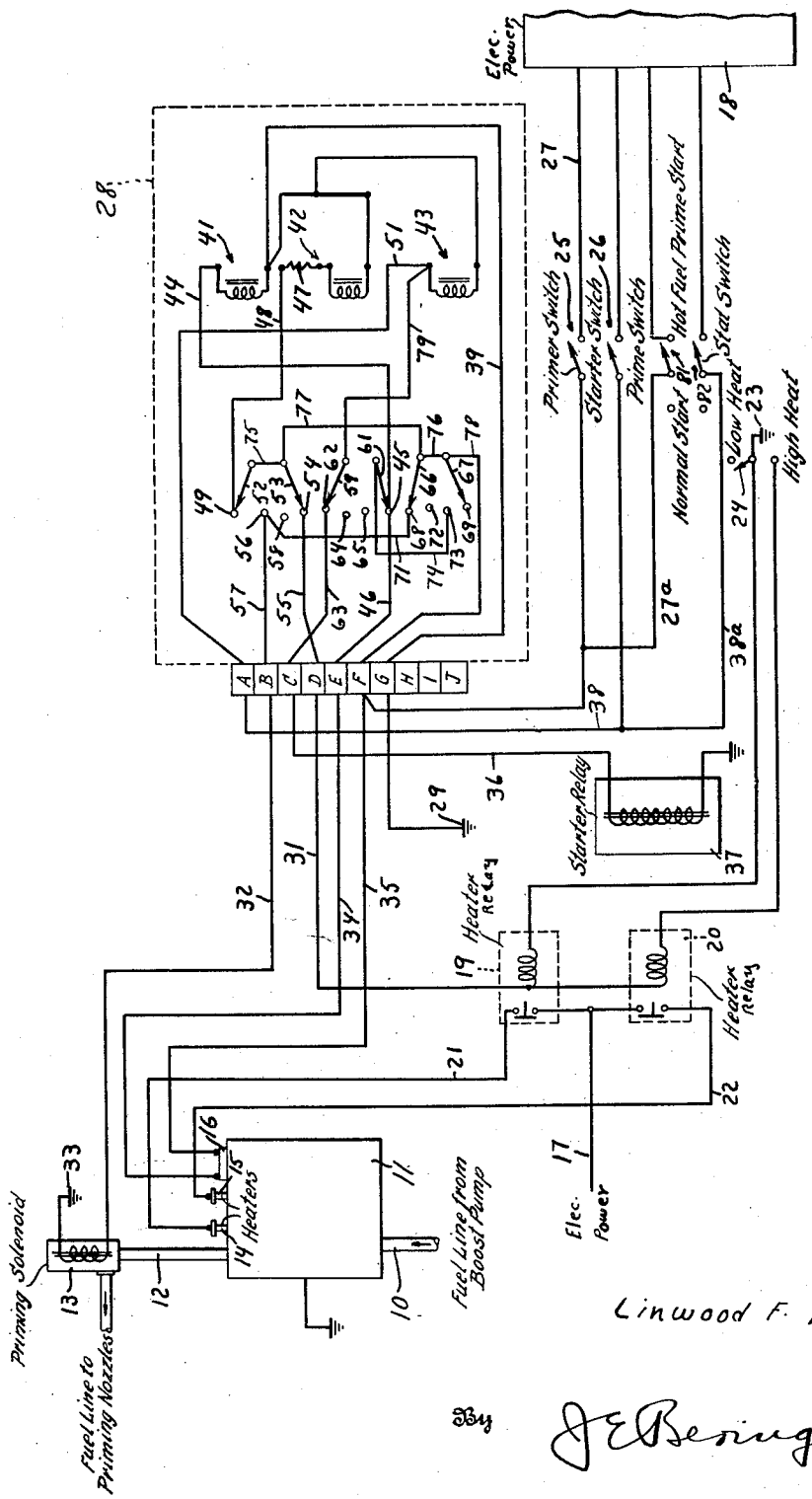
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ENGINE STARTING SYSTEM

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ENGINE STARTING SYSTEM

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This invention relates to the cold weather starting of internal combustion engines, and particularly to improved components of a hot fuel priming system wherein a supply of priming fuel is heated and supplied to the engine in conjunction with actuation of the engine starter.

Systems of the kind described incorporate automatic controls, and also are subject to a selective manner of operation according to which priming fuel may be supplied to the engine continuously or intermittently and in a heated or an unheated condition.

