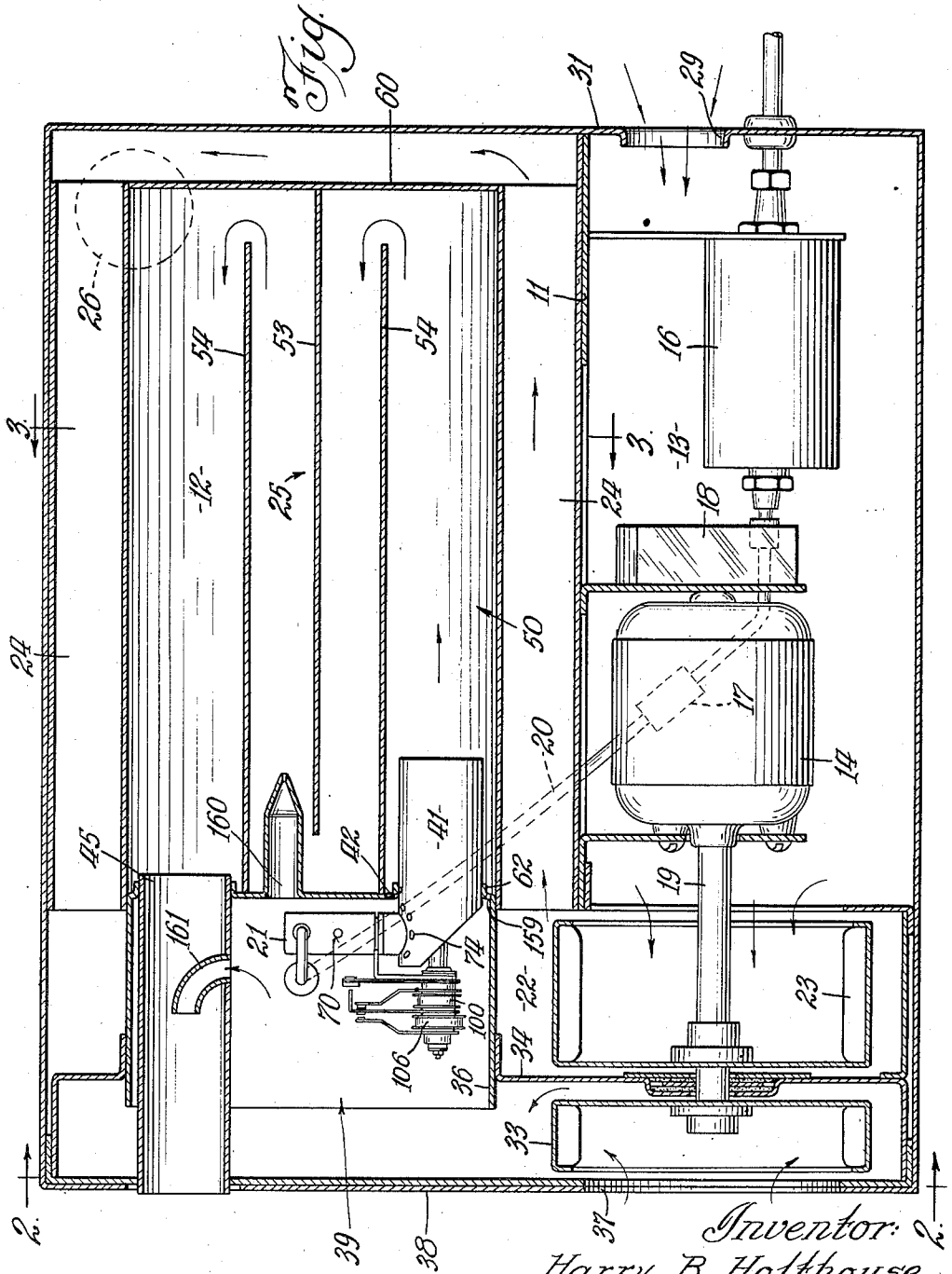
Sept. 18, 1945. H. B. HOLTHOUSE 2,384,836

HEATER

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Fig. 1.



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HEATER

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Fig. 2.

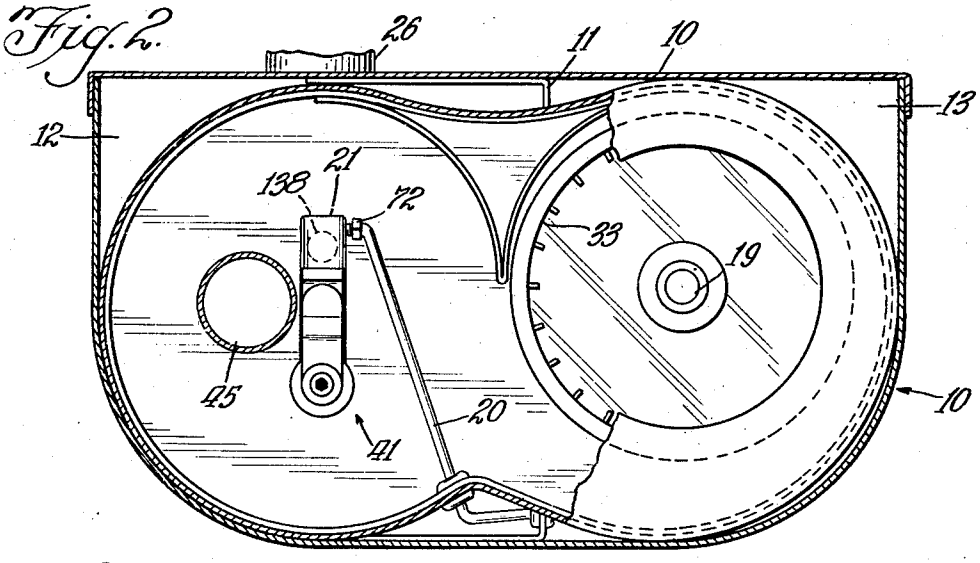


Fig. 3.

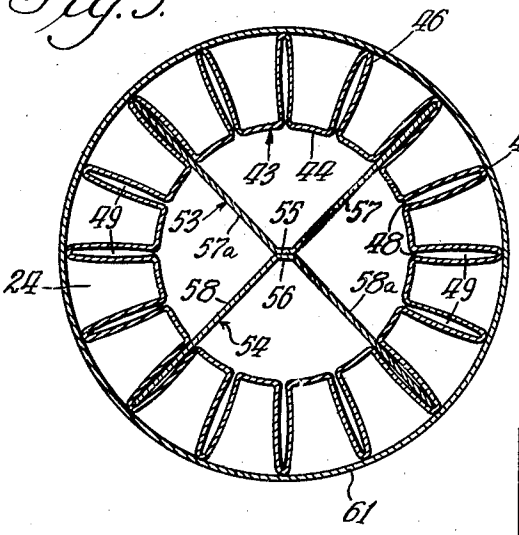


Fig. 4.

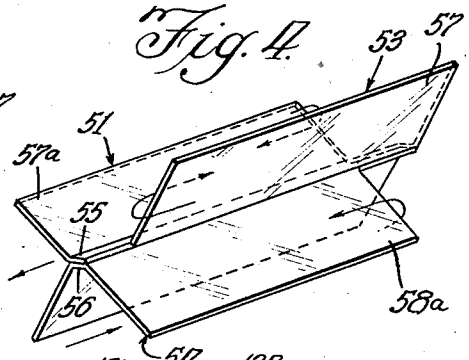
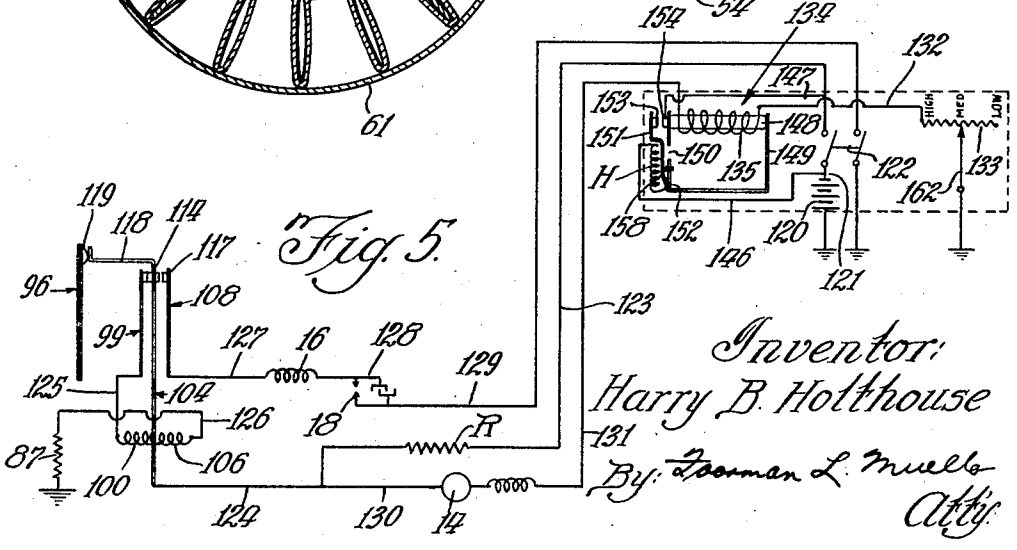


Fig. 5.

