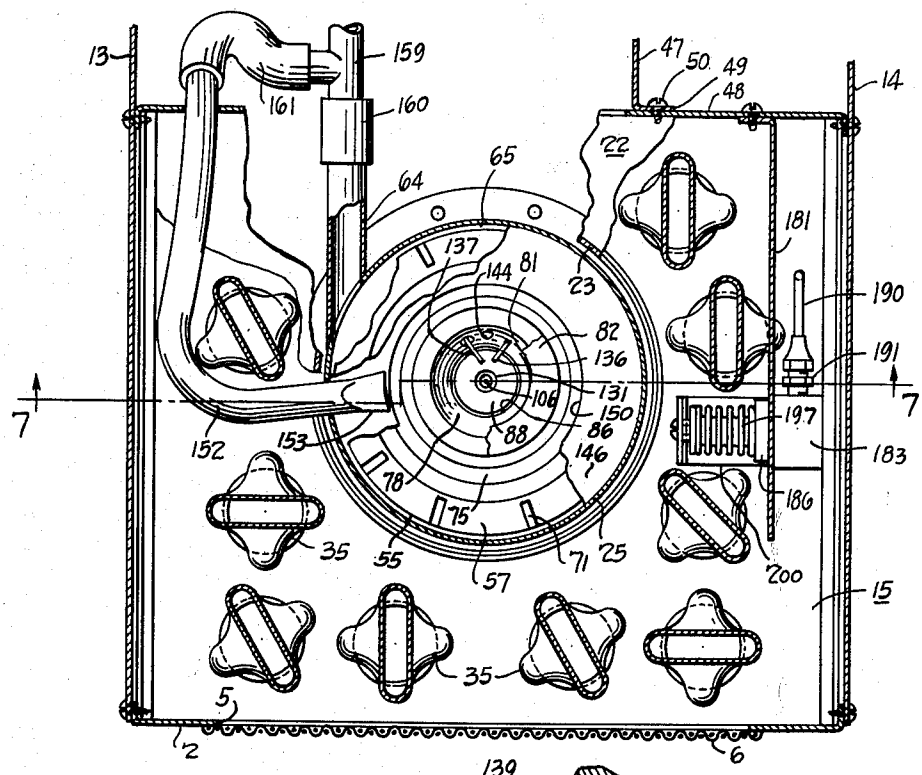


Fig. 2

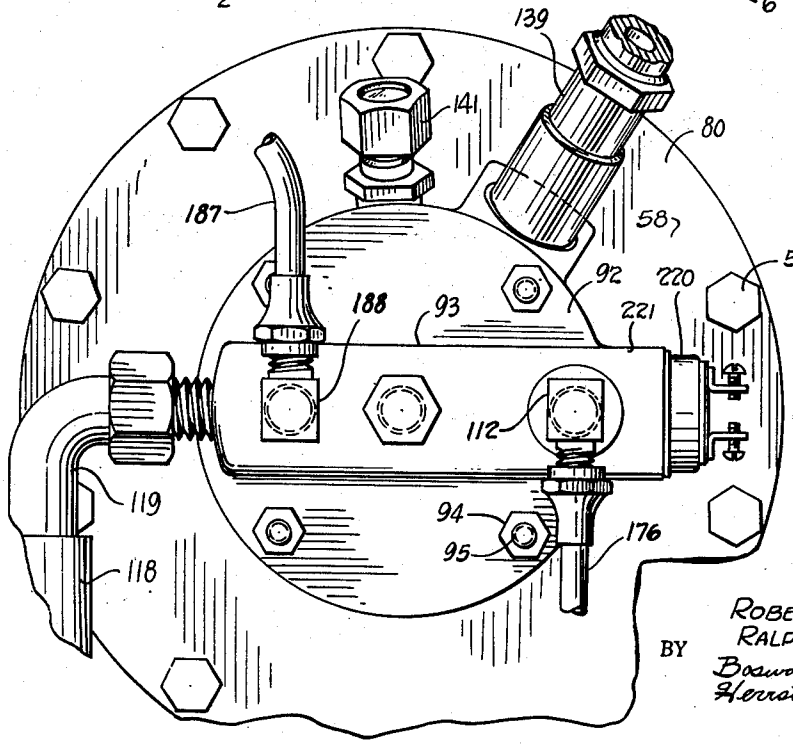


Fig. 3

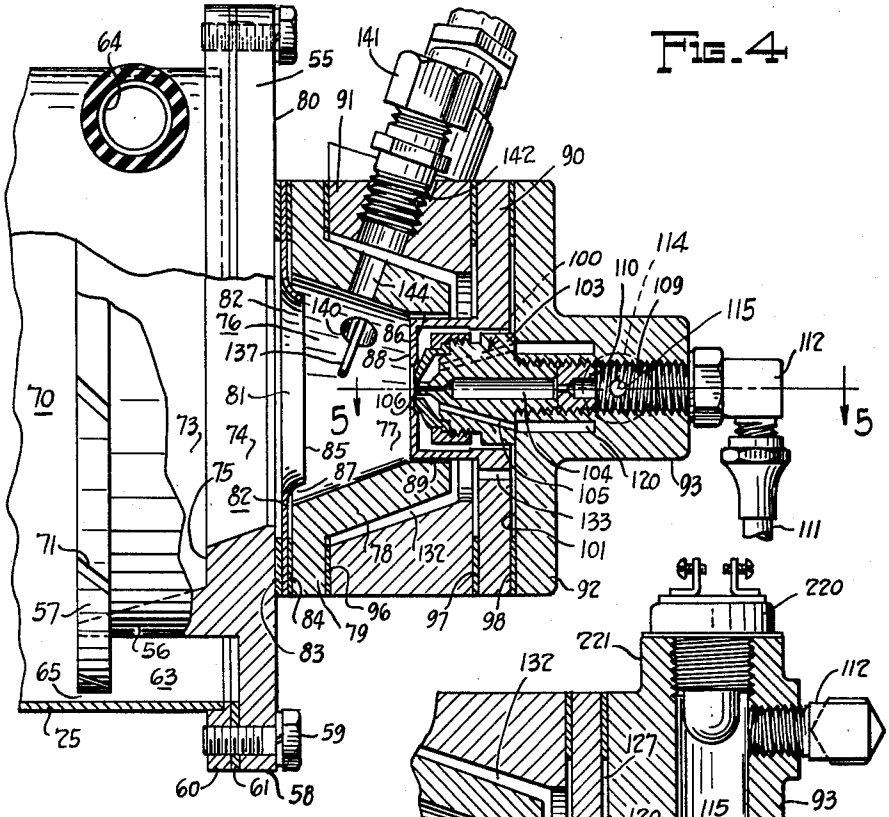
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THERMOSTATICALLY CONTROLLED MULTIPLE FUEL BURNER

