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ELECTRICAL APPARATUS

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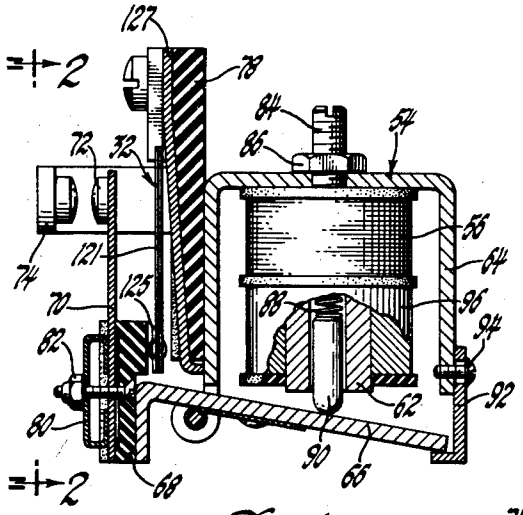


Fig. 1

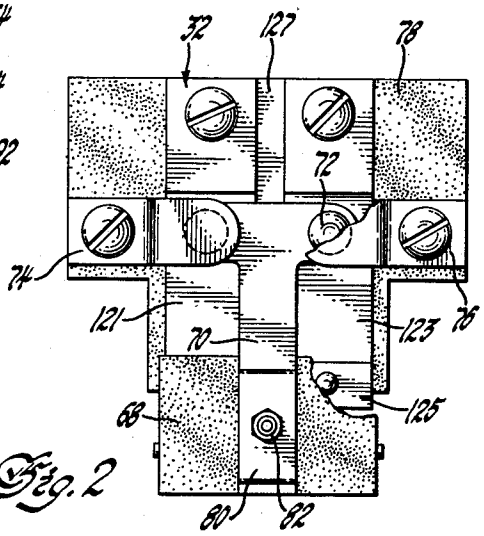


Fig. 2

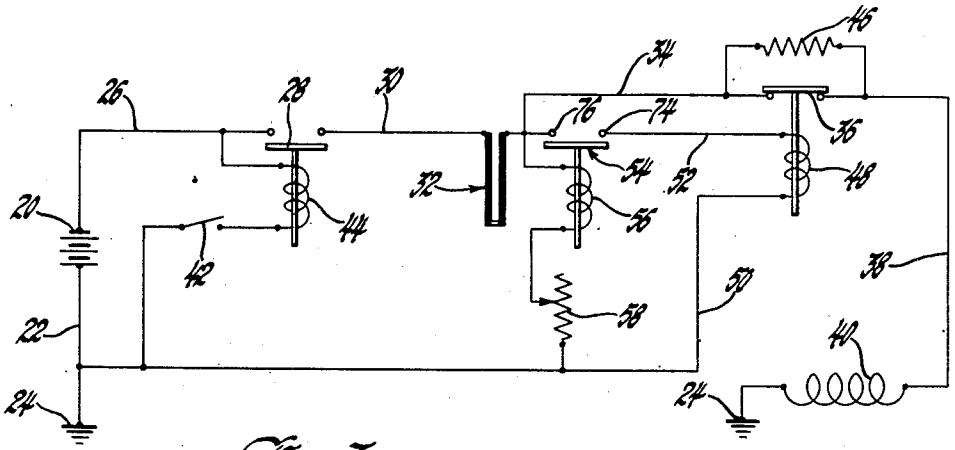


Fig. 3

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ELECTRICAL APPARATUS

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1

This invention relates to electrical apparatus and more particularly to time delay relays having a delay of a few milliseconds. It particularly relates to time delay relays such as may be used to change the circuit in a glow plug ignition system to reduce the high energy current as soon as the glow plug has been heated to its operating temperature.

It is an object of my invention to provide an accurate reliable time delay relay in which a time delay of a few milliseconds is provided through the use of an electrical conducting means associated with the iron circuit of the relay.

It is another object of my invention in providing a variable time delay relay having an arrangement for reducing the time delay when the temperature of the glow plug is above its normal cold starting temperature.

There is disclosed in this application a glow plug ignition system provided with a time delay relay for opening a shunt around a resistance in series with the glow plug when the glow plug is expected to reach its operating temperature. The time delay relay includes a non-magnetic short circuited electrical conductor encircling the core of the iron magnetic circuit along side the electromagnet coil. The time delay relay also includes a U-shaped bimetal element connected in series with the glow plug and deflected by the heating effect of the current to contact and push a portion of the relay armature towards the attracted or closed circuit position as the glow plug rises in temperature.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein a preferred form of the invention is clearly shown.

In the drawings:

Fig. 1 is a view in elevation, partly in section, of a relay embodying one form of my invention.

Fig. 2 is a side view of the relay shown in Fig. 1 taken substantially along the lines 2—2.

Fig. 3 is a wiring diagram of a glow plug ignition system embodying the relay as shown in Figs. 1 and 2.

While my time delay relay is applicable to many electrical systems, it is believed that it will be better understood by first describing its use in a glow plug ignition system. This glow plug ignition system is intended for use in starting and maintaining ignition in a rocket engine.

