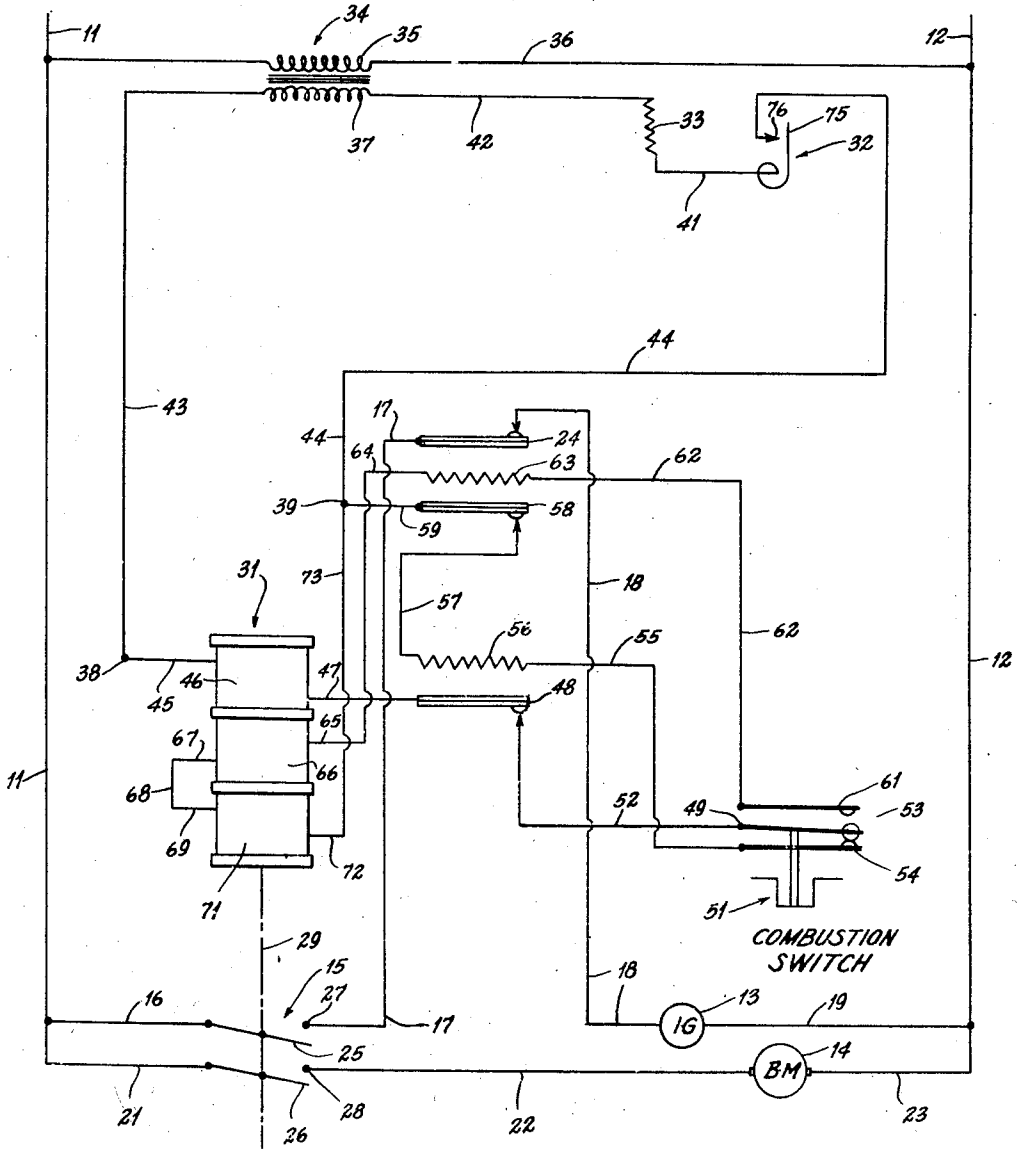
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CONTROL CIRCUIT FOR FUEL BURNER SYSTEMS

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## CONTROL CIRCUIT FOR FUEL BURNER SYSTEMS

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This invention pertains to control devices generally, and concerns itself more particularly with a heating control device in which a heat-producing medium is controlled in response to a demand for heat within a given space.

It is an object of the invention to provide a control device adaptable for use with a heat supply element, such as an oil burner, having means taking the form of a starting circuit for placing the burner motor in operation and, if desired, operating an igniter therefor, and a running circuit made operable before the opening of said starting circuit for controlling the operation of said burner thereafter.

