April 28, 1959 A. C. ALLEN 2,884,196

COMBUSTION HEATER CONTROL

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Fig. 1.

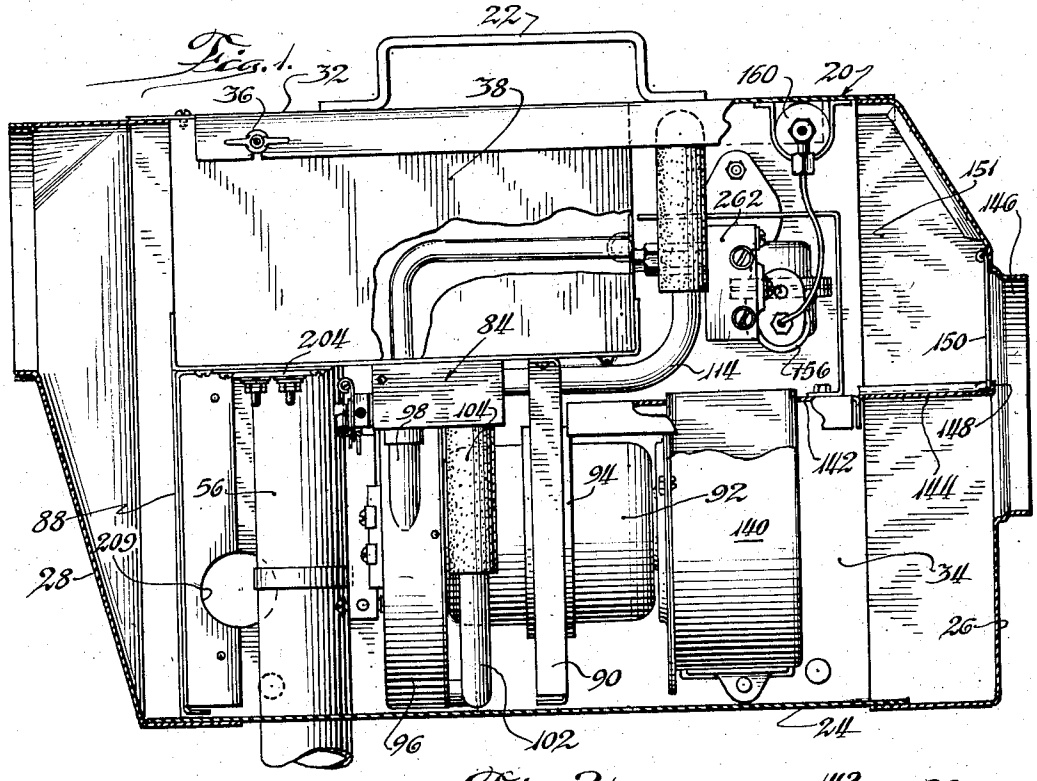
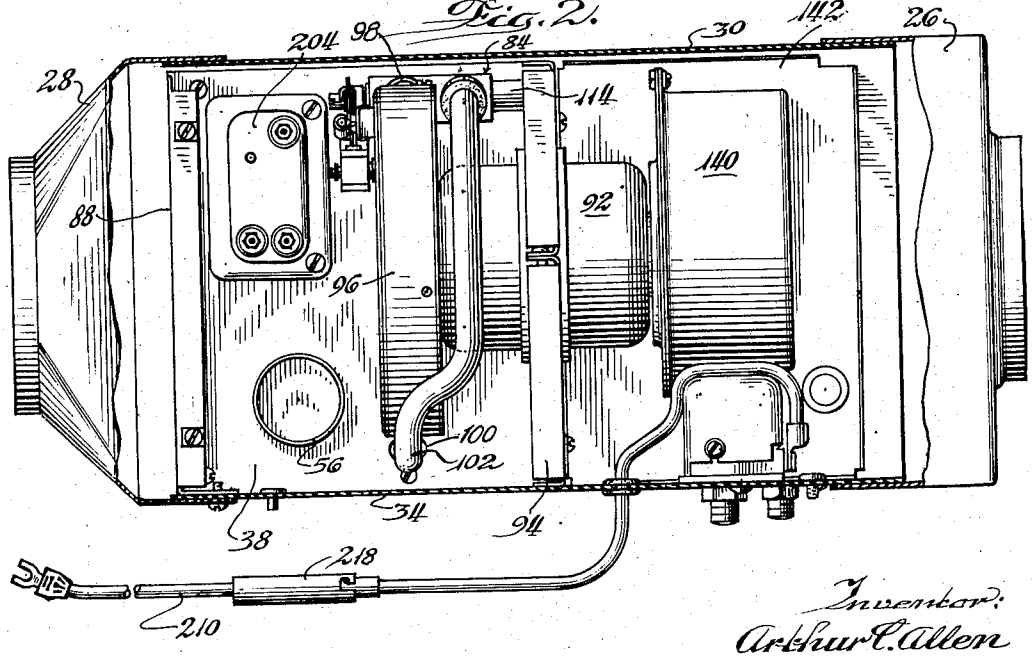


Fig. 2.



Inventor:
Arthur C. Allen
By Ahlberg, Kupper & Gradolph
Attorneys.

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COMBUSTION HEATER CONTROL

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Fig. 3.