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Fig. 4



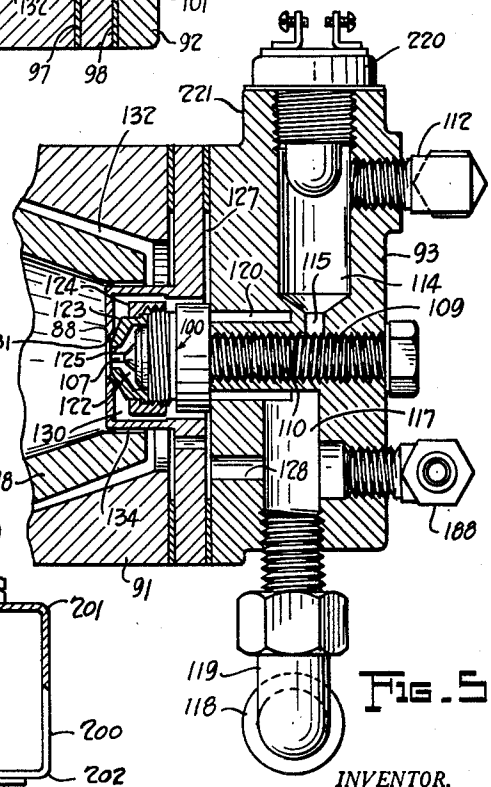


Fig. 5

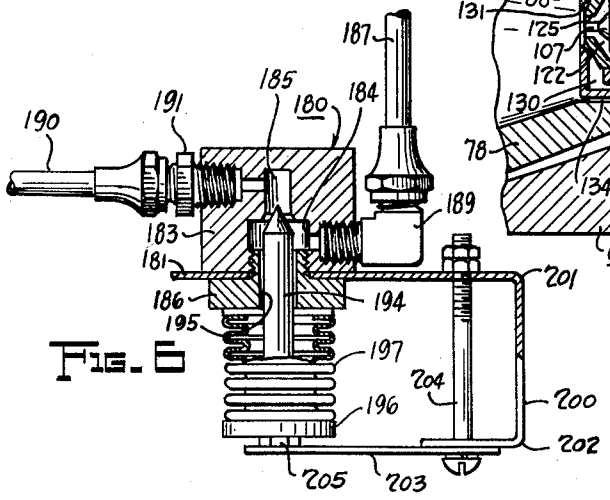


Fig. 6

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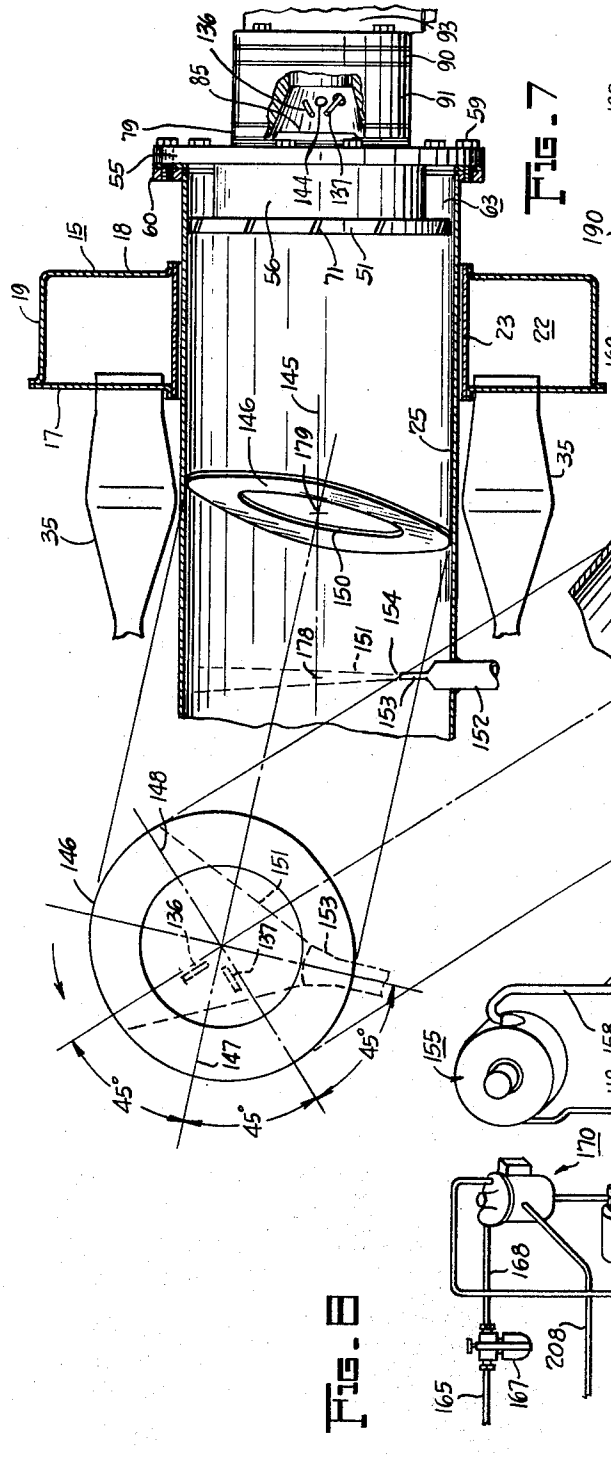


FIG. 7

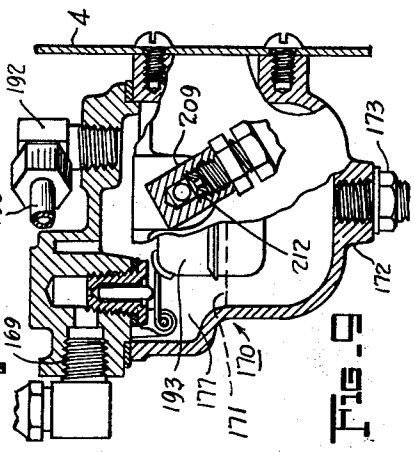
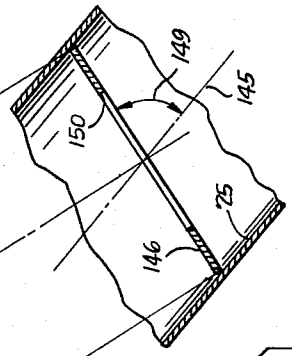


