March 5, 1935. G. B. TJOFLAT 1,993,633

MAGNETIC RELAY

Filed Nov. 30, 1931 3 Sheets-Sheet 1

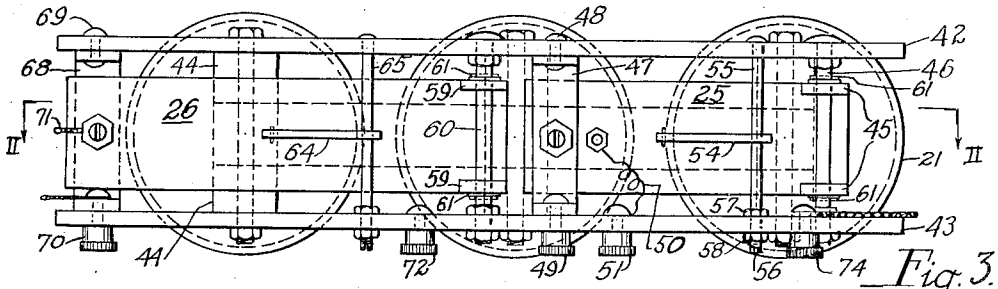

Fig. 3.

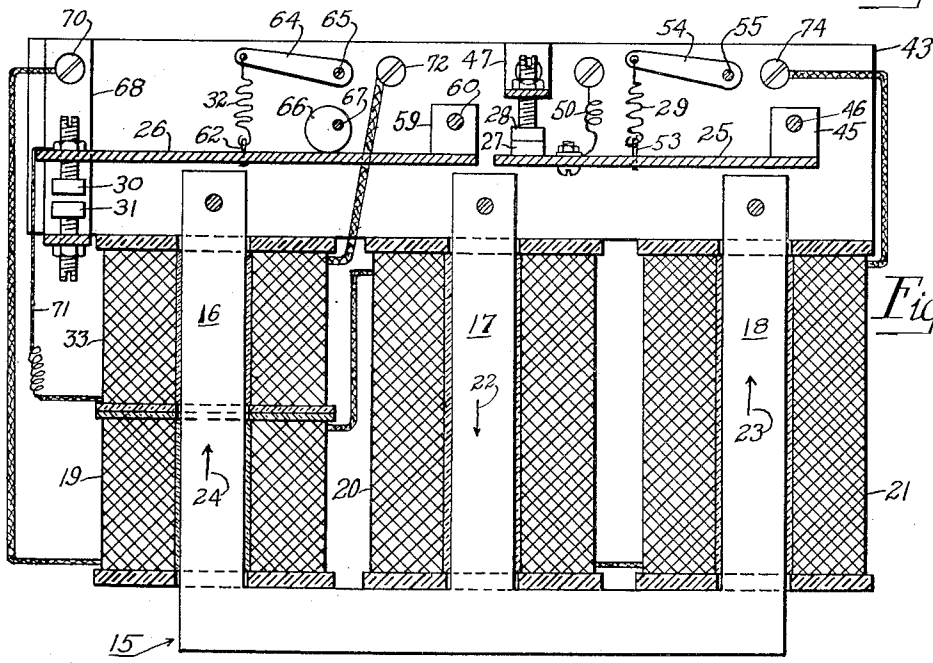

Fig. 2.

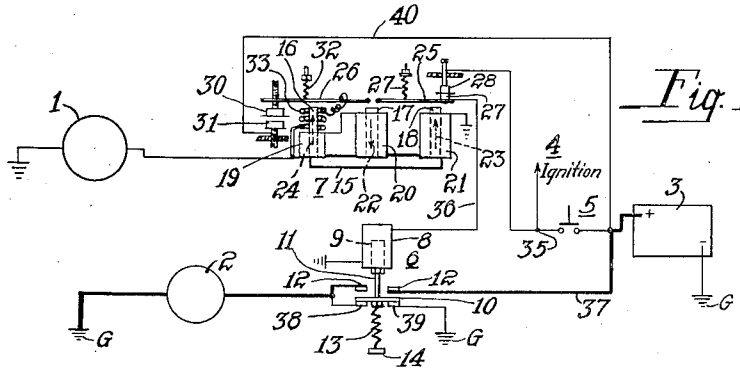

Fig. 1.

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MAGNETIC RELAY

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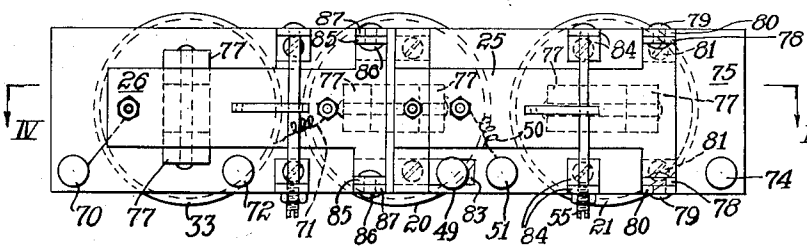

Fig. 5.

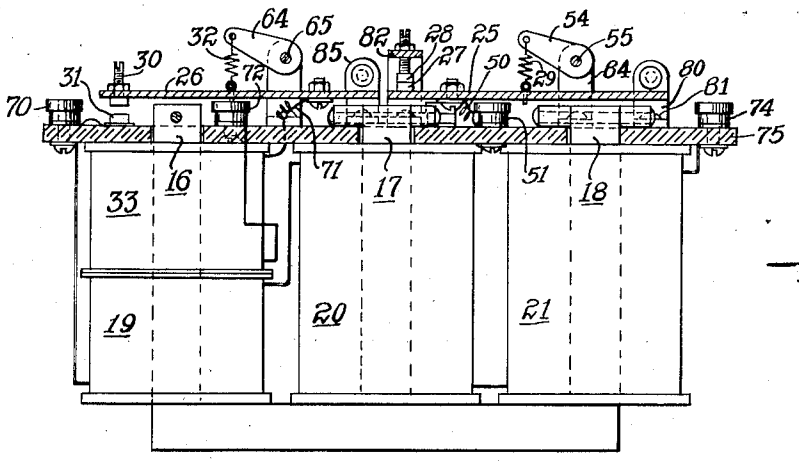

Fig. 4.

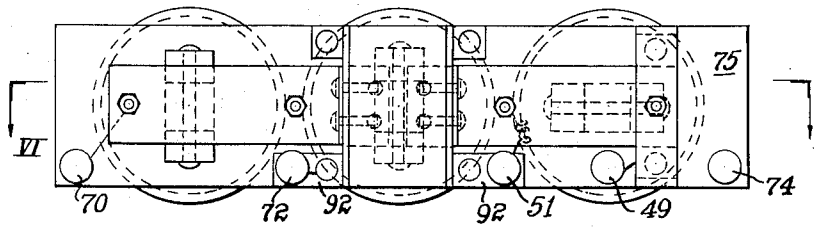

Fig. 7.

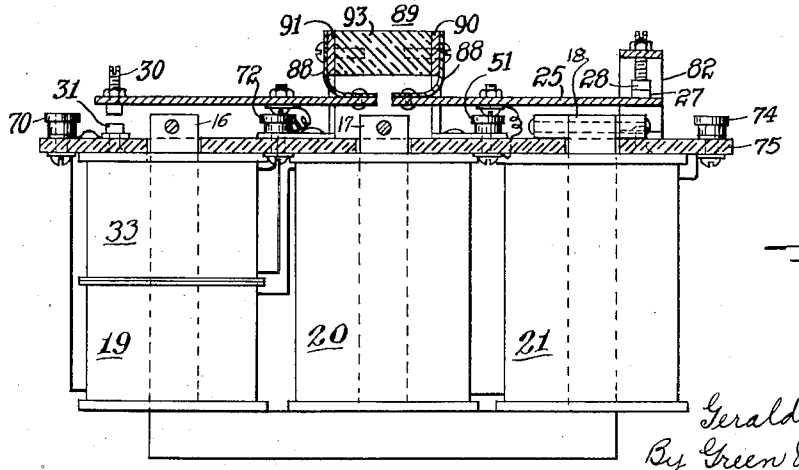

Fig. 6.

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MAGNETIC RELAY

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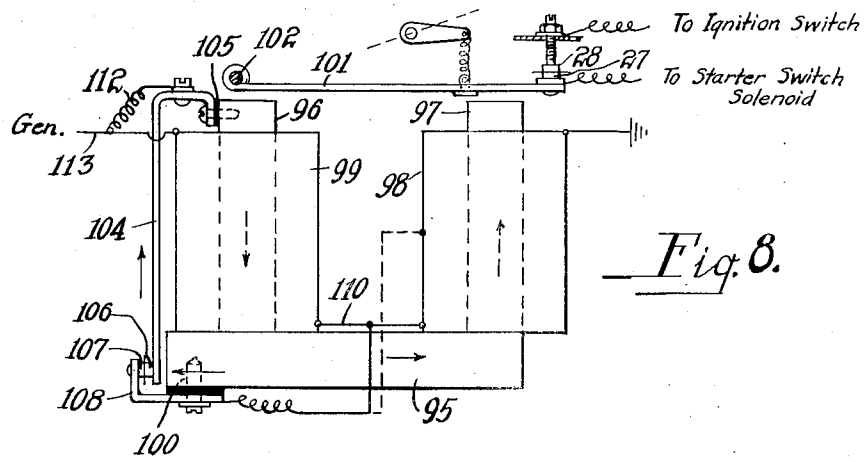

Fig. 8.

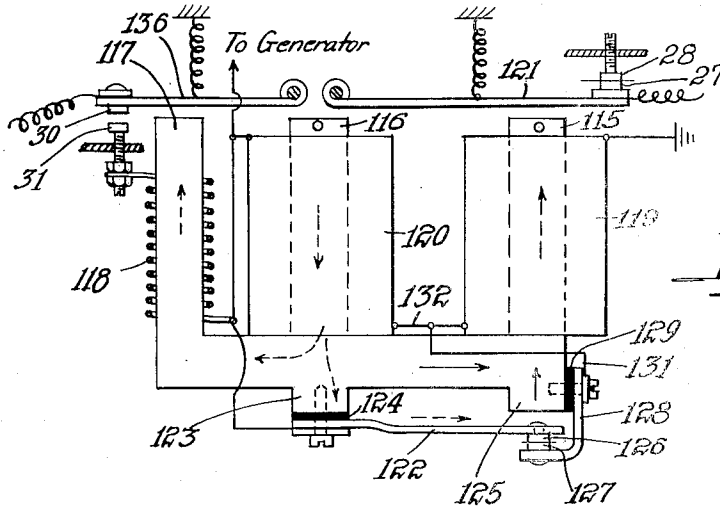

Fig. 9.

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Patented Mar. 5, 1935 1,993,633

UNITED STATES PATENT OFFICE

1,993,633

MAGNETIC RELAY

Gerald B. Tjoflat, Mount Lebanon, Pa.

Application November 30, 1931, Serial No. 577,939

4 Claims. (Cl. 200—98)

This invention relates to automatic starting systems for internal combustion engines such as employed with automobiles, or other motor driven vehicles, having, as a part of the system, a storage battery, starter motor and generator, and motor particularly to relays for automatically controlling the cranking of the engine by the starter motor and also for controlling the battery generator charging circuit in accordance with the voltage developed by the generator.

An object of this invention is the provision of an efficient, simple relay that shall be responsive to generator voltage and designed to automatically control the cranking operations of the starter motor, and the connection and disconnection of the generator to and from the battery as the voltage of the generator rises to or falls below the battery voltage.

Another object of the invention is the provision of a relay, such as referred to above, that shall be adapted to perform a plurality of different functions in sequence as the generator voltage rises or falls.

A further object of the invention is the provision of a magnetic relay having a plurality of parallel magnetic circuits, and for magnetically energizing said circuits in accordance with the sequence of the multiple functions to be performed thereby in accordance with variations in the voltage developed by the generator.

A still further object of the invention is the provision of a generator voltage responsive relay that shall be adapted to effect disconnection of the starter motor from the battery the moment the engine cranked by the starter motor is operating on its own power, and to prevent the connection of the starter motor to the battery until the engine has stopped.

While the invention to be hereinafter described in detail, is particularly applicable to electrical systems of automobiles, it will be apparent to those skilled in this art that the invention is also applicable to other electrical systems where it is desired to perform a number of functions or to control a number of circuits by means of a single relay.

Other objects of the invention will, in part, be apparent and will, in part, be obvious from the following description taken in conjunction with the accompanying drawings in which:—

Figure 1 is a diagrammatic illustration of circuits and apparatus comprising an automotive starting system having therein a relay arranged and constructed in accordance with an embodiment of the invention;

Fig. 2 is a view, in section, taken on line II—II of Fig. 3, of a relay embodying the invention;

Fig. 3 is a top plan view of the relay shown in Fig. 2;

Figs. 4 and 5 are sectional and top plan views, respectively, of a relay embodying a modified form of the invention, the sectional view being taken on line IV—IV of Fig. 5;

Figs. 6 and 7 are sectional and top plan views, respectively, of a relay embodying a still modified form of the invention, the sectional view being taken on line VI—VI of Fig. 7;

Fig. 8 is a diagrammatic view in side elevation of a relay embodying a further modified form of the invention; and

Fig. 9 is a diagrammatic view in side elevation of a relay embodying a still further modified form of the invention.

Throughout the drawings and the specification, like reference characters indicate like parts.

The circuits and apparatus illustrated in Fig. 1 represent diagrammatically the so-called dual unit electrical starting system for automotive vehicles. The system comprises a generator 1, a starter motor 2, which is utilized to crank an internal combustion engine (not shown), and a storage battery 3 to which the starter motor is connected while the engine is being cranked, and to which the generator is connected when the voltage thereof is equal to or slightly above that of the battery.

The battery is also utilized to supply current to the ignition system and the lighting system (not shown) as is common in the art. In Fig. 1, the ignition system is represented diagrammatically at 4, and is connected to the battery by means of the usual ignition switch or key 5.

In order that the starter motor 2 may be connected to the battery in response to the closure of the ignition switch, and disconnected from the battery the moment the engine starts and is operating on its own power, a motor starting switch 6 and a relay 7 are provided.

The relay 7 is so constructed that it will disconnect the starter motor from the battery, by causing the starter switch to open, and to reclose in case the engine should stop or stall for any reason, thereby reconnecting the starter motor to the battery to effect cranking of the engine automatically without further effort or attention on the part of the operator, provided the ignition switch 5 is closed.

The relay is also provided with means, so constructed that, when the generator voltage is equal to or slightly above the battery voltage, the relay

operates to connect the generator to the battery to charge the same and to disconnect the generator from the battery in case the generator voltage falls slightly below the voltage of the battery.

Thus, relay 7 performs two independent functions, but both functions are dependent upon the voltage developed by the generator. Since the generator is connected to the engine and driven thereby, it follows that the generator speed and the engine speed will bear a definite ratio to one another; therefore, the terminal voltage of the generator, until the generator is connected to the battery, will be substantially directly proportional to the engine speed.

The starter switch 6 comprises a solenoid 8 disposed about a core 9, and a disc 10 of metal, such as copper, which is attached to the end of a stem 11 carried by the core. When the solenoid is energized, the plunger is pulled upwardly causing disc 10 to bridge a pair of stationary contact members 12, thus connecting the motor 2 across the battery. In order that the starter switch may be positively opened when the solenoid is deenergized, a tension spring 13 is provided which is connected to the lower end of the stem and to a stationary or anchoring support 14.

Relay 7 comprises a core 15 of E-shape. The core being of E-shape it embodies a plurality of legs 16, 17 and 18 on some or all of which coil windings may be disposed. As shown in Fig. 1, coil windings 20 and 21 having substantially the same number of turns are mounted on legs 17 and 18, and a coil winding 19 having approximately half as many turns as the other two windings, is disposed on leg 17 of the core. Coil windings 19, 20 and 21 are preferably connected in series circuit relation across the generator 1. The windings are so connected that the polarity or the direction of flux in the middle leg 17 is opposite to that in the outer legs 16 and 18. The windings being so connected, the flux in the middle leg acts in the direction of arrow 22 and the flux in the outer legs act in the direction of arrows 23 and 24.

The relay core being constructed, as shown, thus provides two parallel magnetic circuits. Since the middle leg of the relay carries the total flux of both circuits, it necessarily follows that the flux in this leg is materially higher than the flux in the other two legs. Also since there are a larger number of turns of coil winding on legs 17 and 18 than there are on legs 17 and 16, it will be apparent that the magnetomotive force acting on the circuit including the middle leg 17 and outer leg 18 will be greater than the magnetomotive force acting on the other magnetic circuit comprising the middle leg and the outer leg 16.

The relay also includes armatures 25 and 26. Armature 25 is hinged over outer leg 18 and extends partly over the middle leg 17. A contact member 27 is mounted on armature 25 which is normally disposed to engage a stationary contact member 28, a tension spring 29 being provided to urge the armature upwardly so that these contact members are normally closed.

Armature 26 carries a contact member 30 which is disposed to engage a stationary contact member 31 when the voltage of the generator is equal to or slightly above that of the battery voltage. Armature 26 is urged upwardly by means of a spring 32 so that if the generator voltage is below that of the battery, contact members 30 and 31 will be disengaged from each other; in other words, these contact members are normally open.

In order that armature 26 may be released to that position in which contact members 30 and 31 are open, to thereby disconnect the generator from the battery, when the voltage of the generator is slightly below that of the battery, a reverse current coil 33 is provided.

The reverse current coil is mounted on leg 16 of the core, preferably on top of coil winding 19 so as to be near to the air gap between the armature 26 and core leg 16 where it is most effective. Recerse current coil winding 33 so wound that when the generator is delivering charging current to the battery, the fluxes developed by said coil 33 and by coil winding 19 are additive and in the same direction, thus increasing the total magnetic flux in the magnetic circuit including legs 16 and 17 and the armature 26. However, when current flows from the battery to the generator, the voltage in the generator being lower than that of the battery, the current in coil winding 33 reverses, thereby demagnetizing the magnetic circuit including legs 16 and 17 and armature 26 to such an extent, that spring 32 will pull the armature upwardly and thereby break contact between contact members 30 and 31, thus disconnecting the generator from the battery.

Armature 26 may be raised and lowered to make and break contact between contact points 30 and 31, without interfering with or detrimentally disturbing the flux traversing the magnetic circuit including legs 17 and 18 and armature 25, because the reverse current coil is effective to demagnetize only the magnetic circuit in which the armature 26 is included.

In order to start an internal combustion engine arranged to be cranked by the starter motor 2, the ignition switch or key 5 is closed thereby establishing a circuit for the solenoid 8 of starter switch 6, that extends from the battery 3 through ignition key 5 to a junction point 35. From the junction point current flows to the ignition circuit in the usual manner. Current for the starter solenoid switch also flows from the junction point through normally closed contact members 27 and 28, conductor 36 and the solenoid 8 to ground at G and thence to the ground side of the battery. When the solenoid is energized, the starter switch closes thereby establishing a circuit for the starter motor that extends from the battery, through conductor 37, stationary contact members 12, the bridging disc 10, and the armature of motor 2 to ground at G, and thence to the ground side of the battery. The starter motor will now operate to crank the engine.

Where the starter motor is connected mechanically to the internal combustion engine by means of the so-called Bendix drive, the turning of the starter motor advances the pinion into the fly-wheel gear and thereby cranks the engine. If the engine fires and operates on its own power, the pinion is thown out of mesh with the fly-wheel gear. Simultaneously with the starting of the engine, the normally cosed contact members 27 and 28 of the relay are opened because the voltage impressed on the coil windings thereof by generator 1 will be sufficient to magnetize the core to that value required to pull armature 25 downwardly and open the normally closed contact members. When the normally closed contact members are open, the starter switch solenoid is deenergized thereby causing the switch to open, under the action of spring 13, and disconnect the starter motor from the battery.

Under certain conditions of starting, as for example when the internal combustion engine is

cold, the engine may fire on one or two cylinders and then stop or stall. However, the firing of one or two cylinders may be sufficient to cause the Bendix pinion to be thrown out of mesh with the fly-wheel gear, and the voltage generated by the generator as impressed on the relay coil windings, may have been sufficient to open the normally closed contact members and effect deenergization of the starter switch solenoid. But, since the contact members 27 and 28 are reclosed when the engine stalls, they may close before the starter motor armature and the pinion driven thereby have come to rest. If such is the case, and the starter motor is connected to the battery while the pinion is spinning, the pinion will not advance into mesh with the fly-wheel gear because of insufficient differential between the rotative speed of the pinion and the starter motor shaft. Therefore, in order to insure that the starter motor shall come to rest the moment the starter switch is opened, as in the case where the engine may fire on one or two cylinders and then stall, the starter switch may be provided with a pair of back contact members 38 and 39 which are bridged by the starter switch disc 10 when the starter switch opens. When back contact members 38 and 39 are bridged by the starter switch disc 10, the armature of motor 2 is short-circuited, whereby dynamic braking takes place, causing the starter motor to stop almost instantly.

If the engine has started and is operating on its own power, then when the engine speed increases to that value at which the voltage developed by the generator is equal to or slightly above the voltage of the battery, armature 26 will be pulled downwardly to close the normally open contact members 30 and 31 thereby connecting the battery to the generator so that the generator may charge the battery. Upon the closure of the normally open contact members, current flows from the generator through the reverse current coil winding 33, the normally open contact members 30, 31 which are now closed, conductor 40, through the battery to ground, and back to the ground side of the generator.

When the engine speed falls to a value such that the voltage developed by the generator is below that of the battery, current flows through the above described circuit in the reverse direction thereby causing the reverse current coil to develop a flux in opposition to that developed by coil windings 19 and 20 in the magnetic circuit with which they are associated. Such demagnetization of this circuit causes the armature 26 to move upwardly under the action of spring 32, thereby opening the normally open contact members and disconnecting the generator from the battery.

So long as the ignition switch is closed the above described operations will be repeated each time the engine stalls, and the connection and disconnection of the generator from the battery will take place in accordance with the voltage of the generator as it rises above or falls below that of the battery.

In practice, the relay may be constructed as illustrated in Figs. 2 and 3. The elements of construction, embodied in the relay shown in Figs. 2 and 3 which are common to those described in connection with the relay, diagrammatically illustrated in Fig. 1, are designated by the same reference characters.

As shown in Fig. 2, coil windings 19, 20 and 21 are mounted on the core legs 16, 17 and 18, respectively, and insulated therefrom as indicated. The reverse current coil winding 33 is mounted on core leg 16 on top of coil winding 19, and is also suitably insulated from the core, as shown.

As is well known in the art of winding coils, a coil has inside and outside leads. Therefore in order to obtain the proper flux relation between the two magnetic circuits described in connection with Fig. 1, the outside lead of coil winding 19 is arranged to be connected to the ungrounded terminal of the generator, and the inside lead or terminal thereof is connected to the outside terminal of coil winding 20. The inside lead or terminal of coil winding 20 is connected to the outside lead of coil winding 21, and the inside lead of coil winding 21 is connected to the ground side or terminal of the generator.

Thus coil windings 19, 20 and 21 are connected in series across the generator so that the direction of flux in the middle leg 17 is opposite to the direction of flux in the outer legs.

When the coil windings have been mounted on the core they may be secured in place by means of vertically disposed slabs or strips 42 and 43 of insulating material that extend across the tops of the coil windings as shown. The slabs may be bolted to the upper ends of the core legs 16, 17 and 18, thereby securing the slabs in place and also providing means for holding the coil windings in place on the core. The slabs may be appropriately spaced, to provide ample room for the armatures, by means of spacing blocks 44 disposed between the slabs and the sides of the core legs.

Armature 25 may, as shown, be provided with two upwardly extending lugs or ears 45 through which a hinge bolt 46 may be passed. The hinge bolt as shown extends through the side slabs 42, 43, thus supporting the armature in place thereon. As shown in Fig. 2, the hinge point of armature 25 is to the right of outer leg 18, so that the flux permeating said leg may exert a turning force on the armature. The free end of the armature is disposed over the middle leg 17 so that the middle leg also exerts a turning force on the armature in the same direction as that exerted by the outer leg 18. The stationary contact member 28 is threaded into a support 47, preferably of U-shape, which is secured to the side members or slabs 42 and 43 by means of a screw or rivet 48 and a binding post 49, which forms a terminal to which the ignition switch may be connected as shown in Fig. 1. In order that the stationary contact member 27 carried by armature 25 may be connected to the starter switch solenoid 8, a shunt 50 is secured to the armature and to a binding post 51 mounted on slab 43.

Spring 29 which is utilized to urge armature 25 to the position in which contact members 27 and 28 are normally closed, has one end attached to the armature by means of an eyelet 53, and the other end to the outer end of a lever 54 which is rigidly secured to a shaft 55 that extends through the side slabs of the relay. One end of shaft 55 is threaded, and has a slot 56 formed therein so that by means of a screw-driver or suitable tool, arm 54 may be turned in one direction or another to vary the spring tension on the armature. When the proper spring tension has been obtained, the shaft may be locked in place by means of nuts 57 and 58 disposed one on each side of the slab 43.

By raising or lowering the stationary contact member 28 in its support 47, the air gap between the middle leg of the core and the free end of the armature may be increased or decreased ac-

cording to requirements. The length of the air gap, when the contact members are closed, and the force exerted thereon by spring 29 determines largely the voltage which the generator must develop before the armature will be pulled downwardly to break contact between contact members 27 and 28.

By properly choosing the gauge of wire used in winding the coils, the number of turns and shape of coil, armature 25 may be caused to open the normally closed contact member the instant the internal combustion engine starts and operates on its own power. The voltage developed by the generator at the instant of starting, varies with the design but on the average this voltage is from three to six tenths of a volt, and this voltage is sufficient to open the normally closed contact members.

Armature 26 is also provided with lugs or ears 59 at one end through which a hinge pin 60 extends. The hinge pin 60 is mounted in the side slabs 42, 43 as shown.

Armatures 25 and 26 may be held in alinement with respect to the core legs by means of cotter pins 61 disposed on the outside of the lugs or ears through which the hinge pins pass.

The spring 32 which is provided to actuate armature 26 to the position shown in full lines in Fig. 2 is anchored at one end in an eyelet 62 attached to the armature and at its opposite end to the free end of a lever 64 which is rigidly secured to a shaft 65. The shaft is constructed in the same fashion as the shaft 54, previously described, and is utilized for adjusting the tension of spring 32.

In order to limit the upward movement of armature 26, a stop 66 is provided. The stop may take the form of a circular disc which is mounted eccentrically on a shaft 67. The shaft extends through the side slabs and is turnable so that the upward limit of travel of the armature may be regulated to suit operating requirements. In practice, the tension of spring 32 and the air gap between armature 26 and core leg 16 are so adjusted that the armature will not be pulled downwardly to close the normally open contact members 30 and 31 until the voltage developed by the generator is equal to or slightly above that of the battery. The spring tension, it will be understood, must be such as to positively withdraw the armature to the position shown in Fig. 2 when current is flowing from the battery through reverse current winding 33 to the generator.

Stationary contact member 31 is threaded into a support 68 of U-shape, which is secured to the side slabs by means of a rivet 69 and a binding post 70 to which the ungrounded side of the generator is connected, as shown in Fig. 1. The movable contact member 30 is connected by a shunt 71 to the outside terminal of the reverse current winding 33, and the inside terminal thereof is connected to a binding post 72 secured to slab 43 to which the ungrounded side of the battery is connected. Thus, when the relay 7 is connected in a circuit such as shown in Fig. 1, and contact members 30 and 31 are closed, current will flow from the generator through support 68, stationary contact member 31, contact member 30, the shunt 71, coil winding 33 to binding post 72 and thence to the battery. By properly adjusting contact members 30 and 31, the downward limits of travel of the armature may be limited to secure the best operation of these contact members or cut-out points.

The inside terminal of coil winding 21 is connected to a binding post 74, which in practice is connected to ground.

To connect the relay shown in Figs. 2 and 3 to the starting system of an automobile, the relay is mounted in a convenient place, the generator connected to binding post 70, and binding post 74 connected to ground. These connections place coils 19, 20, 21 across the generator. Binding post 72 is connected to the battery, post 49 to ignition switch 5, and post 51 to the starter switch solenoid. When the starter switch has been mounted in place, and the proper connections made, such as illustrated in Fig. 1, the system is ready for operation.

Relay 7 may also be constructed as shown in Figs. 4 and 5. The relay shown in Figs. 4 and 5 differs from the relay shown in Figs. 2 and 3 only in the form of construction employed for holding the coil windings in place on the core and for mounting the armatures 25 and 26, the contact members and binding posts in operative position. Since the relay shown in Figs. 4 and 5 is otherwise similar to the one shown in Figs. 2 and 3, similar and corresponding parts will be designated by the same reference characters.

Instead of using the side slabs 42 and 43, a rectangular panel or base 75 of insulating material, may be mounted flatwise on top of the coil windings, as shown, and secured in place by means of rivets 76 that extend through blocks 77 and the tops of the core legs 16, 17 and 18, respectively. The blocks 77, as shown, bear on the base 75 so as to hold it in place. The base is apertured, as shown, to permit the tops of the core legs to extend therethrough.

Armature 25 is of somewhat T-shape at the hinged end and is provided with upwardly extending lugs 78 to accommodate hinge pins 79. The armature is supported by the hinge pins on brackets 80 of substantially L-shape which are secured to base 75 by means of rivets or screws 81. Stationary contact member 28 is threaded into a support 82 of substantially U-shape having horizontally extending flanges 83 that rest on the base and through which screws or rivets extend for securing the same thereto. Shaft 55 on which the spring tension adjusting arm 54 is mounted may be supported by L-shaped brackets 84 secured to the base.

Armature 26 is substantially of the same shape as armature 25 and is provided with upwardly extending lugs 85 through which hinge pins or rivets 86 extend, the hinge pins being supported in L-shaped brackets 87 secured to the base. Stationary contact member 31 is mounted on base 75 instead of on the U-shaped support 68 such as employed in the form shown in Figs. 2 and 3. In other respects the relay shown in Figs. 4 and 5 is similar to that shown in Figs. 2 and 3.

The binding posts described in connection with the relay shown in Figs. 2 and 3 are designated by the same reference characters and may be mounted directly on the base 75. The same electrical connections are made to the relay shown in Figs. 4 and 5 as described in connection with the relay shown in Figs 2 and 3.

In Figs. 6 and 7, a still further form of relay is shown. This relay differs primarily in the method or manner of mounting the armatures 25 and 26. It will be noted that in the relays shown in Figs. 2 and 3, 4 and 5 armature 25 is hinged at a point to the right of core leg 18; whereas in the relay shown in Figs. 6 and 7, both armatures 25 and 26 are hinged over the

middle core leg 17. Instead of placing the support for stationary contact member 28 over the middle leg of the core as is done in the relay shown in Figs. 4 and 5, this support is placed slightly to the right of outer core leg 18 and is secured to base 75. The inner end of armature 25 is yieldingly mounted by means of a spring 88, on a support 89. The support, as shown, comprises metal supporting members 90 and 91 having flanges 92 by means of which they are attached to the base. An insulating block 93 is disposed between supports 90 and 91 and may be secured thereto by means of screws. These screws also serve to support the spring 88.

The metal supports 90 and 91 may, as shown, be of substantially inverted U-shape with the flanges formed thereon as shown in Fig. 7. Binding post 51 which is connected to the starter switch solenoid may be utilized to secure one side of support 88 to the base. Similarly the battery binding post 72 may also be utilized to secure support 91 to the base. Other elements in common to the relays shown in Figs. 4 and 5, 2 and 3 which are embodied in the relay shown in Figs. 6 and 7 are designated by similar and corresponding reference characters.

Armature 26 is similarly mounted on support 89 by means of a spring 88.

In Fig. 8 of the drawings, a relay is shown which is adapted to effect automatic connection and disconnection of the starter motor to and from the battery in accordance with operating conditions of an internal combustion engine, while the ignition switch is closed. This relay does not embody the cut-out feature of the relays shown in Figs. 1 to 7, inclusive, but is designed to effect disconnection of the starter motor from the battery the moment the engine starts. With the type of relay shown in Fig. 8 any standard form of cut-out may be utilized for controlling the battery-generator charging circuit.

The relay shown in Fig. 8 comprises a core 95 of substantially U-shape having legs 96 and 97 on which coil windings 98 and 99 are disposed. The core is also provided with an extension 100 disposed below coil winding 99. The relay is provided with an armature 101 which is hinged at one end as at 102 on a hinge pin, and free to move at the other end. The free end of the armature carries a contact member 27 that is normally engaged by a stationary contact member 72 which may be mounted on a suitable support, after the fashion indicated in Figs. 2 to 7, inclusive. The contact members 27 and 28 are held normally closed when the coil windings are deenergized, by means of a tension spring 29 the tension of which may be adjusted to suit operating requirements by means of an arm 59 which is securely fastened to a turnable shaft such as the shaft 55 shown in Figs. 2 and 3. The stationary contact member is arranged to be connected to the ignition switch 5 and contact member 27 carried by the armature is arranged to be connected to the starter switch solenoid shown in Fig. 1.

During starting of the engine, that is, while the engine is being cranked in response to the closure of the ignition switch 5, coil winding 99 is short circuited and means are provided for so short circuiting this coil. When coil winding 99 is short circuited, winding 98 provides magnetomotive force for a pair of parallel magnetic circuits, but such force is more effective on one circuit than the other. The means is disposed to connect coil winding 99 in series with coil winding 98 across the generator when the engine is operating on its own power and the speed is such as will cause the generator to develop a voltage of, for example, 2½ to 3½ volts.

The means illustrated for normally short circuiting coil winding 99 comprises an armature 104, preferably made from spring steel. The armature may be of substantially L-shape, and rigidly secured to the upper end of core leg 96, insulation 105 being disposed between the armature and the core leg so as to insulate the same from the core. The free end of the armature is provided with a contact member 106 that normally engages a stationary contact member 107 carried by a metallic support 108 which is secured to the extension 100 of the core.

To insulate the support from the core, a strip 109 of insulation of suitable form and composition is interposed between the support and the core. The support 103 is connected to conductor 110 that connects coil winding 99 to winding 98, and the armature, as shown, is connected by means of a shunt 112 to the terminal 113 of coil winding 99. Thus when armature 104 is in the position shown in Fig. 8, and contact members 106 and 107 are closed, coil winding 99 is short circuited, and coil winding 98 is connected directly across the generator.

The resistance of coil winding 98 is preferably such that a relatively large current will flow therethrough, while coil winding 99 is short circuited, so that the moment the engine starts and operates on its own power, armature 101 will be pulled downwardly to break contact between contact members 27 and 28 thereby opening the starter switch and disconnecting the starter motor from the battery.

When the engine speed increases to a predetermined value, and the voltage developed by the generator is somewhere between 2½ and 3½ volts, the flux in the circuit including armature 104 will be sufficient to attract it to the core extension 100, thereby opening contact members 106 and 107 and connecting coil winding 99 in series with coil winding 98 across the generator. The current will, therefore, be reduced in coil windings 98, but the value of current flowing in both windings will still be sufficient to maintain armature 101 in that position in which the starting contact members 27 and 28 are held open.

Instead of connecting the support 108 to the conductor 110, the support may be connected to the midpoint, for example, of coil winding 98. In order to make such a connection, a tap would be formed on the coil winding, so that during starting conditions when contact members 106 and 107 are closed, approximately one-half of coil winding 98 will be traversed by current from the generator. This alternative connection may be made as indicated by the broken lines. With either form of connection, the relay is rendered highly responsive to the generator voltage at low engine speeds, so that sufficient force will be acting on the armature 101, to insure the disconnection of the starter motor from the battery the moment the engine starts. Also this form of relay will maintain contact members 27 and 28 open even at the lowest engine idling speeds.

The form of relay shown in Fig. 8 also provides a pair of magnetic circuits, the reluctances of which are in parallel. One of these circuits includes core legs 96 and 97 and the armature 101,

and the other circuit includes core leg 96, extension 101 and the spring armature 104. As in the case of the other relays shown and described previously herein, the spring armature 104 may operate in its intended manner without disturbing or detrimentally affecting the flux in the circuit controlling the armature 101. Thus armature 104 may move to and from the core at the lower generator voltages without causing armature 101 to be released before the engine stops or stalls.

An advantage to be gained by the type of relay shown in Fig. 8 is that at the lower voltages, which necessarily correspond to the low engine speeds, the flux traversing the magnetic circuit including core legs 96 and 97 and the armature 101 is increased materially with respect to the value of flux that would obtain if coils 98 and 99 were continually connected in series circuit relation across the generator.

Thus it will be apparent that the flux permeating core legs 96, 97 and the armature 101 will be substantially constant over a wide range of engine speeds and will be relatively high at low engine speeds where it is necessary and important that the armature 101 be held in a position to maintain contact members 27 and 28 open.

In Fig. 9 a still further modified form of relay is shown. This relay embodies the features of the relay shown in Fig. 8 and the cut-out features of the relays shown in Figs. 1 to 7, inclusive. The relay shown in Fig. 9 comprises a core of substantially E-shape having core legs 115, 116 and 117. A reverse current coil winding 118 is mounted on leg 117, and generator voltage responsive coil windings 119 and 120 are mounted on core legs 115 and 116. Coil windings 119 and 120 are connected in series circuit relation as shown, the connection being such that the flux permeating the middle leg is opposite in polarity to the flux permeating the outer legs.

The relay embodies an armature 121 that controls normally closed contact members 27 and 28 to which the starter switch 6 and the ignition switch 5 may be connected, as in Fig. 1. The armature is urged upwardly by means of a spring, the tension of which may be adjusted as in the other types of relays heretofore described.

In order that coil winding 120 may be short circuited during the starting of the engine and while the engine is operating at relatively low speeds, an armature 122 is mounted at the bottom of the core on a depending lug 123 disposed beneath core leg 116. The armature may be of the preformed spring type and may be anchored at one end to lug 123 by means of screws, and insulated from the core by means of a strip 124 of insulation. The free end of this armature extends across a depending lug 125 and is provided with a contact member 126 that normally engages a stationary contact member 127 carried by a support 128 which is also secured to the core as shown by means of screws. A strip 129 of insulation may be placed between the support and the core to insulate the same therefrom. The stationary support is connected by means of a conductor 131 to a conductor 132 which connects coil windings 119 and 120 together. The anchored end of armature 122 is connected by a conductor 134 to one terminal of the reverse current coil winding 118 and the generator terminal of coil winding 120. Thus during the starting of the engine and during the time that the engine is operating at low engine speeds, coil winding 120 is short circuited, so that coil winding 119 receives a high magnetizing current at these speeds. As in the relay of Fig. 8, coil winding 119, at low engine speeds provides magnetomotive force for all of the magnetic circuits thereof so that the armatures will function as described.

The cut-out function of the relay shown in Fig. 9 is obtained by means of an armature 136 which is hinged over the middle core leg in any suitable manner and which carries a contact member 30 at its free end. Contact member 30 is disposed to engage a stationary contact member 31 which is connected to the other terminal of the reverse current coil winding. Contact member 30 is arranged to be connected to the ungrounded terminal of the battery, the same as in the relays described previously herein. Armature 136 is urged upwardly by means of a spring so that contact members 30 and 31 are normally open. Armatures 121 and 122 of the relay shown in Fig. 9 function in substantially the same manner as the armatures 101 and 104 of the relay shown in Fig. 8. The cut-out armature 136 functions in the same manner as the cut-out armatures of the relays described in connection with the relays shown in Figs. 1 to 7, inclusive.

While the relays herein shown and described have been illustrated in connection with automotive starting systems, it will be appreciated by those skilled in this particular art that the relays may be applied to or utilized in other systems where multiple functions are desired, and particularly where such functions shall take place in a predetermined order or sequence in accordance with the happening of certain conditions in the system.

While certain practical forms of relay have been shown and described it will be appreciated that various modifications and changes may be made therein without departing from the spirit or the scope of the invention. Therefore it is desired that only such limitations shall be placed on the invention as are imposed by the prior art and the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. A magnetic relay comprising a core having at least two parallel magnetic circuits, independently movable armatures in each of said magnetic circuits, coil windings on said core for magnetically energizing both of said circuits, said windings being so distributed that one of said circuits is energized to a greater extent than the other, a pair of normally closed contact members arranged to be opened by one of said armatures when the current in said coil windings reaches a predetermined minimum value, and a pair of normally open contact members arranged to be closed by the other of said armatures when the current in said coil windings reaches a predetermined maximum value.

2. A magnetic relay comprising a core having two parallel magnetic circuits, an independently movable armature in each of said magnetic circuits, a coil winding arranged to magnetically energize both of said magnetic circuits, a pair of normally closed contact members arranged to be opened by one of said armatures when the current in said coil winding reaches a predetermined minimum value, a pair of normally open contact members arranged to be closed by the other of said armatures when the current in said coil winding reaches a predetermined maximum value, and a reverse current coil winding on said core for effecting the release of the armature controlling said normally open contact members

when the current in said coil winding reaches a predetermined value.

3. A compound relay comprising a three-legged core having coil windings on each leg, the number of turns in the coil on one of said legs being less than the number of turns on the other two legs, said coil windings being in circuit with each other and so connected that the direction of the flux in one leg is opposite to that in the other legs, an armature arranged to be attracted by the flux permeating the middle and one of said other legs, when a voltage of a relatively low value is applied to said coil windings, and to release said armature when the voltage decreases to a predetermined value below said relatively low value, an armature arranged to be attracted by the flux permeating said middle leg and the other of said legs when a voltage of a higher predetermined value is applied to said coil winding, and circuit controlling devices arranged to be operated by said armatures.

4. A compound magnetic relay comprising a core having two independent magnetic circuits, an armature movably disposed in each of said circuits, a coil winding disposed on said core in flux linkage relation to both of said circuits, normally closed contact members arranged to be opened by one of said armatures when an electromotive force of a predetermined value is impressed on said coil winding, a pair of normally open contact members arranged to be closed by the other of said armatures when the electromotive force impressed on said coil winding is of another predetermined value, and a reverse current coil winding on said core, in flux linkage relation with the magnetic circuit in which the armature controlling said normally open contact members is disposed, for causing the armature controlling said normally open contact members to be released by said core when the electromotive force impressed on said winding falls to a value intermediate said first and second mentioned values.

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