2

The system is preferably provided with a 24 volt battery 20 capable of delivering 200 amperes for a period of a few milliseconds. One terminal of this battery 20 is connected by the conductor 22 to the ground 24. The other terminal of the battery 20 is connected by the conductor 26 to one of the contacts of the normally open relay 28. Another of the contacts of the relay 28 is connected by the conductor 30 to a U-shaped bimetal element 32 which in turn is connected by the conductor 34 to one of the contacts of another relay 36 which is of the normally closed type. Another of the contacts of the relay 36 is connected by the conductor 38 to the glow plug element 40 which may include a conductor of platinum alloy. The other terminal of the glow plug element 40 is connected to the ground 24.

The ignition circuit is energized by closing the manually operable switch 42 connected in series with the electromagnet coil 44 of the relay 28 across the terminals of the battery 20. This causes the closing of the normally open relay 28. The closing of the relay 28 permits a current of 200 amperes to flow from the ground 24 through the conductor 22, the battery 20, the conductor 26, the contacts of the relay 28, the conductor 30, the U-shaped bimetal element 32, the conductor 34, the contacts of the relay 36, the conductor 38 and the glow plug 40 and back to the ground 24. This high current flow will quickly heat the glow plug 40 to its operating temperature, for example at 2500° F.

As soon as this operating temperature is reached, the current flow must be cut down to prevent overheating of the glow plug. To do this, the resistance 46 is connected in shunt with the contacts of the relay 36 with its terminals connecting to the conductors 34 and 38. The problem is to provide a reliable system which under all conditions will open the relay contacts 36 when the glow plug 40 reaches its operating temperature of, for example 2500° F. This must not be done too soon or the glow plug will not be hot enough to immediately start the engine. This must not be done too late or the glow plug will burn out. It is therefore necessary that the opening of the relay contacts 36 be done with considerable accuracy in timing.

The relay 36 is provided with an electromagnet operating coil 48 having one of its terminals connected by the conductor 50 to the conductor 22. The other terminal of the electromagnet coil 48 is connected by the conductor 52 with

the contact 74 of the relay 54 having a movable armature 72. The other stationary contact 76 of the relay 54 is connected to the conductor 34. The relay 54 is provided with an electromagnet operating coil 56 having one of its terminals connecting through an adjustable resistance 58 with the conductor 50. The resistance 58 may be adjusted to vary the time delay of the relay 54 by varying the current flow through the coil 56. The other terminal of coil 56 is connected to the conductor 34. The relay 54 including the electromagnet coil 56 and the U-shaped bimetal element 32 in Fig. 3 diagrammatically indicate the physical time delay relay shown in Figs. 1 and 2 which is designed so as to energize at the proper time the electromagnet coil 48 of the relay 36 to open the contacts of the relay 36 to connect the resistance 48 in single series circuit relationship with the glow plug 40 to reduce the current flow to about 25 amperes to prevent the overheating of the glow plug 40.

Referring now more particularly to Figs. 1 and 2, the electromagnet coil 56 is shown encircling a soft iron core 62. This core is mounted in the center of a U-shaped soft iron frame 64 to one leg of which is pivoted the armature 66 also of soft iron material. The core 62 together with the frame 64 and the armature 66 form the magnetic circuit. The armature 66 is connected through an insulating mounting 68 with a movable T-shaped contact arm 70 carrying a pair of contacts 72. These contacts 72 and contact arm 70 are adapted to bridge the contact terminals 74 and 76 each provided with contacts adapted to be contacted by the pair of contacts 72 when the armature 66 is attracted. These contact terminals 74 and 76 are mounted upon the insulating mounting 78.

The position of the contacts 72 relative to the armature 66 is adjusted through the use of a contact adjusting rectangular type spring 80 having its two end portions fastened to two portions of the contact arm 70. A nut 82 is provided which bears upon the center bridge portion of the rectangular type spring so as to hold the contact arm upon the insulating mounting 68 and also to cause the portion of the arm 70 resting upon the mounting 68 to be bent in the amount desired according to the adjustment of the nut 82. It should be noted that the insulated mounting 68 has raised edges so that the contact arm 70 forms a bridge between these edges and this bridge portion can be deflected by the tightening of the nut 82 to move the contacts 72 closer to the terminal contacts 74 and 76.

The insulation mounting 78 is mounted upon one leg of the frame 64. The frame 64 is provided with an adjusting screw 84 and a lock nut 86 connected to a compression type coil spring 88 within the iron core 62 which in turn connects to a plunger 90 of a nonmagnetic material which freely moves within the iron core 62. The spring 88 extends between the adjusting screw 84 and the plunger 90 within the core 62 to hold the plunger 90 against the armature 66. The armature 66 is limited in its downward or open circuit position by the armature stop 92 which is adjustably connected by the screw 94 and a suitable slot with the adjacent portion of the frame 64.

In addition to the adjustments already described, this relay includes two additional novel timing features. To reduce the speed of operation of the relay so as to give sufficient time for the glow plug 40 to heat up to its operating temperature before the resistance 46 is effectively connected into the glow plug circuit, there is provided a heavy copper ring 96 encircling the iron core along side of the electromagnet coil 56. This location of the copper ring is preferred, but it is possible to mount the copper ring encircling other portions of the magnetic circuit. The copper ring retards and opposes the building up of the flux in the magnetic circuit. By the well known law of Lenz, an electromotive force is induced in the copper ring circuit as a result of the building up of the magnetic flux by the energization of the electromagnet coil 56. This copper ring absorbs energy from the flux thereby delaying the rise in the flux to a value high enough to attract the armature 66 until the glow plug 40 has received sufficient current to be heated to its operating temperature. This value, necessary to attract the armature however, is attained within a few milliseconds which allows just sufficient time for the glow plug 40 to attain its operating temperature. At this time, the armature 66 is attracted pushing the plunger 90 upwardly into the core 62 and causing the contact 72 to engage the contacts of the terminal members 74 and 76 to energize the electromagnet coil 48 to cause the opening of the contacts of the relay 36.

The time delay relay shown in Figs. 1 and 2 has an additional feature. There is a possibility that the ignition system may be shut off or de-energized and then turned on or re-energized before the glow plug 40 is allowed to cool to its original normal cold starting temperature. If the same amount of current for the same period of time would be provided whenever the ignition circuit is energized, there is a possibility that the already hot glow plug might become overheated under this particular circumstance. To prevent this, the U-shaped bimetal element 32 has been provided. This bimetal element 32 includes the bimetal legs 121 and 123 which are connected by a cross bar 125 to provide its U-shaped construction. The cross bar 125 is connected to the bimetals 121 and 123 by rivets and these rivet heads are adapted to bear against the insulating mounting upon the armature 66 when the bimetals 121 and 123 have been heated by the flow of current to the glow plug.

Under this arrangement, the bimetals 121 and 123 will be heated by the current flowing to the glow plug 40 whenever the glow plug 40 is in operation. The high expanding sides of the bimetals 121 and 123 face the insulated mounting 78 so that upon heating, the rivets on these bimetals will bear against the insulated mounting 68 with increasing force as the temperature of the glow plug 40 increases to assist the electromagnet coil 56 and the magnetic circuit to attract the armature 66 more quickly. When the ignition circuit is de-energized, the bimetals 121 and 123 will cool as the glow plug 40 cools. In this way, the time delay of the relay 54 is reduced as the temperature of the glow plug increases.

A copper plate 127 is mounted on the insulating mounting 78 between this mounting and the U-shaped bimetal element 32. This copper plate 127 shields the frame 64 from the magnetic field surrounding the U-shaped bimetal element 32 produced especially when this element carries the initial 200 ampere current.

While the form of embodiment of the invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms

might be adopted, as may come within the scope of the claims which follow.

What is claimed is as follows:

1. A relay including an electromagnetic coil, a magnetic iron circuit associated with said coil including a core and a frame and an armature, an electrothermal means mounted on said frame, said armature having a portion extending into the path of movement of the electrothermal means, and a plate of a nonmagnetic electrical conducting material located between said electrothermal means and said frame and having a sufficient area to shield said frame from said electrothermal means.

2. A relay including an electromagnet coil, a magnetic iron circuit associated with said coil including a normally open armature, an electrothermal means having an operative connection with said armature and operative to move the armature in a closing direction upon an increase in temperature to adjust the open position of the armature for automatically controlling the time delay, and an electrical heating circuit connected in series with said electromagnet coil and associated with said electrothermal means to heat the electrothermal means and move the armature toward the closed position in proportion to the heating effect of the current flowing through the coil.

3. A relay including an electromagnet coil, a magnetic iron circuit associated with said coil including a normally open armature, a movable stop means cooperating with said armature for setting the limit of opening of said armature, an electrothermal means operatively connected to said stop means and having its temperature responsive expansion directed in the direction to move the stop means to move the armature toward the closed position to automatically control the time delay, and an electrical heating circuit connected in series with said electromagnet coil and associated with said electrothermal means to heat the electrothermal means to move the stop means and the armature toward the closed position in proportion to the heating effect of the current flowing through the coil.

4. A relay including an electromagnetic coil, a magnetic iron circuit associated with said coil including a core and a frame and an armature, an electrothermal means mounted upon said frame, an electrothermal means having an operative connection with said armature and operative to move said armature upon an increase in temperature, said electrothermal means being mounted on the opposite side of said plate from said frame, an electrical heating circuit energized coincidentally with said electromagnet coil for heating said electrothermal means to move the armature, said plate having a sufficient area located to shield said frame from the magnetic field established around said electrothermal means by the flow of energy through said heating circuit.

5. A relay including an electromagnetic coil, a magnetic iron circuit associated with said coil including a core and a frame and an armature, an electrothermal means mounted upon said frame, an electrothermal means having an operative connection with said armature and operative to move said armature upon an increase in temperature, said electrothermal means being mounted on the opposite side of said plate from said frame, an electrical heating circuit connected in series with said electromagnet coil and associated with said electrothermal means to heat the electrothermal means to move the armature, said plate having a sufficient area located to shield said frame from the magnetic field established around said electrothermal means by the flow of energy through said heating circuit.

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