March 13, 1962 F. A. RYDER 3,024,835

MILD WEATHER COMBUSTION HEATER

Filed July 8, 1959 2 Sheets-Sheet 1

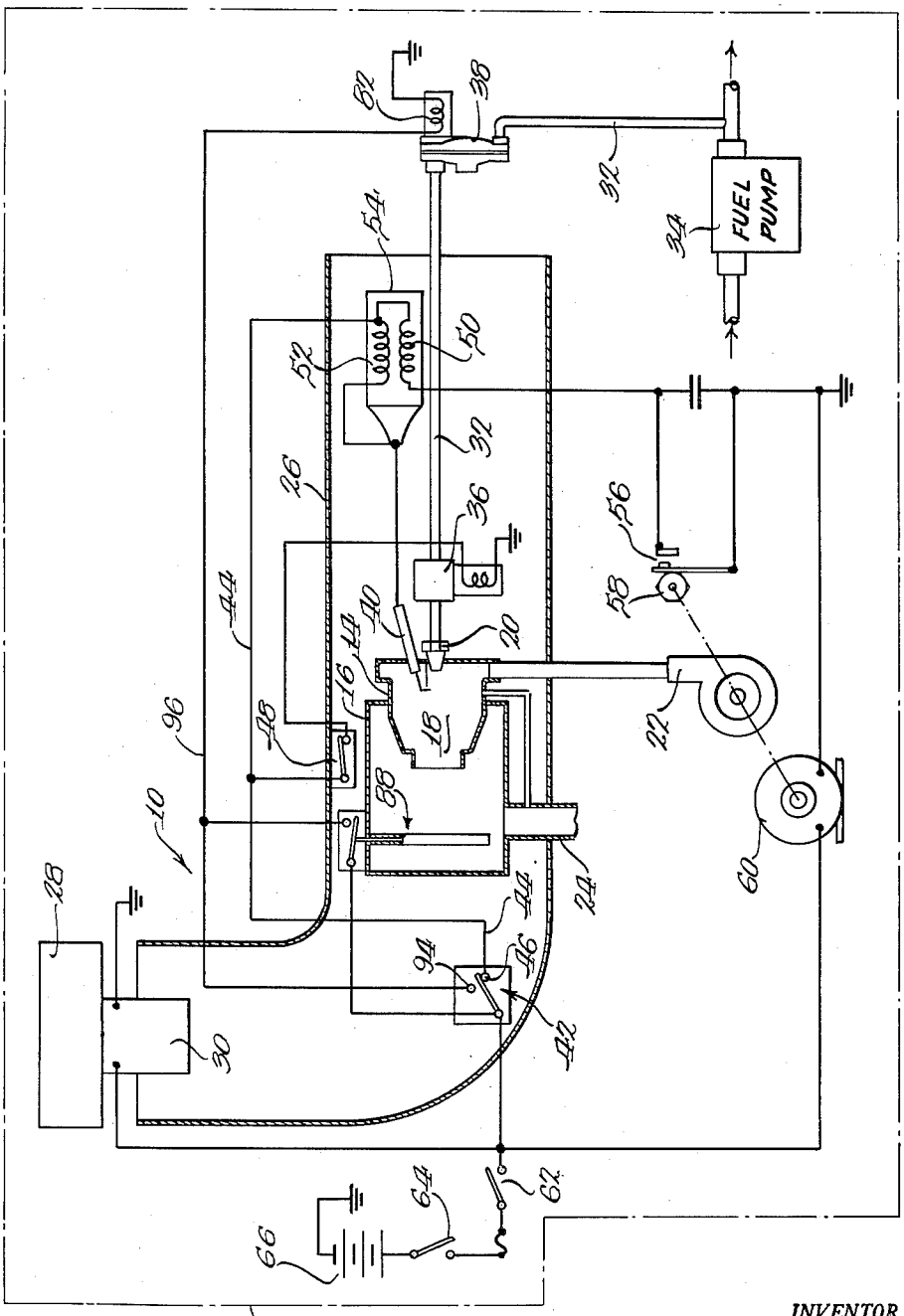


Fig. 1.

INVENTOR.
Frank A. Ryder.
BY
Augustus G. Douvas
Atty.