It is an object of the present invention to simplify the construction and mode of operation, in systems as described, to the ends that the system may be more reliable in operation and less subject to misoperation, as well as to the end of making the component parts of the system less costly of manufacture.

Another and particular object of the invention is to simplify the electrical controls of the system in order that the several functions performed by the system may be carried out using fewer electrical circuits and electrical relays than was known heretofore.

Other objects and structural details of the invention will appear from the following description when read in connection with the accompanying drawing, which is a diagram of an engine starting system incorporating a hot fuel prime system in accordance with an illustrative embodiment of the invention.

Referring to the drawing, priming fuel is supplied by way of a pipe 10 opening into the bottom of a tank 11. Flow out of the tank 11 is through the upper end thereof by way of a pipe 12 in which is interposed a solenoid operated shut-off valve 13, termed the priming solenoid. The fuel is conducted to the tank 11 under pressure, there being in the line 10 a boost pump (not shown) driven independently of the engine. Depending upon whether the priming solenoid is energized or deenergized, flow out of the tank 11 is permitted or denied. In the energized condition, the flow is directed through the pipe 12 to the priming nozzles in the induction system of the engine.

While engine priming has various purposes, a principal object thereof is to enable heated fuel to be supplied to the engine for purposes of more facile starting under extremely cold conditions. In this connection, there is installed in the tank 11 a pair of immersion heaters 14 and 15 which when energized transmit heat to the contained fuel within the tank. Also forming a part of the tank structure is a thermally sensitive switch 16 which is arranged to sense the temperature of the contained fuel and to close upon the achieving of a predetermined high value in such temperature, the thermal switch device being normally open.

The system provides for a direct connection through a conductor 17 with an electrical power source, as well as with an instrument cable 18 also connected to the power source. Power from the line 17 is supplied directly to the heaters 14 and 15, through respective electrical relays 19 and 20, the relays being located on opposite sides of the conductor 17 in respective conductors 21 and 22.

The coil of relay 19 is connected to ground at 23 and so may be energized independently of the relay 20. The coils of the two relays may be bridged, however, by a switch 24 in which case the relays are energized simultaneously. The switch 24 is operator controlled and it will be understood that by its use, only one or both of the heaters 14 and 15 may be energized, thus providing alternatively for low and high rates of heating of the fuel in the tank 11.

Other operator controls are a primer switch 25 and a starter switch 26. The former is in a line 27 extending from the instrument cable 18 to a terminal pin F on a relay-switch assembly 28. The latter, along with the tank 11 and associated parts forms a principal component of the hot fuel prime system. A terminal pin G thereon is connected to ground at 29. Another pin D of the assembly is connected by a lead 31 to the coils of the heater relays 19 and 20. Pin B is connected by a lead 32 to the priming solenoid 13, grounded at 33. Pins E and F are connected to opposite sides of the thermal switch 16, by leads 34 and 35, while pin C is connected by a lead 36 to a starter relay 37 and pin A is connected to a lead 38 extending from the instrument cable 18 and in which is interposed the starter switch 26.

Within the relay switch assembly 28 is a conductor 39 leading to the ground pin G. The conductor 39 is connected to a common side of three relays 41, 42 and 43. The opposite side of the relay 41 is connected by a lead 44 to a contact 45 which is in turn permanently connected by a lead 46 to the terminal pin E. The opposite side of the relay 42 is connected by a resistor 47 and lead line 48 to a contact 49. The opposite side of the relay 43 is directly connected by conductor 51 to the terminal pin A. It will be understood that the so-called opposite sides of the relays 41, 42 and 43 are the high potential sides thereof, and that the supply of current thereto through the respective lines 44, 48 and 51 results in the energizing of the respective relays.

