April 15, 1947. H. B. HOLTHOUSE 2,418,882

FUEL CONDITIONING MEANS

Filed June 15, 1942 2 Sheets-Sheet 1

Fig. 1

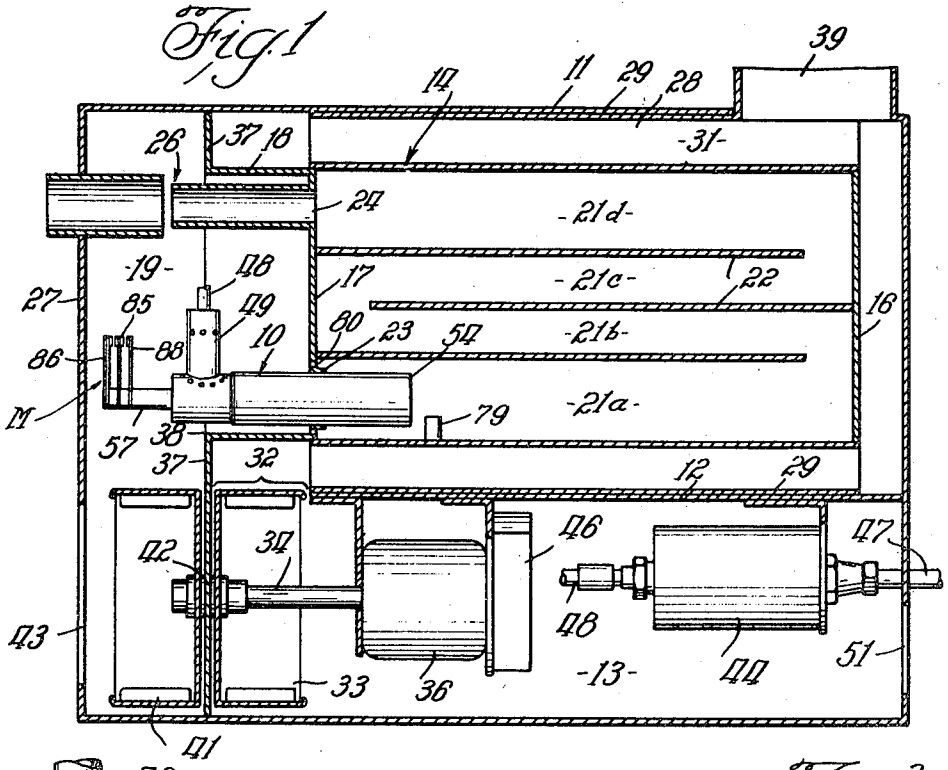


Fig. 2

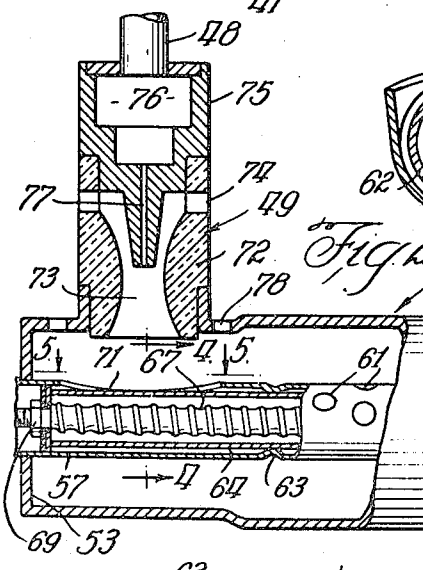


Fig. 4

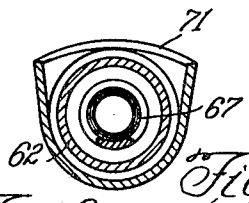
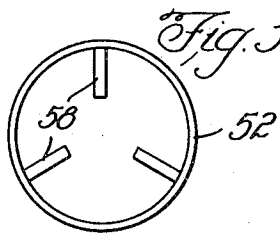


Fig. 3



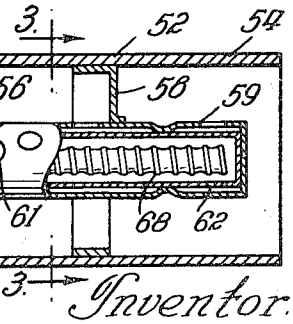
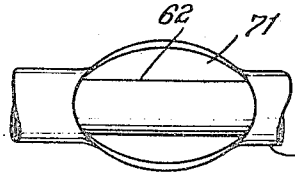


Fig. 5



Inventor:
Harry B. Holthouse
By: Seaman & Mueller
Atty.