FIG. 9



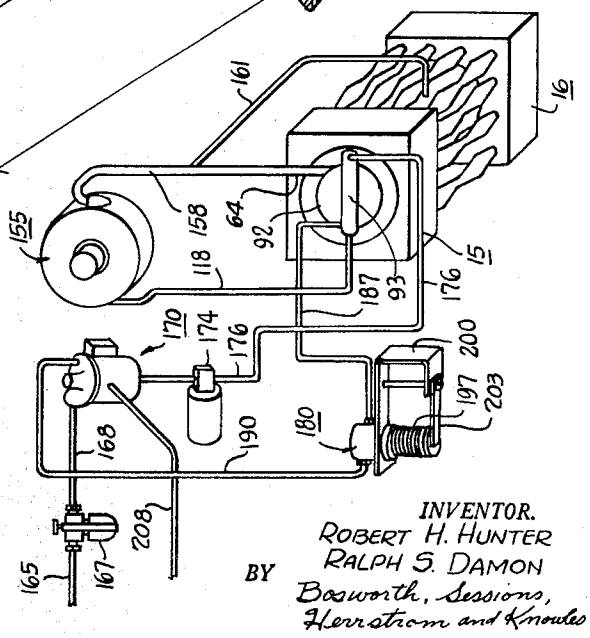


FIG. 8

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United States Patent Office 3,173,467 Patented Mar. 16, 1965

3,173,467

THERMOSTATICALLY CONTROLLED MULTIPLE FUEL BURNER

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Filed Sept. 4, 1959, Ser. No. 838,157
16 Claims. (Cl. 158—28)

This invention relates to liquid fuel heaters, especially heaters having burners capable of using fuels of different viscosities. It has been recognized, as pointed out in United States Patent 2,876,763, that a liquid hydrocarbon fuel can be burned efficiently by carrying it in the form of a spray into a combustion chamber together with a quantity of primary air for supporting initial combustion and thereafter supplying secondary air to complete the combustion.

It is the principal aim of the present invention to provide an automatic fuel feed control in a system of the type in which a float bowl maintains a constant level supply of liquid fuel and air pressure in the float bowl chamber forces the fuel to the nozzle from which the fuel is released into the combustion chamber of the burner. According to this aspect of the invention the air pressure in the float bowl chamber is varied automatically by thermostatic means to obtain an increased fuel flow rate in response to an increased demand for heat and to obtain a decreased fuel rate upon a lessening of the heat demand. More particularly, the float bowl air pressure variation is achieved by releasing and introducing air through flow restrictors and automatically varying one of the restrictors in response to a condition of the burner.

Other objects and advantages relate to certain novel features of construction, combinations and arrangements of parts and the liquid fuel burning process as set forth in the following detailed description of a heater embodying the invention. This description is made in connection with the accompanying drawings which form a part of the specification.

In the drawings:

FIGURE 1 is a side elevational view, partly diagrammatic, partly in section, with parts broken away or removed, showing the heater device of the present invention;

FIG. 2 is a transverse sectional detail, with parts removed or broken away, taken substantially in the plane represented by the line 2—2 of FIG. 1 and enlarged with respect to that figure;

FIG. 3 is an end elevational view of the burner head, with parts broken away or removed, to show the location of the air and fuel connections, this view being drawn to an enlarged scale relative to the preceding figures.

FIG. 4 is a fragmentary vertical sectional detail, with parts broken away or removed, showing the burner head assembly and a fragment of the combustion tube, this view being enlarged with respect to the preceding figures;

FIG. 5 is a sectional detail taken substantially in the plane represented by the line 5—5 of FIG. 4;

FIG. 6 is an enlarged elevational detail, partly in section and with parts broken away or removed, showing the thermostatic air valve of the fuel feed control system;

FIG. 7 is a description layout in the form of a fragmentary upwardly looking horizontal section, partly schematic, with parts removed or broken away, taken substantially in the plane represented by the line 7—7 of FIG. 2, showing the location of the air control ring in and its relation to the combustion tube;

FIG. 8 is an isometric diagram showing the fuel and air connections of the heater; and

FIG. 9 is an elevational detail, partly in section and with parts removed, of the float bowl assembly of FIG. 1, being enlarged with respect to that figure.

The space heater shown in the drawings represents the best known mode of practicing the invention. It comprises a generally rectangular sheet metal casing having (see FIG. 1) top 1, bottom 2, end walls 3 and 4 and (see FIG. 2) side walls 13, 14. The side wall 14 is removed in FIG. 1 and the wall 13 is behind the illustrated components and is parallel to the plane of the drawing. The casing sheet metal panels are bolted, welded or riveted together and provided with suitable stiffeners and suitable openings through which the fuel and electrical conduits and conductors are admitted. One or more of the walls are formed with louvers or grills such as indicated at 7 in the end wall 4 to admit atmospheric air into the casing for circulation through the heat exchanger and to supply combustion air for the burner. An opening 5 (FIG. 2) in the casing bottom 2 is covered by a screen 6, this opening constituting the exit through which heated air is discharged after passing through a burner and heat exchanger unit located between the side walls 13, 14 and against the bottom 2.

The heat exchanger unit comprises a spaced pair of hollow tube connected headers 15 and 16, each of generally rectangular configuration and constructed of heat resistant sheet metal such as stainless steel, suitably formed and welded together. These headers have approximately the same profile and are of such size that they have easy sliding fits between the spaced side wall panels 13 and 14. By thus making the headers 15 and 16 so that they closely fit the side wall panels 13 and 14, the headers constitute end closures so that air forced into the top of the heat exchanger unit is confined to flow downwardly therethrough and out the bottom opening 5 in the casing.

The header 15 includes inner and outer walls 17 and 18 disposed in spaced parallel relation to one another and connected by suitable top and bottom walls and side walls 19, 20, the wall 19 being disposed closely adjacent and parallel to the inside of the wall panel 13 and the wall 20 being disposed closely adjacent and parallel to the inside of the wall panel 14.