It is a further object of the invention to provide a control circuit, described in the foregoing object, having safety means within the starting circuit thereof operable to shut down a burner motor in the event a condition of combustion is not effected within a predetermined time, and, moreover, to provide such circuit with means for maintaining it open for an interval of time known as a scavenging period.

It is yet another object of the invention to provide a control device of the type described in which the burner motor and ignition circuits are controlled by a relay device having a first main relay coil in a starting circuit branch thereof and a second main relay coil in the running circuit branch thereof.

It is a further object of the invention to provide a control circuit of the type described in which an electrical means providing for a scavenging period and a similar means providing for the opening of an ignition circuit are under the control of a common operating means located within the running circuit branch of the control system.

It is also intended, as an object of the invention, to provide a control circuit of the type described having a relay device operable upon a demand for heat in a given space to place a burner motor and an ignition means, or the like, in operation upon such demand, and a second circuit operable to control the continued operation of said burner motor through the functioning of a plurality of heat-responsive means providing for positive operation of the burner motor under absolutely safe operating conditions.

It is a further object of the invention to provide a control circuit of the type described in which the operation of the burner motor and ignition means, or the like, is controlled by a relay device having first and second main relay coils and a bucking coil so wound and arranged as to place

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a first main relay coil in a starting branch of the circuit and a second main relay coil and the bucking coil in a running circuit branch of the control circuit.

As a principal object of the invention, it is intended to provide a control circuit capable of carrying out the aforementioned objects of the invention which will meet rigidly imposed requirements as to the size, operation and safety of the control device.

Other objects and advantages will become apparent as the description proceeds, and a more comprehensive understanding of the invention will be afforded from the following detailed description when taken in conjunction with the accompanying drawing, in which the drawing is a schematic circuit diagram of a control device embodying the instant invention.

As is well known to those skilled in the art, control circuits of the type described are subject to rigid requirements concerning safety of operation and the physical size of certain component parts of the control apparatus. When considered in conjunction, these requirements oftentimes present very difficult problems. For example, a safety switch in a starting branch of the control circuit, in order to conform to underwriter requirements, must be operative to open the circuit within a given period of time for a given range of operating voltages. Thus, the starting branch of the circuit may be called upon to deliver a heavy current to the switch heater to effect such operation. Such a demand for initial starting current could possibly be fulfilled by using a large size transformer, but, on the other hand, the use of this transformer would, in turn, increase the size of the control unit. Since actual requirements dictate that the space occupied by the control unit be limited, the solution of the first problem in the obvious manner presents an equally greater problem as to a different requirement. Accordingly, each of the problems presented must be solved in terms of other requirements.

By arranging a circuit in accordance with the instant invention, and, as applied to the problems cited by way of example, it is possible to use a small transformer and, at the same time, provide the starting circuit with a large starting current. In addition, it provides a control circuit that is absolutely safe, that is small and compact, and simple in its construction.

In the particular form of the invention illustrated, the control circuit comprises a primary branch having two lines 11 and 12 connected to

a suitable source of power and feeding an ignition device 13, if desired, and a burner motor device 14 through a relay operated switch 15. Electric current to these devices is supplied by the lines 16, 17, 18 and 19, in the case of the ignition device, and the lines 21, 22 and 23, in the case of the burner motor device. Interposed between the lines 17 and 18 in the ignition circuit is a heat-responsive switch 24 whose function will be described in connection with the operation of the circuit. The relay operated switch 15 has two contacts 25 and 26, movable, respectively, into engagement with two stationary contacts 27 and 28 by the action of an armature 29 of a relay device 31 connected in the control or secondary branch of the circuit.

The last-mentioned branch of the circuit contains a heat-responsive device taking the form of a thermostat 32 which may, if desired, be equipped with an anticipating heater 33. The secondary or control branch of the circuit is supplied energy by a transformer 34 having a primary winding 35 connected across the source lines 11 and 12 by a conductor 36. A secondary winding 37 of the transformer 34 is connected in series with the thermostat 32 and its anticipating heater 33 and may be considered, for the sake of convenient description, as being connected across a pair of points 38 and 39 within the secondary branch of the circuit by means of the lines 41, 42, 43 and 44. The point 38 is connected to a lead 45 connected to one terminal of a main relay coil 46 on the relay 31. Another lead 47, connected to the other terminal of the main coil 46, is connected through a heat-responsive switch 48 to a terminal 49 of a combustion switch, generally designated by the reference numeral 51, and preferably taking the form of a rate-of-change type such as is described in this applicant's copending application, Serial No. 588,554, filed April 16, 1945, or in Patent No. 2,331,464, issued October 12, 1943, to Francis B. Fillo. In this instance, a line 52 provides the connecting means.

From the terminal 49 of the combustion switch 51, the starting branch of the circuit is traceable through a pair of movable contacts 53 and 54 of the switch 51, a conductor 55, and a heating element 56, serving as a heat element for the thermo-responsive switch 48. From the heating element 56, this branch of the circuit continues by means of a conductor 57 through a thermo-responsive switch 58 serving as a scavenging warp switch, thence through a line 59 to the point 39.

A running circuit branch, including the thermostat 32, its anticipating heater 33, and the secondary winding 37, is traceable from the point 38 through the first main coil 46 of the relay 31, the switch 48, to the point 49, exactly as for the starting circuit branch previously discussed. From this point, the circuit is traceable from the movable contact 53 of the switch 51 to a third contact 61 therein. From the movable contact 61, line 62 connects with a heating element 63 which serves as a common electro-thermo operator for the thermo-responsive switches 24 and 58. A line 64 connects the heater 63 with a terminal 65 of a second main coil 66 forming a part of the coil windings of the relay 31. The coil 66 terminates in one lead 67 which is connected by a conductor 68 to one lead 69 of a bucking coil 71, wound on the relay 31. The other lead of the bucking coil winding 71, marked 72, is connected to the point 39 by means of a line 73 completing the running circuit branch.



*Operation*

While it is not intended to limit the invention to any specific values for the various components thereof or its operating characteristics, a full teaching of the invention requires a statement of these values as they concern a particular requirement. For example, the problems previously alluded to make certain component parts of the various circuit branches critical for the limits imposed.

Stated specifically, but with the express understanding that the invention is not to be limited thereto, present underwriter requirements dictate that the safety switch 48 be opened within a period of time ranging from two to five minutes over a given range of operating voltages extending from 90 to 135 volts. Hence, the heater 56 must be supplied with a sufficient amount of current to meet this requirement. Likewise, the main relay coil 46, upon energization of the starting circuit, must carry a sufficient current, of itself, to draw in the switch 15 and move it to its closed position. In the circuit illustrated, these requirements may call for an initial current in the order of 610 milliamperes in the starting circuit for a normal operating voltage of 115 volts.

To supply the required current over a given period of time would require a rather large transformer. As stated before, however, the size of the control unit must be limited, and, accordingly, the circuit must be so designed as to employ a small transformer. This is done by arranging the starting and running circuit branches in a manner such that during the brief operation of the starting circuit branch the transformer is heavily overloaded to supply initial current requirements and, thereafter, during the energization of the running circuit branch, is operated at its normal rating.

If taken alone, these requirements would not present difficulties. When in the running circuit branch, however, the relay 31 must be so energized as to hold the switch 15 closed, once it is placed in the closed position by the starting circuit branch. On the other hand, should a power failure occur during operation of the running circuit and before the contact 53 of the combustion switch 51 has moved to its cold position, and a resumption of power follows, it must not allow the relay 31 to pull in the switch 15. Since the coils 46, 66 and 71 are in series in the running circuit, the current in this branch must be of a magnitude sufficient to hold in the armature 29 but insufficient to draw it in (due to the action of the bucking coil 71) over the entire range of operating voltages. Further, since the starting circuit must remain closed until the running circuit is closed, there is a brief time in the circuit operation in which both the starting and running branches are in parallel. For this period of time, the circuit common to the running and starting circuits down to the safety switch 48 may be drawing a current in the order of 640 milliamperes, the remaining portion of the starting circuit a current of 500 milliamperes, and the remaining portion of the running circuit 140 milliamperes. During this period, and, if for any reason the contact 53 of the combustion switch 51 should fail to open from the contact 54, the current to the heater 56 (in this case 500 milliamperes) must be sufficient to operate the safety switch 48 within the time requirements mentioned above over the same range of operating voltages.

Since the presence of the bucking coil 71 in the running circuit decreases the impedance of this branch with an attendant increase in the current therein, the second main relay coil 66 is arranged in the circuit to counter this effect. With its presence in the running circuit and with a proper selection of the number of turns in each of the relay coils, the operating current of the relay 31 will be approximately 360 milliamperes. This current will meet the requirements above stated for the running circuit branch of the system.

For an operating voltage of 115 volts, a resistance of 8 ohms for the coil 46, 10 ohms for the heater 56, 30 for the heater 63, and a combined resistance of 18 ohms for the second main relay coil 66 and the bucking coil 71 have been found satisfactory.

For the purpose of explaining the operation of the illustrated embodiment of the invention and the salient features thereof, it will be assumed that the thermostat 32 is located in a space wherein a temperature is to be maintained at a predetermined value by means of a furnace, not shown, heated by the operation of the burner motor 14. Upon a cooling of the thermostat's temperature-responsive element, a movable contact 75 is closed against a stationary contact 76 to close the starting circuit branch, which is traceable through the line 41, anticipating heater 33, line 42, secondary transformer winding 27, lines 43 and 45, the main coil 46, line 47, safety warp switch 48, the cold contacts 53 and 54 of the combustion switch 51, the line 55, and heater 56, line 57, the scavenger warp switch 58, and line 44, back to the contact 76 of the thermostat 32. Through this closed circuit, energy is supplied to the main coil 46 of the relay 31, and its armature is drawn upwardly to close contacts 25 and 26 of the relay switch 15 and energize the ignition device 13 and the burner motor 14.

Under normal operation, energization of the burner motor 14 will supply fuel to the burner, not shown, where it will be ignited by the igniter 13. Responsive to the heat of combustion, the switch 51 will become operative to move both of the contacts 53 and 54, which are engaged when the switch is in cold position, in a manner such that the contact 53 will first engage the contact 61, and thereafter will be moved out of engagement with the contact 54. Upon such action, the starting circuit branch, previously described, is opened, and the running circuit branch completed. This branch of the control system is identical with the starting circuit branch down to the terminal 49 of the switch 51. From this point, the running circuit may be considered as including the contacts 53 and 61, the line 62, the heater 63, serving the switches 24 and 58, the line 64, line 65, through the second main coil 66, the bucking coil 71, the line 72, line 73, back to the point 39, from which terminal the circuit is likewise identical with that described previously as the starting circuit branch.

The safety warp switch 48 which is connected in the heater circuit is preferably of the manual reset type. In the event a demand for heat by the thermostat 32 fails to produce a flame through the operation of the ignition device and the burner motor 14 within a predetermined length of time fixed by the characteristics of the heating element 56, the warp switch 48 will open and thereafter a manual resetting of this switch will have to be made. This safety measure



makes it possible to enforce instructions requiring an inspection of equipment.

Connected also in the starting circuit is an additional safety expedient taking the form of the warp switch 58, the heater element of which is connected in the running circuit. Assuming a normal operation of the heating system, the scavenger warp switch 58 will open before the safety switch 48. If the ignition device and burner motor are brought into operation and combustion results for a time sufficient to pass current through the heater 63 and open the scavenger warp switch 58 and, thereafter, should a power failure occur, it will be impossible to energize the starting circuit until such time as the bimetal elements of the switch 58 have cooled to permit its closing. This interval of time is fixed at a period sufficient to permit the dissipation of any unburned gases remaining in the furnace, before the igniter is again turned on, and is commonly known to the art as a scavenging period.

The igniter 13 has connected in its circuit the warp switch 24, heated by the element 63 in the running circuit. This switch is designed to open only after the occurrence of a condition of combustion. Thus, until the running circuit is energized, the heater 63 cannot open the switch 24, and this action, being dependent upon the closing of the contacts 53 and 61 by the combustion switch 51, makes the operation of the igniter 13 dependent also upon combustion. This control of the igniter does enable it, however, to be removed from across the line after it has served its purpose in igniting the fuel.

It is to be noted that the movable contacts of the combustion switch 51 are arranged so that the contacts 53 and 54 are closed to each other when the switch is in its cold position. Upon the occurrence of combustion, both of these contacts are urged toward the movable contact 61, contacts 53 and 54 remaining closed to each other until the contact 53 engages the contact 61. Thus, the main coil of the relay 31 is continued to be energized through the starting circuit until the running circuit is closed, assuring the continuous holding of the switch 15 in its closed position until the running circuit is conditioned to assume control. After the contact 53 has engaged the contact 61, further movement of the combustion switch moves the contact 53 from engagement with the contact 54 and opens the starting circuit, cutting the safety warp switch heater and the scavenger warp switch itself out of the circuit.

Thereafter, if a power failure occurs and power is instantaneously restored before the combustion switch 51 has moved to its cold position, the bucking coil 71, wound on the relay 31, will prevent the pulling force of the main coils 46 and 66 from pulling in the armature 29 and closing the switch 15. In this manner the burner motor and the igniter are prevented from being operated subsequent to an instantaneous power failure until the combustion switch has returned to its cold position and the entire control circuit conditioned for operation in a normal manner.