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FUEL CONDITIONING MEANS

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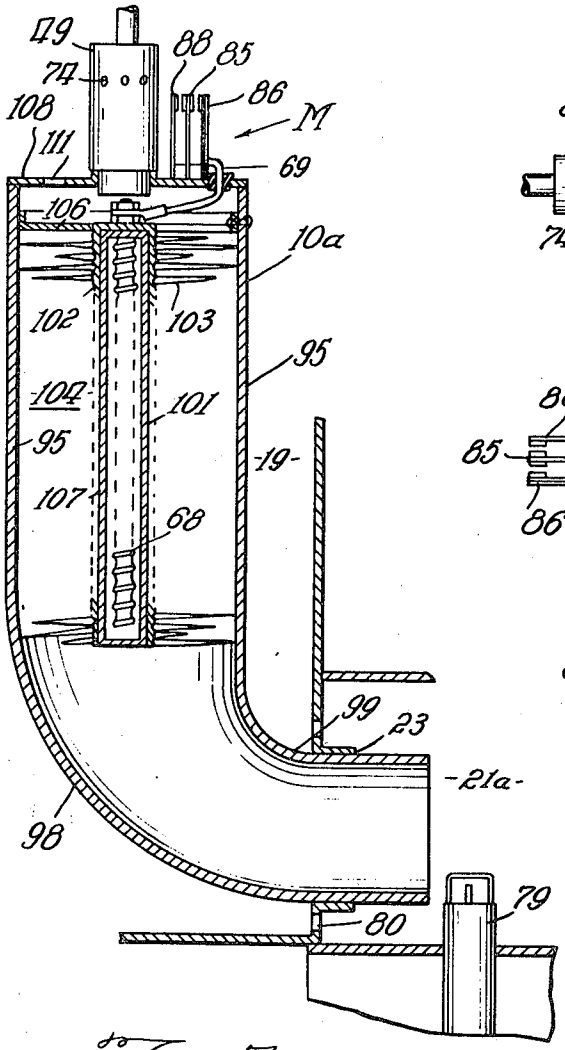


Fig. 7.

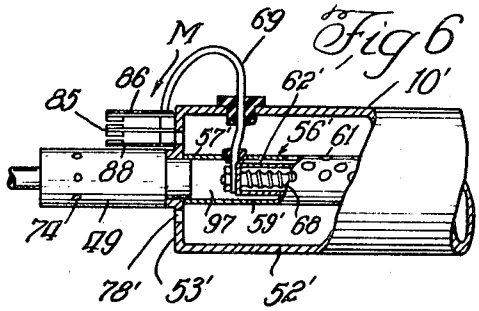


Fig 6

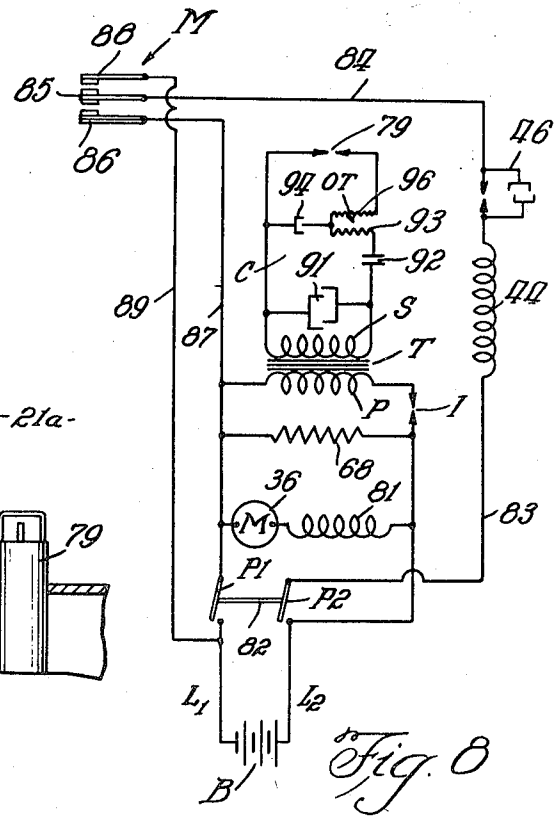


Fig. 8

Inventor:
Harry B. Holthouse
By: Foorman L. Mueller
Atty.

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UNITED STATES PATENT OFFICE

2,418,882

FUEL CONDITIONING MEANS

Harry B. Holthouse, Chicago, Ill., assignor to Galvin Manufacturing Corporation, Chicago, Ill., a corporation of Illinois

Application June 15, 1942, Serial No. 447,054

8 Claims. (Cl. 48—103)

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This invention relates generally to heating apparatus and in particular to heating apparatus of internal combustion type adapted to operate efficiently with substantially all usual liquid fuels including fuel oils and oils of like characteristics.

An object of this invention is to provide improved heating apparatus of internal combustion type.

A further object of this invention is to provide improved means for preparing a combustible fuel oil mixture and efficiently burning the same in a heater apparatus of internal combustion type.

Another object of this invention is to provide improved liquid fuel conditioning means.

Yet another object of this invention is to provide electrically operated heating apparatus of internal combustion type for operating with fuel oil, in which at least a portion of the fuel is vaporized prior to burning by means including electrical heating means of low current drain, and all of the fuel is ignited for burning by high frequency ignition means capable of producing electrical discharges of high intensity.

A further object of this invention is to provide a preassembled fuel conditioning unit which is simple and rugged in construction, comprised of but a relatively small number of parts and capable of forming a vaporous air and fuel mixture for burning at a substantially atmospheric pressure.

A feature of this invention is found in the provision of liquid fuel conditioning means in which a hermetically sealed electrical unit is utilized to condition the fuel for intimately mixing with combustion air.

Another feature of this invention is found in the provision of fuel conditioning means in which fuel and air are introduced together at one end of an elongated walled portion for travel therethrough together and in a heat exchange relation with heating means capable of vaporizing the fuel for mixing with the air, to provide a vaporous mixture of substantially uniform quality at the opposite end of the walled portion.

A further feature of this invention is found in the provision of a fuel conditioning portion in which air is supplied in a confined space about a combination fuel carrying and heating means adapted to vaporize the fuel for mixing together with the air.