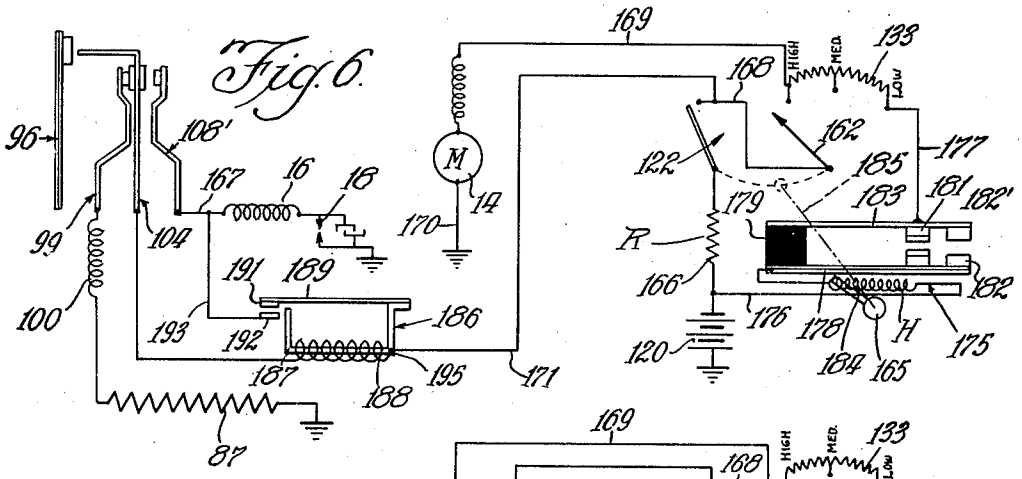


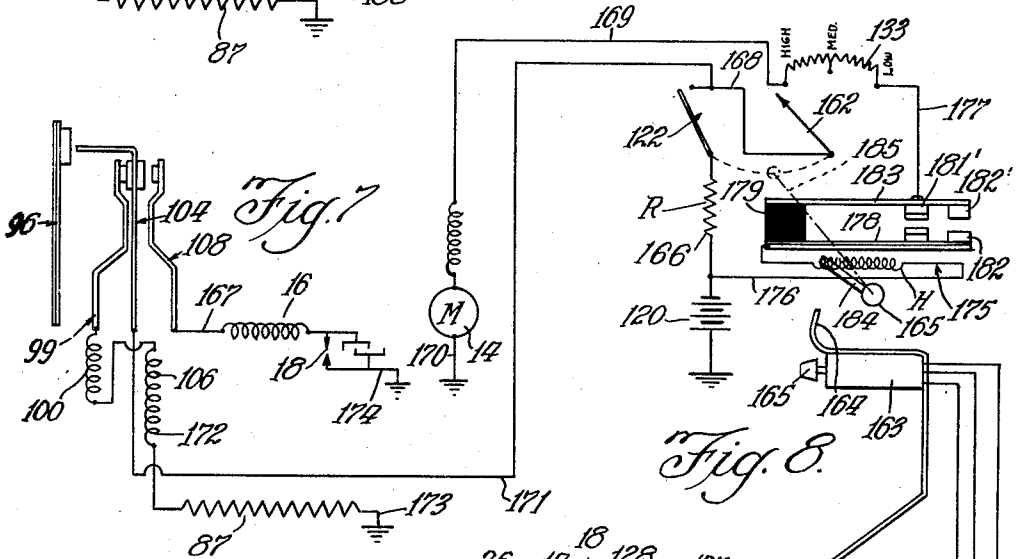
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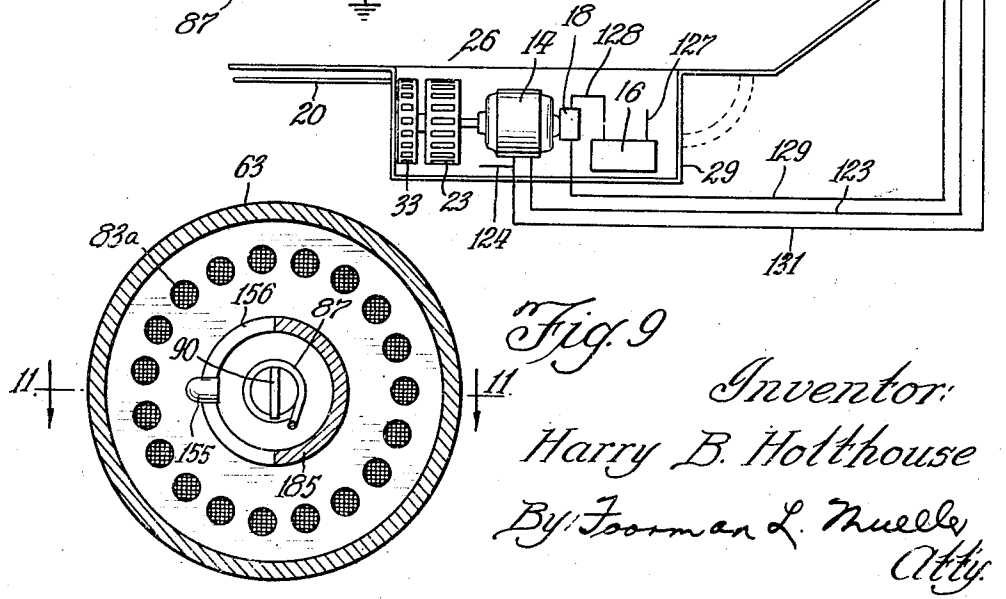
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HEATER