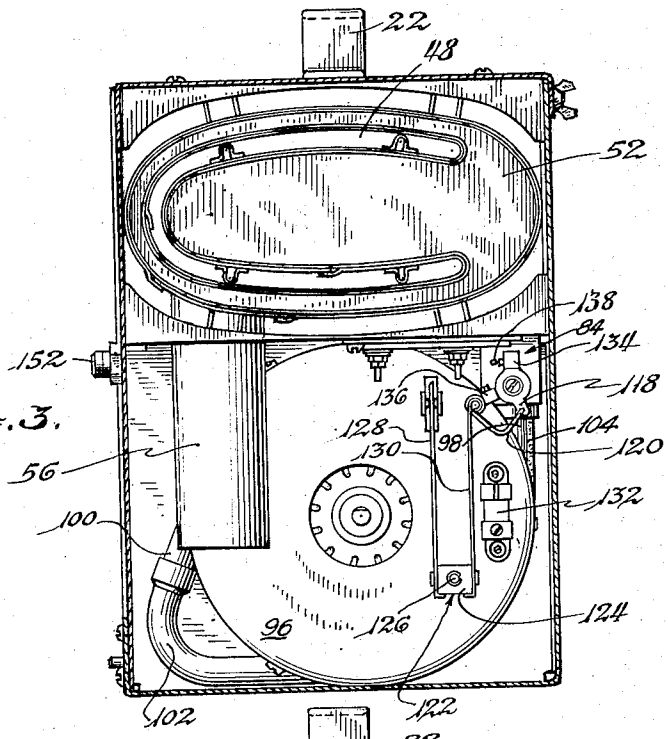
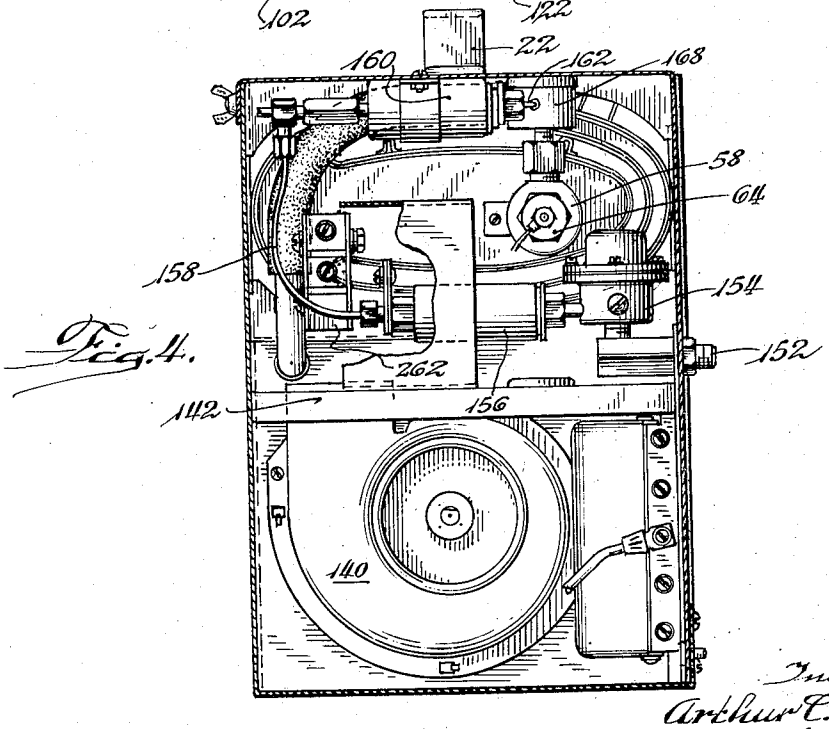


Fig. 4.



Inventor:
Arthur C. Allen
By Ahlberg, Wupper & Gradolph
Attorneys

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COMBUSTION HEATER CONTROL

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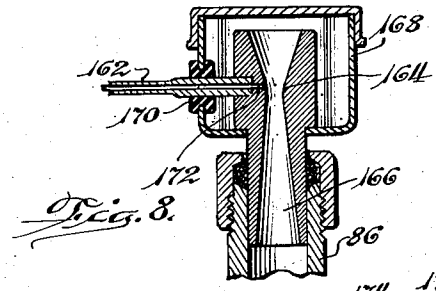


Fig. 8.

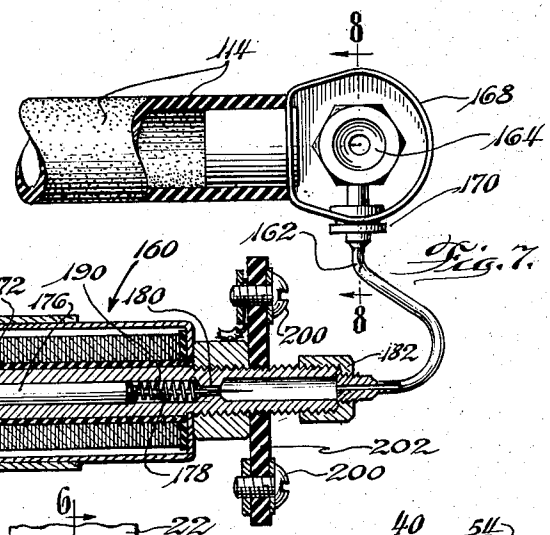
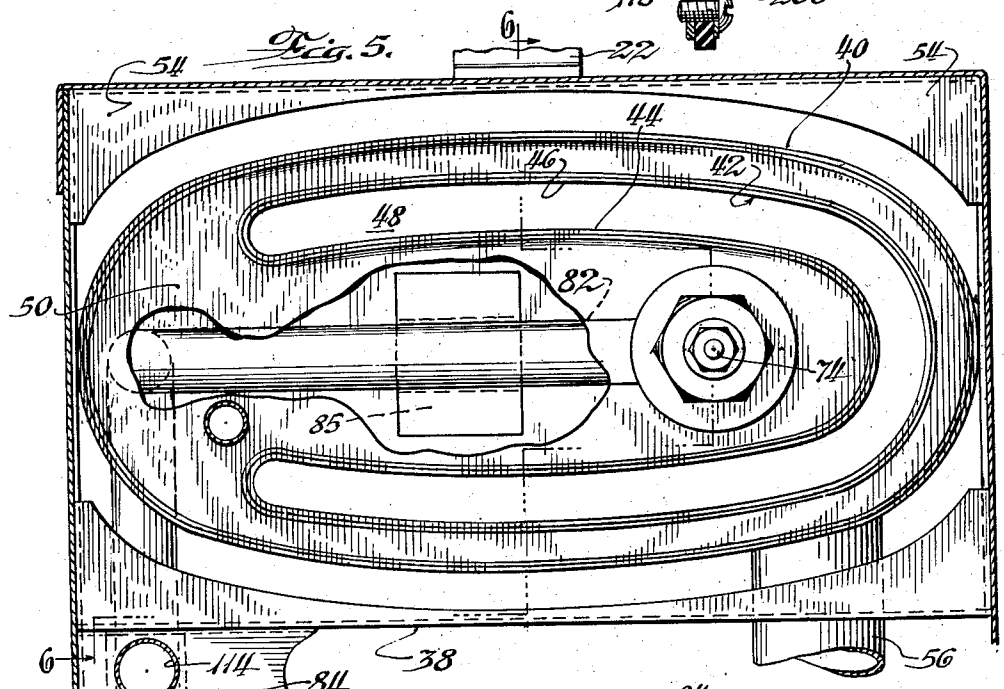


Fig. 7.

Fig. 5.



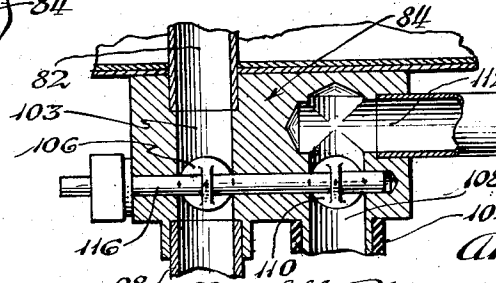


Fig. 9.

Inventor:
Arthur C. Allen
By Ahlberg, Wupper & Gradolph
Attorneys

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Fig. 6.