Extending through chamber 22 of the header 15 is a cylindrical sleeve 23 the ends of which are received in flanged openings in the header walls 17 and 18. Circular weld joints seal the sleeve ends into the header walls. This sleeve receives and accommodates main combustion tube 25 of the burner in a sliding fit to permit relative expansion and contraction. The header 16 comprises walls corresponding to the top, bottom, inner and outer walls of the header 15 and is similarly positioned with its side walls in closely spaced confronting relation to the casing walls 13, 14.

Hot gases projected into the header 16 through the remote discharge end of the combustion tube 25 are circulated between the headers by suitable baffling within the headers, or one of them, and ultimately discharge to atmosphere through a suitable flue (not shown) to which is connected tubular outlet nipple 34 suitably secured to the outer wall of the header 16 as by a circular welded seam to receive the spent gases from such header.

Circulation of the hot gases or fluid heating medium between the headers 15 and 16 is effected through tubes 35 which are of stainless steel or other heat resistant metal.

Circulation of atmospheric air through the heat exchanger is induced by a blower or fan 44 comprising a squirrel cage rotor (not shown) carried on a shaft 45 journaled in bearings which support the rotor in a sheet metal scroll 46. The outlet of the fan scroll is of rectangular shape and connects as through a flexible sleeve

or by registering directly (as shown) with an opening in an air box 47 continuous with the interior of the heat exchanger through an opening in sheet metal closure panel 48. An integral flange 49 about the air box outlet is disposed flatwise against the outside of the closure panel 48, being secured to the latter as by screws 50.

An electric motor 52 suspended as a unit with the fan assembly 44 from a frame 51 having resilient connection with the casing top 1 drives the fan 44 by belt 53 trained around pulleys fast on the motor shaft and on the shaft 45 of the fan rotor. The motor 52 is controlled conventionally to operate the fan to force air into the chamber defined by the heat exchanger closure panel 48, the casing side panels 13, 14 and bottom 2 and the headers 15 and 16, either continuously or intermittently in response to heat demand sensed as by a thermostat or other suitable control.

Main combustion chamber 70 is defined by the cylindrical combustion tube 25. At the receiving or, as viewed in FIGS. 1, 4 and 7, right hand end of the combustion tube 25 is a burner assembly comprising a series of coaxial rings or members stacked one against another. Main ring 15, which constitutes a secondary air diffuser, as will appear, is spool shaped and comprises a body portion 56 and radial end flanges 57, 58. The smaller or inner flange 57 and the body 56 are received within the end of the combustion tube 25, the larger or outer flange 58 being of greater diameter than the combustion tube so as to project radially beyond the combustion tube for attachment as by circumferentially spaced cap screws 59 to an external anchor ring 60 suitably made fast as by welding to the end of the combustion tube. A deformable sealing gasket 61 of asbestos or other suitable heat resistant material is interposed between the flange 58 of the burner base and the ring 60 on the combustion tube.

The body 56 of the base ring is separated from the cylindrical internal wall of the combustion tube 25 by an annular clearance space 63 located between the axially spaced spool flanges 57, 58 and constituting a distributing or plenum chamber for secondary air introduced tangentially as through a metal pipe 64. This feed pipe is welded to the combustion tube 25 and is in communication with the annular chamber 63 through a suitable registering opening in the combustion tube. The inner flange 57 of the burner base member 55 has a narrow cylindrical periphery separated from the internal cylindrical surface of the combustion tube 25 by a narrow clearance 65 having a radial extent of the order of about 1/16 inch in the case of a combustion tube 25 having an internal diameter of about 5 inches, such clearance constituting a circular orifice through which air under pressure in the plenum chamber 63 is discharged into the main combustion chamber 70 in the form of a spirally advancing cylindrical jet or sheath which completely surrounds the flame. A number of radial slots 71 oblique to the burner head axis are formed in the inner flange 57 of the base ring 55 and are continuous with the annular clearance 65 which surrounds the flange.

The axial through passage of the ring member 55 of the burner assembly provides a primary combustion chamber which comprises a pair of coaxial and sequential stepped diameter portions having frusto-conical walls 73, 74. A circular radial shoulder 75 is at their juncture. Such primary combustion chamber is continuous at its large diameter end with the cylindrical main combustion chamber 70 defined by the walls of the combustion tube 25 and at its small diameter end with a tapered ignition chamber 76 defined by frusto-conical wall 77 of a hat-shaped partition ring member 78 comprising a sheet metal stamping or, as shown, a metal casting. Circular outwardly directed radial flange 79 of the partition member 78 is clamped against outside end face 80 of the main ring member 55 with an intervening flame control plate 82 and gasket rings 83, 84. The gaskets are of suitable heat resistant and heat insulating deformable sealing material such as asbestos. The plate 82 is a stamping of thin heat resistant material such as stainless sheet steel. It is formed with a central circular opening 81 defined by a rearwardly curved inner peripheral flange 85 that extends into the ignition chamber 76. The opening 81 is of less diameter than the adjacent end portion of the frusto-conical wall 77, providing an annular pocket 87 behind the flame control plate.

Extending into a circular axial opening 86 in the small diameter end of the frusto-conical partition member 78 is a radiation shield comprising a thin flat circular wall portion 88 integral at its periphery with a cylindrical wall portion 89. The latter is integral with and projects axially forwardly from the inner periphery of a circular ring plate member 90 clamped between an ignitor mounting ring member 91 and circular base 92 of a mounting block 93.

The several rings and mounting members of the burner assembly are held together and located in coaxial relation as by suitable elongated fasteners such as studs 94 which extend in parallel relation to one another and to the burner head axis through aligned openings in the several ring members, flanges and intervening gaskets. The studs have threaded inner ends screwed into tapped holes in the base ring member 55 and retaining nuts 95 on their outer ends. Asbestos gaskets 96, 97 and 98, similar to the gaskets 83, 84, are interposed and constitute heat insulators between the parts as shown.