Further objects, features and advantages of this invention will become apparent from the following description when taken in connection with the accompanying drawings in which:

Fig. 1 is a longitudinal sectional view of the heater apparatus of this invention, the combustion chamber for the heater apparatus being shown in development for the purpose of clarity;

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Fig. 2 is a longitudinal sectional view showing in detail the construction of the liquid fuel conditioning means illustrated in Fig. 1;

Fig. 3 is an elevational detail view taken along line 3—3 in Fig. 2 of a supporting member embodied in the construction of the fuel conditioning means in Fig. 2;

Fig. 4 is a transverse sectional view taken along the line 4—4 in Fig. 2;

Fig. 5 is a fragmentary plan view of a combination heating and fuel carrying means embodied in the fuel conditioning means of Fig. 2 taken along the line 5—5 of Fig. 2;

Fig. 6 is a fragmentary elevational view of a modified form of fuel conditioning means with parts thereof broken away to show its construction;

Fig. 7 is a transverse sectional view of yet another form of the fuel conditioning means; and

Fig. 8 illustrates diagrammatically a control circuit for the heater apparatus shown in Fig. 1 which is applicable to each of the liquid fuel conditioning means shown in Figs. 2, 6 and 7.

The air heating apparatus of this invention is illustrated in the drawings adapted for battery operation so as to be applied to space heating in a mobile craft. It is to be understood, however, that the heater may also be used for space heating in homes, garages, offices and the like. The heater apparatus includes a combustion portion having a fuel conditioning means arranged in the inlet thereof. Air and fuel to be burned are introduced adjacent each other into the fuel conditioning means which includes a casing member having combination fuel carrying and heating means supported in a spaced relation therein, with the fuel supplied to the conditioning means being received within the combination means and directed to travel longitudinally thereof in heat exchange relation with a heating element therein. The heating element is adapted to heat at least a portion of the fuel to a vaporizing temperature, with the vaporized fuel being mixed with air supplied within the casing and directed to flow about the combination means. This mixture is admitted into the combustion portion to be ignited and completely burned therein.

To accomplish a complete burning of the air and fuel mixture in the combustion portion there is provided high frequency ignition means capable of producing an electrical discharge of such

intensity that all portions of the vaporized and unvaporized fuel in the mixture are immediately ignited. By virtue of this ignition means it is not necessary that the heating element in the conditioning means be heated to high temperatures capable of vaporizing all types of fuels which might be used, so that the electrical energy required for its operation can be appreciably reduced, to in turn reduce the drain on the battery. Apart from the reduction in drain of the heating element on the battery it is well recognized of course that the life of the heating coil is prolonged by its operation at a low temperature. Thus it is contemplated in the present invention that the heating element operate at temperatures from about 900° F. to 1200° F. to provide a temperature in the conditioning means of from 150° to 200° F. It is obvious of course that these temperatures will substantially completely vaporize gasoline and like fuels, while only partially vaporizing fuel oils and the like. However, by virtue of the high frequency ignition means all of the vaporized and unvaporized fuel portions admitted into the combustion portion are immediately ignited so that the heater operates efficiently with all usual liquid fuels.

Referring to Fig. 1 of the drawings the heater of this invention is illustrated as having a housing 11 which is divided longitudinally thereof over substantially its entire length by a partition member 12 to provide a mechanical compartment 13 and a heating compartment. Within the heating compartment is a substantially cylindrically shaped combustion chamber 14, shown in development in Fig. 1, which is closed at one end by a cover plate 16 and at its opposite end by the bottom 17 of a substantially cup-shaped member 18. The member 18 defines in part an air supply chamber 19 which is in axial alignment with the combustion chamber 14.

The combustion chamber 14 is divided longitudinally thereof into four axially extending and connected passages 21*a*—21*d* by partition means 22. The combustion chamber inlet 23 and outlet 24 are formed in the bottom portion 17 of the member 18 in communication with the passages 21*a* and 21*d*, respectively. A fuel conditioning means 10 is located within the fuel inlet 23 with a portion thereof projecting within the passage 21*a* and an opposite portion thereof extended within the air supply chamber 19. The outlet 24 is provided with a tail or exhaust pipe assembly 26 which projects into the air supply chamber 19 and outwardly therefrom through the end 27 of the housing 11. Angularly spaced about the outer wall or body portion of the combustion chamber and extended axially thereof are heat radiating fins 28. A sleeve 29 positioned about the outer ends of the fins 28 forms an annular passage 31 about the combustion chamber 14 for air to be heated.

The air to be heated is admitted into the passage 31 through an inlet 32 connecting the passage with the mechanical compartment 13 and is circulated through the passage 31 by a fan 33 located within the compartment 13 and mounted on a shaft 34 of an electric motor 36. The compartment 13, and the air passage 31 are separated from the air supply chamber 19 by a partition member 37 extended transversely of the housing 10 and having an opening therein adapted to receive the open end 38 of the cup-shaped member 18. It is seen, therefore, that the air supply chamber 19 is defined by the cup-shaped member 18, the partition member 37 and the end 27 of the housing 11. Air circulated from the fan 33 is thus confined to travel within the compartment 13 and passage 31 and is discharged from the passage 31 through an outlet 39 which is connected to a space to be heated.

The air supply chamber 19 receives air from a fan 41 located therein and mounted on the motor shaft 34 which is journalled in the partition plate 37 as indicated at 42. An inlet 43 for the fan 41 is provided in the housing end 27. It is thus seen that the fans 33 and 41 are operated by a common electric motor 36 and are mounted directly on the shaft 34 thereof.