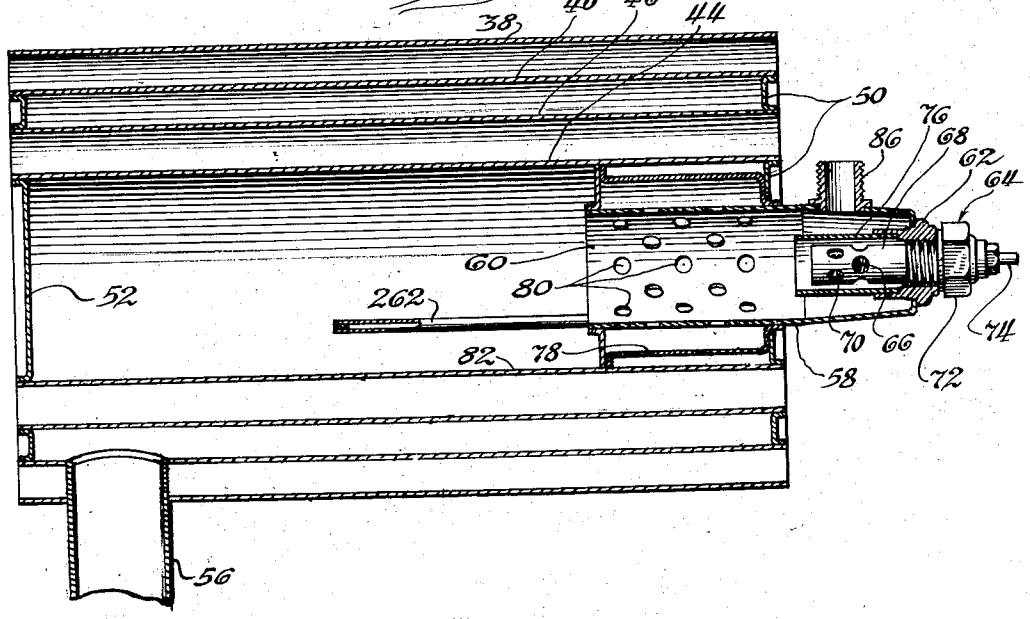
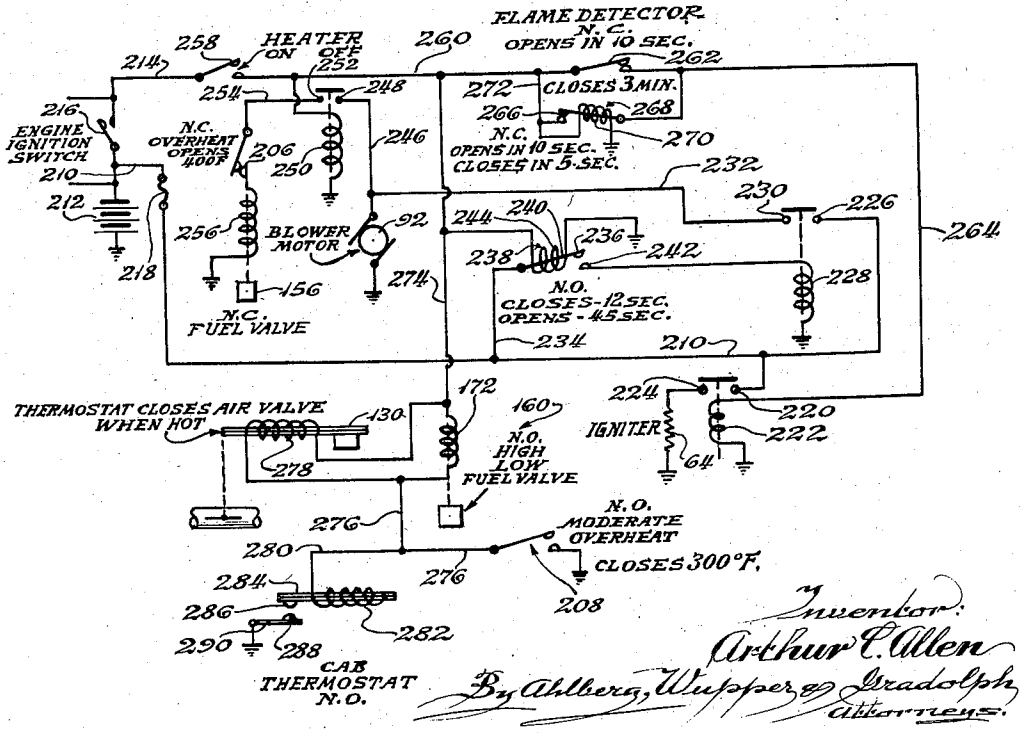


Fig. 10.



Inventor:
Arthur C. Allen
By Ahlberg, Wupper & Gradolph
Attorneys.

United States Patent Office 2,884,196 Patented Apr. 28, 1959

2,884,196

COMBUSTION HEATER CONTROL

Arthur C. Allen, Chicago, Ill., assignor to Stewart-Warner Corporation, Chicago, Ill., a corporation of Virginia

Application August 10, 1953, Serial No. 373,335
5 Claims. (Cl. 236—1)

The present invention relates to combustion heaters, particularly compact sealed heaters of this type well adapted for use in automotive vehicles and which are intended for operation on the same fuel as the vehicle engine.

One of the objects of the present invention is to provide a novel self contained heater which is well adapted for operation from a pressurized fuel connection and the electrical connections available in automotive vehicles.

Yet another object is to provide an improved heater of the above type which establishes a high standard of safety and efficiency and which may be manufactured at relatively low cost.

Still another object is to provide a novel automobile heater which is easily installed as a unit in any available space within an automobile or like vehicle and which is well adapted for automatic regulation to supply the amount of heat necessary to maintain a predetermined temperature level within the space to be heated under fluctuating ambient conditions.

Yet another object is to provide an improved heater adapted for operation upon gasoline or similar fuels which has a novel arrangement for varying the heat output of the heater depending upon the prevailing conditions.

Yet another object is to provide a novel heater of the above type which has improved mechanisms and control devices for aiding the starting thereof.

Still another object is to provide an improved heater of the type discussed above which imposes a minimum load upon the vehicle electrical system commensurate with the heating effect produced.

Other objects and advantages will become apparent from the following description of a preferred embodiment of my invention which is illustrated in the accompanying drawings.

In the drawings, in which similar characters of reference refer to similar parts throughout the several views:

Fig. 1 is a vertical longitudinal sectional view taken just inside the case wall of the heater, showing one side of the operating mechanism in elevation;

Fig. 2 is a bottom view of the heater with the major portion of the case wall broken away so as to show the operating mechanism in elevation;

Fig. 3 is a vertical transverse sectional view just inside the end wall of the heater, showing the operating portion of the heater mechanism at the outlet end;

Fig. 4 is a view similar to Fig. 3 excepting that it shows the inlet end of the heater;

Fig. 5 is an enlarged end view of the heater burner and heat exchanger at the inlet end of the heat exchanger;

Fig. 6 is a longitudinal vertical sectional view through the burner and heat exchanger and may be considered as taken substantially along the line 6—6 of Fig. 5 in the direction indicated by the arrows;

Fig. 7 is a horizontal sectional view taken downwardly through a portion of the fuel control and mixing mechanism of the heater of the present invention.

