July 18, 1944. C. S. JANES 2,353,900

ELECTROMAGNETIC BRAKE

Filed Sept. 19, 1942

Fig. 1

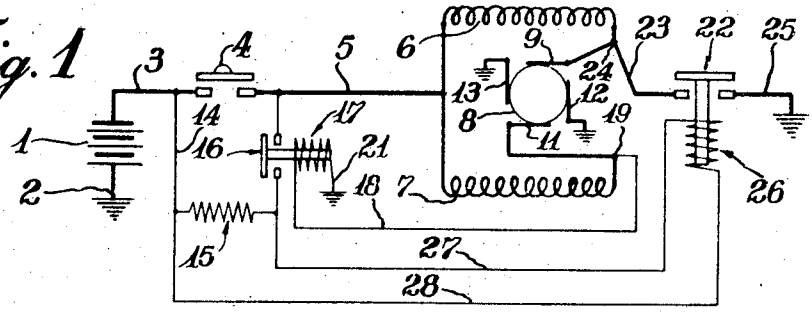


Fig. 2

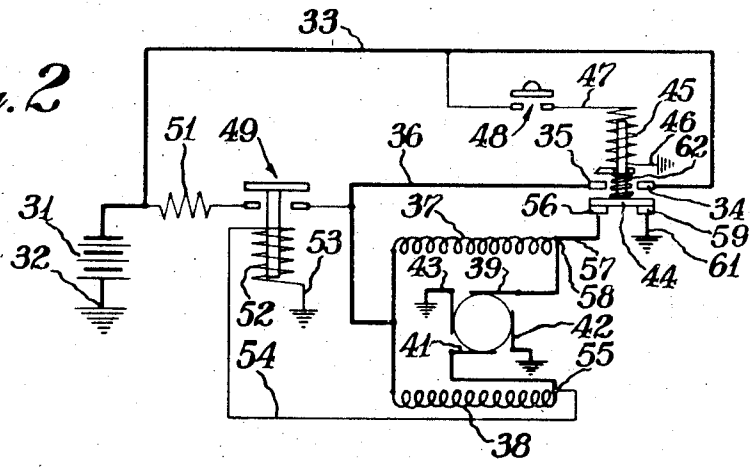
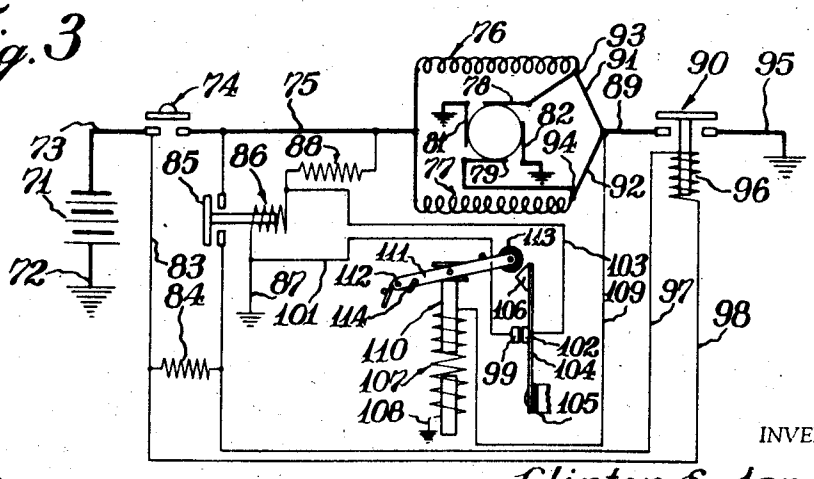


Fig. 3



INVENTOR.

Witness:
Burr W. Jones

BY Clinton S. Janes
N. D. Parker
ATTORNEY

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ELECTROMAGNETIC BRAKE

Clinton S. Janes, Elmira Heights, N. Y., assignor to Bendix Aviation Corporation, South Bend, Ind., a corporation of Delaware

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6 Claims. (Cl. 290—38)

The present invention relates to an electromagnetic brake for motors and more particularly to an arrangement for automatically arresting the rotation of an engine starting motor when the starting switch is opened.