The motor 36 is also utilized in the operation of a fuel pump 44 which is illustrated as being of solenoid type. It is to be understood, however, that other types of pumps can be used within the limits of this invention. The breaker assembly 46 for controlling the energization of the pump 44 is operatively associated within the motor shaft 34. Fuel for the pump 44 is supplied thereto from a suitable source (not shown) through a pipe 47 and is delivered through a pipe 48 to an air and fuel delivery nozzle 49 formed as a part of the fuel conditioning means 10. The pump 44, breaker assembly 46, motor 36 and fan 33 are thus all located within the mechanical compartment 13 which is provided with an inlet 51 for supplying either fresh or recirculated air to the fan 33 for delivery to the air passages 31.

The fuel conditioning means 10, which is shown in detail in Figs. 2–5, includes a substantially elongated tubular casing or housing member 52 having a substantially closed end portion 53 projecting within the air supply chamber 19 and an open end portion 54 extended within the combustion chamber passage 21*a* and in fluid connection therewith. In one embodiment of the invention the tube 52 has a diameter of about one inch and is about eight inches long, with its length being projected substantially equal distances within the air supply chamber 19 and the combustion passage 21*a*. Longitudinally positioned in a spaced relation within the casing 52 and substantially coextensive in length therewith is a combination fuel carrying and heating means indicated generally as 56 which has one end 57 extended through and supported in the closed end 53 of the casing 52, and its other end supported within the casing 52 by a spider member 58. The fuel carrying portion of the combination means 56 includes an outer sleeve 59 of tubular form closed at the opposite ends thereof and having perforations 61 over the upper portion thereof, as viewed in Fig 2, for a purpose to be later explained. The heating portion of the combination means 56 includes an inner sleeve 62 of tubular form concentrically arranged within the outer sleeve 59 and retained in a spaced relation therein by angularly spaced lug portions 63 bumped or punched out in the outer sleeve 59. It is seen, therefore, that an annular passage 64 is formed about the inner sleeve 62 and within the outer sleeve 59 which is in communication with the space 66 within the casing 52 through the perforations 61. In the embodiment above mentioned the inner sleeve 62 is about one quarter of an inch in diameter with the lug portions 63 being adapted to space the inner sleeve about one sixteenth of an inch from the outer sleeve 59.

Suitably supported in a spaced relation within the inner sleeve 62 is an electrical heating unit including an insulating body portion 67 having a resistance element or coil 68 wound thereon. The opposite ends of the inner sleeve 62 are

entirely closed so as to hermetically seal the resistance coil 68 therein. Thus in the operation of the liquid fuel conditioning means 10 air and fuel flowing therethrough is entirely out of contact at all times with the resistance element 68 whereby to provide for its efficient operation over a prolonged service life. Electrical connection of the coil 68 into the heater control circuit, which will be later explained in connection with Fig. 8, is made at connection 69 extended axially from the combination means 56 through corresponding closed ends of the sleeves 59 and 62.

As best shown in Figs. 4 and 5 the outer tube 59 at a portion thereof within the casing 52 and adjacent the closed end 53 thereof has an enlarged opening 71 which is flared outwardly so that parts of the marginal edges of the opening project beyond the periphery of the tube 59. The opening 71 is adapted to receive fuel therethrough for travel in the passage 64 from the fuel nozzle or delivery means 49, previously noted.

The nozzle 49 is located at the closed end 53 of the casing 52 and is positioned entirely within the air supply chamber 19. The nozzle is comprised of a heat insulating body portion 72 mounted directly on the casing 52 and having a Venturi passage 73 therein which is in fluid communication with the air chamber 19 through air ports 74. A top portion 75 of the nozzle 49 is constructed of metal and includes a fuel reservoir 76 connected with the fuel supply line 48 and having an elongated outlet passage 77 for discharging fuel from the reservoir 76 into the Venturi passage 73.

In the construction of the fuel conditioning means 10 the casing 52, the sleeve members 59 and 62 of the combination means 56 and spider member 58 are all constructed of copper or a like heat conducting material with the casing 52 being thermally connected with the combination means 56 through the spider member 58 and the closed end portion 53. By virtue of this construction and relative assembly of the fuel conditioning means 10 heat radiated from the resistance coil 68 is readily transferred to all portions of the combination means 56 and to the casing 52 so as to heat these parts quickly and to a substantially uniform temperature. The coil 68 is adapted to heat the air and fuel mixing means 10 to a temperature capable of vaporizing at least a portion of the fuel therein to facilitate its mixing together with the air therein, with such temperature in the above noted embodiment being in the neighborhood of from 150° F. to 200° F. As previously noted the body portion 72 of the fuel injection nozzle 49 is composed of a heat insulating material. Thus on initial operation of the fuel conditioning means 10 the dissipation of heat therefrom through the nozzle 49 is appreciably reduced whereby to accelerate the initial heating of the casing 52 and the parts therein to an optimum temperature.

The fuel delivered to the fuel injection nozzle 49 by the pump 44 is directed into the opening 71 of the combination means 56. A portion of the air for mixing with the fuel enters the nozzle 49 through the ports 74 therein and travels with this fuel into the space 66 within the casing 52. Further air is admitted directly into the space 66 through apertures 78 in the casing 52 and about the fuel nozzle 49. In the embodiment mentioned above the air within the supply chamber 19 is at a pressure of about 2 inches of water while the fuel passing through the Venturi passage 73 into the casing 52 is in substantially droplet form. It is thus seen that both air and fuel are supplied to the conditioning means 10 at low pressures. The fuel thus directed into the opening 71 and in turn into the passage 64 between the two sleeve portions of the combination means 56 is heated to at least a fuel vaporizing temperature, with the vaporized fuel passing through the openings 61 in the top portion of the outer sleeve 59 for intimate mixing with the air in the space 66. This mixing is facilitated by the initial turbulence of the air at the casing end portion 53. It is to be understood of course that the air and fuel are both heated within the casing 52 and that the air is permitted to also pass within the openings 61 for mixing with the fuel vaporized within the combination means 56.