Fig. 8 is a vertical transverse sectional view which may be considered as taken in the direction of the arrows substantially along the line 8—8 of Fig. 7;

Fig. 9 is a fractional longitudinal vertical sectional view

through a portion of the combustion air control mechanism of the heater of the present invention; and

Fig. 10 is a circuit diagram of the heater electrical operating and temperature controlling system.

By referring principally to Figs. 1 to 4 of the drawings, it will appear that the heater which forms the subject matter of the present invention is made up of a group of operating elements enclosed within a rectangular case indicated generally by the numeral 20. As shown, the top of the case is equipped with a handle 22 which may be used for carrying the device and which is also useful for lifting out the entire operating portion of the mechanism in one easily removable assembly in the event that servicing is required. This arrangement also of course facilitates installation of the heater.

The case is made up of panels of sheet metal properly shaped and welded or otherwise suitably secured together to form a base plate 24 connected at its ends to ventilating air inlet and outlet adapters 26 and 28, respectively. These adapters and the base are also secured to an upstanding front panel 30. This assembly is to be fixed in place in the automotive vehicle with the adapters connected into a suitable ducting system for the ventilating air.

The top panel, indicated at 32, is secured to a downwardly extending back panel 34 which is parallel to the front panel 30. All of the heater operating mechanism which might need servicing is attached to the cover and back panel so that by loosening appropriately arranged wing nuts, one is indicated at 36, all of the operating mechanism can be lifted out of the assembly by the handle 22.

In the upper left portion of Fig. 1 there is a rectangular case 38 open at both ends which contains the combined heat exchanger and burner unit for the heater. The outermost heat exchange element is an oval sheet metal tube 40 which extends from end to end of the rectangular casing 38. Inside the tube 40 there is a second sheet indicated at 42 which may be considered as a cylinder which has been re-entrantly folded from one side so as to form a U-shaped structure with the inside surface thereof shown at 44 continuous with the external surface at 46. These two surfaces 44 and 46 are spaced from each other by an approximately constant distance excepting where they are joined together at the ends of the arms of the U. This structure therefore forms a slot 48 which is U-shaped in cross section extending from end to end of the heat exchanger and lying between the surfaces 44 and 46. Transverse header plates 50 and 52 are arranged at each end of the heat exchanger and are welded to the sheets 40 and 42 so that the space within the oval shaped tube 40 is sealed at both ends excepting for the U-shaped slot 48. Therefore ventilating air introduced at one end of the heat exchanger can flow longitudinally therethrough by way of the slot 48 and can also flow along the external surface of the oval tube 40 between this tube and the rectangular shell 38. Preferably, so as to distribute the ventilating air more uniformly over the heat exchange surface the rectangular shell 38 is fitted internally with baffles 54 which are spaced from the tubular sheet 40, but which in general conform to the contour thereof.

The burner for the heater is located in the end header plate 50 along the horizontal center line of the heat exchanger and toward the back thereof, so that it is near the bight of the U formed by the internal sheet 34. Thus, burning gases from this burner flow into the combustion chamber space at the center of the heat exchanger. From there they travel toward the front of the heater through the slot between the arms of the U-shaped sheet 42. The hot gases then divide, a portion flowing upwardly and the remainder downwardly and both flowing reversely between the heat exchanger ex-

ternal sheet 40 and the external sheet 46 of the U-shaped structure. The hot products of combustion in both the upper and lower passes eventually reach and flow through a downwardly extending exhaust spud 56 which communicates with the gas passage of the heat exchanger through the lower surface of the external oval tube 40. These hot products of combustion, therefore, raise the temperature of the entire surface of the re-entrantly folded sheet 42 and also the external heat exchange tube 40 and this heat is exchanged to ventilating air passing longitudinally through the heat exchanger by way of the U-shaped slot 48 and the oval slot externally of the tube 40.

The burner is made up of a generally cylindrical tube 58 one end of which is open as indicated at 60 while the other end is tapered downwardly somewhat and is closed by a bushing 62 internally threaded to receive an igniter of the hot wire type. This igniter extends approximately a third of the way into the tubular shell 58 and consists of a coil of resistance wire 66 lying within a cylindrical sleeve 68 which has a perforated side wall as indicated at 70. The shell 68 and the heating element 66 are secured to a head element 72 threaded to fit the bushing 62 and providing a terminal 74 for attachment of one side of the electrical energizing circuit, the other side being grounded.

The igniter shell 68 lies within a second concentric cylindrical shell 76 secured to the bushing 62. This second shell 76 prevents liquid fuel from coming directly into contact with the inner shell 68 and heating coil 66. The heating and electrical characteristics of the igniter, therefore, are not appreciably affected by the collection of carbon deposits as is frequently the case with hot wire igniters.

The portion of the burner tube 58 within the heat exchanger is enclosed within a generally cylindrical shroud 78 which is sealed at both ends to the burner tube 58 and which communicates with the interior of the burner tube 58 through a plurality of perforations 80 drilled or punched through the side wall of the tube 58 within the zone confined by the shroud 78.

The shroud 78 receives combustion air by way of a bent tube 82. By referring to Fig. 5 of the drawings it will be seen that this air tube 82 extends from the air shroud 78 along the inside face of the header plate 50 in a horizontal direction so that it passes between the arms of the U-shaped sheet 42. The tube 82 is supported by being welded to the shroud 78 at its end and also by a sheet metal clip 85 which embraces this tube and is welded to the inside surface of the header plate 50. Near the front of the heat exchanger the tube 82 is bent at right angles so as to extend toward the center of the front of the heat exchanger in a horizontal direction. At approximately the center of the front of the heat exchanger the tube 82 is again bent at right angles so as to extend downwardly through the external heat exchanger sheet 40 and through the heat exchanger case 38. It therefore emerges from the heat exchanger structure in a downwardly direction near the front edge thereof as seen in Fig. 1. Externally of the heat exchanger structure the tube 82 enters a combustion air control valve box indicated generally by the numeral 84. This latter structure will be described in greater detail presently, it being necessary at this juncture merely to appreciate that it serves as a means for supplying a regulated rate of combustion air to the inlet end of the tube 82.

A rich fuel and air mixture is supplied to the burner tube 58 near its external end by way of a fitting 86 which is welded into the top side of the tube in a position directly above the shell 76 which protects the igniter proper. The means for supplying the rich fuel and air mixture to the fitting 86 will be discussed subsequently in connection with the fuel supply system for the heater.

The space beneath the heat exchanger casing 38 is partitioned transversely below the outlet end of the heat exchanger by a panel 88 which seals the space below the heat exchanger casing 38 from communication with ventilating air leaving the heat exchanger. Near the opposite end of the heat exchanger casing 38 the space therebelow is partitioned transversely by a second wall 90 which also supports a longitudinally extending electric motor 92 at its center. Preferably the motor casing is surrounded by a rubber shock absorbing ring 94 which is secured in an opening in the wall 90. This prevents vibration being transferred from the motor casing to the remaining portion of the structure.