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Fig. 2.

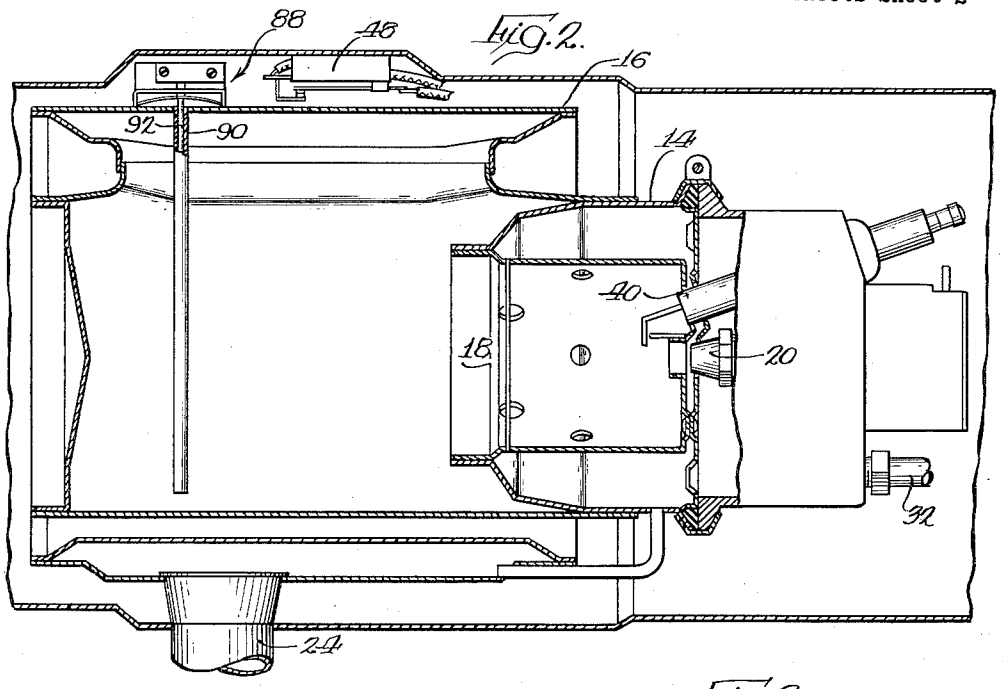


Fig. 3.

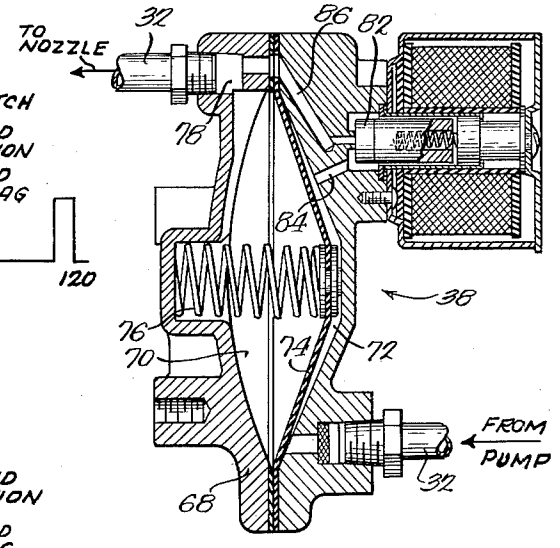


Fig. 4.

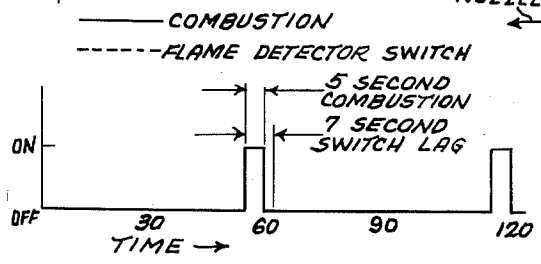
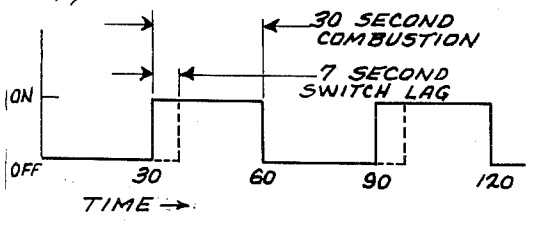


Fig. 5.