Moreover, the novel arrangement of the scavenger switch 24 in the running circuit provides an additional safety feature which is intended to meet the condition arising out of that created by a flame failure accompanying a power failure or a sudden opening and closing of the room thermostat. Thus, if the running circuit branch has been energized for a time sufficient to open the scavenger warp switch 58, and, thereafter, it is

broken as by a fortuitous opening of the thermostat or an instantaneous power failure, and this condition is accompanied by a flame failure, or one occurs immediately thereafter, then the starting circuit branch cannot be energized upon a cooling of the combustion switch 51 until such a time as the warp switch 58 has cooled and moved into its closed position. This novel arrangement prevents the operation of the burner motor or the igniter until such a time as the heating unit has been conditioned for recycling by holding it inoperative for an ample scavenger period. Were it not for the scavenger warp switch 58, the presence of a flame failure concurrent with an instantaneous power failure, or the like, would, due to the characteristics of the combustion switch 51, close the starting circuit and place the burner motor and igniter in the circuit immediately following the flame failure. Since this series of events would follow closely after the power failure, the igniter would be conditioned to ignite any unburned fuel or fumes present in the heater before they had time to be dissipated out of the stack. This would result in a dangerous condition which might cause an explosion. With the scavenger switch 58 in the starting circuit, however, the latter cannot be energized when the combustion switch 51 moves to its cold position until the former cools and this dangerous condition is obviated.

While a specific embodiment of the invention has been illustrated and described, it is, of course, possible, and particularly in view of the foregoing disclosure, that changes and modifications thereto may be made. Accordingly, it is intended that all such changes and modifications are to be included as if described, and the scope of the invention is to be limited only by the appended claims.

What is claimed is:

1. In a control circuit adaptable for use with a space heating unit having a fuel supply control means, a relay device having a plurality of coil windings for effecting the operation of said control means, comprising a first main coil, a second bucking coil, and a third supplemental coil, a starting circuit branch including the first of said coils and an electro-thermo responsive switch means therein for opening said circuit branch, and a running circuit branch including the first, the second and the third of said coils in series for controlling the operation of said control means once it has been started, said relay coils being such that the starting circuit will carry a sufficiently high current for a given range of operating voltages to operate said relay and energize said electro-thermo responsive switch to effect its operation in a given period of time, and moreover that the running circuit will carry a current of such magnitude as to hold said relay in operative position once it is established but insufficient to actuate said device, and means to initially connect the starting circuit branch for energization, said means being operable to connect the running circuit branch for energization after predetermined initial energization of the starting circuit branch.

2. In a control circuit adaptable for use with a space heating unit having a fuel supply control means therefor, the combination of a relay operated switch for controlling the operation of said fuel supply control means, a relay device for operating said relay switch comprising a first and a second main relay coil and a bucking coil, a starting circuit branch comprising in series a heat-responsive switch, a source of energy, said first relay coil, a thermo-responsive switch, the cold contact means of a switch having means to shift from cold contact means to hot contact means responsive to combustion, and a second thermo-responsive switch, and a running circuit branch comprising, in series, the heat-responsive switch, the source of electrical energy, said first main relay coil, said first thermo-responsive switch, the hot contact means of said combustion switch, a heater for said second thermo-responsive switch, said second main relay coil and said bucking coil.

3. In a control circuit adaptable for use with a space heating unit, a relay device comprising a movable armature, first and second main relay coils operatively associated therewith, and a bucking coil operable to oppose the effect of said first and second main relay coils, said first main relay coil being energizible by a starting circuit to pull in said armature, and said first, second, and said bucking coils being energizible in series by a running circuit whereby said armature is conditioned to be held in but incapable of being pulled in by said coils.

4. In a relay for use in a control with a fuel supply device, said relay comprising a single armature to control the operation of the fuel supply device, and multiple coil means therefor, comprising two coils arranged to produce flux in the same direction and one arranged to produce a flux in the opposite direction, one of said first two coils being capable of pulling in the armature when subjected to predetermined voltage, and said third coil and at least one of the first two coils simultaneously energized being capable of holding the armature in but incapable of pulling it in when subjected to said voltage.

5. In a control for use with a fuel supply device, the combination of a relay having a switch controlling operation of the fuel supply device and having main coil means capable of pulling the switch closed, additional coil means capable of reducing the magnetic pull of the main coil means to that capable only of holding the switch closed, a combustion safety switch, the combustion safety device having a cold switch means, circuit connections between the cold switch means and the main coil means to effect energization of the main coil means only when the safety device is cold; the combustion safety device also having a hot switch means, and circuit connections between the hot switch means and the main and additional coil means to effect energization of said main and additional coil means when the safety device is hot.

6. In a control for use with a fuel supply device, the combination of a relay having a switch controlling operation of the fuel supply device and having main coil means capable of pulling the switch closed, additional coil means capable of reducing the magnetic pull of the main coil means to that capable only of holding the switch closed, a combustion safety switch, the combustion safety device having a cold switch means, circuit connections between the cold switch means and the main coil means to effect energization of the main coil means only when the safety device is cold; the combustion safety device also having a hot switch means, and circuit connections between the hot switch means and the main and additional coil means to effect energization of said main and additional coil means when the safety device is hot, said combustion safety device having heat-responsive

means that when cold effects closure of the cold switch, and when heated closes the hot switch and thereafter opens the cold switch.

7. In a control for use with a fuel supply device, the combination of a relay having a switch for controlling operation of the fuel supply device, said relay having main coil means capable of operating the switch, a bucking coil for opposing the main coil means, and supplemental main coils, the impedance of said main, bucking, and supplemental coil means in series being such, relative to the impedance of the main coil means, that current through them is reduced from that passing through the main coil, the net magnetic pull of all being less than enough to operate the switch but enough to hold it operated.

8. In a control for use with a fuel supply device, the combination of a relay having a switch for controlling operation of the fuel supply device, said relay having main coil means capable of operating the switch, a bucking coil for opposing the main coil means, and supplemental main coils, the impedance of said main, supplemental, and bucking coil means in series being such, relative to the impedance of the main coil means, that current through them is reduced from that passing through the main coil, the net magnetic pull of all being less than enough to operate the switch but enough to hold it operated, a timer relay operating means connected in series with the main coil means, and adapted to be connected in parallel with the bucking and supplemental coils, the impedance of the parallel coils being such that the timer relay operating means draws operating current when the parallel coils are so connected.

9. In a control a relay having a main coil and an armature device, a time delay switch mechanism having switch means and a current-energized time-delay operating device connected in series with the main coil, additional cooperable coil means operatively associated with the main coil to reduce the magnetic pull thereof below that to displace the armature device, but nevertheless adequate to hold it displaced, said additional coil means being connectable in series with the main coil and in parallel with the time-delay operating device, the impedance of the additional coil means being sufficient relative to that of the time-delay device to permit the time-delay device to draw an operating current when it is connected in parallel with the additional coil means.

10. In a control, a burner device, a relay including a switch for controlling the burner device and coil mechanism for operating the switch, said coil mechanism including main coil means energizable to operate the switch, bucking coil means to reduce the magnetic power of the main coil means, and means to prevent excessive current through said main coil means, as a result of reduction of total impedance by the bucking coil, starting circuit means for the burner device including the main coil to operate the switch, and running circuit means for the burner device including the main coil and the bucking coil in series, and the excess current-preventing means.

11. A control for a fuel supply device including a main switch for controlling said device, coil means energizable to close said switch, added coil means energizable to effect holding of the switch closed but incapable of closing it, combustion-responsive means operable from cold to hot positions, connections between said means in cold position and the closing coil means to effect energization of the main switch closing means to cause closure of the main switch only when in cold position, and connections between said combustion-responsive means in hot position and said main switch holding means to effect energization of the main switch holding means, when in hot position.

12. In a control circuit adaptable for use with a space heating unit having a fuel supply means, a relay including main and bucking coils and a switch for controlling the operation of the fuel supply means, a starting circuit branch for initiating the operation of said fuel supply means including a part of the main coil to operate the relay switch, and a running circuit branch for controlling the operation of said fuel supply means after it is once started including the full main coil and the bucking coil connected in series to hold the relay switch in operation, and means to initially connect the starting circuit branch for energization, said means being operable after initial energization of the starting circuit branch to connect the running circuit branch for energization and to disconnect the starting circuit branch.

RYDER PRATT.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 1,705,676 | Parsons | Mar. 19, 1929 |
| 1,980,796 | Goff | Nov. 19, 1929 |
| 2,108,770 | Kriechbaum | Feb. 15, 1938 |
| 2,119,503 | Kriechbaum | May 31, 1938 |
| 2,200,908 | Beggs | May 14, 1940 |