A nozzle assembly 100 is carried by the mounting block 93, projecting from flat face 101 of the latter into a chamber of circular section provided by the shield member comprising the elements 88, 89, 90. The nozzle assembly comprises a body 103 which may take the form of a turning of brass or similar machinable metal of high heat conductivity. It is formed with a central axial fuel passage 104 and a number of primary air passages 105 spaced radially outwardly from and distributed angularly about the fuel passage 104. The forward end of the nozzle body 103 has a frusto-conical face and is formed at its center with a relatively small tubular axial projection 107 (FIG. 5) having an axial passage continuous with the fuel passage 104 and terminating in a discharge orifice 106 through which the fuel is released into the ignition chamber 76. At its base or rear end the nozzle body 103 is formed with an externally threaded reduced diameter axial extension screwed into the internally threaded end portion of an aligned through passage 109 of the mounting block 93. A threaded metering plug 110 is screwed into another threaded portion of the passage 109 from the opposite end and is located between the nozzle body and the fuel supply chamber.

Fuel is supplied to the nozzle assembly through a tubular conduit 176 connected as by threaded fitting 112 screwed into a tapped entry port in the mounting block 93 continuous with a fuel supply chamber 114 located in one end of the block and which, in turn, is continuous with the chamber 109 through a connecting passage 115.

Air is supplied under pressure to a chamber 117 formed in the other end of the mounting block 93 through a conduit or tube 118 which is connected to the chamber 117 through a fitting 119 screwed into a tapped port provided in such other end of the mounting block 93.

From the supply chamber 117 the primary air enters an annular passage 120 which surrounds that portion of the block in which is formed the threaded portion of the fuel chamber 109. The ends of the air passages 105 which open through the base of the nozzle body 103 at angularly spaced points radially outwardly of the threaded axial extension of the nozzle, are thus continuous with and adapted to receive pressurized air from the annular passage 120. Such air is released through the forward end of the nozzle body in a series of jets distributed angularly about the nozzle projection 107. These air jets are directed into a tip chamber 122 (FIG. 5) provided by a

hollow cap 123 fitted over the end of the nozzle body 103 and held by a flanged collar 124 threadedly engaging the nozzle body. The cap 123 is formed with a central circular opening 125 through which air is discharged from the nozzle tip chamber 122 into the ignition chamber 77.

In addition to the primary air which enters the nozzle body passages 105 through the annular passage 120 in the mounting block 93, another fraction of primary air is led from the mounting block supply chamber 117 through a passage 128 drilled or otherwise formed in the mounting block into an annular chamber 127 provided between the mounting block and the shield member 90. The chamber 127 surrounds the base of the nozzle assembly 100 and is continuous with an annular shield chamber 130 provided between the radiation shield and the nozzle assembly. A central opening 131 in the flat radiation shield 88 coaxial to the fuel orifice 106 and to the primary air orifice 125 provides an outlet from the chamber 130.

Additional primary air is supplied to the ignition chamber 77, supplementing that which enters through the nozzle chamber 122 and the shield chamber 130. One source of such supplemental primary air is an annular distribution chamber 132 which surrounds the rear end of the partition member 78, constituting the clearance between the external frusto-conical surface of such partition member and the internal frusto-conical surface of the mounting ring member 91. Such chamber also constitutes the clearance between the end of the partition member and the ring member 90. One or more drill holes 133 through the ring member 90 communicate the chamber 132 with the chamber 127 receiving pressurized air from the supply chamber 117 through the drill hole 128 in the mounting block 93. Between the cylindrical external surface of the tube shaped wall 89 and the cylindrical internal surface defining the end opening of the partition member 78 in which the radiation shield is received there is provided an annular clearance 134 through which pressurized air in the chamber 132 is released into the ignition chamber 77.

The mixture or spray of fuel and primary air in the ignition chamber 77 is suitably ignited as by an electric spark produced between the spaced tips of a grounded electrode 136 and an insulated electrode 137. These electrodes are both supported by the mounting ring member 91, the electrode 136 comprising a suitable metal wire of nickel chromium alloy or the like received in a drilled socket in the ring 91 and retained by a set screw. The insulated electrode 137, of similar metal wire, is part of an assembly 139 screwed into a drilled and tapped socket in the same ring member. Openings 140 are drilled through the frusto-conical portion of the partition member 78 in alignment with the electrode sockets in the mounting member 91 so that the electrodes project through the partition member 78 each with a surrounding clearance.

Between the ignition electrodes is a sight glass assembly comprising a tubular member 141 screwed into a threaded through socket 142 formed in the mounting ring member 91. A suitable heat resistant transparent glass is secured in the sighting tube assembly as by a threaded cap so that the condition of the ignition spark produced between the ends of the electrodes may be observed through the tube 141 and an aligned passage 144 in the partition ring member 78.

Within the combustion tube 25, located closer to the receiving or head end than to the discharge end of such tube, is a baffle ring 146 formed of flat heat resistant sheet material such as stainless steel. The preferred location of the baffle ring 146 and that which achieves optimum efficiency and ignition certainty by preventing disturbance and migration of the flame away from the burner head in a burner having a combustion tube 25 of approximately 5 inches internal diameter and other parts in proportion, as shown, is with the baffle ring positioned so that the axial plane 148 through the combustion tube to which the baffle ring is normal is displaced approximately 45 degrees in the direction of flame rotation from the axial plane, represented by the line 147, which bisects the angle between the electrodes.

The angle of inclination of the baffle ring 146 relative to the combustion tube axis 145 determines the axial spread of the burner flame and gas column with which the baffle ring is in contact. In the example mentioned, an inclination of from about 68 to about 78 degrees is desired, preferably of the order of about 73 degrees, represented by the angle 149, FIG. 7.

Another factor influencing the characteristics of the burner is the effective area of the baffle ring 146, such area being related to the fuel burning rate. The higher the fuel rate the higher the ratio of the area of circular opening 150 in the center of the ring to the area of the surrounding plate annulus.

At a point beyond the baffle ring 146 a thin flat wedge shaped jet 151 of additional or tertiary air is introduced into the combustion chamber through a metal pipe or conduit 152 which extends through the combustion tube 25 in radial relation, being suitably secured and sealed in the latter as by welding. The conduit 152 terminates in a narrow nozzle portion 153 formed as by flattening its end in the provision of a narrow orifice 154 which projects the desired fan or sector shaped air jet 151 across the path of the advancing column comprising the flame, the combustion products and the unburned fuel. Admission of the tertiary air through the orifice 154 is at a point within the effective zone of the baffle ring 146, being spaced from the baffle ring a distance no greater than the diameter of the combustion tube, preferably a distance approximately equivalent to the diameter of the baffle ring circular opening 150. Such distance is measured along the axis 145 of the combustion tube from point 178 at which such axis pierces the plane of the fan shaped jet 151 and point 179 at which such axis pierces the plane of the baffle ring.