Filed Feb. 26, 1941 4 Sheets-Sheet 3







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HEATER

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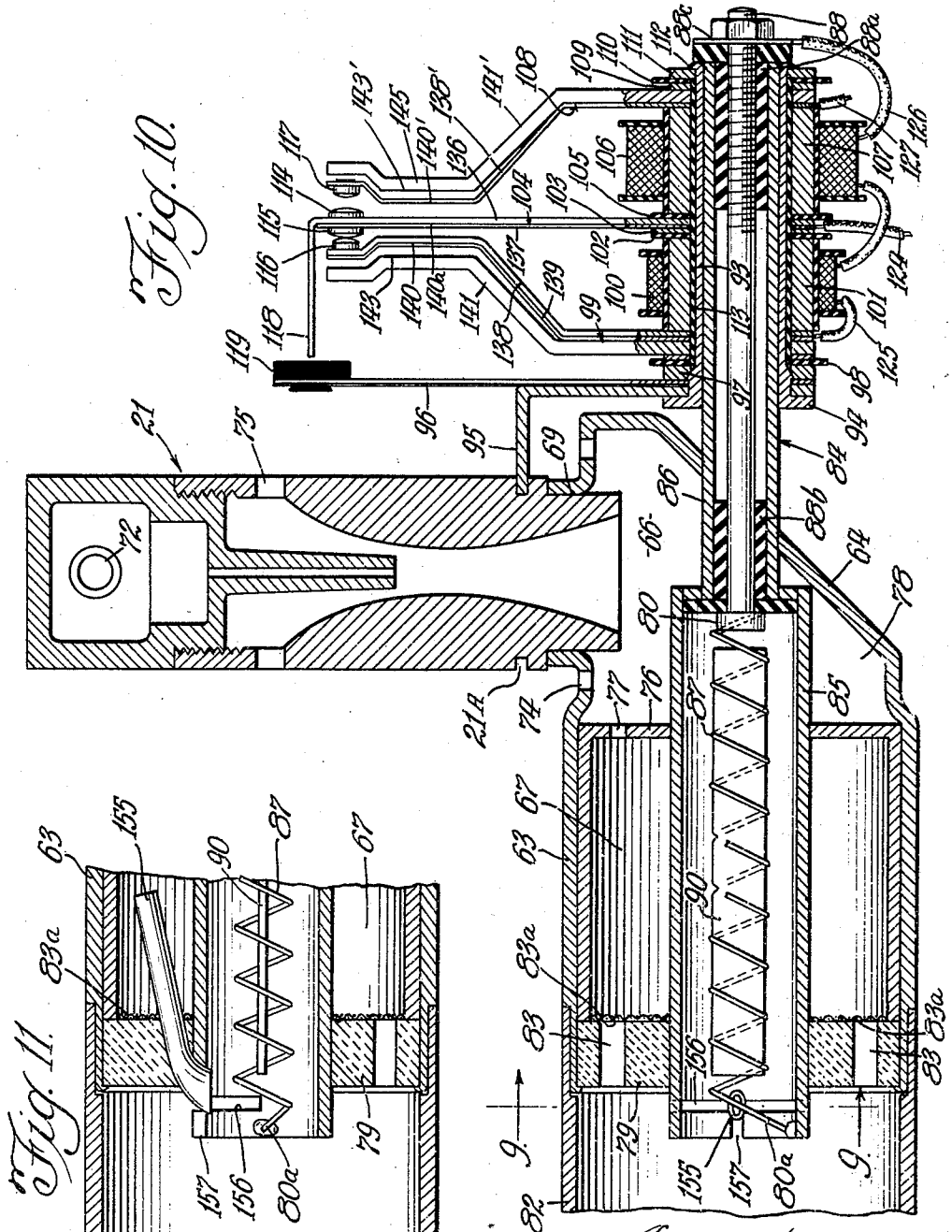


Fig. 10.

Fig. 11.

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UNITED STATES PATENT OFFICE

2,384,836

HEATER

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Application February 26, 1941, Serial No. 380,717

6 Claims. (Cl. 158—28)

This invention relates generally to heater systems of internal combustion type and in particular to a unit heater of internal combustion type for an automobile. This application is a continuation in part of application Serial No. 355,484, filed September 5, 1940, now Patent No. 2,286,854 issued June 16, 1942.

It is an object of this invention to provide an improved heater system of internal combustion type.

Another object of this invention is to provide an improved unit heater of internal combustion type for an automobile which operates entirely independently of the usual automobile engine.

A further object of this invention is to provide a heater which is simple and rugged in construction, relatively inexpensive in cost, efficient in operation, and which is completely electrical and capable of being operated on the power from a usual car battery.

A feature of this invention is found in the provision of a heater of internal combustion type for an automobile in which the temperature in the passenger compartment is controlled by varying directly the potential heat output of the heater.

A further feature of this invention is found in the provision of a heater of internal combustion type having a control system which operates to uniformly condition all portions of the combustible fuel at all times of heater operation.

Another feature of this invention is found in the provision of a heater of internal combustion type having a fuel conditioning unit with an electrically operated heating element, in which the operation of the heating element in maintaining the conditioning unit substantially constant at a predetermined operating temperature is controlled by an improved combination magnetic and thermostatic switch unit.

A further feature is found in the provision of a heater of internal combustion type having a control system, in which the circuit for the fuel supply means is rendered inoperative until the heater is conditioned to burn such fuel, and in which the air supply means is automatically continued in operation for a predetermined time interval after effective combustion has been stopped to exhaust from the heater any combustible fuel which might be left therein.

Yet another feature of this invention is found in the provision of a heater of internal combustion type having an active pilot flame which aids in initiating the burning of the combustible mixture in the combustion chamber.

A still further feature of this invention is found in the provision of a combustion chamber having heat radiating fins with cavities formed therein adapted to collect any excess raw fuel which might be present in the combustion chamber.

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 developed view of the improved heater of this invention taken along the line 1—1 in Fig. 2;

Fig. 2 is a true end view of the heater shown partly in section and taken along the line 2—2 in Fig. 1;

Fig. 3 is a true sectional view of the combustion chamber as seen along the line 3—3 in Fig. 1;

Fig. 4 is a view in perspective of a partition member used in the assembly of the combustion chamber shown in Fig. 3;

Fig. 5 is a diagrammatic illustration of a control circuit for the heater of Fig. 1;

Figs. 6 and 7 illustrate diagrammatically other control circuits adapted for use with the heater of Fig. 1;

Fig. 8 is a schematic illustration showing the arrangement of the heater of Fig. 1 and the control circuit of Fig. 5 relative to the passenger compartment of an automobile.

Fig. 9 is a view partly in section taken along the line 9—9 in Fig. 10;

Fig. 10 is a longitudinal sectional view of the fuel conditioning unit shown in the heater of Fig. 1; and

Fig. 11 is a fragmentary sectional view as seen along the line 11—11 in Fig. 9.

The improved heater of this invention is of unit type and is shown as applied to the heating of a passenger compartment for an automobile. The heater is completely enclosed in housing means and is illustrated as being mounted below the floor of the passenger compartment. Included within the housing is a recirculating air passage arranged directly about a combustion chamber and in communication with the passenger compartment in at least two places to provide for a complete circulation of air through the automobile and heater. Also enclosed within the housing are a unit for conditioning the fuel prior to its combustion, means for circulating air through the above mentioned passage, a fan for supplying air to the conditioning unit, a pump for supplying fuel to the conditioning unit, and an operating motor which is common to both the

air supply and air circulating fans and to the fuel pump. The fuel conditioning unit is provided with an electrical heating and igniting element, and it is contemplated that this element and the common operating motor receive their electrical energy entirely from the usual car battery. Because of this limitation in the electrical power available to operate the heater, the motor and the air fans are of relatively small size so that the velocity of the air from the air supply fan is insufficient to accomplish any appreciable atomization of the fuel. Likewise, the fuel pump which may be of solenoid type, develops a limited operating pressure so that fuel discharged therefrom is in substantially droplet form. In preparing the fuel for burning, therefore, the fuel conditioning unit vaporizes the fuel for mixing with the air, means being provided to retain the mixture in a vaporous form until it is burned. By virtue of the fact that the fuel pump and air supply fan are operated by a common motor the invention contemplates a control of the temperature in the passenger compartment by a direct control of the speed of the operating motor, this change in speed varying directly the air and fuel supplied to the heater and hence the potential heat output of the heater.

With reference to Figs. 1 and 2, of the drawings, the heater is shown as being completely enclosed by a housing member 10 which is divided substantially over its entire longitudinal length by a frame member 11, into a combustion compartment 12 and a mechanical compartment 13. Arranged within the mechanical compartment 13 are a motor 14, a fuel pump 16, and a fuel metering device 17 arranged in a fuel line 20 connecting the pump with a fuel nozzle 21, to be explained later. The fuel pump 16 is illustrated as being of solenoid type and is controlled in its operation by a breaker assembly indicated at 18 and operated from the shaft 19 of the motor 14. Compartment 13 is in communication with a fan chamber 22 for an air circulating fan 23 which is operated by the motor 14 and is mounted on the shaft 19 thereof. The fan 23 functions to circulate air through passages 24 formed about the combustion chamber 25 and to discharge such circulated air through an outlet 26 which may be suitably connected with the passenger compartment 28 of an automobile (Fig. 9). Air for the fan 23 is supplied through an inlet 29 formed in the end 31 of the housing member 10 and opening into the mechanical compartment 13. This inlet is also suitably connected with the passenger compartment 28 so that the recirculated air from the passenger compartment is first drawn through the length of the compartment 13 prior to being heated by its travel through the passages 24. All of the operating devices in the compartment 13 are thus continuously cooled by the recirculated air from the passenger compartment during the normal operation of the heater. It is to be understood, of course, that the inlet 29 may be open to the atmosphere so as to provide for the passage into the car compartment of heated fresh or outside air, or a mixture of fresh and recirculated air.