The left hand end of the motor 92 supports and drives a centrifugal combustion air blower 96 which has its central inlet faced away from the motor 92. This blower 96 has two tangential outlet fittings 98 and 100 approximately 180° apart such that one fitting 98 is on the forward surface of the blower casing as seen in Fig. 1 and extends straight upwardly into the combustion air valve box 84 near its left end. The other blower outlet fitting 100 is connected to a tube 102 which extends alongside the casing of the blower 96 in a position beneath the motor 92 to the front of the heater and thence upwardly so as to be connected by a length of rubber tubing 104 to a fitting near the right hand end of the combustion air valve box 84.

The valve box 84, as is best seen in Fig. 9, has a vertical passage 103 extending therethrough from the blower outlet 98 to the combustion air tube 82, with a butterfly valve 106 within this valve passage. A separate valve passage 108 is connected to the blower tube 104 and extends upwardly into the valve box 84. This second passage 108 is also provided with a butterfly valve 110 and above this valve the passage 108 is connected to an intersecting outlet passage 112 leading to an outlet tube 114 which extends to mechanism to be described presently for forming a rich fuel and air mixture for the burner. The two butterfly valves 106 and 110 are mounted upon a common shaft 116 which extends out of the left hand end of the valve box 84 where this free end is connected to a fitting providing a crank arm 118 linked in turn by a piece of bent stiff wire 120 to the free end of a compensated thermostatic element indicated generally by the numeral 122.

The compensated thermostatic element 122 consists of a small block 124 which is generally rectangular and which is pivoted for rotation about a horizontal pin 126 fixed to the left face of the housing of the blower 96. The opposite parallel vertical sides of the block 124 are connected to the lower ends of vertical thermostatic bimetal blades indicated at 128 and 130. These blades have substantially identical characteristics. The upper end of the blade 128 is anchored to a fitting attached to the face of the combustion air blower housing, whereas the free end of the other bimetal blade 130 is connected to the link 120 previously mentioned. Changes in the ambient temperature surrounding the compensated thermostat 122 therefore do not affect the position of the link 120, since both bimetal elements will distort identically and in the same direction. The deflection of one will cancel the deflection of the other.

For a reason to be pointed out presently during the discussion of the electrical circuit, the bimetal blade 130, which is attached to the link 120 is wound with an insulated resistance wire heating element, the ends of which are connected to terminals mounted upon a terminal block 132 which is attached to the left hand face of the combustion air blower housing. Whenever the electrical terminals on the block 132 are energized, the temperature of the heating eelment wound about the thermostatic blade 130 will rise and causes the free end of the blade 130 to move toward the left as seen in Fig. 3. This pulls the link 120 toward the left and causes rotation of the crank arm 118 in a clockwise direction as seen in Fig. 3. This in turn causes rotation of the valve shaft 116 which has the effect of partially closing both of the butterfly valves

106 and 110. In order to provide limits for the rotational movement of the valve shaft 116, the fitting at the end thereof which carries the crank arm 118 also carries a pair of radial arms 134 and 136 which are provided with adjustment screws extending therethrough substantially tangentially with respect to the circle through which they move when the shaft 116 is rotated. They are so positioned that when the shaft 116 is oscillated, the ends of these screws strike against a horizontal pin 138 located between them and extending outwardly from the end of the valve box 84. This arrangement may best be seen in Fig. 3.

At its right hand end as seen in Figs. 1 and 2 the motor 92 supports and drives a centrifugal ventilating air blower indicated generally by the numeral 140. The inlet of this blower faces toward the right, while the outlet thereof extends straight upwardly and exhausts into the space to the right of the inlet end of the heat exchanger. In order to prevent air leaving the exhaust of the blower 40 from finding its way back to the blower inlet, a horizontal partition 142 is located above the blower and surrounds the outlet thereof. It extends from front to back of the heater case and from the partition 90 to the inside edge of the air adapter fitting 26 where it is in alignment with a similar horizontal shelf 144 which acts as a continuation thereof into the inlet air adapter. The shelf 144 is so positioned that it approximately bisects a circular inlet spud 146 in the adapter 26 through which ventilating air is brought by ductwork to the heater.

As best seen in Fig. 1, the right hand edge of the shell 144 is bent upwardly at right angles so as to form a stop 148 for the lower edge of a horizontally hinged depending check valve plate 150. This plate 150 is generally rectangular and is hinged in a position above the inlet spud 146 such that when the pressure in the ventilating air inlet compartment 151 formed by the heater case and partitioning just mentioned is greater than the pressure in the inlet spud 146, the valve plate 150 will be swung toward the right against the stop 148 thereby effectively preventing air in the compartment 151 at the inlet end of the heat exchanger from escaping into the spud 146. On the other hand if the pressure within the spud 146 is greater than that in the inlet compartment 151, the valve plate 150 will be swung toward the left, thereby permitting air to enter the compartment 151 from the inlet spud 146.

Ordinarily with the motor operating, the pressure in the heat exchanger inlet compartment 151 will be higher than that in the inlet spud 146 because of the pressure boost given by the blower 142. However, the spud 146 will ordinarily be connected to a scoop or ram which faces forwardly of the automotive vehicle in the slip stream thereof. The ramming effect will thus produce a pressure within the spud 146 which is greater than that tending to hold the valve plate 150 in closed position when the vehicle reaches a speed of twenty to thirty miles an hour or so. Under these conditions the valve 150 will open and permit air to enter the chamber 151 directly from the spud 146. This has an important advantage in that the blower 142 need not be of sufficient capacity to supply ventilating air through the heat exchanger and to the space to be heated in the quantity needed under the conditions which prevail when the vehicle is traveling rapidly. It does provide a means, however, for keeping the heater in operation at a satisfactory level of heat output to take care of the need when the vehicle is stationary or traveling at low speed. This is because heat is much less rapidly exchanged from the interior of a vehicle to the outside air when it is stationary or moving slowly and therefore less heat is needed under these conditions.

Fuel for the heater is ordinarily obtained from the pressure side of the fuel pump customarily present for feeding the engine carburetor of the automotive vehicle. If desired, a separate pump may of course be used. This fuel enters the heater by way of a fitting 152 which may be seen in Figs. 3 and 4. Fuel so entering passes upwardly to a conventional automatic pressure regulator 154 which serves to insure that the fuel on the outlet side thereof is at a low but comparatively constant pressure. From the automatic pressure regulator 154 the fuel passes through a conventional on-off solenoid valve 156 and thence by way of a tube 158 to a high-low solenoid valve 160. It then passes through a small tube 162 to the throat of a venturi 164 which has its outlet end 166 in communication with the fitting 86 on the heater burner. The upper air inlet end of the venturi 164 is enclosed within a chamber 168 formed of sheet metal which receives air from the tube 114 previously mentioned as being attached to the fitting at the right hand end of the combustion air valve 84.