By virtue of the elongated construction of the casing 52 substantially all of the fuel admitted within the fuel carrying tube 59 is vaporized for mixing with the air. The initial turbulence of the air at the closed end 53 of the casing 52 is gradually smoothed out as the air progresses through the casing 52 toward the open end 54 thereof, so that the resultant air and fuel mixture passing outwardly from the open casing end 54 is of uniform quality with the fuel being dispersed substantially uniform therein. Because of the resistance coil 68 being hermetically sealed within the inner sleeve 62 no portions of the air and fuel or air and fuel mixture contact the coil so as to impair the heating function thereof or shorten its operating life. The resultant mixture is ignited by high frequency ignition means 79 located at the casing end 54 and within the combustion passage 21*a* and capable of readily igniting all portions of the mixture entering the combustion chamber. By virtue of the high intensity and character of the electrical discharge across the electrodes or ignition means 79 it is unnecessary for the heat applied to the fuel in the conditioning means to completely vaporize such fuel. This condition is particularly important since it is readily appreciated that because of the many fuels commercially available, a wide application of the heater would be appreciably restricted by special heating requirements for the fuel conditioning means in accordance with a particular fuel to be used in the heater. Thus although some of the fuels which may be used, such as fuel oil, may be only partially vaporized in the fuel conditioning means the resultant mixture of vaporized and unvaporized fuel portions is instantly ignited so as to be efficiently burned in the combustion chamber 14.

Since the initial air and fuel mixture entering the combustion chamber is relatively rich to facilitate its ignition, supplementary air for completely burning the mixture is introduced into the combustion passage 21*a* through ports 80 provided in the bottom portion 17 of the cup-shaped member 18 about the combustion chamber inlet 23 and communicating the passage 21*a* directly with the air supply chamber 19. As is clearly shown in Fig. 1 this supplementary air passes about the casing 52 and is not mixed with the air and fuel mixture leaving the conditioning means 10 until after its ignition by the igniting means 79. Since the air within the air supply chamber 19 is at about 2 inches of water it is apparent that combustion proceeds within the combustion chamber 14 at substantially atmospheric pressure.

In Fig. 8 there is illustrated a control circuit for operating the heater apparatus of Fig. 1 from

a battery B having power lines L1 and L2. The motor 36 and associated field coil 81, the heating coil 68, and the primary P of a transformer T utilized in a high frequency oscillating system C for the ignition means 79 are connected in parallel across conductor 87 and power line L2. The operation of these parts is initiated concurrently by a double throw-switch 82 having one pole P1 arranged to connect conductor 87 with the line L1. On closing of the switch 82, therefore, the motor 36, coil 68 and ignition means are started together, the pump circuit being retained open through a thermostatic switch M, which as shown in Fig. 1 is mounted on the extended portion 57 of the combination means 56 and in thermal connection therewith so as to be responsive in operation to the heat of the conditioning means 10. Since the air through the conditioning means 10 from the supply chamber 19 acts to move the combustion gases through the combustion chamber to scavenge the same, an initial scavenging action is thus provided to sweep out any residual fuel vapors in the combustion chamber prior to the admission of fuel thereto on starting of the heater.

The pump circuit includes a conductor 83, connected with the pole P2 of the switch 82, the pole P2 on closing of the switch 82 connecting the conductor 83 at one end with the power line L2. The pump circuit from the conductor 83 includes further the pump 44, breaker assembly 46, conductor 84, a contact arm 85 and bi-metal contact arm 86, which are normally open and included in the thermostatic switch M, and the conductor 87. On a continued energization of the coil 68 the bi-metal contact arm 86, which is responsive in operation to the heat from the fuel conditioning means 10, and in turn to the heat of the coil 68, moves upwardly, as viewed in Fig. 8, to initially engage the contact 85 and close the pump circuit. This engagement of the contacts 85 and 86 occurs when the fuel conditioning means 10 is heated to at least a fuel vaporizing temperature. On a continued heating of the fuel conditioning means 10 the bi-metal contact arm 86 moves contact arm 85 into engagement with contact arm 88 in the thermostatic switch M, the contact 88 being connected through conductor 89 to the power line L1. This engagement of the contacts 85 and 88 produces no function in changing the normal operation of the heater apparatus and serves a purpose which will be later explained. Thus after closing of the pump circuit by the thermostatic switch M all parts of the heater apparatus are in operation, which operation is continued during the normal operation of the heater.