INVENTOR.
Frank A. Ryder
BY
Augustus G. Douvas
Atty.

United States Patent Office

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MILD WEATHER COMBUSTION HEATER

Frank A. Ryder, Springfield, Ill., assignor to Stewart-Warner Corporation, Chicago, Ill., a corporation of Virginia

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7 Claims. (Cl. 158—28)

The present invention relates to combustion heaters and more particularly to automotive vehicle heaters having highly efficient heat exchangers of light weight which have a very limited capacity to absorb heat. Combustion heaters of this character are disclosed in U.S. Patents Nos. 2,834,336; 8,844,140; and 2,844,195.

In operation, heaters of this character cycle through combustion periods, during which fuel is ignited and burned at the full rated capacity of the heater, followed by dormant periods during which combustion ceases and ventilating air is heated by heat previously absorbed by the heater structure. Provision must be made in such heaters for preventing a hazardous condition from arising in the event fuel supplied to the combustion space within a heater fails to ignite.

One approach to this has been to limit the quantity of fuel that can be released in a heater for combustion without combustion taking place. For this purpose, fuel is supplied into the combustion space of a heater during an initial or ignition phase of a combustion period by means which, in itself, is automatically operable to terminate the supply of fuel to the combustion space at the end of an ignition phase or portion of a combustion period. Such ignition phase or portion of a combustion period is ended either by the exhaustion of a limited quantity of fuel made available for the ignition phase or by the running out of a limited time period allotted to the ignition phase. Normally, the fuel is ignited early in the ignition phase of a combustion period and the heat of combustion is sensed by thermally responsive means which operates to sustain the supply of fuel to the combustion space throughout a combustion period of unlimited duration, independently of the action of the means which would terminate the fuel supply at the end of the ignition phase if ignition did not occur.

Heater control systems which function in this general manner have not been completely satisfactory under all conditions in which vehicle heaters are operated. Some otherwise satisfactory control systems are subject to operational failures during relatively mild weather conditions in which combustion periods of only very short duration are required to supply the heat desired.

One object of the invention is to provide for use in automotive vehicles or the like an improved combustion heater which is controlled for cyclic operation and protected against ignition failure hazards by improved control means which provides a highly effective and unfailing control of the heater under all environmental conditions including operation in mild weather during which the heater is cycled through combustion periods of very short duration.

Another object is to provide an improved heater, suited for use in automotive vehicles, having improved controls which effectively maintain within safe limits the maximum quantity of fuel which can be supplied to the heater for starting combustion at the beginning of a heater cycle while at the same time providing an optimum supply of fuel to the heater for starting combustion at the beginning of an unlimited number of successive combustion periods without in any way restricting the brevity of the individual combustion periods.

A further object is to provide a combustion heater of the above character which assures that fuel supply means in the heater, which operates to provide only a limited

supply of fuel during the ignition phases of successive combustion periods, is reset or restored to its normal starting condition before the beginning of each combustion period of an unlimited series regardless of the brevity of the individual combustion periods.

A further object of the invention is to provide an improved combustion heater of the above character in which the basic components of previously inadequate heater control systems have been used to provide a new and improved heater control system which will operate reliably and dependably even in the mildest of weather, all without significantly increasing the cost of the heater or its controls.

A further object is to provide an improved combustion heater of the above character having an improved heater control system, formed largely of the basic components of a prior control system, which has been made fully adequate and dependable even when operated in mild weather, all without significantly increasing the cost of the heater incorporating the improved control system.

Other objects and advantages will become apparent from the following description of the exemplary form of the invention illustrated in the drawing, in which:

FIGURE 1 is a diagrammatic illustration of a combustion heater embodying the invention and installed on an automotive vehicle, illustrated in phantom;

FIG. 2 is a longitudinal sectional view of major components of the heater;

FIG. 3 is a longitudinal sectional view of fuel supply control structure;

FIG. 4 is a graphic illustration of combustion cycles of the heater when operated under mild weather conditions, and

FIG. 5 is a graphic illustration of combustion cycles of the heater when operated in colder weather.