Combustion air is supplied to the burner by a suitable centrifugal blower 155 the intake of which is within the heater casing. This blower is suspended from the casing top 1 as by a suitable rubber cushioned mounting device and driven by an electric motor suitably controlled. Tangential outlet tubes 156 and 157 fast to the periphery of the blower casing receive air from the blower, at a pressure preferably of from about 13 inches of water to about 16 inches of water, although air pressures in the range of from 10 inches to 20 inches of water are satisfactory. The metal outlet tube 156 is connected as by flexible rubber hose 158 to a metal T-fitting 159 that has one branch connected through rubber hose 160 to the secondary air supply tube 64 leading to the diffuser ring and another branch connected through flexible rubber hose 161 to the tertiary air inlet tube 152.

The blower outlet 157 is connected by the tube 118 which may comprise a flexible rubber hose to the fitting 119 so as to feed pressurized air into the burner head air supply chamber 117 at the same pressure the secondary and tertiary air is fed through the blower outlet 156.

The liquid fuel is supplied from a suitable storage reservoir (not shown) either by gravity or electric pump. Such fuel is received through a supply pipe 165 and led into the casing through a fitting 166 carried by the end wall 4, a suitable filter 167 being interposed between the supply pipe and the through wall fitting 166.

A conduit 168 is connected to the fitting 166 on the inside of the casing wall 4 and carries the filtered fuel to inlet 169 of a standard float bowl assembly 170. This assembly comprises a hollow casing providing a chamber 177 into which fuel delivered to the inlet 169 under the slight pressure of the pump or gravity supply is admitted through a suitable valve under the control of a float 193 so as to maintain a predetermined fuel level. An outlet 172 is provided in the bottom of the float bowl assembly and is connected as by a short tubular nipple

173 to the inlet of a shut-off valve 174 actuated by an electro magnet or solenoid 175. The solenoid valve outlet is connected by a tubular conduit 176 to the fitting 112 leading into the fuel supply chamber 114 in the mounting block 93.

The float bowl assembly 170 is located so that the surface of the fuel therein, indicated at 171 (FIG. 9), is maintained by the automatic float control mentioned at a level several inches above the burner head supply chamber 114 and the nozzle fuel orifice 116 so that, when the solenoid 175 is energized to open the valve 174, fuel tends to flow by gravity from the bowl 170 into and through the mounting block chamber and through the nozzle assembly 100.

In order to augment the gravity force causing fuel to flow to the nozzle assembly when the valve 174 is open, pressurized air from the supply chamber 117 in the mounting block 93 is bled off and conducted into the top of the chamber 177 in the float bowl 170. The float bowl chamber 177 is hermetically sealed, except for the inlets and outlets mentioned and the supply of fuel from the storage tank to the float bowl assembly is maintained by gravity flow or pump at a pressure sufficient to overcome the maximum air pressure developed by the blower 155 in the chamber 177. Thus a positive gauge air pressure is maintained in the chamber 177 of the float bowl which acts against the surface of the fuel and thereby increases the apparent pressure head forcing the fuel to the nozzle orifice. Because of the constant escape of air from the float bowl through a vent tube 208, later described, and because of friction losses in the air supply system feeding the float bowl, the air pressure that is developed in the bowl chamber 177 even in the full open position of a thermostatic valve 180 is considerably below the air pressure in the outlet tube 157 of the blower. In the example given, wherein the blower produces an air pressuer head of about 16 inches of water, the air pressure in the bowl chamber does not exceed a head of about 12 inches of water. Hence, the float bowl pressure is varied automatically over a relatively wide range from a zero head which prevails when the thermostat closes the valve 180 to a maximum pressure head equivalent to about three-fourths of the pressure head provided by the blower 155 to the primary air system.

In order to vary the force on fuel being fed to the nozzle assembly 100 from the float bowl, and to thereby vary the fuel feed rate, the present invention provides for variation of the air pressure imposed on the fuel in the float bowl chamber. Such variation of the fuel feed air pressure is obtained by introducing pressurized air into the float bowl chamber 177 at a variable rate while venting air continuously from such chamber through a suitable orifice or restriction of constant size. The flow of the pressurized air into the float bowl chamber is governed by the thermostatically operated automatic packless valve 180 so as to achieve optimum performance without overheating of the heat exchanger. This valve assembly is mounted on a flat metal plate 181 suspended by screws 182 from the closure panel 48 on the top of the heat exchanger assembly. The plate 181 is formed along its upper margin with a right angle flange disposed flatwise against the undersurface of the closure panel, the screws 182 being threaded into such flange.

The valve 180 comprises a body part 183 of brass formed with internal inlet and outlet chambers 184, 185 respectively. These valve chambers are formed as by boring and counterboring the metal block comprising the valve casing 183, the opening into the inlet chamber 184 being tapped to receive the externally threaded stem of a flanged closure plug 186. The valve casing 183 and the closure plug 186 are disposed on opposite sides of the mounting plate 181, the plate being clamped between these parts with the stem of the closure plug extending through a suitable hole provided in the plate.

Pressurized air is supplied to the inlet chamber 184 through a metal tube or conduit 187 connected at its receiving end to the air supply chamber 117 by a fitting 188 screwed into a socket of the mounting block 93 and at its outlet end to the chamber 184 by a fitting 189 screwed into a socket in the valve casing 183. The outlet chamber 185 of the air control valve is connected by a metal tube or conduit 190 to the chamber 177 in the float bowl 170; end fittings 191, 192 on such conduit are screwed into threaded sockets in the valve casing 183 and the float bowl casing respectively. At the juncture of the chambers 184, 185 in the casing of the air control valve is formed a circular seat for cooperation with the tapered end of a needle valve 194 guided for axial movement toward and away from such valve seat in a bore 195 of the closure plug 186. The outer end of the needle valve 194 is made fast as by a cap screw 205 to the center of a circular metal disc 196. A flexible metal bellows 197 is secured and hermetically sealed at its outboard end to such disc and at its inboard end to the closure plug 186. The bellows serves as a support for the needle valve 194, permitting movement of the latter to and from the valve seat, and provides a hermetic seal for the casing 183; it is made of resilient spring material such as brass or bronze and is slightly compressed in assembly so that its inherent resiliency biases the needle valve 194 away from the valve seat to full open position in which pressurized air received in the inlet chamber 184 flows freely into the outlet chamber 185 and thence into the float bowl chamber 177.