When it is desired to shut the heater off the switch 82 is opened. This opening of the switch serves only to stop the operation of the fuel pump 44 by breaking the connection of the conductor 83 with the line L2 at the switch pole P2. However, by virtue of the thermostatic switch M being in a position such that all of the contacts 85, 86 and 88 thereof are in a closed position the motor 36, heating coil 68 and ignition means 79 continue to operate since the conductor 87 is connected through the contacts 85, 86, 88 and conductor 89 with the power line L1. As the fuel conditioning means becomes cooled the bi-metal contact arm 86 moves downwardly as viewed in Fig. 8 to initially disengage contacts 85 and 88 whereby to stop the operation of the motor 36, heating coil 68 and ignition means 79. The delayed operation of these parts, relative to the pump 44 provides a scavenging action in the

combustion chamber and a continued operation of the ignition means therein to burn any residual mixture which might be present in the combustion chamber. It is apparent of course that the continued engagement of the contacts 85 and 86 are rendered ineffective to close the pump circuit because of the open position of the pole P2 of the switch 82. From the above description of the control circuit, therefore, it is seen that the motor 36, heating coil 68 and ignition means 79 are operated together, with the pump 44 being energized later on closing of the contacts 85 and 86, and that on shutting down of the heater the pump 44 is initially shut down, with the delayed operation of the motor 36, heating coil 66, and ignition means 79 being provided through the thermostatic switch M.

As has been explained above the heater is capable of operating effectively with all usual liquid fuels regardless of their relative combustibility characteristics or the degree to which vaporization thereof is completed in the conditioning means 10, by virtue of the high frequency ignition means 79. Referring to Fig. 8 the oscillating system C including the ignition means 79 has a primary oscillating circuit including a condenser 91, the terminals of which are connected to corresponding ends of the secondary S of the transformer T. The primary P of the transformer T is connected in series with an interrupter I to supply a pulsating current thereto. The interrupter I may be actuated from the motor shaft 34 by a breaker assembly similar to the breaker assembly 46. The transformer T is of step-up type and capable of producing a voltage of about 5000 volts in the secondary thereof. The primary ocsillating circuit includes also a spark gap 92, a primary winding 93 of an oscillation transformer OT which are connected in series with the condenser 91 and connected across the terminals of a condenser 94, which is also in series with the elements of the secondary oscillating circuit including the secondary winding 96 of the transformer OT and the discharge electrodes or ignition means 79 which may be the sparking points of a spark plug. The various elements comprising the circuit are constructed, of course, according to the results desired and the spark gap 92 may be of any suitable type and may be of the rotary, stationary or quenched spark type and preferably adjustable. This spark gap is preferably placed in series with the other elements of the primary oscillating circuit and not necessarily confined to the particular point in the circuit illustrated. It is seen, therefore, that each of the primary and secondary oscillating circuits is composed of a condenser, an inductance, and a spark gap connected in series. The frequency of the secondary circuit and hence of the oscillating electrical discharge across the electrodes 79 depends essentially upon the relative characteristics of the condenser 91 and the inductance or primary 93. It is apparent of course that the operation of the oscillating circuit C is not limited in its application to the energy source B but may also be used in conjunction with a magneto, or a power line in a manner all as is explained in detail in applicant's Patent 1,710,541. The discharge across the electrodes 79, is of an intensity such that any unvaporized fuel particles of gasoline or fuel oil admitted into the combustion chamber 14 are immediately ignited for burning. As a result the high frequency ignition means provides for a complete burning of all usual liquid fuels, and is capable of readily igniting all of such fuels even

when portions thereof have not been completely vaporized in the fuel conditioning means 10. Ignition means of this type also produces a generation of ozone about the discharge electrodes 79 which prolongs the life of such electrodes and further improves the combustion of the fuels ignited thereby.

A modified form of fuel conditioning means is shown in Fig. 6 which is similar in many respects to the embodiment in Fig. 2. Similar numerals of reference, therefore, will be used to designate corresponding parts.

Referring to Fig. 6 the conditioning means or unit 10' includes a tubular casing 52' and combination means 56' positioned within the casing in a spaced relation therewith, and supported at its end 57' in the substantially closed end 53' of the casing 52'. The outer sleeve 59' of the combination means 56' is similar in all respects to the sleeve 59 in Fig. 2 except that the fuel opening 71 is eliminated and the end thereof at the casing wall 53' is open for fluid communication with the fuel nozzel 49. The fuel nozzle 49 is carried in the closed end of the casing 52' in axial alignment with the combination means 56'. The inner sleeve 62' is substantially coextensive in length with the outer sleeve 59' but terminates inwardly of the open end of the outer sleeve 59' to form a space 97 within the outer sleeve between the injection nozzle 49 and the end of the inner sleeve 62'. A resistance coil 68 is supported in a spaced relation within the inner sleeve 62' and is hermetically sealed therein in all respects similar to the corresponding parts in Fig. 2. The electrical connection 69 to the coil 68 for connection with the contact 86 of the thermostatic switch M is extended through the outer sleeve 59' and the casing 52'. The thermostatic switch M is mounted in thermal relation with and on the casing end 53' of the casing 52' and adjacent the fuel nozzle 49. It is seen, therefore, that air and fuel from the nozzle 49 is admitted directly into the outer sleeve 59' for passage therein about the inner sleeve 62' to be vaporized by the heat in these parts. The remainder of the operation of the fuel conditioning means 10' is similar in all respects to the operation of the fuel conditioning means 10 in Fig. 2 so that a further description thereof is believed to be unnecessary. It is to be understood of course that the fuel nozzle 49 in Fig. 6 is also located within the air supply chamber 19 with air from the air supply chamber being admitted into the casing 52' through the ports in the fuel nozzle and through the openings 78' formed in the casing end 53' about the fuel nozzle.