In electrical starters for internal combustion engines of the type in which a pinion is projected into mesh with an engine gear by the initial acceleration of the starting motor, and is thrown out of mesh when the engine starts, it is desirable to have the starting motor stop quickly when it is de-energized so that if it be necessary to re-start the engine, a "spinning engagement" will be avoided. If the starting motor be re-energized while it is still spinning from a previous actuation, the consequent acceleration may not be sufficient to cause the pinion to move into mesh with the engine gear, whereby the starting mechanism fails to function. On the other hand, if the pinion does go into mesh, the starting motor will then be rotating much faster than it does in a normal start, and the consequent kinetic energy which must be transmitted to the engine may be destructive to the starter drive. This hazard is particularly serious in heavy duty installations where the rotating parts are heavy, and the drive is usually operating close to the limit of its safe load capacity.

Moreover, in those forms of starter drive in which the demeshing of the pinion is aided or effected by the deceleration of the starting motor when it is de-energized, some form of braking means for the starting motor is often desirable to assist the demeshing action, such for instance as shown in the patents to Loehr et al., 2,135,620, or Janes, 2,167,891.

It is an object of the present invention to provide a novel automatic electrical braking arrangement for motors which is efficient and reliable in operation and simple and economical in construction.

It is another object to provide such a device which secures the braking effect by maintaining or strengthening the field of the starting motor while reducing or stopping the flow of current from the battery through the armature.

It is another object to provide such a device in which the braking effect is secured by short-circuiting the armature either partially or completely.

It is another object to provide such a device which is automatically brought into action by the opening of the starting switch.

It is another object to provide such a device in which the braking effect is removed as soon as the starting motor comes substantially to rest.

It is another object to provide such a device including means for maintaining the braking effect for a predetermined time after the starting switch is opened.

Further objects and advantages will be apparent from the following description taken in connection with the accompanying drawing, in which:

Fig. 1 is a diagrammatic representation of a starting system showing a preferred embodiment of the present invention;

Fig. 2 is a similar view of such an arrangement in which the brake-applying magneto switch is also used as the remote controlled starting switch; and

Fig. 3 is a similar view of an embodiment of the invention incorporating a positive time delay mechanism which maintains the braking effect for a measured interval of time.

In Fig. 1 of the drawing there is illustrated a starting circuit comprising a battery 1 grounded at 2 and connected by a lead 3 to a starting switch 4. Switch 4 is connected by a lead 5 to a conventional type of series wound starting motor comprising a pair of field coils 6 and 7, an armature having a commutator 8, and two sets of commutator brushes 9, 11 and 12, 13, brushes 9 and 11 being connected to the field coils 6 and 7 respectively, and brushes 12 and 13 being grounded to complete the starting circuit.

A shunt circuit around the starting switch 4 is provided comprising a lead 14, a resistor 15 and a magnetic switch 16. The value of the resistance 15 is not at all critical, but may conveniently be such that when the starting switch 4 is open and the battery is connected to the starting motor through the shunt circuit, the voltage drop through the resistor 15 will be a substantial fraction of the battery voltage. Means for closing the switch 16 during rotation of the starting motor and for holding it closed until the starting motor comes substantially to rest is provided in the form of a coil 17 connected at one end by a lead 18 to the junction 19 between the field coil 7 and brush 11, the opposite end of coil 17 being grounded at 21.

In this embodiment of the invention, the electromagnetic braking effect is secured by grounding the junction between field coil 6 and brush 9 when the starting switch 4 is opened, thus increasing the current flow through said

field coil and at the same time short circuiting that part of the armature which is served by the brush 9. As here shown, this is accomplished by means of an electromagnetic switch 22 connected by a lead 23 with the junction 24 between field coil 6 and brush 9, and connected by a lead 25 to the ground. Grounding switch 22 is provided with an actuating coil 26 which is arranged to close said switch responsive to opening of the starting switch 4. This is brought about by connecting the coil 26 in shunt with the resistor 15 by means of leads 27 and 28 so that the voltage drop across the resistor 15 is impressed on said coil.