Referring to the drawings in greater detail, the heat generating structure of the combustion heater **10** forming the illustrated embodiment of the invention is generally similar to that shown in the previously mentioned U.S. Patents Nos. 2,834,336; 2,844,140; and 2,844,195.

In general, the heater **10**, which is installed in an automotive vehicle **12** illustrated in phantom in FIG. 1, comprises a burner **14** fitted into one end of a lightweight, highly efficient heat exchanger **16** which together with the burner defines an enclosed combustion space **18**. Fuel, ordinarily gasoline, is sprayed to the combustion space **18** from a nozzle **20** in the burner **14**. Combustion air is supplied to the burner **14** from a blower **22** and products of combustion are exhausted through an exhaust vent **24** from the heat exchanger **16**.

Ventilating air for heating the vehicle **12** is directed past the heat exchanger **16** by a duct **26** encircling and extending beyond opposite ends of the heat exchanger as shown. Fresh air is drawn through the duct **26** and forced into the vehicle **12** by means of a blower **28** driven by an electric motor **30**.

Fuel is supplied to the nozzle **20** through a line **32** leading from the discharge side of a conventional engine driven fuel pump **34**, which supplies fuel to the vehicle engine carburetor (not shown). The flow of fuel to the nozzle **20** is controlled by a normally closed solenoid valve **36** and a safety, ignition failure device **38**, which will be described presently in greater detail in connection with control of the heater.

When turned on, the heater **10** is operated cyclically through combustion periods, during which fuel is ignited by a spark plug **40** in the burner **14** and burned at the maximum rated capacity of the heater, followed by dormant periods during which combustion ceases and ventilating air passing through the duct **26** is heated by heat previously absorbed by the heat exchanger **16**.

Such cyclic operation of the heater **10** is controlled by

a thermostatic switch 42 mounted in the duct 26 downstream from the heat exchanger 16, as shown in FIG. 1. The thermostatic switch 42 responds to a drop in the ambient duct air temperature below a predetermined level to initiate a combustion cycle and terminates the combustion cycle when the ambient duct air temperature exceeds a higher predetermined value.

As shown in FIG. 1, a control wire or conductor 44 from an output terminal 46 of the thermostatic switch 42 is connected to the solenoid valve 36 through a normally closed overheat switch 48 mounted adjacent the heat exchanger 16. The overheat switch 48 is merely a safety switch which opens to deenergize and effect closure of the fuel valve 36 in the event the temperature of the heat exchanger 16 exceeds a predetermined value.

The output conductor 44 from the thermostatic switch 42 also connects to a tap between the primary and secondary coils 50, 52 of an ignition transformer or coil 54. The primary coil 50 is intermittently grounded through breaker points 56 operated by a cam 58 rotated by an electric motor 60 which drives the combustion air blower 22. High voltages generated in the secondary coil 52 are discharged through the spark plug 40.

The heater is put into operation by closing a heater switch 62 in series with the vehicle ignition switch 64. Closure of the two switches 62 and 64 supplies power from the vehicle battery 66 to the two blower motors 30 and 60 and to the thermostatic control switch 42.

The thermostatic switch 42 energizes the conductor 44, as explained, to open the fuel valve 36 and to energize the ignition circuit which produces fuel igniting sparks from the plug 40. This begins a combustion period of the heater.

During an initial, fuel igniting phase of a combustion period, fuel is supplied to the nozzle 20 by means which will operate automatically in the event that ignition does not occur to terminate the supply of fuel to the nozzle before a sufficient quantity of fuel has been discharged into the combustion space 18 to create a hazardous condition. In the illustrated embodiment of the invention, the quantity of fuel that can be discharged into the combustion space 18 without ignition taking place is limited by operation of the previously mentioned safety control device 38 connected into the fuel supply line 32 between the main fuel valve 36 and the pump 34.