In Fig. 7 there is illustrated yet another form of fuel conditioning means which can be used in the heater apparatus of this invention in which the fuel conditioning means 10a is adapted to be operated when arranged in a vertical position. Thus as shown in Fig. 7 the conditioning means 10a includes an elongated casing or housing member 98 of substantially L-shape located in the air supply chamber 19 and having a bent portion 99 extended within the combustion passage 21a of the combustion chamber 14. The combination fuel carrying and heating means 101 is longitudinally positioned within the straight portion 95 of the casing 98 and in a spaced relation therewith. The combination means 101 includes an outer sleeve or fuel carrying portion 102 integrally formed on the outer periphery thereof with radially extending heat radiating elements 103 of variable lengths, but extended substantially entirely across the space 104 between the sleeve 102 and the inner periphery of the casing portion 95. The tube 102 and in turn the combination means 101 is supported in a spaced relation within the casing by a spider member having leg portions 106 connected at one end to the casing portion 95 and at their opposite ends to the upper end of the tube 102, as viewed in Fig. 7. The inner sleeve 107 is fitted within the outer sleeve 102 which is closed at the opposite ends thereof. The coil 68 is hermetically sealed in a spaced relation within the inner sleeve, with the connection 69 therefor being extended through the sleeves 102 and 107 and the substantially closed casing end 108 for connection with the contact arm 86 of the thermostatic switch means M. The thermostatic switch means is supported on the casing end 108 and in thermal connection therewith so as to be responsive to the heat of the fuel conditioning means 10a. The fuel nozzle 49 is also located on the casing end 108 adjacent the thermostatic switch means M and in axial alignment with the combination means 101. It is to be understood of course, that the fuel injection nozzle 49 and the thermostatic switch means M are located within the air supply chamber 19.

In the operation of the fuel conditioning means 10a in Fig. 7 fuel from the injection nozzle 49 is introduced into the casing 98 at the upper end of the combination means 101. The air is initially mixed with this fuel through the openings 74 in the fuel nozzle with further supplementary air being introduced for mixing with the fuel in the casing 98 through ports 111 formed in the casing end 108 about the nozzle 49. The fuel thus admitted into the casing 98 contacts the combination means 101 and travels progressively about the heat radiating portions 103 downwardly of the combination means and through the casing 98. As the fuel becomes vaporized it is mixed with the air in the casing 98, which is also heated by the heat radiating portions 103 so as to be intimately mixed therewith. Thus a continuous mixing action takes place over the entire length of the combination means 101 with the heat therefrom vaporizing at least a portion of the fuel for mixing with the air and retaining already vaporized fuel in a vaporous form. The air initially entering the casing 98 at the end 108 thereof is in a somewhat turbulent state, but by virtue of the length of the straight portion 95 of the casing 98, and the impeding action of the fins 103 thereon, its turbulence is appreciably reduced or smoothed out so that a mixture having the fuel substantially uniformly dispersed therein passes outwardly from the casing 98 through the portion 99 thereof and into the combustion chamber passage 21a to be ignited by the high frequency ignition means 79. By virtue of the ignition means 79 being adapted to produce a high frequency oscillating electrical discharge it is readily apparent that any free particles of fuel which might pass outwardly from the conditioning means 10a are immediately ignited for burning within the combustion chamber 14. Supplementary air for burning is admitted into the combustion chamber passage 21a through the ports 80 arranged about the combustion chamber inlet 23 as was above described in connection with Fig. 1. It is to be understood of course that the control circuit of Fig. 8, including the oscillating system C for the ignition means 79, is also applicable to the operation of the liquid fuel conditioning means illustrated in Figs. 6 and 7.

From a consideration of the above description and drawings, it is seen that the invention pro-

vides a heater apparatus of internal combustion type capable of operating efficiently over a prolonged service life, and adapted to utilize liquid fuels having different combustibility characteristics without requiring any changes therein. In other words the efficiency of the heater is substantially the same when operating on fuels like gasoline, and fuel oils. To facilitate the burning of all these fuels which are initially prepared for burning in an improved liquid fuel conditioning means there is provided a high frequency oscillating ignition means which is capable of igniting either a completely vaporous air and fuel mixture or an air and fuel mixture having unvaporized fuel particles therein. It is to be understood, however, that other ignition means may be used in conjunction with the liquid fuel conditioning means described above. Further although electrical heating means have been particularly described as being utilized in the operation of the fuel conditioning means, it is obvious that other means may be used for heating the fuel conditioning means such as for example the waste heat from the engine of a mobile craft with which the heater is associated.

Although the invention has been described with respect to preferred embodiments thereof it is to be understood that it is not to be so limited since modifications and changes in the various parts thereof can be made which are within the full intended scope of this invention as defined by the appended claims.

I claim:

1. In fuel conditioning means which includes an elongated housing member having an open end and a substantially closed opposite end; combination heating and fuel carrying means horizontally supported within said housing member and substantially coextensive in length therewith including an outer casing member having openings in a top portion thereof, an inner casing member within said outer casing member and in a spaced relation therewith, an electrical heating element hermetically sealed within said inner casing member, means mounted at said opposite end of said housing member for delivering fuel between said inner and outer casing members, and means for supplying air within said housing member at said opposite end for passage therethrough and about said combination means, with the heat from said electrical element acting on said fuel and air and vaporizing said fuel for mixing together with said air, with the length of said housing member being such that substantially all of said fuel is in a vaporous form and substantially uniformly distributed throughout the vaporous mixture prior to the passage of said mixture through the open end of said housing member.