The motor 14 is also common to an air supply fan 33 which is mounted on the motor shaft 19 adjacent the fan 23 but separated therefrom by a sealing or partition plate 34. As is clearly indicated in Fig. 1, the plate 34 in conjunction with a substantially cup-shaped end-cover member 36 for the combustion chamber 25 serves to completely seal the fan 23 and the passages 24 from the air supply fan 33. The fan 33 operates to draw fresh air through inlet 37 formed in the end 38 of the housing 10, and to deliver this air into an air supply chamber 39 arranged at the left end of the combustion chamber 25 as viewed in Fig. 1. The air from this chamber 39 is mixed with the fuel from the fuel nozzle 21 mounted on a fuel conditioning unit 41, which is located in the chamber 39 at the inlet 42 of the combustion chamber, and which will be later fully described.

The combustion chamber 25 (Figs. 1, 2, 3, and 4) is of substantially cylindrical shape and includes a body member 43 of unit construction formed from a single piece of flat sheet steel or suitable like material. The member 43 is press-shaped to form a series of alternate peripheral sections 44 and radially extending fin elements 46. A fin element 46 is thus arranged between adjacent peripheral sections 44. Also as is clearly apparent from Fig. 3, each fin 46 is bent double so that its outer end 47 is closed while its inner end 48 is slightly open. The side portions of each fin at the inner end 48 are brought close together so that the cavity or pocket 49 formed in the fin is in communication with the combustion passage 50 in the combustion chamber through a restricted or narrow opening. By virtue of this construction of each fin element 46, relatively narrow axially extending cavities 49 are provided over the complete length of the combustion chamber and on the inside thereof, to serve a function which will be hereinafter fully explained.

Positioned within the body member 43 is a partition member 51 comprised of a pair of V-shaped members 53 and 54. The members 53 and 54 are constructed with flat apex portions 55 and 56, respectively, adapted for mating back-to-back engagement, with the leg portions of each member 53 and 54 extending in opposite directions. Thus as is clearly indicated in Figs. 3 and 4 on attaching the members 53 and 54 together, as by spot welding of the apex portions 55 and 56, there is formed a partition member 51 of substantially cross shape. In arranging the member 51 within the tubular body member 43, the opposite leg portions 57 and 58 of the members 53 and 54, respectively, are positioned within a pair of diametrically opposed fins 46, while the leg portions 57a and 58a are correspondingly positioned in another pair of oppositely positioned fins 46, the latter pair of fins being angularly displaced approximately ninety degrees from the first pair of fins. As shown in Fig. 4 the leg portions 57 and 57a of the member 53, and the leg portion 58a of the member 54 each have an end section thereof removed. On closing of the open ends of the tubular member 43 by cover plates 36 and 60 (Fig. 1), therefore, to complete the assembly of the combustion chamber 25, a continuous passage 50 approximately four times longer than the axial length of the combustion chamber is formed within the combustion chamber. As is also shown in Fig. 1 one end of the passage 50 is at the combustion chamber inlet 42, while its opposite end is at the outlet 45. A cylindrical shell or sleeve 61 is positioned about the fin ends 47 to form the air passages 24 which have been previously mentioned. Heat from the fins 46 may thus be radiated into the air passages 24 to heat the air passing therethrough.

The inlet 42 of the combustion chamber 25 (Fig. 1) is of somewhat smaller diameter than the combustion passage 50 and is provided with

an inwardly extending flange portion 62 for supporting the fuel conditioning unit 41. As shown in detail in Figs. 9, 10, and 11 the unit 41 includes a substantially cylindrically shaped housing 63 of tubular construction having one end closed by a slanted wall portion 64 while its opposite end is open. The housing 63 is comprised of an air and fuel mixing chamber 66 located at the closed end 64, and an equalizing chamber 67 arranged adjacent thereto. The wall portion 64 is located substantially opposite the inlet 69 to the chamber 66. Inlet 69 is formed with a suitable mounting portion for the fuel nozzle 21 which is connected at 72 with the fuel line 20 from the fuel pump 16. Supply air for combustion is admitted into the chamber 66 from the air supply chamber 39 through apertures 74 arranged about the inlet 69 and apertures 75 formed in the fuel nozzle 21.

The equalizing chamber 67 is separated at one end from the mixing chamber 66 by a partition plate 76 which is positioned transversely of the housing 63 near the sloped end wall 64. The partition member 76 is formed over its upper portion with a plurality of apertures 77 (only one of which is shown), communication between the chambers 66 and 67 being only through these apertures. The slope of the end wall 64 is away from the member 76 so that a trough or pocket 78 is formed at the bottom of the unit 41 between the plate 76 and the sloped wall 64 for a purpose to be later explained. The other end of the equalizing chamber 67 is separated from the combustion passage 50 by a heat insulating plate 79 positioned over the open end of the housing 63 but inwardly from such end so as to leave an annular rim or flange 82 projecting outwardly beyond the plate 79, as is clearly shown in Figs. 10 and 11. The insulating plate 79 is formed with a plurality of apertures 83 which are arranged in substantially a complete circle near its peripheral edge, communication between the chamber 67 and the combustion passage 50 being accomplished through these apertures.

As was previously mentioned, the air and fuel supplied to the conditioning unit 41 are at low pressures which are insufficient to properly atomize the fuel for mixing with the air. In one commercial embodiment of the heater the motor 14 is rated at 3400 R. P. M. with 5.6 amperes. At this motor speed the fan 33 has a maximum output of about 5 cubic feet per minute with a velocity pressure of approximately $\frac{5}{16}$ inch of water. The corresponding output of the fan 23 with this size motor is about 65 cubic feet per minute, with the discharge of the pump 16 being about 5 cubic centimeters per minute. It is thus apparent, that the quantities of air and fuel supplied by and the operating pressures of the fan 33 and pump 16 are very low due to the limitation in the size of the motor 14 as determined by the electrical power available from the usual car battery. In order, therefore, to thoroughly mix the fuel and air under these operating conditions, it is contemplated that the fuel and air be heated in the mixing chamber 66 to a temperature which is sufficient to vaporize the fuel, with mixing resulting from such vaporization.

This heating of the air and fuel is obtained by a heating and igniting unit 84, including a tube having a steel body portion 85 and a copper extension 86 of reduced section. A resistance coil 87 extends axially through the tube portion 85 but spaced therefrom. One end 80 of the coil 87 is connected with a locking and terminal screw 88 which is positioned within the tube portion 86 but insulated therefrom by insulators 88a and 88b. The opposite end 80a of the coil is grounded to the tube portion 85 near the free end thereof. Coil 87 is relatively stiff so that the support at its ends is sufficient to maintain the coil in a spaced relation with respect to the inside of the tube body portion 85. However, further support is provided by a mica strip 90 or the like which is positioned within the coil. The mica strip 90 is of flat shape and is formed with serrated sides, the coil being wound about the mica by a threading engagement of the coil with the serrations. The heating unit 84 extends axially of the housing 63 and across the chambers 66 and 67 and is supported in the end wall 64 and partition members 76 and 79, with the end 86 of the unit projecting outwardly from the wall 64.

It is contemplated that the heating unit 84 function also as an igniting means for the conditioned fuel. This ignition of the fuel occurs near the coil end 80a and as a result of the heat projected outwardly from the tube portion 85 at such end, the degree of ignition heat being determined essentially by the length of the coil 87 and being contemplated in the present invention to be about 1800 degrees Fahrenheit. The temperature in the mixing and equalizing chambers 66 and 67, respectively, however, is at all times less than that which would effect an ignition or burning of the fuel within such chambers and is contemplated to be about 300 degrees Fahrenheit. By virtue of this large temperature difference and a fine mesh screen 83a covering apertures 83, any burning of the fuel or flash back within the chambers 66 and 67 is positively eliminated.

Operation of the fuel conditioning unit 41 at a temperature which is adapted to properly vaporize the fuel supplied to the mixing chamber 66 is accomplished by means of a combination magnetic and thermostatic switch unit which is mounted on the heating and igniting unit 84 at its reduced end 86 (Fig. 10). The combination magnetic and thermostatic switch unit is of a preassembled construction and includes a copper supporting or base member 93 of tubular shape having an annularly extending flange 94 at one end thereof. Stacked in succession axially of the copper tube 93 and against the annular shoulder 94 are an aligning element 95, a bi-metal or thermostatic element 96, a copper washer 97, an insulator or mica washer 98, a conductor unit 99 for the heating and igniting unit 84, a magnetic or induction coil 100 mounted on but insulated from a spacer or core member 101, a mica washer 102, an iron washer 103, a conductor arm 104, a mica washer 105, a second coil unit 106 having a spacing member 107, a conductor unit or switch arm 108 for the pump 16, a steel washer 109, a mica washer 110, and another steel washer 111. All of the above defined parts mounted on the copper sleeve 93 are retained in their assembled position by peening the end 112 of the tube 93 against the outside steel washer 111. That portion of the switch assembly included between the mica washers 98 and 110 is insulated from the copper tube 93 by an insulating sleeve 113 which may be formed of mica or the like.

Assembly of the magnetic and thermostatic switch unit with the fuel conditioning unit 41 is accomplished by slipping the copper tube 93 over the reduced section 86 of the heating and igniting unit 84, the aligning member 95 being of a form to engage an annular recess 21A formed in the fuel nozzle 21. This engagement of the

member 95 with the nozzle 21 serves both to align the magnetic and thermostatic switch unit in a position relative to the other parts of the conditioning unit and also to maintain the fuel nozzle 21 in a supported position in the inlet 69. The switch unit is held in place on the tube end 86 by locking means 88c threaded on the screw member 88.

The battery switch arm 104 is of substantially straight form and is provided with contact points 114 and 115 on opposite sides thereof, contact 115 being engageable with a contactor 116 on the switch arm 99 for the heating and igniting unit, and the contact point 114 being engageable with a contact 117 provided on the switch arm 108 for the pump 16. As shown in Fig. 10 contacts 115 and 116 are normally closed while contacts 114 and 117 are normally open. Although the supporting portions of the arms 99 and 108 are axially spaced a relatively large distance from the switch arm 104, because of the coil windings 100 and 106 positioned therebetween, the upper portions of the arms 99 and 108 are inclined inwardly toward the arm 104 so that all of the contacts 114–117 are relatively close together. Arm 104 is formed at the top thereof with an extension 118 which is engageable with the upper end of the bi-metal element 96, and specifically with an insulator portion 119 thereon. The bi-metal arm 96, by virtue of its direct support on the end 86 of the heating and igniting unit 84 is immediately responsive to the heat conditions of the heating unit and is adapted to move toward the right, as viewed in Fig. 10, as the coil 87 becomes heated. On heating of the element 87, therefore, the conductor arm 104 is moved toward the right and out of contact with the arm 99 and toward the arm 108 as will be later fully explained.

Energization of the heating and igniting unit 84 is accomplished by its connection with a suitable electrical source such as a car battery 120 (Fig. 5) the circuit from the battery including a conductor 121, a double throw main switch 122, conductors 123 and 124, switch arms 104 and 99, conductor 125, coil windings 100 and 106, conductor 126, and coil 87, the circuit being completed to ground. Conductors 123 and 124 and the switch arm 104 are also common to the circuit for the fuel pump 16. This circuit from the switch arm 104 is completed through switch arm 108, conductor 127, fuel pump 16, conductor 128, breaker assembly 18, conductor 129 and switch 122 to ground. The conductor 123 from the main switch 122 is also common to the circuit for the motor 14, the motor circuit including further conductor 130, the armature and field for the motor 14, conductor 131, conductor 132 and a variable resistance 133. The motor circuit also includes a time delay switch 134 which is shunted about the switch 122 and includes an induction coil 135 connected in series between conductors 131 and 132. This time delay unit will be later explained.

In operating the heater the main control switch 122 is initially closed to in turn close the circuit for the motor 14 and also the circuit for the heating and igniting unit 84 through the connections just described. This closing of the circuit for the heater element 87 energizes the induction windings 100 and 106 to magnetize the arms 99, 104 and 108. These arms, therefore, are constructed so as to be efficiently magnetized without impairing their conducting capacity. Because of this fact the battery switch arm 104 includes a silicon steel portion 136 and a copper portion 137; the silicon steel portion 136 being readily magnetized, and the copper portion serving to carry the current from the battery 120 to the switch arm 99. The switch arm 99 is similarly provided with a silicon steel portion 138 and a copper portion 139 and includes further a stationary magnetic carrier 141 composed of iron. This carrier increases the magnetic flux transfer from the coil 100 to the pole face 140 formed over a part of the silicon steel element 138. The switch arm 108 includes a silicon steel portion 138' and a flux transfer element 141'. A copper current carrying element for the switch arm 108 is not required since the current necessary to operate the pump 16 is relatively small compared to that needed for the coil 87.

In the construction of the conductor arms 99 and 108, the steel portions 138 and 138' are formed with pole faces 140 and 140', respectively, which are positioned opposite corresponding pole faces 143 and 143' formed on the flux transfer elements 141 and 141'. In practice it is contemplated that the air gap between each pair of corresponding pole faces be about .005 to .020 inch. Since each magnetic carrier 141 and 141' functions to lower the reluctance of the magnetic path from a corresponding coil 100 and 106, respectively, to a pole face 140 and 140' respectively, the magnetic flux at such latter pole faces is greatly increased, by virtue of the flux transfer between the pole faces 140 and 143, and 140' and 143'.

As is clearly shown in Fig. 10 the coil cores 101 and 107 are insulated at their adjacent ends by the mica washers 102 and 105, respectively, from the battery arm 104, but are in magnetic connection at their outer ends with the arms 99 and 108, respectively. Thus on energization of the coils 100 and 106 the pole faces 140 and 140' are magnetically charged with like polarity, while the portion 140a of the arm 104 between such pole faces is charged with an unlike polarity. On closing of the main switch 122, therefore, the arms 99 and 108 are magnetically attracted to the arm 104 whereby to close the contacts 114 and 117 and to magnetically lock the normally closed contacts 115 and 116. Closing of the main switch 122, therefore, effects a substantially simultaneous operation of the fans 23 and 33, fuel pump 16 and heating and igniting unit 84. If on closing of the main switch 122 the circuit for the unit 84, for some reason, does not become energized the windings 100 and 106 are rendered inoperative to magnetically charge the switch arms 99, 104 and 108 so that contact 117 is not attracted toward the contact 114. The circuit for the fuel pump 16 thus remains open through the normally open position of the contact points 114 and 117 so long as the coil 87 is not capable of being energized.

Closing of the motor circuit provides for the closing of the time delay unit 134 by virtue of the energization of the winding 135 as will now be explained (Fig. 5). The time delay or thermostatic and magnetic unit 134 is connected in the motor circuit by conductors 146 and 147 which are connected to conductors 121 and 123, respectively. The winding 135, previously mentioned, is wound on an iron core 148 which is mounted on one portion of a substantially C-shaped magnetic yoke 149. Suitably mounted so as to extend over the gap 150 in the C-shaped yoke 149 is a bi-metal conductor armature 151. The armature 151 is connected at one end 152 to the yoke, but is insulated therefrom, the end 152 being connected also with conductor 146. The opposite end of the

armature has a contact 153 engageable with an insulated contact 154 mounted on the yoke 149 and connected with conductor 147. On energization of the winding 135, therefore, the yoke 149 is magnetically charged so that a high magnetic flux occurs at the gap 150 of the yoke. This magnetic flux is of sufficient intensity to attract the bi-metal armature 151 inwardly toward the yoke an amount sufficient to close the contacts 153 and 154, thereby also closing the motor circuit about the main switch 122. It is thus seen that the shunt circuit is closed substantially concurrently with the closing of the switch 122. However, when the switch 122 is closed it acts to short-circuit the shunt circuit. Although the motor circuit, therefore, is closed both through the switch 122 and about such switch, but very little current flows through the shunt circuit during the normal operation of the heater. From the above description it is seen that when the heater is started by closing the main switch 122, the circuits for the heating and igniting unit 84, fuel pump 16, and motor 14, and for the switch unit 134 in the motor circuit are all closed at substantially the same time.