The safety device 38 itself is not new. A disclosure of this device may be found in U.S. Patent No. 2,568,107, issued September 18, 1951, to G. W. Allen. As disclosed in that patent and as illustrated in FIG. 3, the safety device 38 is effective at the beginning of a combustion period to close off the nozzle 20 from direct communication with the fuel supply pump 34 while at the same time making available for discharging into the combustion space 18 a limited supply of fuel, which is sufficient to start combustion and yet not enough to create a hazard if ignition fails to occur.

As shown in FIG. 3, the safety device 38 comprises a casing 68 defining an internal chamber divided into two compartments 70, 72 by a diaphragm 74, which is biased by a spring 76 in a direction to enlarge the compartment 70 to include substantially the entire space within the casing while effecting a corresponding diminution in the effective size of the compartment 72. The compartment 70 is connected through an outlet 78 to a section of the fuel line 32 extending to the nozzle 20. The other compartment 72 is connected to a section of the line 32 leading from the pump 34. A normally closed solenoid valve 82 has an inlet 84 connected to the compartment 72 and an outlet 86 connected to the compartment 70.

At the beginning of a combustion period the valve 82 is closed, thus blocking direct communication between the fuel pump 34 and nozzle 20. However, the output pressure of the pump 34 connected to the compartment 72 produces a pressure force on the diaphragm 74 which greatly exceeds the strength of the spring 76 to produce a fuel pressure in the chamber 70 only slightly less than the pump output pressure.

Upon opening of the main fuel valve 36 at the beginning of the combustion period, fuel flows from the chamber 70 to the nozzle 20 where it is discharged to the combustion space 18 and normally ignited by the spark plug 40. This is the ignition phase of a combustion period. In the event that ignition fails to occur, the supply of fuel to the nozzle 20 stops when the initial reserve of fuel in the compartment 70 is exhausted by movement of the diaphragm 74 to the left with reference to FIGURE 3. The valve 82 remains closed to block further admission of fuel into the combustion space.

Normally, the fuel is ignited early in the ignition phase of a combustion period and the heat of combustion is detected by a thermally responsive flame detector switch 88, which operates to open the valve 82 to connect the pump 34 directly to the solenoid valve 36 to sustain the fuel supply to the combustion space until the combustion period is terminated by operation of the thermostatic switch 42 to close the fuel valve 36.

The flame detector switch 88 itself is of a conventional construction and, as shown, comprises a metallic tube 90, FIG. 2, projecting down into the combustion space 18 and encircling a quartz rod 92 extending axially through the tube. The inner ends of the tube 90 and the rod 92 are joined together. The outer ends of these elements project outside of the heat exchanger 16 to operate the switch 88, which is connected electrically between the output side of the main heater switch 62 and the solenoid valve 82 as shown in FIG. 1. The heat of combustion in the space 18 produces a differential elongation of the tube 90 and rod 92, which closes the switch 88 to open the valve 82 as described.

The heater 10 thus formed is constructed and operated in a manner well known and practiced in the combustion heater art. The mode of operation of the heater is in general satisfactory. The safety device 38 which positively limits the quantity of fuel available for starting combustion is inherently dependable in its operation.

However, the heater as described thus far is subject to a serious shortcoming which can create total operational failures under some operating conditions. Operational failures of such heaters, which are the particular concern of the present invention, arise when the heaters are used in mild weather when only a small amount of heat is required.

In mild weather the difference between the temperature of the ventilating air before it is heated and the temperature of the air after heating is low. Because of the relatively high initial temperature of the ventilating air and the limited heat absorbing capacity of the light weight heat exchanger 16, only a very short combustion period is required in mild weather to heat the ventilating air sufficiently to actuate the thermostatic switch 42 to terminate the combustion period.

The brevity of the combustion periods of a typical combustion heater operated under mild weather conditions may be visualized to advantage by reference to the graphic illustration in FIG. 4 of the cycling of a heater in mild weather. FIGURE 4 should be compared with FIG. 5, which illustrates the cyclic operation of the heater during colder weather. The cyclic action of the heater is depicted by solid lines in both FIGS. 4 and 5 in which time appears as the abscissa.

Under the cold weather operating conditions depicted in FIG. 5, the heater cycles through combustion periods of approximately 30 seconds duration. However, under mild weather conditions the duration of the combustion periods becomes quite brief, as exemplified by the 5 second combustion periods depicted in FIG. 4.

The duration of the individual combustion periods is particularly significant in relation to the time lag of the flame detector switch 88, which is also depicted in FIGS. 4 and 5.

Flame detector switches, such as the switch 88 illustrated, must be capable of operating effectively and reliably under the widely varying environmental conditions in which an automobile heater is used. As a practical matter, flame detector switches suitable for this purpose have a time lag in their operation in the sense that an appreciable amount of time elapses between the starting of combustion in a heater and operation of the switch to continue the fuel supply to the heater. The seven second time lag illustrated in FIGS. 4 and 5 is typical for flame detector switches used in this environment.

When a heater is operated under conditions in which the combustion periods substantially exceed the time lag of the flame detector switch used no difficulty arises.

In this connection it is noteworthy that operation of the flame detector switch 88 serves two functions. By energizing the by-pass valve 82 it sustains the fuel supply to the combustion space throughout combustion periods which are limited only by operation of the thermostatic switch 42. A second and equally significant function of the switch 88 is to effect resetting or restoration to initial starting conditions before the beginning of successive combustion periods of the means which provides a limited supply of fuel for the ignition phase of each combustion period.

With reference to the illustrated construction, this second function of the flame detector switch 88 is performed as an incident to opening the by-pass valve 82. Thus, opening of the valve 82 connects the two compartments 70, 72 of the safety device so that the spring 76 expands the compartment 70 to effect filling of this compartment with a new charge of fuel for the ignition phase of the next combustion period.

Difficulty arises under mild weather operating conditions when the duration of each combustion period is reduced by operation of the thermostatic switch 42 to a time period less than the time lag of the flame detector switch 88. This situation is illustrated in FIG. 4, previously mentioned, in which the combustion period is only 5 seconds, two seconds less than the assumed seven second time lag of the flame detector switch. Hence, the switch 88 does not operate and the valve 82 does not open.

Of course, in this instance, operation of the switch 88 is unnecessary to sustain combustion since the charge of fuel in the compartment 70 is sufficient to fuel the entire combustion period. However, the failure of the valve 82 to open results in an overall depletion of the charge of fuel in the compartment 70 at the end of a combustion period. Since the flame detector switch 88 does not have the opportunity to close during combustion periods shorter than its time lag, it does not perform its function of restoring to starting conditions the means which supplies fuel for ignition purposes. Consequently, the reserve of fuel in the compartment 70 is quickly exhausted by repeated combustion periods and operation of the heater ceases.

This shortcoming of prior heaters is completely avoided in the improved heater 10.

In accordance with this invention such operational failures of the improved heater 10 are obviated by an improved control system which can be manufactured at virtually the same cost as that of prior systems which are subject to the previously discussed shortcomings.

Thus, as illustrated in FIG. 1, the thermostatic switch 42 is provided with a second output terminal 94 which is energized alternately with the previously mentioned output terminal 46. Structurally, the thermostatic switch 42 is a single pole, double throw switch which can be readily provided by those skilled in the art.

The second thermostatic switch output terminal 94 is connected through a conductor 96 to energize and open the solenoid valve 82.

When the duct air temperature reaches a predetermined value the thermostatic switch 42 deenergizes the main solenoid valve 36 to terminate combustion in the heater and at the same time energizes the output terminal 94 to energize the by-pass valve 82. This occurs, regardless of the brevity of the combustion period, to effect opening of the valve 82 even though the flame detector switch 88 may not have operated. Opening of the valve 82 at this time does not permit fuel under pressure to reach the nozzle 20, as the valve 36 is closed, but it does allow the spring 76 to expand in the compartment 70 to replenish the charge of igniting fuel.

Subsequent operation of the thermostatic switch 42 to energize the terminal 46 and open the main fuel valve 36 to start a new combustion period deenergizes the terminal 94 to effect closing of the valve 82 to provide the previously described protection against an ignition failure.

As a result, the improved heater will operate effectively and dependably under all weather conditions regardless of how mild and regardless of the brevity of the individual combustion periods. Moreover, the improved fuel system utilizes a conventional flame detector switch 88 which may have a time lag exceeding the shortest combustion periods.