To promote convenience in assembly and disassembly, the end of the tube 162 is somewhat enlarged so as to form a tight fit through a rubber grommet in the side wall of the chamber 168 when the outlet end of the tube 162 is seated within a socket in the side wall of the venturi fitting 164, this socket being connected to the venturi throat by a drilled passage 172. Thus in assembling the high-low valve with respect to the heater burner it is necessary merely to push the end of the tube 162 through the grommet 170 as far as it will go. Disassembly is of course accomplished by simply pulling the end of the tube 162 out of the grommet 170.

The construction of the high-low valve is apparent from Fig. 7. In this figure a solenoid coil indicated at 172 is shown as fitted over a tube 174 formed of non-magnetic material. Within this tube is a loose fitting plunger 176 formed of magnetic material. At its right or downstream end this plunger carries a finely tapered needle 178 which extends through a small orifice 180 in an obstruction within the tube 174, such that as the plunger 176 is moved toward the right the orifice 180 is progressively closed. Downstream of the orifice 180 the tube 174 is externally threaded and connected by a suitable fitting 182 to the inlet end of the tube 162 previously mentioned as leading to the venturi 164.

The inlet end of the tube 174 is connected to a T fitting 184 which receives fuel at its right angle connection from the on-off solenoid valve. The T fitting connection in alignment with the tube 174 contains a threaded adjusting screw 186 which can be turned inwardly or outwardly to form a stop limiting the movement of the plunger 176 in the opening direction. The upstream end of the plunger 176 is threaded and carries a split collar 188 threaded thereto which is large enough to strike against the end of the tube 174 and act as a stop to limit movement of the plunger 176 in the left hand or closing direction of the valve. The collar 188 nominally has a pitch diameter slightly less than that of the threaded end of the stem 176 and is somewhat sprung when threaded upon this stem. It clamps tightly therefore and remains in whatever position it is set. The stem 176 is urged toward the left, that is in the opening direction of the valve, by a soft acting coil spring 190 which surrounds the needle 178 and bears against the upstream face of the tube constriction through which the orifice 180 is formed.

Ordinarily, therefore, the valve is at rest with the valve stem 176 all the way to the left, with its head end against the end of the screw 76. Under these conditions the valve is in the full flow position. Whenever the coil 172 is energized, the magnetic field so produced acting upon the valve stem 176 will cause the stem to move toward the right until the collar 188 strikes against the end of the tube 174, thereby shifting the valve so as to restrict the flow of fuel therethrough to a relatively low level. Because the stroke of the valve is comparatively long and the taper of the needle 178 is quite gradual, the needle acts in an effective manner to keep the orifice clear of obstructions which are frequently troublesome in valves

of this general character because the passage through the valve must be quite small particularly when the valve is in the low heat output position.

Conveniently the electrical leads for the solenoid 172 can be brought out and attached to terminals 200 attached at the end of an insulating strip 202 threaded at its center to the end of the tube 174. Previously it was mentioned that the plunger 176 is a loose fit within the tube 174. This is done so that fuel can flow from end to end through the tube 174 with substantially no restriction excepting that imposed by the needle 178 in the orifice 180.

Near the outlet end of the heat exchanger the lower surface of the casing 38 has an opening therethrough, not shown, which is covered by a plate 204, best seen in Figs. 1 and 2. This plate supports a pair of bimetal thermostatic blades on its upper surface such that when the plate 204 is in position covering the opening in the heat exchanger casing 38, these bimetal blades are subjected to the heating effect produced both by the hot ventilating air flowing over them and also by radiation directly from the hot heat exchanger shell. These two thermostatic blades are not shown excepting in the circuit diagram since they are essentially conventional in construction, only their terminals being shown in Figs. 1 and 2. They are so adjusted that one of them to be referred to as the "overheat" switch 206 is normally closed and opens at a relatively high temperature, for instance, something of the order of 400° F. The other, which will be referred to as the "moderate overheat" switch 208 is normally open and closes at a somewhat lower temperature, for instance of the order of 300° F. Both switches are of the single pole single throw type.

In addition to the previously mentioned ventilating air ducts and fuel line connections to the heater and the electrical connections to be mentioned presently, the usual installation will include an exhaust pipe connected to the exhaust spud 56, and it may include a combustion air inlet pipe not shown, but which if it is used is to be connected at an opening 209 through one of the heater case walls into the space between the partitions 90 and 88. This opening 209 or an inlet air pipe connected thereto is of course for the purpose of supplying air to the inlet of blower 96.

By premixing a portion of the combustion air with the fuel at the venturi 164 a rich but predetermined mixture is formed which is readily ignited for starting. Also this arrangement of introducing a rich mixture to the burner tube and subsequently diluting it with an additional quantity of hot combustion air gives very smooth operation even when a comparatively long exhaust pipe is attached to the heater. By supplying combustion air to the fuel and air mixer and to the burner tube directly through separate passages having separate control valves, these valves can be adjusted relative to each other to produce the most efficient operation. Also by having the connections for these separate passages connected to separate blower outlets 100 and 98, which are spaced well apart circumferentially on the combustion air blower case, adjustment of the butterfly valves to obtain a proper balance of combustion air flow through the two passages is easily accomplished, since flow through one of the passages is not appreciably affected by the rate of flow through the other.

The electrical circuit for this heater is equipped with two leads in addition to a ground. One of these leads indicated at 210 is connected directly to one side of the battery 212 of the vehicle, the other side of this battery being grounded. The other heater lead 214 is connected to the vehicle ignition switch 216 on the same side as the vehicle ignition coil. Lead 210, therefore, is always energized, whereas lead 214 is energized only when the vehicle engine is functioning.

Lead 210 is connected through a fuse 218 to one of the terminals 220 of a normally open single pole, single throw, relay which is closed by energization of a coil 222. The other terminal 224 of this relay is connected to ground through the heater igniter 64. Lead 210 is also connected to one of the terminals 226 of a second single pole, single throw, normally open relay which is closed by the energization of coil 228. The other contact 230 of this relay is connected by a lead 232 to one side of the blower motor 92 the other side of which is grounded.

The main lead 210 is also connected by a branch 234 to one of the contacts 236 of a time delay relay 238. This relay is of the common type which is comprised of a bimetal blade 240 which holds the contact 236 separated from its mate 242 unless the blade 240 is heated by the energization of a resistance coil 244 wound thereon. This relay is of the single pole, single throw, normally open variety, and its characteristics in the present example are such that when the coil 244 is energized contacts 236 and 244 will close in approximately twelve seconds. Whenever the coil 244 is deenergized, these contacts will separate in approximately forty-five seconds. The relay contact 236 closes against contact 242 which is connected to ground through relay coil 228.

Motor lead 232 is also connected by a branch 246 to one of the terminals 248 of a normally open, single pole, single throw relay which is closed by the energization of coil 250. The other contact 252 of this relay is connected to a lead 254 to the normally closed, single pole, single throw overheat switch 206, which in turn is connected to one end of the coil 256 which energizes the normally closed on-off fuel valve 156, the other side of this coil being grounded.