On starting of the fan 33 and pump 16, respectively, air and fuel is supplied to the chamber 66 (Fig. 10), the nozzle 21 and air ports 74 being arranged to direct such air and fuel toward that portion of the unit 84 within the chamber 66 and the inclined end wall portion 64. The partition member 76 and the housing 63 for the fuel conditioning unit 41 are provided in a suitable heat conducting material such as copper so that the heat from the heating and igniting unit 84 is readily transferred to all portions of the conditioning unit, the variation of the temperature within the chambers and their surrounding walls relative to the heating unit 84 being about 10 degrees Fahrenheit. Thus since the wall 64 is at substantially the same temperature as the heating unit 84, the fuel in the mixing chamber 66 is heated by its contact with both the unit 84 and the wall 64 to facilitate its mixing with the air. The resultant air and fuel mixture passes through the apertures 77 in the partition plate 76 into the equalizing chamber 67 and thence through the perforations 83 in the insulated plate 79 into the end portion 82 where it is ignited by the heat at the end 80a of the heating unit 84. As the heating unit 84 continues in operation its temperature increases to in turn increase the temperature in the chambers 66 and 67.

As was previously mentioned, the difference in the temperatures of the chambers 66 and 67 and the heating unit 84 is only about 10 degrees Fahrenheit, so that the temperature of the unit 84 is essentially the same as the temperature in the mixing chamber 66, which latter temperature is controlling in the conditioning of the fuel for burning. However, for convenience and clarity, only the temperature of the heating unit 84 will be referred to in the following description with respect to the action of the thermo-magnetic control switch. With the heating of the unit 84 to a temperature of about 200 degrees Fahrenheit, the fuel contacting that portion of the heating unit in the chamber 66 and the end wall 64 is substantially immediately vaporized by the heat in these parts, the angular slope or inclination of the wall 64 deflecting the fuel against the partition wall 76 to further vaporize any remaining fuel particles. This vaporization of the fuel is accelerated somewhat by breaking up the fuel stream in the nozzle 21. This is accomplished by the air from the supply chamber 39 passing into the nozzle through the apertures 75, this air entering the chamber 66 with the fuel. Any raw or free fuel particles which are not immediately vaporized are collected at the bottom of the chamber 66 in the fuel trough or cavity 78. Because of the heated condition of the partition wall 76 and end wall 64, the raw fuel thus collected is additionally heated and is further exposed to the warm supply air circulating within the chamber 66 to facilitate its passage into the chamber 67 in a vaporous form. Any passage of raw fuel particles into the equalizing chamber 67 is thus substantially eliminated. The equalizing chamber functions to equalize the velocity flow and pressure of the mixture so that the mixture entering the portion 82 of the fuel conditioning unit 41 has substantially uniform characteristics and is free of any isolated rich or lean portions.

During this period of operation the bi-metal element 96 moves slowly toward the right, as viewed in Fig. 10, moving the contact 115 away from the contact 116 and moving the closed contacts 114 and 117 toward the right. When the temperature of the unit 84 reaches a value of about 200 degrees Fahrenheit, which represents a minimum operating temperature at which the fuel is advantageously mixed with the air, contacts 115 and 116 are opened by the action of the bi-metal element 96, the contacts 114 and 117 continuing closed. Since the magnetic windings 100 and 106 continue to be energized only so lon as the circuit for the heating unit 84 is closed, it is apparent that opening of the contacts 115 and 116 by the bi-metal arm 96 is against the magnetic attraction between the conductor arms 99 and 104. By virtue of this action of the arms 99 and 104 an abrupt and clean break is accomplished between the contacts 115 and 116, with the contact 115 being sufficiently removed from the contact 116 when the break occurs to prevent any fluttering action between these contacts. Undesirable arcing between the contacts is thus entirely eliminated whereby to prevent the occurrence of any spark adjacent the mixing chamber and to prolong the service life of the contacts. Also the circuit for the heating unit 84 is thus positively controlled between very definite temperature limits. Since the arm 104 on opening of the circuit for the heating unit has been moved to the right by the action of the bi-metal element 96, it is in a position to maintain closed the contacts 114 and 117. Thus with the circuit for the coil 87 open the contacts 114 and 117 are held closed by the pressing action of the bi-metal element 96 and not by any magnetic attraction between the arms 104 and 108. The fans 23 and 33 and pump 16 thus continue in operation after the circuit for the coil 87 is opened by the thermal element 96.

The operation of the heater with the circuit of the heating unit 84 deenergized continues until the temperature of the heating unit 84 falls below about 200 degrees Fahrenheit. When this temperature drop occurs the bi-metal element 96 is cooled and moved toward the left, as viewed in Fig. 10, an amount sufficient to permit a closing of the contacts 115 and 116 without opening of the contacts 114 and 117, these contacts being immediately magnetically locked by virtue of the energization of the windings 100 and 106. On closing of these contacts, the circuit for the heating unit 84 is closed, the fuel pump 16 and air fans 22 and 33 continuing in operation, the contacts 114 and 117 in the fuel pump circuit

being magnetically locked concurrently with the magnetic locking of the contacts 115 and 116. When the temperature of the unit 84 and hence of the chamber 66 is again increased to about 200 degrees Fahrenheit, contact is again broken between the arms 99 and 104 to again open the circuit of the unit 86. This controlled operation of the fuel conditioning unit 41 continues at all times during the normal operation of the heater, which operation is stopped by the opening of the control switch 122.

Although practically all of the fuel in the mixture leaving the equalizing chamber 67 is in a vaporous form at times during heater operation raw fuel might enter the combustion chamber. In the event any raw fuel should get into the combustion chamber it is collected in the fin cavities 49 and heated to a vapor by the accumulated heat in the fins. This vaporous fuel then enters the combustion chamber to be burned. The restricted opening 49 to each cavity 49 prevents any flash-back or burning of the fuel in the cavity, by virtue of the fact that insufficient air is supplied to the cavity to support combustion, and by the additional fact that the restricted cavity opening permits a building up of a vaporous pressure in the cavity which is greater than the pressure in the combustion chamber. The vapor in the cavity is thus always forced into the combustion chamber under pressure thus tending to maintain the flame in the combustion chamber. Any accumulation of raw fuel in the combustion chamber is thus eliminated and all of the fuel burned is in a substantially vaporous state so that operation of the heater proceeds both quietly and efficiently.

Further means for accomplishing an even and quick burning of the fuel is found in the provision of an active pilot flame near the coil end 89a (Figs. 9, 10 and 11). In the operation of the heating and igniting unit 84 it has been found that the fuel striking the coil end 89a may immediately cool such end to a temperature which is insufficient to support combustion, and hence insufficient for ignition purposes. To overcome this difficulty, and to permit the use of a light wire in the construction of the coil 87, there is provided a pilot tube 155 supported in the insulator or ceramic plate 79 and having one end thereof positioned within the equalizing chamber 67 and its opposite end arranged in the tube portion 85 at a position substantially opposite the coil end 89a. This pilot tube 155 is of a size to control or meter only that amount of vaporous fuel from the chamber 67 which can be ignited by the coil end 89a without effecting any appreciable cooling of the coil. The mixture passing through the tube 155 into the igniting zone at the coil end 89a is thus more positively and readily ignited than the fuel leaving the chamber 67 through the apertures 93 and acts at all times of heater operation as a pilot light relative to such remaining fuel mixture. It is readily apparent that the use of a lighter wire in the construction of the coil 87 appreciably cuts down the current required to heat the coil to an igniting temperature. In one embodiment of the invention before the pilot meter tube 155 was used, 18 amperes were required to maintain the coil 87 at a proper temperature, while after the tube 155 was used this amperage was cut down to about 9 amperes. The tube used in this instance had an I. D. of .05 inch. The tube 155, therefore, functions to meter or control the ignition of that amount of vaporous mixture which is capable of being ignited by the coil end 89a without appreciably cooling such coil end.

As is clearly indicated in Fig. 10, the outlet of the tube 155 is arranged at the intersection of a pair of slots 156 and 157 formed in that portion of the tube 85 which projects outwardly from the insulator 79. In the practice of this invention it is contemplated that the air and fuel supplied to the mixing chamber 66 be in such relative quantities that the resulting mixture is normally relatively rich. During some times of heater operation, therefore, the mixture passing through the tube 155 may be so rich as to be difficult of igniting. If this should occur additional air is supplied through the slots 156 and 157 to the mixture at the outlet of the tube 155, the mixture within the rim portion 92 of the housing 63 being more lean than the mixture in the equalizing chamber 67 because of the expansion of the mixture in passing through the apertures 93 into the portion 62. Since in practice the conditioning unit 41 is normally operated in a substantially horizontal position, the mixture of most even consistency in the equalizing chamber 67 has been found to occur at substantially the horizontal center of such chamber. It is contemplated, therefore, that the tube 155 be positioned at such horizontal center, so that the outlet thereof is to one side of the coil end 89a.