The contacts 45 and 49 are a part of a bank of contacts traversed by three double pole, double throw switches, one of which is associated with and adjusted under control of a respective one of the relays 41, 42 and 43. The relay 41 controls a switch comprising a pair of switch elements 52 and 53 tending normally to assume the position illustrated wherein element 52 engages contact 49 and element 53 engages a contact 54 connected by a lead 55 with the terminal pin D. Energizing of the relay 41 effects simultaneous movement of the switch elements 52 and 53 to alternate positions of adjustment wherein the element 52 engages a contact 56 connected by a lead 57 with the terminal pin B, and wherein the switch element 53 engages an electrically disconnected contact 58. In similar manner, the relay 42 controls a pair of switch elements 59 and 61. The latter element normally engages the aforementioned contact 45 while the switch element 59 normally engages a contact 62 connected by a lead 63 to the terminal pin C. In their alternate positions of adjustment, achieved upon energizing of the relay 42, the switch elements 59 and 61 engage electrically disconnected contacts 64 and 65. The switch controlled by relay 43 comprises switch elements 66 and 67 respectively normally engaging contacts 68 and 69. The former is jointed by a lead 71 with contact 56. The contact 69 is electrically disconnected in the system. Upon energizing of the relay 43, the element 66 assumes a position of engagement with an electrically disconnected contact 72, while switch element 67 engages a contact 73 connected by a lead 74 with the base of switch element 61. The bases of the pair of switch elements 59 and 61 are electrically disconnected but the bases of switch elements 52 and 53 are electrically connected, as by a line 75, as are the pair of elements 66 and 67, as by a line 76. Further,

the pair of elements 52 and 53 is connected by a lead 77 to the bases of the pair of elements 66 and 67. Further, the latter are connected by a conductor 78 to the terminal pin F. Finally, the base switch element 59, of the pair of elements 59 and 61, is permanently connected by a lead 79 to the lead 51 or to the high potential side of the relay 43.

In the operation of the system, therefore, closing of the primer switch 25 closes a circuit through conductor 27, terminal pin F, lead 78, and then by way of lines 76 and 77 to switch element 52 and line 48 to the high potential side of relay 42, energizing this relay. Also, the circuit is closed through the switch element 66 to lead 71, contact 56 and lead 57 to the terminal pin B and thence by way of conductor 32 to the priming solenoid 13, energizing this solenoid and opening the valve for flow of the priming fuel to the induction system of the engine. Closing of the starter switch 26 supplies current to the terminal pin A and thence by way of conductor 51 to the high potential side of relay 43, energizing this relay. Since conductor 79 is connected to conductor 51, current is supplied also through the switch element 59 and lead 63 to the terminal pin C, and thence by way of conductor 36 to the starter relay 37 to effect cranking of the engine. In the case of the thermal switch 16, it may be seen that since one lead 35 therefrom is connected to the terminal pin F and since the other lead therefrom is connected to the terminal pin E, the closing of the thermal switch, while the primer switch 25 is closed, has the effect of energizing the relay 41, since the latter is connected to the terminal E through the conductor 44, contact 45 and lead 46.

The closing of primer switch 25 also tends to close a circuit through the heater relays 19 and 20 to energize the heaters 14 and 15, since the relays 19 and 20 are connected to terminal pin D which through the lead 55, contact 54 and switch element 53 is normally connected through the conductor 77 which has a permanent connection as described with the terminal pin F.

Since the closing of the switches 25, 26 and 16 tend to energize respective relays 42, 43 and 41, and since the energizing of these relays alters the position of the double pole double throw control switches in the relay-switch assembly, the mode of operation of the system and the results achieved vary with the order in which the several switches are operated. For cold weather starting, when it is desirable to heat the priming fuel, the priming switch 25 first is closed and the starting switch 26 is closed immediately thereafter. The thermal switch 16 is open at this time due to the low temperature of the fuel in tank 11. The closing of primer switch 25 is effective as described to open the priming solenoid 13 and to energize the heaters 14 and 15, and is effective also to energize the relay 42. The latter accordingly moves the switch elements 59 and 61 to electrically disconnected positions in engagement with the contacts 64 and 65. Now, as starter switch 26 is closed, the relay 43 is energized as before described, but current is not supplied to the starter relay 37 since the switch element 59 in this circuit has been shifted to an electrically disconnected position. Energizing of relay 43 shifts switch elements 66 and 67 to their alternate positions wherein element 66 engages contact 72 and element 67 engages contact 73. Upon this switch adjustment, therefore, current supply to the priming solenoid by way of switch element 66 and lead 71 is discontinued and the priming valve is closed whereby to cut off the supply of priming fuel to the engine. Also at this time, the switch element 67 is positioned to supply power to the switch element 61 by way of line 74, but the element 61 is engaged with electrically disconnected contact 65 so that no operation results.

While the switches 25 and 26 remain closed, the heaters 14 and 15 continue in operation, warming the fuel in the tank 11, which contained fuel is prevented from moving to the engine by reason of the closed valve 13.