The lead 214 is connected to one side of the heater on-off single pole, single throw switch 258 which on its other side is connected to ground by way of relay coil 250. The cold side of heater switch 258 is also connected to a lead 260 which extends through a normally closed single pole, single throw flame detector switch 262 to a lead 264 connected in turn to one side of relay coil 222 the other side of which is grounded.

Although any suitable flame detector switch may be used in the application indicated at 262, I prefer that it be of the type actuated by the differential expansion of a heat and corrosion resistant metal tube enclosing a low expansion rod, made preferably of a material such as fused quartz for instance. To those unfamiliar with thermostatic flame detector switches of this type reference may be had to Patent No. 2,581,942 issued January 8, 1952, to A. R. Collins et al. which illustrates and explains a switch of this character. As shown in Fig. 6 this thermostatic flame detector is mounted upon the end plate 50 of the heat exchanger so that its sensitive element extends into the gas passage thereof so that the actuating element of the switch is submerged in the hot products of combustion. In the specific arrangement herein described this flame detector switch 262 is adjusted to open in about ten seconds after combustion has been established and under the conditions of operation requires about three minutes to close after the extinguishment of combustion.

Flame detector 262 is wired in parallel with the contacts 262 of a normally closed time delay single pole, single throw relay 268. This relay, like relay 238, is of the type comprised of a thermostatic bimetal element which is heated by a coil of resistance wire 270, this coil being connected between lead 260 and the ground by a branch 272. This relay opens in about ten seconds after being energized and recloses in about five seconds when deenergized.

A branch 274 extends from the lead 260 to ground through time delay relay coil 244 and also is connected to one end of the coil 172 of the normally open high-low fuel valve 160, the other end of which is wired through a lead 276 to one side of the normally open moderate overheat switch 208 the other side of which is grounded.

The resistance heating coil indicated at 278 for the bimetal blade 130 which actuates the combustion air valve butterflies is wired in parallel across the coil 172 of the high-low fuel valve so that these coils are energized together.

Lead 276 is also connected by a branch 280 to one end of a heating coil 282 which is in heat exchange relation to a bimetal blade 284 to which the opposite end of the coil 282 is connected. This bimetal blade 284 carries a contact 286 which cooperates with a second contact 288 mounted upon a second bimetal blade connected to ground. The bimetal blade 284 is so oriented that when the contacts 286 and 288 are closed they will soon be separated after the coil 282 has been energized. Thus when lead 280 is energized contacts 286 and 288 will cycle open and closed, since current flow through the coil 282 to ground by way of contacts 286 and 288 will cause the contacts to separate, after which the bimetal element 284 will cool until the contacts 286 and 288 are again together, whereupon the cycle will be repeated.

A practical embodiment of an impulse sending thermostat of this type is illustrated and described in my copending application Serial No. 350,731 filed April 23, 1953, now Patent No. 2,740,862. In that and in the present arrangement the second thermostatic element 290 is positioned so as to be sensitive to the temperature of the air within the space to be heated. As the temperature therein rises, contact 288 is moved toward contact 286 until they touch, whereupon the pulsing starts and as the temperature within the space continues to rise, the current impulses become longer and the time intervals between these impulses shorter. The converse of this is of course also true. The temperature within the space to be heated therefore can be preset by the user of this system by adjusting the position of the mount for the bimetal blade 288.

The circuit diagram of Fig. 10 is illustrated with the elements thereof as they are with the system at rest. Under these conditions the magnetic on-off fuel valve 156 is closed while the high-low fuel valve 160 is in the high or full flow position. Since the on-off valve is closed no fuel can flow to the heater. Inasmuch as the engine ignition switch 216 will normally be open, the lead 214 is not energized. However, lead 210 connected directly to the battery 212 is energized, with the result that relay contacts 220, 226 and 230 are energized. These contacts are all open, however, and the system is therefore merely conditioned for operation. If now the engine ignition switch is closed, lead 214 is energized but the circuit in this branch is open at the heater switch 258.

If now the heater on-off switch is closed, lead 260 is energized along with the normally closed contacts 262 of the flame detector, lead 264, and relay coil 222. This closes relay contacts 220—224 with the result that igniter 64 receives energization by way of these contacts and lead 210 connected directly to the battery 212. The igniter therefore begins to heat. Also coil 250 is energized so as to close relay contacts 248—252. Simultaneously, heater coil 244 for the time delay relay 238 starts to heat with the result that this relay will close in approximately twelve seconds. In addition, relay heater 270 is energized so as to open contacts 266 in about ten seconds. Neither the high-low fuel valve coil 172 nor the heater 278 for the combustion air control valve will be energized, since the contacts of the moderate overheat switch 208 are open as are the contacts 286—288 of the cab thermostat. For ten seconds, therefore, the only operating elements energized are the igniter 64 and the relay heaters 244 and 270. The igniter therefore has an opportunity to heat to ignition temperature before the fuel and combustion air are supplied. This greatly facilitates starting, since it prevents the possibility of the heater becoming loaded with excess fuel during the interval while the igniter is heating.

At the end of approximately ten seconds, relay contacts 266 open, but since they are in parallel with closed contacts 262 the starting conditions are not changed. After about twelve seconds, time delay relay contacts 236 and 242 close with the result that energy is supplied to relay coil 228 thereby closing relay contacts 230 and 226. Current is therefore supplied from the main line 210 by way of relay contacts 226 and 230 to lead 232 and thence to the blower motor 92 as well as by way of closed relay contacts 248 and 254 to the on-off fuel valve coil 256 through the normally closed overheat thermostatic switch 206. The fuel is therefore turned on and combustion and ventilating air are supplied to the heater. Under these conditions the heater will start immediately, since the igniter is already hot.

As soon as the combustible mixture within the heater is ignited, the flame detector switch 262 begins to heat and will open in about ten seconds. As soon as this happens, lead 264 and relay coil 222 are deenergized thereby separating contacts 220 and 224 so as to deenergize the igniter 64. The heater therefore continues in operation with the igniter deenergized.

With the heater running at full output, the temperature within the space to be heated will soon rise sufficiently to heat thermostatic element 290 enough to bring contact 288 against contact 286. Current is therefore supplied from branch lead 274 through the high-low fuel valve coil 172, and by way of heater element 278 to lead 276 and thence to ground by way of the heating element 282 for the thermostatic impulse sending unit and contacts 286—290 thereof. This causes contacts 286 and 288 to pulse open and closed as previously described and results in intermittent energization of coil 278 and the gradual heating of thermostatic blade 130. This tends to shift the butterfly valves 106 and 110 toward the restricting position. This heating effect takes place slowly enough to produce steady motion or positioning of the valves 106 and 110, which is a function of the average current flowing through coil 278. Each current impulse, however, shifts the high-low fuel valve 160 to the restricting position for the duration of the impulse. The result is that whereas the butterfly valves in the combustion air supply system modulate the airflow rate according to need, the fuel is modulated by interspersing periods of high flow rate with low flow rate, these periods being of short duration. Because of the fact that there is some delay between the time fuel enters the burner and the time it is vaporized and burned, the heater does not surge inasmuch as the intervals between shifting of the modulating valve are short as compared with the interval required for the burner to respond to an increase or decrease in the rate of fuel flow. Pulsing of the needle of the high-low valve, however, serves as a very effective means for keeping the fuel restricting orifice 180 clear of obstructions.