Yet, the means provided for assuring resetting of the ignition fuel supply means before the beginning of each successive combustion period provides reliable heater operation where previous heaters have failed.

It will be appreciated that the invention is not necessarily limited to the particular embodiment illustrated, but includes variants and alternatives within the spirit and scope of the invention defined by the claims.

I claim:

1. For use in an automotive vehicle, a cyclic combustion heater comprising, in combination, fuel burning means, temperature responsive control means having a means for cycling said fuel burning means through combustion periods followed by dormant periods, means for supplying fuel to said fuel burning means during each combustion period, said fuel supplying means including fuel supply limiting means for automatically terminating the supply of fuel to said burning means after a predetermined limited supply of fuel has been supplied thereto for starting combustion, said fuel supplying means including normally inactive means for sustaining the fuel supply to said burning means independently of the terminating action of said fuel supply limiting means, said fuel supply sustaining means including a thermally responsive activating control having a lag period before response thereof mounted to respond to the heat of combustion in said burning means to activate said sustaining means to continue the fuel supply to said burning means and simultaneously restore the fuel supply limiting means to the starting condition thereof, and said temperature responsive control means including other means coacting with said fuel supplying means to restore the fuel supply limiting means to the starting condition thereof to ensure the supply of fuel for starting combustion in successive combustion periods regardless of the duration of the combustion periods with respect to lag period.

2. A lightweight, cyclic combustion heater operable in mild weather and comprising, in combination, fuel burning means defining combustion space therein, control means including a first circuit having a first contact and a thermostatic switch arm engageable therewith for cycling said fuel burning means through combustion periods followed by dormant periods, means providing only a limited supply of fuel to said combustion space for ignition at the beginning of each combustion period, normally inactive means including a normally closed solenoid valve and a source of fuel for providing a sustained supply of fuel to said combustion space during individual combustion periods of indefinite length, thermally responsive control means for responding to the heat of combustion in said fuel burning means to activate said normally inactive means to open said solenoid valve to

continue the supply of fuel to said combustion space and simultaneously refill the means providing the limited supply of fuel, said control means including a second circuit having a second contact engaged by said thermostatic switch arm after the switch arm disengages the first contact and operable to restore said first mentioned fuel supply means to the starting condition thereof independently of the thermally responsive control means for ensuring the ignition supply of fuel, and a source of electrical potential connected to the thermostatic switch arm.

3. In a space heater having cyclic periods of combustion of variable duration dependent on the heat demand with each period of combustion being followed by a dormant period, the combination of fuel burning means, initial fuel supply means for supplying a limited supply of fuel to said burning means for starting combustion, temperature sensing means in the fuel burning means operable within a lag period after combustion to respond to combustion, sustaining fuel supply means for simultaneously supplying an unlimited supply of fuel to said burning means and restoring said initial fuel supply means to the starting condition in response to the temperature sensing means, electrically operated valve means for connecting both said fuel supply means to said burning means to start a combustion period and for disconnecting both said fuel supply means from said burning means to terminate a combustion period, a thermostatic control switch having an input terminal and first and second output terminals which are contacted alternately in response to decreases and increases respectively in the ambient temperature, an electrical potential source connected to the input terminal, means connecting said first output terminal and forming a first circuit to energize and open said electrically operated valve means, and means connecting said sustaining fuel supply means to said second output terminal and forming a second circuit to restore said initial fuel supply means to the starting condition thereof independently of the temperature sensing means to ensure the limited supply of fuel in the initial fuel supply means for a subsequent starting combustion regardless of the duration of the period of combustion with respect to the lag period.