When the contained fuel has reached a predetermined high temperature value, the thermal switch 16 closes. When this occurs, there is as before noted an energizing of the relay 41 and a shifting of the switch elements 52 and 53 to their alternate positions. Movement of switch element 53 from the contact 54 to the electrically disconnected contact 58 opens the circuit through terminal pin D to the heater relays 19 and 20, which accordingly are deenergized to discontinue heating of the fuel. Movement of the switch element 52 from the contact 49 to the contact 56 interrupts the supply of current to the relay 42, causing this relay to become deenergized. Also, the circuit to the priming solenoid 13 is re-closed, this time by way of the lead 77. The priming solenoid thus opens and the heated priming fuel is admitted to the engine.

The deenergizing of solenoid 42 as described permits the switch elements 59 and 61 controlled thereby to reassume the normal positions illustrated. So adjusted, the switch element 59 closes the starting circuit from conductor 51 to terminal pin C and starter relay 37. A further circuit is also closed at this time through relay 41 by way of switch element 67, lead 74 and switch element 61 engaging contact 45. Even though the thermal switch 16 may re-open, therefore, as the heated fuel leaves the tank 11 and is replaced by unheated fuel, the relay 41 will remain energized while the primer switch 25 continues to be held closed. The described position of the parts is maintained until the engine starts, whereupon the starter switch 26 may be released and the primer switch 25 released after a stable running of the engine has been achieved.

In engine starts in which it is desired to prime without pre-heating, the starter switch 26 is closed ahead of the primer switch 25. Closing of the starter switch under these conditions results in immediate energizing of the starter relay 37. Closing of the primer switch 25 has the effect, since the relay 43 has previously been energized by closing of the starter switch 26, of energizing the relay 41 through the switch element 67, lead 74, switch element 61 and conductor 44. Closing of the primer switch 25 tends also to close a circuit across and thereby to energize the relay 42. With current supplied simultaneously to the relays 41 and 42, under these circumstances, the resistor 47 in the line 48 to relay 42 plays the part of a time delay mechanism so that relay 41 is the first to be energized. As a result, the switch elements 52 and 53 controlled thereby are set to their alternate position of adjustment and the circuit to the relay 42 is interrupted. The relay 42 is thus not energized at this time. Adjustment of the switch element 52 closes a circuit through terminal pin B to the priming solenoid 13 causing the solenoid to open. Adjustment of the switch element 53 out of engagement with contact 54 opens the circuit through terminal pin D and thereby through the heating relays so that the heaters 14 and 15 are not energized.

Under these conditions of operation, the starter relay is continuously energized until the engine begins to operate. The primer switch 25 may be held continuously closed or it may be intermittently opened and closed with the result of supplying priming fuel in intermittent manner as may be required.

The manual control switches 25 and 26 may conveniently be constructed of the pressure actuated, normally open type. Switches of this kind are closed only when held closed and when released reassume an open position. In order to relieve the operator of the necessity for holding the priming and starting switches depressed there may be provided another set of switches 81 and 82 respectively in lines 27*a* and 38*a* parallel to the lines 27 and 38. The switches 81 and 82 are of the kind having alternate positions of adjustment, in each of which the switch will remain until manually adjusted to its other position. The switches 81 and 82 thus may be used as holding switches, after a priming operation has been initiated by the switches 25 and 26, or they may be used in lieu of the switches 25 and 26.

In connection with a hot fuel priming operation, it will be observed that release of the starter switch after the engine has started and while the priming switch continues to be held closed, will result in re-energizing of the heater relays so that fuel supplied to the engine under the continued or intermittent actuation of the priming switch is heated. The engine accordingly may warm up using heated fuel. The wiring of the relay switch assembly is such that the engine starter and the heaters in the priming fuel tank cannot both be energized at the same time.

What is claimed is:

1. Electrical controls in a hot fuel prime system for supplying fuel for engine starting and wherein a tank holds priming fuel, heaters are arranged to heat the fuel in said tank when energized, a priming solenoid controls flow from the tank and a thermal switch closes in response to a predetermined high temperature of the fuel in the tank; said electrical controls including a priming switch and a starting switch, a circuit closed by closing of said priming switch to open said priming solenoid; a relay energized by closing of said starting switch to open said circuit to said priming solenoid; and another relay energized in the closed position of said thermal switch to reclose said circuit.

2. Electrical controls according to claim 1, characterized by another circuit closed by closing of said priming switch to energize said heaters, said other circuit being unaffected by energizing of the first said relay and opening in response to energizing of the said other relay.