In the operation of this embodiment of the invention, starting with the parts in the positions illustrated, closure of the starting switch 4 by the operator completes the starting circuit in the usual manner whereby the motor is energized by the battery to rotate and perform its cranking operation. When the armature of the starting motor rotates, a counter-electromotive force is generated therein causing a substantial voltage to be built up between the brushes 9 and 11 and the grounded brushes 12, 13. The potential of the brush 11 is impressed on the ccoil 17 of magnetic switch 16 by means of the connection 18, whereby said switch is closed, thus closing the shunt circuit through resistor 15, although no current flows therethrough so long as the starting switch 4 is held closed.

When the engine starts, the operator opens the starting switch 4, whereupon the battery current is caused to flow through the shunt circuit including resistor 15 and switch 16. The consequent voltage drop across the resistor 15 is impressed on the coil 26 of the grounding switch 22, causing it to close, thus grounding the field coil 6 and short-circuiting the armature through the brush 9. The field coil 6 is consequently strengthened by the removal of the counter E. M. F. of the armature therefrom, and at the same time a current caused by the counter E. M. F. of the armature is permitted to flow through the circuit comprising brush 9, connection 23, switch 22, ground connection 25 and the grounded brushes 12, 13. This current is in a direction to cause reversal of the rotation of the armature and thus quickly arrest its forward rotation.

When the armature comes substantially to rest, the counter E. M. F. of the armature disappears and the brush 11 consequently is at approximately ground potential. The coil 17 of shunt switch 16 is thus de-energized, thereby permitting said switch to open. The shunt circuit being thus broken, coil 26 of the grounding switch 22 is de-energized, permitting said switch to open, placing the starting mechanism in condition for re-actuation.

It will be noted that the resistor 15 performs two functions. It provides a potential for controlling the operation of the grounding switch 22, and it also serves to limit the flow of current through the field coil 6, when grounded, to prevent overheating.

In the embodiment of the invention illustrated in Fig. 2 the magnetic grounding switch is caused to serve double duty as a remote-controlled starting switch. As there shown, a battery 31 grounded at 32 is connected by a lead 33 to a starting switch contact 34. A corresponding switch contact 35 is connected by a lead 36 to a series-wound starting motor comprising parallel field coils 37 and 38, commutator brushes 39, 41 connected to the fields respectively, and brushes 42, 43 grounded to complete the starting circuit. Means for connecting contacts 34, 35 to close the starting circuit is provided in the form of a bridging contact 44 actuated by a coil 45 grounded at one end at 46 and connected at the other end through lead 47 and push button 48 to the battery lead 33. It will be understood that the push button 48 will be located conveniently to the operator to provide a remote control of the starting operation.

A shunt circuit around the starting contacts 34, 35 is provided comprising a magnetic switch 49 and a resistor 51, which are arranged to connect the battery lead 33 with the starting motor lead 36. Switch 49 is provided with a coil 52, one end of which is grounded at 53 and the other end connected by a lead 54 to the junction 55 between the field coil 38 and armature brush 41, whereby said coil is energized by voltage corresponding to the counter E. M. F. of the armature when it is in rotation.

Means for grounding the field coil 37 and short circuiting the armature through the brush 39 is provided, comprising a grounding switch contact 56 connected by a lead 57 to the junction 58 between the field coil 37 and brush 39, and a contact 59 grounded at 61. Contacts 56, 59 are positioned so as to be normally connected by the bridging contact 44, this engagement being maintained by suitable means such as a spring 62.

In the operation of this embodiment of the invention, closure of the push button 48 by the operator causes energization of coil 45 which moves the bridging contact 44 out of engagement with the grounding contacts 56, 59 and into engagement with the starting switch contacts 34, 35. The starting motor is thereby energized to cause the engine to be cranked in the usual manner. When the armature rotates, the counter E. M. F. thereof is impressed on the coil 52 of shunt switch 49 by virtue of the connection 54 to brush 41, causing said switch to close and complete the shunt circuit around the starting switch. When the engine starts, the operator releases the push button 48, thereby disconnecting contacts 34, 35 and closing the ground connection through contacts 56, 59, thus grounding the field coil 37 and completing the reversing circuit through the armature, brush 39, lead 57, ground connection 61 and grounded brushes 42, 43. The rotation of the armature is thereby immediately arrested, whereupon the voltage of brush 41 falls substantially to zero and the coil 52 is de-energized permitting switch 49 to open.

Since in this embodiment of the invention, the resistor 51 has no functional effect in so far as the operation of the grounding switch is concerned, it may be omitted altogether and the shunt switch 49 connected directly with the battery lead 33. In such case, however, the braking effect may be undesirably energetic, and the field coil 37 and grounding contacts 56, 44, 59 may become over-heated after continued repetitious operation of the starter. It is preferred therefore to retain the resistor 51 simply for the purpose of preventing overloading of the field coil and contacts.

Fig. 3 shows the utilization of a positive form of time delay mechanism for maintaining the electromagnetic braking effect for a predetermined time after opening the starting switch. In this figure a battery 71 grounded at 72 is connected by a lead 73 to a starting switch 74. Switch 74 is connected by a lead 75 to the usual starting motor comprising parallel field coils 76 and 77, commutator brushes 78 and 79 connected to said field coils, and grounded commutator brushes 81 and 82.

A shunt circuit around the starting switch 74 is provided comprising a lead 83, a resistor 84 and a shunt magnetic switch 85 having an actuating coil 86. One end of coil 86 is grounded at 87 and the other end is connected through a resistor 88 to the starting motor lead 75. The value of resistor 88 is not critical but is preferably of the same order as the resistance of the coil 86. Coil 86 is designed to close switch 85 when actuated by battery current flowing through resistor 88.

Means for grounding both of the field coils 76, 77, and completely short-circuiting the armature through both brushes 78, 79 is provided in the form of a grounding switch 90 connected by leads 89, 91 and 92 to the junction points 93 and 94 between the field coils 76, 77 and brushes 78, 79 respectively and connected to the ground through a lead 95. Grounding switch 90 is provided with an actuating coil 96 which is energized by the voltage drop across the resistor 84 by virtue of connections 97, 98.

Means are provided for opening switch 85 a predetermined time after the starting switch 74 is opened. As here shown this means comprises a fixed contact 99 connected by a lead 101 to one end of the coil 86, and a movable contact 102 connected by a lead 103 to the opposite end of said coil, contact 102 being mounted on a flexible reed 104 anchored at 105 and provided with a weighted bob 106 on its free end whereby when the bob is flicked, the reed will vibrate for a predetermined time before permitting the contact 102 to come to rest against the contact 99. Means are provided for opening contacts 102, 99, during the cranking operation comprising a solenoid 107 grounded at one end at 108 and connected at the other end by a lead 109 to the junctions of the field coils 76, 77 and commutator brushes 78, 79 through leads 91, 92. A plunger 110 arranged to be actuated by the solenoid 107 is connected to a lever 111 pivoted at 112 and having a roller 113 on its free end in position to engage the bob 106 of the vibrator reed 104 and bend the reed back to open contacts 102, 99.

In operation, with the parts in the positions illustrated, closure of the starting switch 74 completes the starting circuit through the motor causing it to crank the engine in the usual manner. Closure of the starting switch also completes a circuit to the ground through resistor 88, lead 103, contacts 102, 99 and lead 101.

When the armature of the motor rotates, the counter E. M. F. thus generated is impressed upon the solenoid 107 by virtue of connections 91, 92, 109, thus causing plunger 110 to move the lever 111 to open contacts 99, 102. Thereupon the coil 86 of the shunt switch 85 is energized by the current flowing through the resistor 88 to cause closure of said switch.

When the engine starts, the starting switch 74 is opened by the operator whereupon the current to the starting motor is forced to traverse the shunt circuit including resistor 84 and shunt switch 85. The consequent voltage drop across the resistor 84 is impressed on the coil 96 of the grounding switch 90, thus causing said switch to close and ground the field coils 76, 77 and short-circuit the armature by connecting both the brushes 78, 79 to the ground. Closure of the grounding switch 90 also grounds and de-energizes the solenoid 107 which releases the plunger 110, permitting the lever 111 to return to its idle position by suitable means such as a spring 114. This return motion of the lever 111 flicks the bob 106 of reed 104, setting the reed in vibration. After a period of time predetermined by the physical constants and adjustment of the vibrating system, the contact 102 comes to rest against the contact 99, thus again short-circuiting the coil 86 and causing the shunt switch 85 to open. When this switch opens, the shunt circuit is broken, coil 96 of the grounding switch is de-energized and the grounding switch permitted to open.

It will be understood that if the braking effect secured by grounding both the field coils is unnecessarily energetic, the operation of the device may be rendered less drastic by omitting one of said ground connections 91 or 92 without otherwise affecting the operation of the braking system.

While the operation of a vibrator type time delay to retard closure of a switch is old, as shown for instance in the patent to Loehr et al., 1,912,904, the use of such a mechanism to delay the opening of a switch is believed to be novel. Applicant's understanding of the theory of operation in this case is as follows: When the contacts 102, 99 are opened, thus removing the short circuit around the coil 86, the coil becomes energized by the current traversing the resistor 88, thus building up a magnetic field around the coil until the flow of current through the coil reaches a substantially constant value, and the magnetic circuit thereof is substantially saturated. The inductive reactance of the coil is therefore very low, and practically the only resistance to the flow of current through said coil is now its pure ohmic resistance. When the plunger 110 of solenoid 107 is released, thus flicking the reed 104, the fluttering of the contacts 102, 99 produces the effect of an intermittent current applied to the coil 86 during the intervals when the contacts are open. Since as above pointed out, the coil has very little reactance, this pulsating current traverses it freely, and the self-inductance of said coil smooths out these pulsations into a substantially continuous current flow through the coil which accordingly maintains the magnetic field until the contacts 99, 102 come to rest in engagement. Then the coil 86 is short-circuited and de-energized and the shunt switch 85 permitted to open.

Whether or not this is the precisely correct theory of operation of the device is believed to be immaterial, since the operation thereof has been carefully observed and has been found to take place as described in the statement of operation above set forth.

The device as at present constructed utilizes a non-inductive resistor as the resistance 88, by virtue of its economy and convenience, and no undue amount of sparking at contacts 99, 102 has been observed. Obviously an inductive resistor 88 would be still more efficient.

While certain embodiments of the invention have been shown and described in detail, it will be understood that other embodiments are possible and that various changes may be made in the design and arrangement of the parts without departing from the spirit of the invention as defined in the claims appended hereto.

What is claimed is:

1. In combination with a starting circuit including a battery, a starting switch and a starting motor having a field and an armature, a circuit comprising a resistor and a switch in shunt with the starting switch, means for closing the shunt switch responsive to the counter E. M. F.

of said armature during rotation of the starting motor, and means actuated by the voltage drop across the resistor when the starting switch is opened, operative to short-circuit the armature.

2. In combination with a starting circuit including a battery, a starting switch and a starting motor having a field and an armature, means responsive to opening of the starting switch for diverting the flow of battery current from the armature while maintaining said flow through the field, and means for opening the starting circuit when the starting motor comes substantially to rest.

3. In combination with a starting circuit including a battery, a starting switch and a starting motor having a field and an armature, means responsive to opening the starting switch for short circuiting the armature while maintaining a connection from the battery through the field of the motor, and means for breaking said connection after a time delay sufficient to allow the armature to come substantially to rest.

4. In an engine starter a starting circuit including a motor and a switch, closure of which causes energization of the motor to crank the engine, and means responsive to opening of the switch for short circuiting the armature of the motor while maintaining a connection from the battery through the field of the motor.

5. In an engine starter a starting circuit including a motor having a field and armature connected in series, and a double-throw magnetic switch normally short-circuiting the armature, manually operable means for energizing the switch to open the short-circuit and to close the starting circuit, and means including a second magnetic switch energized by the counter E. M. F. of the armature for maintaining the starting circuit closed after de-energization of the first switch until the armature comes substantially to rest.

6. In an engine starter a starting circuit including a battery, a starting switch and a series-wound motor having parallel fields and parallel commutator brushes, one set of brushes being connected to the field coils and the other set being grounded to complete the starting circuit; a circuit in shunt with the starting switch comprising a resistor and a magnetic switch having a coil, one end of which is grounded and the other end connected to the junction of one field coil with its connected commutator brush, and a second magnetic switch arranged when closed, to ground the junction of another field coil with its connected commutator brush, and having an actuating coil connected in shunt with said resistor.

CLINTON S. JANES.