The mounting plate 181 parallels and is spaced from the casing side wall 15, being disposed between such wall and the heat exchanger tubes 35. It is formed with or has secured thereto along one edge a projecting portion 200 having spaced parallel right angle bends 201, 202 (FIG. 6) providing a flange paralleling and offset from the main portion of the plate. A bimetallic thermo-responsive strip element 203 is rigidly secured at its base end to the offset flange of the plate portion 200 as by brazing and also by a bolt 204 which extends through aligned openings provided in the thermostatic element, the plate flange, and the body portion of the plate. The thermostatic element 203 has a free end which projects across the outboard end of the bellows 197 and engages the disc 196 or the cap screw 205 by which the needle valve 194 is secured to the disc 196 so as to locate and influence or govern the axial position of the needle valve relative to the seat in the casing 183. The bellows end of the thermostatic valve 180 projects from the mounting plate 181 with the bimetal actuator 203 located between adjacent radiation tubes 35 where it is subjected to direct radiant heat from such tubes as well as from the main combustion tube 25. Such actuator is also subject to convective heat from the heat exchanger so as truly to react to the environment of the exchanger. The bimetal element is positioned or related to the bellows so that upon an increase in temperature of its environment its free end bows toward the valve seat as from the full line to the broken line position of FIG. 6, exerting an axial force on the needle valve 194 which moves the latter toward the valve seat progressively reducing the area of the passage or opening connecting the inlet and outlet chambers 184, 185. Upon a decrease in such temperature the thermostatic element bends away from the valve seat allowing the stressed bellows and internal air pressure to move the needle valve away from the seat and thereby progressively open the passage between the valve chambers for increased rate of flow of air into the float bowl. Adjustment of the thermostatic control of the valve 180 is provided by means of nuts 206 on the bolt 204 so that the environmental temperature at which the thermostatic element 203 is effective to accomplish complete closure of the valve may be varied. Tightening the nuts on the bolt lowers the temperature at which the valve is closed whereas loosenings such nuts increases the closing temperature.

It is contemplated that, in normal operation, a con-

tinuous flow of air occurs from the supply chamber **117** in the mounting block **93** through the thermostatically controlled valve **180** and through the chamber **177** in the float bowl assembly **170**. The air is vented from the float bowl through a metal tube or conduit **208** the receiving end of which is connected to a fitting **209** screwed into a tapped hole in the side wall of the bowl casing. The vent tube **208** may discharge into the burner head or combustion chamber or, as shown, is connected to a panel fitting **210** mounted in the end wall **4** of the heater casing. A suitable discharge conduit may be attached to the fitting **210** for carrying away, as to the outside atmosphere, the air and any fuel that escapes from the float bowl assembly through the vent tube **208**. The rate at which air is permitted to escape from the float bowl chamber is controlled by a suitable restriction in the vent line such as an orifice plug **212** held captive in the fitting **209**. The fitting **209** communicates with the float bowl chamber above the level of the liquid fuel therein and provides for venting of such chamber through a fixed outlet restriction comprising plug **212** (FIG. 9). The system supplies air to the float bowl chamber from a source of constant pressure through the valve **180** which provides a thermostatically variable inlet restriction. When the heat exchanger is in need of heat the need is manifested by a relatively low environmental temperature in the zone of the bimetallic strip element **203** governing the air control valve **180** and results in opening of the valve to provide increased flow rate of air into the chamber **177** of the float bowl. In the example mentioned, a metering plug **212** having an orifice diameter of from about .050 inch to about .070 inch, preferably about .060 inch obtains satisfactory control.

Power for energizing the several electrical components of the heater is supplied from a suitable source as through a cable connected to terminals in a control box indicated at **214**. In the drawings the various electrical wires have been omited for clarity, it being understood that the electrical components, connections and controls are conventional. The wires may be connected and joined as by means of a terminal block **215** secured to the casing bottom **2** beneath the burner head assembly. A high limit switch **216** mounted on the plate **181** adjacent the thermostatic valve **180** is included in the electrical control circuit to shut down the burner as by deenergizing the fuel valve solenoid **175** and the ignition electrodes when the environmental temperature of the heat exchanger exceeds a predetermined maximum.

In response to a demand for heat the electrical control effect energization of the transformer (not shown) which supplies the electrical current to the ignition electrodes **136, 137** to produce a spark in the chamber **76** ahead of the nozzle assembly **100**. The drive motor for the air blower or pump **155** is energized simultaneously with the ignition transformer to force air flow through the primary air supply tube **118** and through the tube **158** which supplies the secondary air to the annular chamber **63** that surrounds the base ring member **55** and supplies the tertiary air to the combustion chamber through the radial pipe **152**. The solenoid **175** may be energized simultaneously with the ignition transformer and the motor for the blower **155** or preferably, and as described in the patent referred to, the fuel valve solenoid may be monitored by a pressure responsive switch which delays the opening of the fuel supply valve until a predetermined pressure is achieved in the outlet tubes **156, 157** of the blower. Upon opening of the fuel valve **174** the fuel, maintained at constant level in the float bowl **170** is forced to the nozzle orifice **106**, entrained in the primary air issuing through the opening **125** in the nozzle cap **123** and ignited by the continuous spark maintained between the tip ends of the electrodes.

The present invention thus provides a heater capable of burning various types of liquid hydrocarbon fuels such as all grades of ordinary automotive vehicle gasolines, fuels such as JP–4 and JP–5 jet fuels, number 1 domestic heating oil of about 132,000 B.t.u. per gallon, number 2 domestic heating oil, and United States Army vehicle fuels known as DF No. 1, DF No. 2 and DFA (Arctic). As the viscosity of the fuel oil varies, as by change in environmental temperature of the storage reservoir, the fuel feed system, by variation of the air pressure maintained in the float bowl **170** automatically compensates for the change in flow characteristics so as to maintain the desired rate of fuel feed to the nozzle orifice **106**.

If desired, provision may be made for heating of the mounting block **93** and the fuel oil contained therein as by a glow plug **220** screwed into a tapped boss **221** of the mounting block. This glow plug is energized by electric current supplied through leads connected to its external terminals, a suitable timing circuit being provided for energization of the glow plug during an initial warm-up period prior to opening of the fuel valve and for deenergizing the glow plug after the burner head or the mounting block **93** has been brought up to a predetermined operating temperature.

In accordance with the patent statutes the principles of the present invention may be utilized in various ways, numerous modifications and alterations being contemplated, substitution of parts and changes in construction being resorted to as desired, it being understood that the embodiment shown in the drawings and described above and the particular method set forth are given merely for purposes of explanation and illustration without intending to limit the scope of the claims to the specific details disclosed.

What we claim and desire to secure by Letters Patent of the United States is:

1. In a heating system including a heater of the type having a burner head adapted to receive liquid fuel and pressurized air and to produce a combustible mixture of such fuel and air, an hermetically sealed bowl providing a closed chamber adapted to be pressurized for receiving liquid fuel supplied thereto and including means controlling the fuel supply automatically to maintain a substantially constant level of fuel in the bowl chamber, means connected to the bowl and adapted to supply air under pressure to the bowl chamber, means connecting the bowl chamber to the burned head for feeding fuel to the latter under the influence of fluid pressure in the bowl chamber, thermostatic valve means in and controlling the flow of air through said connection between the air supply means and the bowl chamber, said valve means being responsive to the temperature of the heater automatically to increase the pressure of supplied air upon a decrease in such temperature and to decrease such pressure upon an increase in such temperature, and fixed flow restrictor means venting the bowl chamber whereby the air pressure in the bowl chamber is increased automatically upon and in response to decrease in heater temperature to thereby increase the rate of fuel feed to the burner head and such bowl chamber air pressure is automatically decreased upon heater temperature increase to thereby decrease the fuel feed rate to such head.

2. In a heating system as defined in claim 1, the air supply means comprising a blower and means connecting it to both the burner head and the float bowl chamber for concurrent supply of primary air to the burner and fuel feeding pressurized air to such chamber.

3. In a heating system as defined in claim 1, the valve means comprising a body member formed with a passage and having a valve seat about such passage, a valve member and means mounting it for movement toward and away from the valve seat, thermal responsive means acting on the valve member to move it toward the seat upon said temperature increase thereby to decrease the valve opening, and the mounting means biasing the valve member away from the seat to increase the valve opening upon said temperature decrease.

4. In a heating system as defined in claim 3, the mounting means comprising an expansible bellows fast at one end to the body and at the other end to the valve member.

5. In a heating system as defined in claim 1, the thermostatic valve means comprising means providing a valve seat and a valve member mounted for movement to and from such seat, a heat sensitive bimetal element disposed to act on the valve member and move it toward the seat upon such temperature increase, and means opposing the action of the bimetal element adapted to yield under such action to permit seating of the valve member and to move the valve member away from the seat upon such temperature decrease.

6. In a heater comprising a heat exchanger and a liquid fuel burner for supplying heat to the exchanger, said burner being of the type having means defining a combustion chamber and nozzle means adapted to project fuel and air into the combustion chamber, a fuel system comprising a float bowl assembly providing a closed chamber for receiving fuel supplied thereto from a storage reservoir and means controlling the fuel supply to maintain a substantially constant fuel level in the bowl chamber, means connecting the bowl at a point of the latter below said level to the nozzle means for conducting fuel therebetween, means supplying air under pressure to the interior of the bowl to force feed fuel from the bowl through the connecting means to the nozzle, and means automatically governing the pressure of air within the bowl in response to the temperature of the exchanger to increase such pressure and the fuel feed rate upon decrease in such temperature and to decrease such pressure and the fuel feed rate upon increase in such temperature.

7. In a heater as claimed in claim 6, the connection of the bowl chamber to the nozzle including a magnetic valve monitoring the fuel feed and adapted to close such connection and prevent fuel feed to the nozzle regardless of the temperature of the exchanger.

8. In a heater having a combustion chamber, means feeding air to the chamber continuously and at a pressure above that of the atmosphere, a system for feeding liquid fuel from a supply source to the chamber, said system including casing means defining an enclosed fuel chamber, the system including means to carry the fuel into the fuel chamber from the source and to maintain a substantially constant fuel level in such fuel, said system including conduit means connected at one end to the fuel chamber below said level and adapted to receive fuel at said one end and carry it to the combustion chamber, and control means governing the rate of fuel flow through said conduit means, said control means comprising means maintaining fluid pressure in said fuel chamber above the pressure of the atmosphere, and substantially independently of the air feed to the combustion chamber, automatically varying such pressure over a range wholly above atmospheric pressure in response and in inverse relation to variations in the temperature of the heater.

9. In a heater having a fuel feed system as claimed in claim 8, the pressure maintaining means comprising an air pump and piping connecting the outlet of said pump to the chamber, variable opening valve means governing the flow of air through such piping, and automatic temperature responsive means controlling the valve and effecting said automatic variation of fuel chamber pressure.

10. In a heater having a fuel feed system as claimed in claim 8 the pressure maintaining means comprising means connected to the casing means and adapted to supply a fluid medium to the chamber at one rate, means adapted to vent such fluid medium from the chamber at another rate, and means adapted automatically to vary one of said rates in response to said temperature.

11. In a heater having a fuel feed system as claimed in claim 10, the venting means comprising fixed orifice means and the rate varying means comprising adjustable valve means connected in the conduit means.

12. In a heater having a fuel feed system as claimed in claim 8, the pressure maintaining means comprising means connected to the casing means and adapted to supply fluid to the chamber under pressure and valve means in said fluid supply connection, said valve means comprising means providing a valve seat, a valve body, means mounting the valve body for movement toward and away from the seat, and said control means including thermostatic means automatically regulating the valve body movement.

13. In a heater having a fuel feed system as claimed in claim 12 the thermostatic means comprising an expansible and contractible bellows, a heat sensitive fluid body in said bellows, and means mounting the bellows in the heater environment.

14. In a heater as claimed in cleam 6, the air supplying means including conduit means leading to the nozzle means and being adapted to supply pressurized air simultaneously both to said nozzle means as primary combustion air and to said chamber as a fuel force feeding medium.

15. In a heater as claimed in claim 6, the pressure governing means comprising vent means and means connecting the vent means to release air continuously from the chamber.

16. In a heater as claimed in claim 15, the air supplying means comprising variable valve means controlling the admission of the air to the chamber and the governing means comprising thermostatic means located adjacent and in heat exchange relation to the exchanger and operatively connected to the valve means.

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