3. In a hot fuel prime system for supplying fuel for engine starting under control of a separably operable priming switch and a starting switch, said system providing a priming solenoid which when energized admits a priming fuel to the engine, said system further providing heaters for heating the fuel and a thermal switch responding to the fuel temperature; operating controls effecting the energizing and deenergizing of said priming solenoid and said heaters in predetermined manner under the control of said priming and starting switches and of said thermal switch, said operating controls comprising three relays and switches controlled thereby.

4. In a hot fuel prime system for supplying fuel for engine starting and wherein circuits extend from a priming switch to a fuel supply solenoid and to heaters for the fuel, another circuit extends from a starting switch to an engine starting relay, and a further circuit includes a thermal switch responsive to the temperature of the fuel; a relay-switch assembly interposed in said circuits comprising a relay energized by closing of a respective one of each of said priming switch, said starting switch and said thermal switch; and a pair of switches controlled by each relay operating the priming system in accordance with the order of closing of said priming switch, said starting switch and said thermal switch.

5. A starting system for an internal combustion engine providing hot fuel prime components including a starting relay, a priming solenoid which when energized admits priming fuel to the engine, heaters for heating the fuel, a thermal switch responsive to the temperature of the fuel, a priming switch and a starting switch; characterized by a relay-switch assembly having terminal pins individually connected to said components, three relays, and a two-part two position switch controlled by each of said relays intermittently interconnecting said terminal pins to one another and to said relays.

6. A starting system according to claim 5, characterized by means interposed in the path of flow of electrical current to one of said relays imposing a time delay upon the operation of said one relay.

7. A starting system according to claim 5, characterized in that one of said relays is connected to be energized upon closing of said thermal switch, another is connected to be closed upon closing of said starting switch and the third is connected to be closed upon the closing of said priming switch, the circuit through said relay-switch assembly to said starter assembly being closed only in conjunction with the energizing of said first relay and the deenergizing of said other relay.

8. A starting system for an internal combustion engine, including a main primer switch and a main starter switch, both assuming normally an open position, a first relay energized by closing of said main primer switch, priming fuel heater control means energized by closing of said primer switch, a priming fuel supply valve opened by closing of said main primer switch, a second relay energized by closing of said main starter switch, a starter relay energized by closing of said main starter switch, a first control switch controlled by energizing of said first relay to interrupt the circuit from said starter switch to said starter relay, a second control switch controlled by energizing of said second relay to interrupt the circuit from said primer switch to said supply valve permitting said valve to close, a thermal switch responsive to the temperature of the priming fuel, a third relay energized by closing of said thermal switch, and a third control switch controlled by said third relay to deenergize said first relay, to interrupt the circuit to said fuel heater control means and to restore the circuit to said fuel supply valve.

9. A starting system for an internal combustion engine, including a main primer switch and a main starter switch, both assuming normally an open position, a first relay energized by closing of said main primer switch, priming fuel heater control means energized by closing of said primer switch, a priming fuel supply valve opened by closing of said main primer switch, a second relay energized by closing of said main starter switch, a starter relay energized by closing of said main starter switch, a first control switch controlled by energizing of said first relay to interrupt the circuit from said starter switch to said starter relay, a second control switch controlled by energizing of said second relay to interrupt the circuit from said primer switch to said supply valve permitting said valve to close, a thermal switch responsive to the temperature of the priming fuel, a third relay energized by closing of said thermal switch, a third control switch controlled by said third relay to deenergize said first relay, to interrupt the circuit to said fuel heater control means and to restore the circuit to said fuel supply valve, a connection controlled by said first and second control switches to said third relay from said primer switch closed when said primer switch is closed subsequently to closing of the starter switch, and means in the connection from said priming switch to said first relay operable to give precedence to energizing of said third relay when said primer switch is operated subsequent to said starter switch whereby at this time to preclude energizing of said first relay.

10. In a hot fuel prime system wherein circuits extend from a priming switch to a fuel supply solenoid and to heaters for the fuel, another circuit extends from a starting switch to an engine starting relay, and a further circuit includes a thermal switch responsive to the temperature of the fuel; a relay-switch assembly interposed in said circuits comprising a relay energized by closing of a respective one of each of said priming switch, said starting switch and said thermal switch; a pair of switches controlled by each relay operating the priming system in accordance with the order of closing of said priming switch, said starting switch and said thermal switch; and means interposed between a pair of said switches and one of said relays imposing a time delay in the energizing of said one relay.

No references cited.