As the temperature within the space to be heated rises, the thermostatic element 290 will be distorted more and more so that the contact 288 is against contact 286 for a longer period of time. The result is that the high-low fuel valve is in the restricting position a larger and larger portion of the time, whereas the air control butterfly valves 106 and 110 are moved farther and farther toward the full restricting position. The output of the heater, therefore, becomes less and less as the need for heat is reduced. The converse of this is also true.

If at any time during the operation of the heater, the temperature of the moderate overheat switch 208 should rise to 300° F. this switch closes, thereby affecting the operation of the heater burner in exactly the same manner as does closing the contacts 286 and 288 of the cab thermostat. In other words closing of the moderate overheat switch 208 shifts the heater to low output condition. Reduction of the heat output soon results in the moderate overheat switch reopening so that the heating system is returned to full output condition.

Ordinarily with the vehicle at rest or traveling slowly,

the moderate overheat switch may close occasionally. This is because the heat supplied by the burner under conditions of full output is more than can be conducted away by the ventilating air stream, particularly if it is warm, at the rate ventilating air is supplied by the blower **120**. As soon as the vehicle is under way at a reasonable speed, however, the pressure within the inlet spud **146** will rise in the manner previously described, thereby opening the check valve **150** and supplying the heater with an additional quantity of ventilating air. Ordinarily under these conditions the moderate overheat switch will not close. The heater therefore is capable of supplying more heat to the space to be heated when the vehicle is traveling at speed than it will when the vehicle is stationary. This has a considerable advantage in that a smaller blower and motor **92** are adequate for operation of the heater when the vehicle is stationary and does not need full output, and therefore the drain upon the electrical system of the vehicle is less than would be true if the motor **92** were required to supply all of the ventilating air for heating the space occupied under all conditions.

If for any reason the heater overheats, switch contacts **206** will be opened, thereby deenergizing the on-off fuel valve coil **256** so as to close the fuel valve **156** thereby shutting off the flow of fuel to the heater.

Whenever the heater on-off switch **258** is opened, the fuel will be shut off since the fuel valve coil **256** depends for its energization upon the energization of relay coil **250**. Also time delay relay heater coils **244** and **270** will be deenergized with the result that relay contacts **266** will reclose in approximately five seconds whereas relay contacts **236** and **242** will open in approximately forty-five seconds. The effect of this is that the blower motor **92** continues to run for approximately three-quarters of a minute so as to cool down the heater and clear out the products of combustion.

If after the heater on-off switch has been opened it is desired to reclose it comparatively promptly, the igniter relay coil **222** will be energized by way of contacts **266** of the time delay relay **268** which closes in about five seconds even though the contacts of flame detector relay **262** will still be open for a matter of three minutes or so. The heater, therefore, restarts promptly even though the rate of response of the flame detector in the closing direction is comparatively slow as is usual with devices of this character if they are rugged enough to have a long service life.

The time of response of the several elements given above and other characteristics are of course subject to variation and should be considered as illustrative only. These and other variations may be made without departing from the scope of the invention which is to be measured by the scope of the following claims.

Having described my invention what I claim as new and useful and desire to secure by Letters Patent of the United States is:

1. In a combustion heater for use with liquid fuels, means forming a combustion chamber, a burner in said combustion chamber, means for supplying fuel to said burner, means for supplying air to said burner, control means for modulating the air supply to said burner gradually and for modulating the fuel flow to said burner in pulses, said control means including a device for producing electrical pulses the average value of which is proportional to the demand for heat, an electrically responsive air control means connected thereto which responds to the average value of current pulses to gradually regulate the air supply in proportion to the average value of current pulses, and an electrically responsive fuel valve connected to said device, said fuel valve responding to the instantaneous value of current pulses supplied thereto to deliver fuel in pulses in proportion to the average value of the current pulses and the air supply.

2. In a combustion heater for use with liquid fuels, a burner, means for supplying liquid fuel to said burner, means for supplying air to said burner, and control means for increasing the air supply to said burner gradually and for modulating the fuel flow to said burner in pulses, said control means comprising a device for producing electrical pulses the average value of which is proportional to the demand for heat, an electrically responsive air control means connected thereto which responds to the average value of current pulses to gradually regulate the air supply in proportion to the average value of current pulses, and an electrically responsive fuel valve connected to said device, said fuel valve responding to the instantaneous value of current pulses supplied thereto to deliver fuel in pulses in proportion to the average value of the current pulses and the air supply.

3. In a combustion heater for liquid fuel, a burner, means for supplying fuel to said burner including an instantaneously acting high-low electromagnetic valve, means for supplying air to said burner including a slowly responding electrically actuated modulating valve, temperature sensitive switch means adapted to send electrical impulses the average value of which is proportional to the demand for heat, circuit means for energizing both said high-low valve and said modulating valve by way of said switch means, said air valve being adapted to open to an extent which is proportional to the average value of current pulses received and said fuel valve responding to the instantaneous value of current pulses to deliver fuel in pulses proportional to the average value of the current pulses and the air supply.

4. In a combustion heater for use with liquid fuels, means forming a combustion chamber, a burner in the combustion chamber, means including a two-position valve for supplying fuel to the burner, one of the valve positions being a high fuel flow position, the other valve position being a low fuel flow position, means including a valve movable to a plurality of positions between two limits for supplying air to the burner, circuit means for intermittently operating the two-position valve to its high flow position from its other position during demands for heat, and further circuit means for varying substantially progressively the position of the other valve in accordance with the average demands for heat.

5. In a combustion heater for use with liquid fuels, means forming a combustion chamber, a burner in the combustion chamber, means including a two-position valve for supplying fuel to the burner, one of the valve positions being a high fuel flow position, the other valve position being a low fuel flow position, means including a valve infinitely variable between two positions for supplying air to the burner, circuit means for intermittently operating the two-position valve to its high flow position from its other position during demands for heat, and further circuit means for progressively varying the position of the other valve in accordance with the average demands for heat.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,884,196 April 28, 1959

Arthur C. Allen

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 69, for "eelment" read -- element --; column 11, line 75, after "supply" and before the period insert -- , said control means operating to increase said air supply gradually and to increase the average fuel flow rate under electric current pulsing conditions reflecting a need for additional heat --.

Signed and sealed this 25th day of August 1959.

(SEAL)

Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents