May 8, 1951 G. D. CERF 2,552,256

STARTER SYSTEM FOR DIESEL ENGINES

Filed Feb. 3, 1950 2 Sheets-Sheet 1

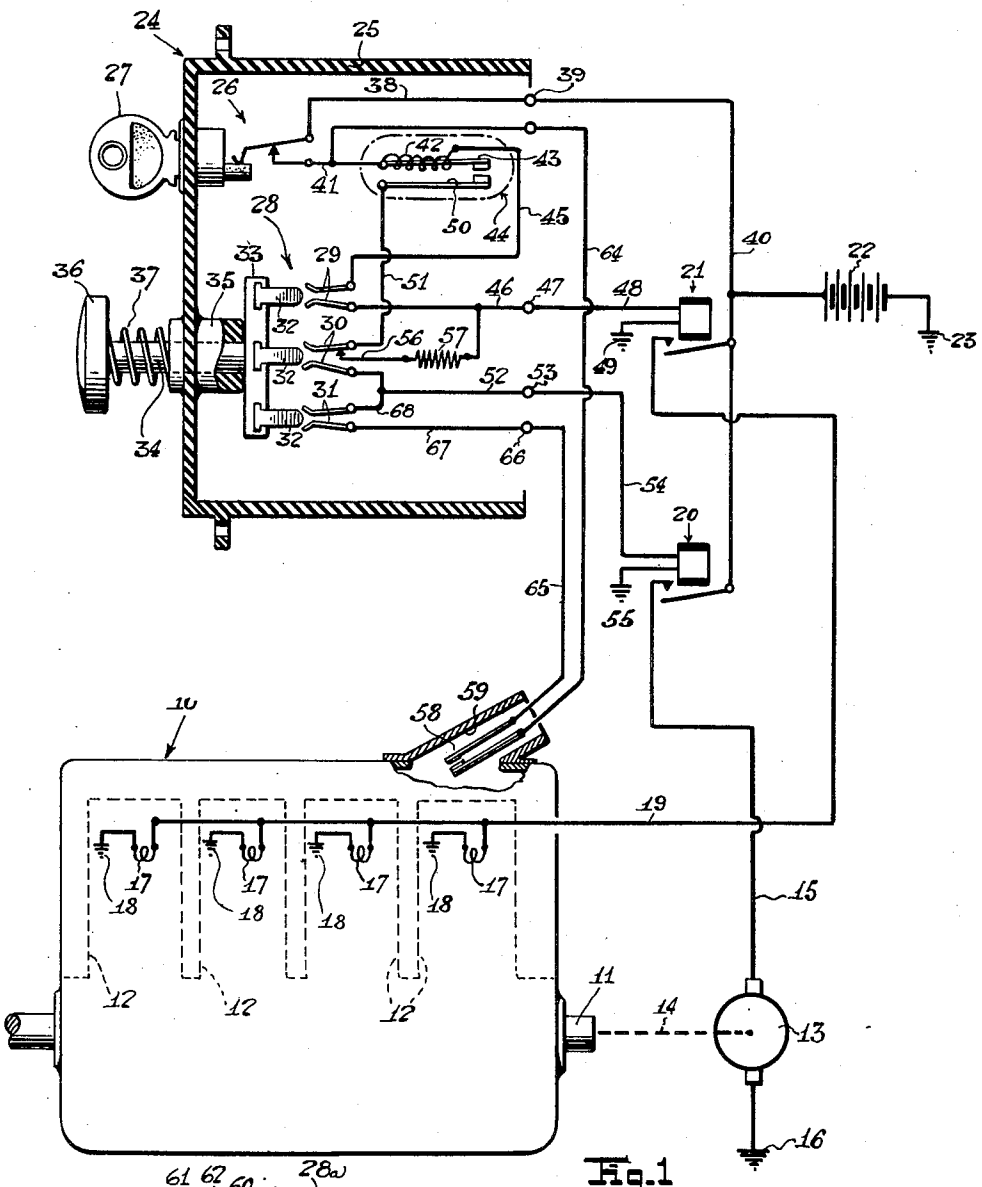

Fig. 1

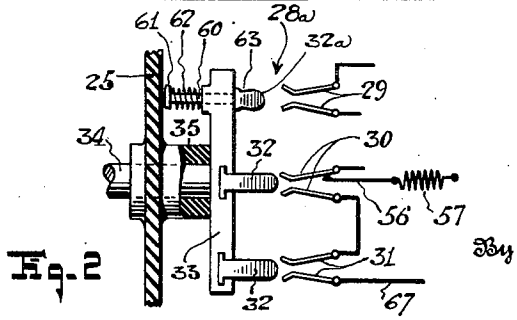

Fig. 2

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STARTER SYSTEM FOR DIESEL ENGINES

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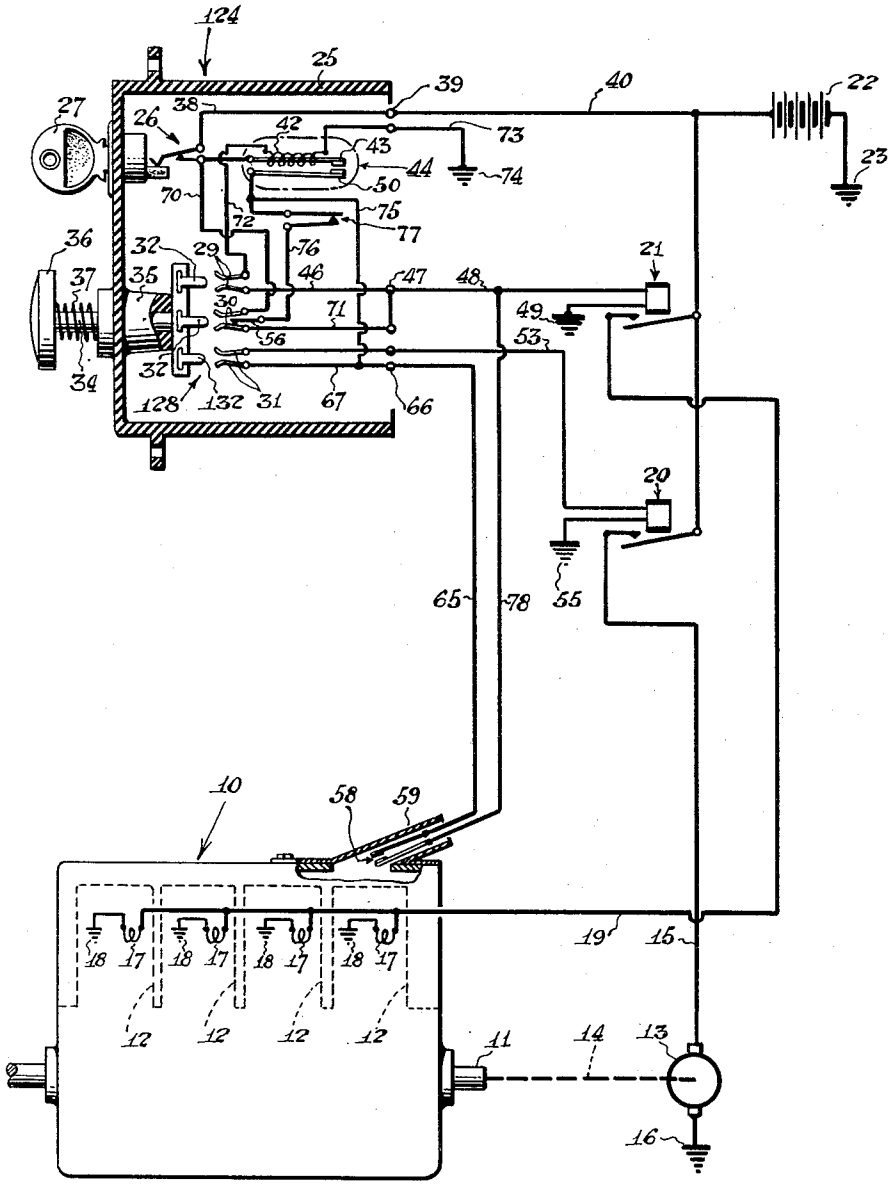

Fig. 3

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Patented May 8, 1951

2,552,256

UNITED STATES PATENT OFFICE

2,552,256

STARTER SYSTEM FOR DIESEL ENGINES

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Application February 3, 1950, Serial No. 142,107

16 Claims. (Cl. 123—179)

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This application is a continuation-in-part of my pending application Serial No. 26,685, filed May 12, 1948, now abandoned.

This invention relates to starter systems for Diesel engines which utilize one or more glow plugs for igniting the fuel-air charges to the cylinders when the engine is cold, and more particularly the invention relates to starter systems for Diesel engines which are adapted to delay the turning of the engine, if the engine is cold, until the temperature in the immediate vicinity of each glow plug reaches a suitable value to cause effective ignition.

Great difficulties are frequently experienced in starting Diesel engines while cold since cold engines absorb such a great amount of heat from the compressed gases during the compression stroke that the compression temperature in the combustion chambers does not rise high enough to cause ignition. If ignition fails, or is late so that only partial combustion occurs, serious damaging effects to the engine may occur such as destructive pounding and hammering of the working parts and bearings.

These difficulties are now commonly overcome by the use of glow plugs. These plugs are generally the shape of spark plugs, and are threaded into the engine block so that the active elements thereof extend into the combustion chambers, but the active elements are in the form of straight or coiled wires which are electrically heated to a temperature of the order of 1700° F.

These glow plugs must be supplied with electric heating current for an initial period, depending on the ambient temperature, before they become hot enough to cause effective ignition. Also they should be left energized for a short while after the engine firing begins and should then be disconnected from their heating current supply. An object of my invention is to provide a control system which is adapted to carry out these and other important steps to assure proper starting of Diesel engines and to maintain the engines running smoothly, regardless of the ambient temperature, until the engines reach normal operating temperature.

Another object is to provide such a starting system for Diesel engines which is arranged so that the operator is required to perform only simple and normal manipulations similar to the common procedure in starting engines generally.

It is another object of my invention to provide a starter system for Diesel engines which is substantially free from possible human error.

It is another object to provide a starter system adapted to carry out the steps of starting a Diesel engine in proper time and sequence relation.

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It is another object to provide a starter system of the character mentioned which is adapted to vary the preliminary period of energization of the glow plugs in accordance with the ambient temperature so that the glow plugs are rendered effective in all seasons of the year before the starter per se is put in operation.

Another object is to provide such starter system which will maintain the glow plugs energized for a limited period following the starting of the engine.

Still another object is to provide such starter system which, if the engine is already at a proper starting temperature, will put the starter per se in operation immediately as soon as the starter system is turned on.

Still another object is to provide a compact control unit for starter systems for Diesel engines which is arranged for convenient manual operation.

Other objects of my invention will be apparent from the following description and the appended claims.

In the description of my invention reference is had to the accompanying drawings, of which:

Figure 1 is a view showing diagrammatically the circuits and mechanism, with parts of the latter in section, of one embodiment of a starter system for Diesel engines according to my invention;

Figure 2 is a fractional view to show a modification of this embodiment; and

Figure 3 is a view similar to Figure 1 showing a second embodiment of my invention.

In Figure 1 a Diesel engine 10 is shown having a crank shaft 11 and cylinders 12 of which four are indicated by dash lines. An electric starter 13 for this engine has a coupling to the crank shaft represented diagrammatically by dash lines 14 and has an energizing circuit 15 connected to ground at 16. One glow plug 17 is provided for each cylinder, each being shown diagrammatically in the accompanying figure as having a coiled heating element in a combustion chamber of a cylinder of the engine. These plugs may be connected either in series or parallel, a parallel connection being shown wherein one end of the heating element of each plug is grounded at 18 and the other end of each heating element is connected to an energizing circuit 19.

The present control system for starting the engine 10 comprises a relay 20 for controlling the

energizing circuit 15 of the starter 13 and a relay 21 for controlling the energizing circuit 19 of the glow plugs 17. Each of these relays comprises an energizable coil and a pair of contacts one of which is operated when the respective coil is energized. The circuit 15 serially includes the contacts of the relay 20 and a source of potential, typically a battery 22 having one end grounded as at 23. Similarly, the circuit 19 serially includes the contacts of the relay 21 and the same battery 22.

A control unit 24 is provided which comprises a case 25 made as of suitable plastic or metal. Mounted on the front face of this case are two on-off controls: (1) a single circuit on-off locking switch 26 adapted to be operated between "Off" and "On" (i. e., open and closed) positions by a key 27 which is removable when the switch is in "Off" position, and (2) an on-off multiple switch 28 push-operable into "On" position and comprising three pairs of spaced contacts 29, 30 and 31 and respective bridging members 32, the bridging members being all carried by one bar 33 mounted on a plunger 34 which slides in a bearing 35 of the case. On the front end of this plunger there is a knob 36 and between this knob and the case there is a compression spring 37 which normally holds the switch in an "Off" position wherein the bridging members are disengaged from the respective pairs of contacts 29—31. When the knob 36 is depressed the contacts of each pair 29—31 are interconnected by the respective bridging member.

The switch 26 is a master on-off control for the system and has one contact thereof connected by a wire 38 to a terminal 39 which in turn is connected by a lead 40 to the positive side of the battery 22. This circuit carries the operating current for the entire controlling part of the starter system. The other contact of this master switch is connected by a lead 41 to both a heating coil 42 and associated movable switch arm 43 of a thermal relay 44 which is preferably of the encased-evacuated type, this being a form of time-delay switch as will appear. The other end of the heating coil 42 is connected by a lead 45 to one of the pair of contacts 29, the other contact of this pair being connected by a lead 46 to a terminal 47 which is in turn connected by a lead 48 to the coil of the relay 21. The other end of the coil of this relay 21 is grounded at 49. Thus, upon turning the key switch 26 to its "On" position and then holding the knob 36 depressed so as to maintain the switch 28 also in its "On" position, the heating coil 42 of the relay 44 and the coil of the relay 21 are connected in series across the battery 22. As soon as the relay 21 is so connected to the battery 22 it is operated to close the energizing circuit 19 and start the heating of the glow plugs 17. Energization of the heating coil 42 is also started immediately but such energization is required for an interval from a minimum of about ten seconds when the ambient is approximately at room temperature to a maximum of about forty-five seconds when the ambient is at a very cold temperature. This interval of energization required to operate the relay—i. e., to close the switch arm 43 with an associated semistationary arm 50—is referred to as its "operate time." It is this operate time of the thermal relay 44 that determines the preliminary period of heating of the glow plugs before the starter 13 is put into operation, as will be herein next understood.

The semistationary switch arm 50 of the relay

44 is connected by a lead 51 to one of the pair of contacts 30. The other of this pair of contacts is connected by a lead 52 to a terminal 53 and this terminal is connected by a lead 54 to one end of the coil of the starter control relay 20, the other end of this coil being grounded at 55. This circuit from the switch arm 50 to ground 55 is a start-stop control circuit for the starter 13. Upon the operator continuing to hold the switch 28 in its "On" position after the key switch 26 is turned on—which he is to do until the engine is started—the contacts of the thermal relay 44 will close at the expiration of the operate time of this relay and will thereby connect the starter control relay 20 across the battery 22 to cause the energizing circuit 15 to be closed and the starter 13 to be put into operation. When the engine starts running, the operator will remove his hand from the knob 36 to allow the spring 37 to return the push switch 28 to "Off" position. Since the contacts 30 are opened as the push switch is so returned, the energizing circuit of the starter control relay 20 is immediately broken and the starter 13 is stopped. It is desired though that the glow plugs be kept energized for a short interval after the engine has started in order to assure continued running of the engine. For this purpose an energizing circuit for the relay 21 is maintained after the push switch 28 is released so long as the contacts of the thermal relay 44 are closed. The interval during which continued energization of the glow plugs is desired is typically about twenty seconds. Accordingly, the thermal relay 44 is chosen to have a release time of this length of interval. This continued energizing circuit for the relay 21 is completed by way of a contact 56, which makes with that one of the contacts 30 connected to the lead 51 when the push switch 28 is released, and a resistor 57 connected to the lead 46. The time of engagement of the contact 56 with the contact 30 just mentioned is to overlap momentarily the time of bridging of the contacts 30 by the respective bridging member 32 as the push switch 28 is released. Since the contacts 29 are interconnected during this interval an energizing circuit for the relay 21 is maintained continuously as the switch 28 is released. For instance, when the knob 36 is fully depressed the energizing circuit for the relay 21 is by way of the heating coil 42 and contacts 29. During the mentioned momentary time overlap as the knob 36 is released, the energizing circuit for the relay 21 is completed both by way of the circuit just mentioned and by way of the circuit including the switch arms 43—50, contacts 30—56 and the resistor 57; and when the knob 36 is fully released the energizing circuit is only by way of the latter circuit. The resistor 57 is included as a voltage cut-down resistor to limit, among other things hereinafter explained, the current to the relay 21 during the release time of the relay 44 following the return of the switch 28 to "Off" position.

Because of the momentary bridging of the contacts 30 while one thereof is connected to the contact 56, there is a momentary circuit set up, as the push switch 28 is depressed, to supply current to the starter relay 20. This circuit is from the battery 22 by way of the leads 40 and 38, switch 26, coil 42 of the relay 44, contacts 29, resistor 57, contact 56, contact 30, and the leads 52 and 54 to the starter relay 20. This is an undesired circuit and in order that the current therein will not be sufficient to operate the relay 20 the resistor 57 is made large, say several times

the resistance of the coil 42. The use of such relatively large resistance will however not prevent the relay 21 from being held operated, after the push switch 28 is released, by the circuit hereinbefore described including the contact 56 and resistance 57, since the current required to hold the relay 21 operated is approximately only 30% of the current required to operate the relay.

An important feature of the apparatus hereinabove described is that the operate time of the thermal relay 44 varies with the ambient temperature to cause the preliminary heating of the plugs to be longer when the ambient temperature is colder, and vice versa. Thus, the thermal relay controls the preliminary heating period so as to tend to bring the immediate vicinity of each plug always to a proper temperature for igniting the fuel-air charges to the respective cylinders in all seasons of the year before the starter 13 is put into operation.

In the event that the engine is already at a proper starting temperature when the key switch 26 is turned on, a thermostat 58 is provided and arranged to cause the starter 13 to be put immediately into operation. This thermostat is placed at any suitable place in or on the engine as, for instance, in a well 59 of the engine block. The thermostat is arranged to be open at cold temperatures and to close when the temperature of the engine block reaches a threshold value at or above which the engine will readily start when turned over by the starter 13. One switch arm of this thermostat is connected to the battery 22 by way of the leads 40 and 38, the key switch 26, and a lead 64. The other switch arm of this thermostat is connected by a lead 65 to a terminal 66 of the control unit 24 and thence by a lead 67 to one of the contacts 31, the other of these contacts being connected by a lead 68 to the leads 52 and 54 running to the starter control relay 20. Thus, if the thermostat 58 is closed an energizing circuit for the starter relay 20 is provided as soon as the key switch 26 is turned on and the push switch 28 is depressed.

In a modification of the push switch 28 shown in Figure 2 and now referred to as 28*a*, one of the bridging members 32*a*—the one associated with the contact pair 29—is carried by a pin 60 which is slidably mounted in a bar 33 for movement relative thereto in directions of movement of the plunger 34. This pin 60 has a head 61 on the end thereof and between this head and the bar 33 there is a compression spring 62 which normally holds the bridging member lightly against the bar 33. The bridging member 32*a* is shorter than the other bridging members 32 so that, when the switch 28*a* is moved to "On" position, it will not interconnect the associated contacts 29 until after the contacts of the pairs 30 and 31 are respectively interconnected. When the switch 28*a* is in fully "On" position, the bridging member 32*a* is gripped releasably by the contacts 29 engaging an annular groove 63 of this bridging member. By so gripping the bridging member 32*a* the same is held momentarily between the contacts 29 as the switch 28*a* is released, with the spring 62 being compressed, until the other bridging members 32 are fully disengaged from the respective contact pairs 30 and 31. The advantage in so delaying the interconnecting of the contacts 29 until after the contacts of the pairs 30 and 31 are bridged by the respective bridging members, as the switch 28*a* is moved to "On" position, is that the contact

56 is disengaged from the associated contact 30 before the contacts 29 are interconnected, with the result that the momentary leakage circuit to the starter relay 20, hereinbefore described, no longer exists. The advantage in delaying the breaking of the contacts 29 from each other until after the contacts of the pairs 30 and 31 are respectively broken is that the contact 56 is reengaged with the associated contact 30 before the contacts 29 are broken and thus there is provided a continuous energizing circuit for the glow-plug control relay 21 as the switch 28*a* is released. For instance, during the initial part of the release movement of the switch 28*a* the energizing circuit for the relay 21 is completed by way of the coil 42 and contacts 29, and during a latter portion of this initial part of the release movement and during the remainder of the release movement of the switch 28*a* an energizing circuit for the relay 21 is completed by way of the switch arms 43—50, contacts 30—56 and resistance 57. Since there is in this arrangement no possible leakage circuit to the starter control relay 20, the resistance 57 may have a smaller value than that above described—typically, a value equal approximately to the effective resistance of the coil 42—so that normal energizing current for the relay 21 is maintained during the release time of the thermal relay 44 following the release of the switch 28*a* to "Off" position.

The second embodiment of my invention, shown in Figure 3, differs from my first embodiment principally by a rewiring of the circuit in the control unit 24. In describing this second embodiment, those parts and components which are the same as in my first embodiment are given the same reference characters, those parts which have been modified but which are still similar to the corresponding parts of the first embodiment are given the reference characters of the latter increased by 100, and those parts which are entirely new are given new reference characters.

The control unit, now referred to as 124, comprises the key-operable master switch 26, a modified push-operable switch 128 and the normally-open thermal relay 44. The switch 128 differs from the foregoing switch 28 of my first embodiment by having a bridging member 132 associated with the contacts 31, which is shorter than the other two bridging members 32. The purpose of this modification in the multiple switch is to delay the closing of the contacts 31 until the auxiliary contact 56 has broken with the associated contact 30 as the push button 36 is depressed, and to open the contacts 31 before this auxiliary contact re-makes with the associated contact 30 as the push button 36 is released, the reason for this action being hereinafter fully explained.

When only the master switch 26 is closed, no circuit of the starting system is normally completed, an exception being when the thermal relay 44 is closed. This exception will normally not occur unless the master switch is closed while the thermal relay is still under the heating influence of the starter 13 from a previous starting attempt. However, as the button 36 is next depressed, the glow-plug control relay 21 is energized as soon as the contacts 30 are bridged by the member 32 by way of the circuit leading from ground 23 through battery 22, lead lines 40 and 38, switch 26, lead line 70, contacts 30 by way of bridging member 32, lead lines 71 and 48, and the relay 21 to ground at 49. As soon as the coil of

the relay 21 is energized it closes the line 19 to supply heating current to the glow plugs from the battery 22. With the closing of the contacts 29, which occurs simultaneously as the contacts 30 are closed, the heater winding 42 of the thermal relay 44 is connected in shunt with the coil of the relay 21 by way of the lead line 46, the contacts 29 and respective bridging member 32, a lead line 72, the heater winding 42 and a lead line 73 to ground at 74. Thus, the heater winding of the thermal relay 44 is energized as soon as heating current is supplied to the glow plugs. By placing the heater winding 42 in parallel with the coil of the relay 21, the heater winding and relay coil can be designed independently of one another for most efficient operation in the system.

As is true with my first embodiment, the operator is to hold the button 36 depressed until the starter 13 is put into operation and the engine is running under its own power. The energization of the starter 13 occurs at the expiration of the operate time of the relay 44. For instance, when the contacts 43 and 50 of the thermal relay are closed, an energizing circuit for the starter control relay 20 is closed by way of the battery 22 through the master switch 26, the contacts 43 and 50, the lead lines 75 and 67, the contacts 31 through the bridging member 132, and the lead line 53 to the coil of the relay 20.

It is normally desired, as explained hereinbefore in connection with my first embodiment, that the glow plugs remain energized after the push button 36 is released until the engine runs smoothly under its own power. For this purpose, the auxiliary contact 56 is closed with one of the contacts 30 when the push button 36 is released and is disconnected from this contact 30 when the push button is depressed. After release of the push button 36, and until the bimetal strip of the thermal relay 44 is cooled sufficiently to open the contacts 43 and 50, the glow-plug control relay 21 is kept energized by way of the circuit leading from the master switch 26 through the thermal relay 44, a lead line 76 serially including a normally-closed thermostat 77 hereinafter explained, the contacts 56 and 30 and the lead lines 71 and 48 to the coil of the relay 21.

In order that there will not occur any momentary interruption in the energization of the relay 21 as the push-button 36 is released, the auxiliary contact 56 is adapted to make with the associated contact 30 before the associated bridging member 32 breaks with the contacts 30. There is accordingly an instant, when the push-button 36 is depressed, wherein both contacts 30 are interconnected by an associated bridging member 32 and one of these contacts is concurrently connected to the auxiliary contact 56. In order that at this instant there will not occur a momentary energization of the starter control relay 20 by way of a circuit leading from the master switch 26 through the lead line 70, contacts 30—30 through bridging member 32, contact 56, lead line 76, thermostat 77, lead lines 75 and 67, contacts 31 through the respective bridging member 132 and the lead line 53 to the starter control relay, the bridging member 132 associated with the contacts 31 is made shorter than the other bridging members 32, to prevent the contacts 31 from being closed until the auxiliary contact 56 is broken with the associated contact 30, as hereinbefore explained. There is accordingly in this embodiment a complete avoidance of any leakage current to the starter relay.

The temperature-time delay characteristic normally required of the thermal relay 44 is such that the contacts 43—50 are open under all ambient temperatures encountered in the field. However, sometimes it is desired to have such fast-decreasing time delays with rising ambient temperature that the contacts 43—50 will close at the higher ambient temperatures sometimes encountered in the field. This would mean that at these higher ambient temperatures the glow plugs would be energized continuously so long as the master switch 26 is closed—by way of the circuit leading from the switch 26 through the thermal relay 44, lead line 76, contacts 56 and 30 and the lead lines 71 and 48—unless some preventive device is provided. Such preventive device is the thermostat 77 serially included in the lead line 76. This thermostat is arranged to be open at all temperatures above the ambient temperature at which the thermal relay closes; preferably, for safety reasons, the thermostat should be open also through a small temperature range, say 10° F., extending below the closing temperature of the thermal relay 44. Thus, if the master switch 26 is closed when the ambient temperature is at or above the closing temperature of the thermal relay, no immediate action will take place. However, on next depressing the push-button 36, the starter relay 20 will be immediately energized to cause the starter 13 to crank the engine, the energizing circuit for the starter relay being through the thermal relay 44, lead lines 75 and 67, contacts 31 through the bridging member 132, and the lead line 53 to the relay 20. This energizing circuit of the starter relay 20 is however broken by the opening of the contacts 31 as soon as the switch button 36 is released. This is permissible since it is generally unnecessary to maintain the glow plugs heated after the engine has started when the ambient is at the high temperature just mentioned.

At ambient temperatures in the range between the opening temperature of the thermostat 77 and the closing temperature of the thermal relay 44, a short time interval equal to the operate time of the relay 44 will transpire after the button 36 is depressed before the starter relay 20 is energized, this being the same whether or not the thermostat is open or closed; however, with the thermostat 77 being now open the energization of the glow-plug control relay 21 is stopped immediately as soon as the push button 36 is released. This, likewise, is permissible when the ambient is in this higher temperature range.

To take care of the requirement of immediate starting, when in cold weather the engine is at operating temperature, another thermostat 58 is mounted in a water jacket or well 59 of the engine, as hereinbefore explained in connection with my first embodiment. This thermostat closes when the engine reaches a temperature at which it can be started satisfactorily without the help of the new plugs. When this thermostat is closed, the coil of the starter relay 29 is energized, to cause the engine to be cranked, as soon as the master switch 26 is closed and the button 36 is depressed, the starting circuit being by way of the switch 26, lead line 70, contacts 30 through the bridging member 32, lead lines 71 and 48, a lead line 78, thermostat 58, lead lines 65 and 67, contacts 31 through the bridging member 132 and the lead line 53 to the starter relay 20.

The embodiments of my invention hereinabove described are intended to be illustrative and not limitative of my invention since the same are subject to changes and modifications without de-

parture from the scope of my invention, which I endeavor to express according to the following claims.

I claim:

1. In a control system for starting a Diesel engine including a glow plug for igniting the fuel-air charges to a cylinder of the engine when the engine is cold, and a starter for the engine: the combination of an on-off control means; means rendered effective by said on-off control means when the same is placed in "On" position for energizing said glow plug; timing means connected to said on-off control means for energization when the control means is in "On" position, said timing means being adapted to be moved to an operated position at the expiration of a predetermined interval of energization thereof; and start-stop means for said starter operably including said on-off control means and said timing means and effective to render said starter operative when said on-off control means is in "On" position and said timing means is simultaneously in its operated position.

2. The combination set forth in claim 1 wherein said timing means is responsive to ambient temperature to cause said time interval of energization of said glow plug to be longer for colder ambient temperatures than it is for warmer ambient temperatures.

3. The combination set forth in claim 1 wherein said on-off control means comprises two independently-operable on-off control devices, and wherein said glow plug is energized and said timing means is put in operation only when both of said control devices are placed in their respective "On" positions.

4. The combination set forth in claim 1 including a thermostat thermally associated with said engine and operatively connected with said start-stop means for causing said starter to be put immediately into operation upon said control means being placed in "On" position while the temperature of said engine is above a predetermined threshold value.

5. In a control system for starting a Diesel engine including a glow plug for igniting the fuel-air charges to a cylinder of the engine when the engine is cold, and a starter for the engine: the combination of a key-operable on-off control device; a push-type on-off control device biased into "Off" position; means controlled by said control devices to cause energization of said glow plug when both of said devices are in respective "On" positions; a timing device; means for energizing said timing device when both said control devices are in respective "On" positions, said timing device being adapted to operate at a time interval following the start of energization thereof; and means controlled jointly by said timing device and said push-type control device and effective when said push-type control device is held in "On" position and said timing device is operated to render said starter effective.

6. In a control system for starting a Diesel engine: the combination of a glow plug for igniting the fuel-air charges to a cylinder of said engine when the engine is cold; an electric starter for said engine; a switch device operable into "On" and "Off" positions; a multiple switch device normally held in "Off" position; a thermal relay adapted to operate at a time interval following the start of energization thereof; circuit means controlled by said switch devices for supplying energizing current both to said glow plugs and to said thermal relay while both of said switch devices are in "On" positions; and circuit means, rendered effective by said thermal relay at the instant of operation thereof, for placing said starter in operation.

7. The combination set forth in claim 6 including a thermostat associated with said engine and closed only when the temperature of the engine is above a predetermined threshold value, and a circuit including said thermostat and a switch element of said multiple switch device for causing said starter to be put in operation when both of said switch devices are in respective "On" positions and the temperature of said engine is above said threshold value.

8. In a control system for starting a Diesel engine including a glow plug for igniting the fuel-air charges to a cylinder of the engine when the engine is cold, and a starter for the engine: the combination of a first relay controlling energization of said glow plug; a second relay for controlling energization of said starter; a switch device operable into "On" and "Off" positions; a multiple switch device normally held in "Off" position; an energizing circuit for said first relay rendered closed by said switch devices only when the same are in respective "On" positions; a thermal relay having a heating coil arranged in said system to be energized when both of said switch devices are in respective "On" positions, said thermal relay having a pair of contacts adapted to close at the expiration of a time interval following the start of energization thereof; and a circuit including said contacts and a switch element of said multiple switch device for supplying current to said second relay to place said starter in operation at the expiration of said time interval following operation of both of said switch devices into respective "On" positions, said last-stated circuit being opened to cause said starter to be rendered inoperative upon release of said multiple switch device.

9. The combination set forth in claim 8 comprising another circuit including said contacts and a switch element of said multiple switch device for supplying energizing current to said first relay while said contacts are closed and said multiple switch device is in "Off" position; and thermostatic means responsive to ambient temperature and associated with said last-stated circuit for disabling this circuit when the ambient temperature is above a predetermined value.

10. The combination set forth in claim 8 wherein said energizing circuit serially includes said heating coil of said thermal relay, comprising a second energizing circuit for said first relay, said second energizing circuit excluding said heating coil and including said relay contacts and the second pair of contacts of said multiple switch device, said second pair of contacts being closed when said multiple switch device is in "Off" position, and said switch device being adapted to cause both said first and second pairs of contacts thereof to be closed momentarily at the same time as said switch device is moved between "Off" and "On" positions.

11. The combination set forth in claim 8 including a thermostat associated with said engine and closed when the temperature of the engine is above a predetermined value; and including another circuit for supplying current to said second relay, said other current-supplying circuit being rendered closed only when both said switch devices are in respective "On" positions and said thermostat is closed.

12. In a control system for starting a Diesel

engine including a glow plug for igniting the fuel-air charges to a cylinder of the engine when the engine is cold, and a starter for the engine: the combination of a first relay controlling energization of said glow plug; a second relay for controlling energization of said starter; a switch device key-operable into "On" and "Off" positions; a push-type switch device normally held in "Off" position and including three pairs of contacts respectively closed when said switch device is held in "On" position; a thermal relay having a heating coil and normally-open contacts, said relay being adapted to close said contacts at the expiration of a time interval following the start of energization of said heating coil; an energizing circuit for said first relay and heating coil of said thermal relay, said energizing circuit serially including said key-operable switch device and a pair of contacts of said push-type switch device; an energizing circuit for said second relay serially including said contacts of said thermal relay and a second pair of contacts of said push-type switch device; a thermostat associated with said engine; and a second energizing circuit for said second relay serially including said key-operable switch device, said thermostat and a third pair of contacts of said push-type switch device.

13. In a control system for starting a Diesel engine including a glow plug for igniting the fuel-air charges to a cylinder of the engine when the engine is cold, and a starter for the engine: the combination of a first on-off master control device; a second on-off auxiliary control device; means rendered effective when both of said control devices are in respective "On" positions to cause energization of said glow plug; timing means adapted to move to operated position at the expiration of a first interval of energization thereof and to return to unoperated position at the expiration of a second interval following the stopping of the energization thereof; means for energizing said timing means as both of said on-off control devices are moved to "On" positions; start-stop means for said starter operatively including said timing means and both of said on-off control devices, said start-stop means being adapted to render said starter operative when both of said on-off control devices are in "On" positions and said timing means is in operated position, and to stop said starter as said second control device is moved to "Off" position; and means controlled jointly by said timing means and said control devices for maintaining energization of said glow plug following return of said second control device to "Off" position until said timing means is restored to unoperated position.

14. The combination set forth in claim 13, including thermostatic means responsive to the ambient temperature and operatively associated with said maintaining means for disabling the latter when the ambient temperature is above a predetermined value.

15. In a control system for starting a Diesel engine including a glow plug for igniting the fuel-air charges to a cylinder of the engine when the engine is cold, and a starter for the engine: the combination of a first relay controlling energization of said glow plug; a second relay for controlling energization of said starter; a switch device key-operable into "On" and "Off" positions; a push-type switch device normally held in "Off" position and including three pairs of contacts respectively closed when said switch device is held in "On" position; a thermal relay having a heating coil and normally-open contacts, said relay being adapted to close said contacts at the expiration of a time interval following the start of energization of said heating coil; an energizing circuit for said first relay and heating coil of said thermal relay, said energizing circuit serially including said key-operable switch device and a pair of contacts of said push-type switch device; and an energizing circuit for said second relay serially including said contacts of said thermal relay and a second pair of contacts of said push-type switch device.

16. In a control system for starting a Diesel engine including a glow plug for igniting the fuel-air charges to a cylinder of the engine when the engine is cold, and a starter for the engine: the combination of a first switch device; a second switch device biased into open position; an energizing circuit for said glow plug controlled by said switch devices and rendered closed when both of said devices are in respective closed positions; a current-energizable timing device including a switch operable into closed position at the expiration of a first time interval of energization of said timing device and into open position at the expiration of a second time interval following stopping of energization of said timing device; an energizing circuit for said timing device rendered closed when both of said switch devices are in respective closed positions; circuit control means serially including said time-operated switch and switch contacts of both of said switch devices for placing said starter in operation at the expiration of said first time interval following the closing of both of said switch devices and for stopping said starter upon release of said second switch device; and circuit means including said time-operated switch for maintaining energization of said glow plug for the duration of said second time interval following said release of said second switch device.

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No references cited.