4. In a space heater, the combination of heat generating means defining combustion space therein, fuel supply means for supplying fuel to said combustion space, a normally closed main solenoid control valve interposed in said fuel supply means, a thermostatic control switch having an input terminal and first and second output terminals which are contacted alternately in response to decreases and increases respectively in the heater temperature, an electrical potential source connected to the input terminal, a first circuit including said first output terminal of the thermostatic switch operable to energize and open said main solenoid valve, said fuel supply means including a fuel supply line to said main control valve, a normally closed solenoid bypass valve interposed in said fuel supply line upstream of said main control valve, a thermally responsive flame detector switch mounted in association with said heat generating means connected electrically to energize and open said bypass valve in response to combustion in said space, means defining a limited volume ignition fuel supply reservoir connected to the upstream side of said main valve and communicating with the downstream side of said bypass valve, means for pressurizing fuel in said reservoir to expel fuel therefrom through said main valve upon opening of the latter to start combustion in said space, and a second circuit including said second output terminal of said thermostatic switch to energize and open said bypass solenoid valve to refill said reservoir in response to an increase in the temperature ambient to the thermostatic switch, so that said reservoir is maintained filled independently of the thermally responsive frame detector switch.

5. A space heater comprising, in combination, fuel burning means, a source of fuel under pressure, a normally closed solenoid main valve for supplying fuel to said fuel burning means, a normally closed solenoid bypass valve connecting said main valve to said source of fuel under pressure, means defining a limited volume reservoir of fuel for starting combustion in said fuel burning means, means connecting said reservoir to the upstream side of said main valve and to the downstream side of said bypass valve, means for expelling fuel from said reservoir through said main valve into said fuel burning means upon opening of said main valve, an electrical potential source, a combustion detector switch electrically connected to said electrical source and said bypass solenoid valve and positioned to respond to the heat of combustion in said fuel burning means to open said bypass valve, heater control switch means including a first contact connected to and completing a first circuit including the electrical source and said main control valve to intermittently open the latter for supplying fuel to said fuel burning means, and said heater control switch means including a second contact connected to and completing a second circuit including the power source and said bypass valve and operating independently of said detector switch to open said bypass valve when said first circuit is deenergized to connect said reservoir to said fuel supply means for replenishing the supply of fuel in said reservoir even though said bypass valve is not opened by operation of said combustion detector switch to insure a substantially filled reservoir after the combustion period for starting combustion of a subsequent combustion period.

6. In a heater having electrically operable fuel burning means effecting cyclic combustion periods in a combustion chamber disposed in heat exchange relationship with circulated heat conducting fluid, and having an electrically operable starter control device for the fuel burning means sequentially providing during each combustion period a limited quantity of fuel to effect initial combustion and thereafter providing an unlimited quantity of fuel to sustain combustion, and having a temperature sensing device operable to actuate the starter control device responsive after a lag period to the heat of combustion in the chamber, an improved safety starter control, comprising a thermostatic switch in heat exchange relationship with the heated fluid and having an input terminal and first and second output terminals, a source of electrical potential connected to the input terminal, a first circuit including the first terminal and fuel burning means and a second circuit including the second terminal and starter control device, with the thermostatic switch responding to a call for heat to energize the first circuit to effect combustion, and responding to a demand for discontinuance of heat to deenergize the first circuit and energize the second circuit for replenishing the limited quantity of fuel in the starter control device to effect a subsequent initial combustion in the heater regardless of the duration of the combustion periods with respect to the temperature sensing device lag period.

7. In a heater having electrically operable fuel burning means effecting cyclic combustion periods in a combustion chamber located in heat exchange relationship with circulated heat conducting fluid, and having an electrically operable starter control device interposed between a fuel source and the burning means and including a limited volume chamber communicating with the burning means and a normally closed solenoid valve interposed between the chamber and fuel source, with the starter control device sequentially providing during each combustion period fuel from the chamber to effect initial combustion and thereafter providing an unlimited quantity of fuel through the opened valve to sustain combustion, and a temperature sensing device operable to open the solenoid valve of the starter control device responsive after a lag period to the heat of combustion in the chamber, an improved safety starter control comprising a thermostatic switch in heat exchange relationship with the heated fluid and

having an input terminal and first and second output terminals, an electrical potential source connected to the input terminal, a first circuit including the first terminal and fuel burning means and a second circuit including the second terminal and solenoid valve of the starter control device, with the thermostatic switch responding to a call for heat to energize the first circuit to effect combustion, and responding to a demand for discontinuance of heat to deenergize the first circuit and energize the second circuit for replenishing the fuel in the chamber to ensure fuel for a subsequent initial combustion in the heater regardless of the duration of the combustion period with respect to the temperature sensing device lag period.

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