2. Fuel conditioning means including horizontally positioned elongated housing means having an open end and a substantially closed opposite end, combination heating and fuel carrying means supported in a spaced relation within said housing means and including a tubular member substantially coextensive in length with said housing means, said tubular member being open at the end thereof which is adjacent the opposite end of said housing means and having openings in the top portion thereof, means supported in the opposite end of said housing means in coaxial alignment with said tubular member for delivering fuel within said tubular member through the open end thereof, a heating unit arranged in a spaced relation within said tubular member, and means for introducing air into said housing means for passage about said combination means, with said heating unit acting to heat said air and fuel and to vaporize the fuel for mixing with the said air, with the length of said housing means and combination means providing for substantially all of the fuel supplied to said tubular member being in a vaporous form before it passes through the open end of said housing means.

3. A fuel conditioning unit for a liquid fuel burning heater, including a tubular housing member having an open end, an electrical heating element extending longitudinally of said member and substantially coextensive in length therewith, a first tubular casing enclosing said heating element within said housing member, a second tubular casing surrounding said first tubular casing and provided with vapor ports over at least a portion of the surface thereof, means maintaining said casings in spaced apart relationship to provide a vaporizing chamber therebetween, means for introducing fuel and air into said vaporizing chamber at a point adjacent the end of said housing member which is opposite said open end, and means for introducing additional air into the space between said second casing member and said housing member at a point adjacent said opposite end of said housing member, whereby the air is mixed with the vaporized fuel emanating from said ports during its passage through said space and out the open end of said housing member.

4. A fuel conditioning unit for a liquid fuel burning heater, including a tubular housing member having an open end, an electrical heating element extending longitudinally of said member and substantially coextensive in length therewith, a first tubular casing enclosing said heating element within said housing member, a second tubular casing surrounding said first tubular casing and provided with vapor ports over at least a portion of the surface thereof, means maintaining said casings in spaced apart relationship to provide a vaporizing chamber therebetween, an element formed of heat insulating material and mounted on said housing member at the end thereof opposite said open end, means including said last-named element for introducing fuel and air into said vaporizing chamber at a point adjacent said opposite end of said housing member, and means for introducing additional air into the space between said second casing member and said housing member at a point adjacent said opposite end of said housing member, whereby the air is mixed with the vaporized fuel emanating from said ports during its passage through said space and out the open end of said housing member.

5. A fuel conditioning unit for a liquid fuel burning heater, including a tubular housing member having an open end, an electrical heating element extending longitudinally of said member and substantially coextensive in length therewith, a first tubular casing enclosing said heating element within said housing member, a second tubular casing disposed within said housing member and surrounding said first casing, said second casing having vapor ports over at least a portion of the surface thereof and being provided with spaced apart inwardly extending projections which engage said first casing to maintain the two casings in spaced apart relationship and thus provide a vaporizing chamber therebetween, said second casing also being provided

with a fuel admission opening through the wall thereof at a point adjacent the end of said housing member which is opposite said open end, means including a fuel nozzle carried by said housing member at a point adjacent said fuel admission opening for introducing fuel and air into said vaporizing chamber through said fuel admission opening, and means for introducing additional air into the space between said second casing member and said housing member at a point adjacent said opposite end of said housing member, whereby the air is mixed with the vaporized fuel emanating from said ports during its passage through said space and out the open end of said housing member.

6. A fuel conditioning unit for a liquid fuel burning heater, including a tubular housing member having an open end, an electrical heating element extending longitudinally of said member and substantially coextensive in length therewith, a first tubular casing enclosing said heating element within said housing member, a second tubular casing disposed within said housing member and surrounding said first casing member, said second casing having vapor ports over at least a portion of the surface thereof and being provided with spaced apart inwardly extending projections which engage said first casing to maintain the two casings in spaced apart relationship and thus provide a vaporizing chamber therebetween, said second casing also having an open end which is opposite the open end of said housing member, means including a fuel nozzle carried by said housing member for introducing fuel and air into said vaporizing chamber through the open end of said second casing, and means for introducing additional air into the space between said second casing and said housing member at a point adjacent said opposite end of said housing member, whereby the air is mixed with the vaporized fuel emanating from said ports during its passage through said space and out the open end of said housing member.

7. Fuel conditioning means including horizontally positioned elongated housing means having openings in the opposite ends thereof, combination heating and fuel carrying means supported in a spaced relation within said housing means and including a tubular member substantially coextensive in length with said housing means, said tubular member being positioned in the opening in one end of said housing and having openings in the top portion thereof, means supported in said one end of said housing in alignment with said tubular member for delivering fuel within

said tubular member, a heating unit arranged in spaced relation within said tubular member, and means for introducing air into said housing means for passing about said combination means, with said heating unit acting to heat said air and fuel and to vaporize the fuel for mixing with said air, with the length of said housing means and combination means providing for substantially all of the fuel supplied to said tubular member being in a vaporous form before it passes through said housing means to the opening in the end thereof opposite to said one end.

8. A fuel conditioning unit for a liquid fuel burning heater, including a tubular housing member having an open end, an enclosed electrical heating element extending longitudinally in said housing member and substantially coextensive in length therewith, a tubular casing formed within said housing member and surrounding said element, said tubular casing having vapor ports over at least a portion of the surface thereof and being provided with projections which engage said enclosed heating element to maintain a fixed relationship therewith and provide a vaporizing chamber therebetween, means for introducing fuel into said vaporizing chamber, and means for introducing air into the space between said tubular casing and said housing at the end thereof opposite said open end, whereby the air is mixed with vaporized fuel from said ports during the passage through said space and out the open end of said housing member.

HARRY B. HOLTHOUSE.

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