As was previously mentioned the switch 122 acts to short-circuit the unit 134 so that but very little current passes through the bi-metal conductor armature 151 during normal heater operation (Fig. 5). On opening of the switch 122, however, all of the current for operating the motor 16, flows through the shunt circuit and hence through the armature, it being understood that the circuits for the fuel pump 10 and heating unit 84 are rendered inoperative. The shunt circuit thus operates to continue the motor 16 in operation after the pump 10 and heating unit 84 have been deenergized. The current which now flows through the shunt circuit is sufficiently high to appreciably heat the bi-metal armature 151, which is constructed so as to move outwardly from the yoke 149 in response to such heat. Thus when the armature 151 is heated to a predetermined temperature value, it is under tension sufficient to overcome the magnetic attraction at the gap 159 and to break the connection between contacts 153 and 154, thus opening the shunt circuit and stopping the operation of the motor 14. It sometimes occurs that the heat derived from the current flow in the armature 151 is insufficient to quickly move the armature to its open position. To assure a fast and positive action of the armature 151 there is provided a heater coil H, arranged in heat exchange relation, with the armature 151 and in series connection therewith. During normal operation of the heater, with the switch 122 closed, the current flow through the coil H is too low to effect any appreciable heating of the armature 151. However, when switch 122 is opened the current flow through the coil H is increased. Thus the armature 151 is moved to an open position by virtue of the heat from the current flow therein and the heat from the heating coil H. It is apparent, of course, that the time required for the armature 151 to open the contacts 153 and 154 is dependent upon the number of windings in the magnetic winding 135 and the heat characteristics of the bi-metal armature 151. By a relative construction of the armature 151 and winding

135, therefore, the switch unit 134 may be adapted to delay the opening of the motor circuit for any desired period of time, a time of two minutes being used in the above-noted commercial embodiment.

The continued operation of the motor 14, after the fuel pump 16 and heating unit 84 have been deenergized, operates the fan 33 so as to exhaust any combustible mixture which might be in the combustion chamber on opening of the main control switch 122. Since the mixture which remains in the combustion chamber is usually burned at a slow rate by the residual heat in the chamber, burning proceeds with an odor which is very disagreeable. A continued operation of the fan 33, therefore, entirely eliminates any after-burning of residual mixture portions and further eliminates any possibility of a later explosion in the heater on subsequent starting thereof. It is seen, therefore, that the armature 151 of the combination magnetic and thermostatic unit 134 is magnetically locked in a closed position on closing of the motor circuit by the switch 122 and that it remains magnetically locked until moved to its open position in response to the heat produced by a current flow therein. Because of this construction the action of the armature in stopping the motor 14 is very positive, since the contacts 153 and 154 are immediately widely separated when the armature is opened. This positive action is assured further by an insulating stop 158 mounted at one side of the yoke gap 150. The stop 158 prevents the armature 151 from moving to its closed position except when it is so moved by the magnetic pull at the gap 150. Heating of the armature thus functions only to open the armature, its closing being accomplished entirely by the magnetic attraction at the gap 150.

From the above description and consideration of Figs. 1 and 5, it is clearly apparent that the rate of operation of the fans 23 and 33 and fuel pump 16 depends on the speed of the motor 14. In the operation of these parts, it has been found that when the speed of the motor is decreased the rate at which air is discharged or displaced by the fans 23 and 33 decreases proportionately faster than the rate at which fuel is discharged from the pump 16. In other words, the fuel to air ratio as provided by the pump 16 and fan 33, increases directly with a decrease in the motor speed so that the richness of the mixture in the heater increases as the motor speed is reduced.

Since the rate at which air and fuel is supplied to the combustion chamber varies directly the potential heat output of the heater, manual means are provided to control the motor speed to in turn control the temperature in the space being heated, which in this instance, is the car compartment 28 (Fig. 8). As was previously mentioned, the circuit for the motor 14 includes a resistance 133. By moving a grounded control arm 162 across the resistance 133 the speed of the motor 14 may be varied in an obvious manner, the motor speeds being designated at the resistance 133 as high, medium and low. The switch unit 134, main switch 122 and motor rheostat control 133—162 are included within a single housing 163 as shown in Fig. 8, which is supported on the dash 164 of the automobile. A control knob 165 mounted on the outside of the housing 163 may be arranged to concurrently control the operation of both the switch 122 and the rheostat arm 162. Thus when the unit is first started the arm 162 is moved to a position of maximum or high motor speed with the desired reduction in the speed of the motor for starting purposes being accomplished entirely by the resistance R in the conductor 123. On the cutting out of the heating unit 84 by the action of the thermo-magnet control switch (Fig. 10) the motor 14 operates at its maximum speed to in turn supply a maximum amount of air and fuel to the heater. The heater thus operates with a maximum potential heat output. As the temperature in the car compartment 28 increases the control knob 165 is actuated to move the arm 162 to the medium or low speed motor position to in turn decrease the amount of air and fuel supplied to the combustion chamber and the available heat from the heater. This reduction occurs concurrently with a reduction in the amount of air being circulated through the passages 24 by the fan 23. Thus not only is the temperature of the heated air reduced, but its quantity is also reduced so that a double control of the temperature is obtained by the single control of the motor 14.

From a consideration of Fig. 8 it is seen that the control circuit of Fig. 5 requires three lead wires from the housing 163 to the heater, namely, conductors 129, 123, and 131. A modified form of this circuit is shown in Fig. 7 in which but two leads are needed to completely connect the heater with the switch mechanism in the housing 163. Since the two circuits are similar in many respects, similar numerals of reference shall be used to designate similar parts. The circuit for the motor 14 from the battery 120 includes a conductor 166, switch 122, conductor 168, resistance control arm 162, conductor 169 and a ground conductor 170. The circuit for the coil 87 of the heating unit from the battery 120 includes conductor 166, switch 122, conductor 171, control arms 104 and 99, coil windings 100 and 106, conductor 172 and ground conductor 173. The circuit for the fuel pump 16 is common with that of the coil 87 up to the control arm 104, the circuit from the control arm 104 comprising the control arm 108, conductor 167, breaker assembly 18 and ground conductor 174. On closing of the main switch 122, therefore, the motor 14, pump 16, and heating coil 87 are simultaneously energized, the switch arms 99, 104 and 108 operating at all times in the manner above fully described in connection with Figs. 5 and 10.

As illustrated in Fig. 7 the circuit for the motor 14 includes a time delay unit 175 which is shunted about the switch 122 by conductors 176 and 177, the conductors 177 and 176 being in series connection with the time delay unit 175 and with the motor resistance 133. The time delay unit includes a bi-metal conductor arm 178 connected at one end to an insulator block 179 and having a contact 181 and a pole face 182 in spaced relation near its opposite end. A mating conductor arm 183 is also secured at one end to the insulator block 179 and is provided at its opposite end with a contact 181' and pole face 182'. Each pole face 182 and 182' is comprised of a permanent magnet which may be composed of Alnico or other like material. The relative spacing between the contacts 181 and 181' is such that contact is made therebetween without any contact being made between the pole faces 182 and 182'.

In the operation of the control circuit of Fig. 7 it is contemplated that the control knob 165 be provided with a radially extending portion 184. With rotation of the control knob 165 in a clockwise direction, as viewed in Fig. 7, the projection 184 engages the bi-metal conductor 178 and moves the pole faces 182 and 182' into magnetically at-

tractable positions. This magnetic attraction closes the contacts 181 and 181' thereby closing the shunt circuit, the circuit being retained closed by the magnets 182 and 182' regardless of later movement of the projection 184 out of engagement with arm 178 during the normal rotation of the knob 165 to control the heat output of the heater.

The shunt circuit is thus closed concurrently with the closing of the circuits for the heating coil 87, fuel pump 16 and motor 14 by the switch 122, the control knob 165 functioning also to operate the switch 122. The switch 122, however, serves to short-circuit the time delay unit 175 so that but little current flows therethrough during normal heater operation. On opening of the main switch 122 by the control knob 165, the projection 184 is moved to a position out of engagement with the contact arm 178, the contacts 181 and 181' remaining closed by virtue of the magnetic attraction between the pole faces 182 and 182'. The motor 14 thus continues in operation after deenergization of the pump 16 and the heating coil 87. However, since opening of the switch 122 increases the current flow through the time delay unit 175 and hence through conductor arm 178, the arm becomes heated. This heating of the bi-metal arm 178 continues until it is sufficiently flexed to overcover the magnetic attraction between the pole faces 182 and 182', at which time the contacts 181 and 181' are opened, thus opening the circuit for the motor 14. In some instances the bi-metal arm 178 may be somewhat lagging in its movement to open the contacts 181 and 181'. This possible action of the arm 178 is entirely eliminated by the arrangement adjacent thereto of a heater coil H, which is connected in series with the arms 178 and 183.

By virtue of the calibrated resistance R in the conductor 186 the circuit of Fig. 7 also functions to provide for an automatic choking effect in the heater on energization of the heating coil 87. It is to be understood also that the motor 14 is common in the operation of the fuel pump 16 and of the air fans 23 and 33 so that the heat output of the heater is varied directly by movement of the knob 165 to its various heat control positions indicated as high, low and medium.

A further modified form of control circuit adapted for use with the heater of this invention is illustrated in Fig. 6. This control circuit is substantially similar in all respects to the control circuit in Fig. 7 except for the substitution of a pump relay unit 186 for the winding 186 of the thermo-magnetic switch unit. The pump relay unit 186 includes a magnetic yoke 187 which is magnetically charged by an induction winding 188 connected in series in the conductor 171. The yoke member 187 is of substantially C-shape, a conductor armature 189 being connected at one end of the yoke in a manner to extend over the gap formed therein, a contact 191 at the free end of the armature being adapted for engagement with a contact 192 connected by conductor 193 to conductor 167 of the fuel pump circuit. The circuit through the pump relay unit 186 is completed by connection of the conductor 171 directly with the yoke member 187 as at 195.

On closing of the main switch 122, therefore, the motor 14, the heating coil 87 and the fuel pump 16 are simultaneously energized, the energization of the coil circuit providing for the magnetic closing of the armature 189 and a consequent closing of the contacts 191 and 192 to close the fuel pump circuit. Thus on initiation of heater operation, the fuel pump circuit is closed through the pump relay 186 and while the switch arms 104 and 108' are still in an open position. However, when the thermal element 98 is sufficiently heated to move the arms 104 and 108' into contact, the circuit for the pump 16 is completed through these two switch arms so that later deenergization of the coil 87 on the opening of the arms 104 and 99 in response to movement of the thermal element 96 does not affect the operation of the fuel pump 16. The fuel pump 16, therefore, remains in operation at all times during normal heater operation.

On opening of the main switch 122, the heating coil 87 and the pump 16 are immediately shut down, but the motor 14 continues in operation for a predetermined time by virtue of the time delay unit 175 fully described above. The pump relay unit 186, therefore, operates only to eliminate any time delay in the starting of the pump at the time the heater is started, and is entirely short-circuited as soon as the switch arms 104 and 108' make contact. It is contemplated that the coil 188 be such that the load of the coil 87 is necessary to sufficiently energize the yoke 187 for magnetically closing the armature 189.

The invention thus provides a unit heater of internal combustion type whose control is entirely electrical and which can be operated from a small source of electrical energy such as the usual car battery. Control of the heater is accomplished entirely by a compact unit located on the automobile dashboard, while the heater as a unit may be mounted in a plurality of positions about the vehicle passenger compartment. All of the heater parts are completely enclosed within a single housing means and connections for the operation of the heater are required only to a source of fuel and electrical supply. The unit is compact and rugged in construction, inexpensive to manufacture so as to be commercially available at low cost, and adapted for operation on any automobile regardless of the type of such automobile. This is due to the fact that the heater operates entirely independently of the automobile engine, and does not depend for its operation on any predetermined suction or force pressure provided by such engine. The relative temperature values used in the above description are representative of one type of fuel, and of course will vary for different kinds of fuel. Although the invention has been described and illustrated specifically with reference to an automobile, it is to be understood that it may also be used in the heating of trailers, small work shops, and the like. It is also apparent that the heater parts may be relatively changed in size to increase the heat output of the heater so that it can be utilized for domestic heating purposes.

It is to be understood also that only preferred embodiments of the invention have been illustrated and described herein, and that alterations and changes therein may be made which are within the full intended scope of this invention, as defined by the appended claims.

I claim:

1. In a heater of internal combustion type having a combustion chamber with an inlet, a fuel conditioning unit located at said inlet and having an air and fuel mixing chamber and an equalizing chamber therein, with said latter chamber

being arranged between the inlet of said combustion chamber and said mixing chamber, perforated partition members at each end of said equalizing chamber, a combination heating and igniting unit supported in said partition members and having a heating portion in said mixing and equalizing chambers and an igniting portion near the inlet of said combustion chamber, said heating unit being adapted to cause the fuel in said mixing chamber to be heated to a vaporizing temperature for mixing with said air so that substantially all of the mixture is in a vaporous form when it passes into said equalizing chamber, whereby the heat in said equalizing chamber retains said mixture in its vaporous form, and means for carrying a portion of the mixture from said equalizing chamber to the igniting portion of said combination unit, whereby the mixture from said latter means is ignited by said igniting portion to initiate burning of the remainder of the mixture passing from said equalizing chamber into said combustion chamber.

2. In a heater of internal combustion type, a tubular combustion chamber having the inner surface thereof formed with longitudinally extending angularly spaced cavities with openings in communication with said combustion chamber, each of said cavities having the longitudinally extending sides thereof converging together to form a slit-like opening, and means for supplying a substantially completely vaporous mixture of air and fuel to said combustion chamber for burning adjacent said cavities, whereby any fuel particles in said combustion chamber will collect in said cavities and be vaporized by the heat therein.

3. In internal combustion heating apparatus provided with a combustion chamber, a fuel conditioning and ignition unit including a tubular member, means including a perforated partition wall for dividing the space within said member into a fuel and air mixing chamber and an equalizing chamber through which the mixture of fuel and air is transmitted from said mixing chamber into said combustion chamber axially of said tubular member, an ignition element disposed adjacent the outlet end of said equalizing chamber, and a member partially housing said ignition element and having an opening in the wall thereof through which a portion of the fuel and air mixture traversing said equalizing chamber is directed into engagement with said ignition element for ignition.

4. In internal combustion heating apparatus provided with a combustion chamber, a fuel conditioning and ignition unit including a tubular member, means including a perforated partition wall for dividing the space within said member into a fuel and air mixing chamber and an equalizing chamber through which the mixture of fuel and air is transmitted from said mixing chamber into said combustion chamber axially of said tubular member, an ignition element disposed adjacent the outlet end of said equalizing chamber, and a second tubular member surrounding said element and having an end which opens into said combustion chamber, said mixture being adapted to surround said second tubular member and to flow into said combustion chamber axially thereof, said second tubular member having one opening in the wall thereof through which a portion of the mixture traversing said equalizing chamber is directed into engagement with said ignition element and having a second opening in the wall thereof at a point outside of said equalizing chamber through which a portion of the mixture entering said combustion chamber is directed into engagement with said ignition element.

5. In internal combustion heating apparatus, means defining a tubular combustion chamber having the inner surface thereof formed with longitudinally extending angularly spaced cavities with openings in communication with said combustion chamber, each of said cavities having the longitudinally extending sides thereof converging together to form a slit-like opening, means for supplying a substantially completely vaporous mixture of air and fuel to said combustion chamber for burning adjacent said cavities, whereby any fuel particles in said combustion chamber will collect in said cavities and be vaporized by the heat therein, and a partition structure for dividing said chamber into a plurality of passages and including walls each having an edge portion held between the converged edge portions of the sides of one of said cavities.

6. In internal combustion heating apparatus, means defining a tubular combustion chamber having the inner surface thereof formed with longitudinally extending angularly spaced cavities with openings in communication with said combustion chamber, each of said cavities having the longitudinally extending sides thereof converging together to form a slit-like opening, means for supplying a substantially completely vaporous mixture of air and fuel to said combustion chamber for burning adjacent said cavities, whereby any fuel particles in said combustion chamber will collect in said cavities and be vaporized by the heat therein, and a partition structure dividing said chamber into a plurality of fluid connected passages and including a plurality of V-shaped members joined at their apexes centrally of said chamber and provided with walls each having an edge portion held between the converged edge portions of the sides of one of said cavities.

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