United States Patent

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[54] **SOLENOID-OPERATED STARTING MOTOR**
3 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** ..... **290/38 R**
[51] **Int. Cl.** **H02p 1/10**
[50] **Field of Search** ..... 290/38, 48, DIG. 1, DIG. 4

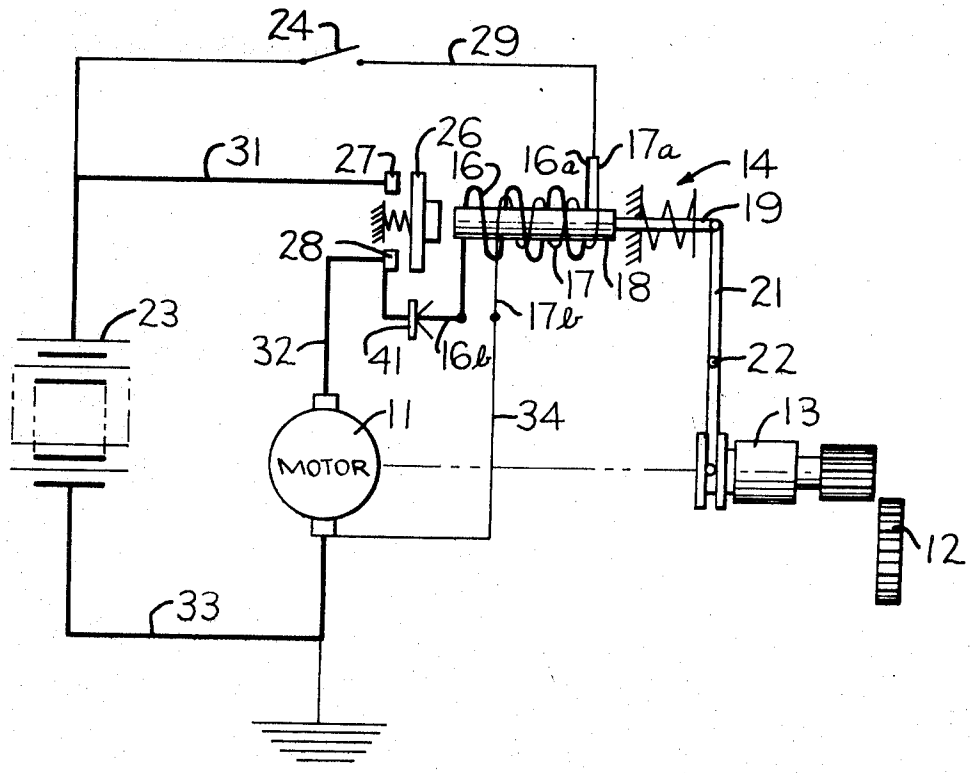
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ABSTRACT: In a solenoid circuit for a staring motor, a solenoid has both a pull-in coil and a hold-in coil for positioning an armature to effect engagement and disengagement of the starting motor with an engine. Shifting of the armature also closes a parallel circuit between an electrical source and the starting motor. A diode is arranged in series with one end of the pull-in coil to prevent reverse current flow through the pull-in coil and the development of a magnetomotive force therein counter to force developed by the hold-in coil.



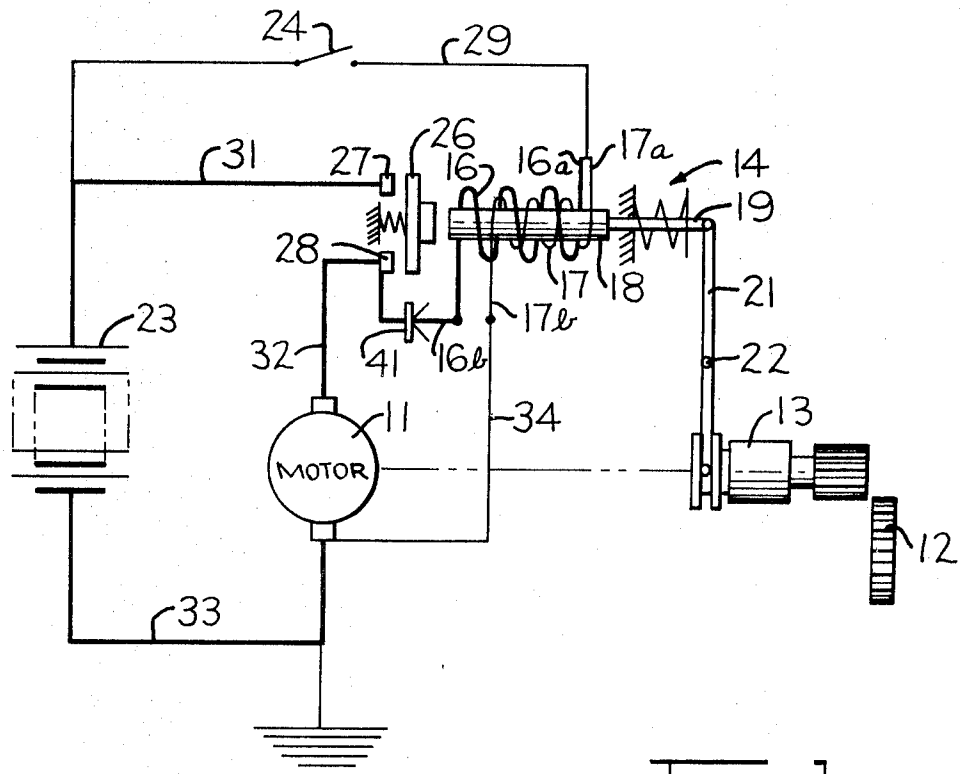


Fig. 1.

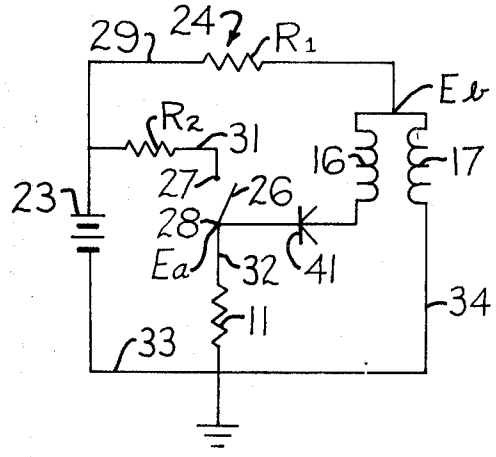


Fig. 2.

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SOLENOID-OPERATED STARTING MOTOR

U.S. Pat. No. 3,433,968, issued Mar. 18, 1969, describes a generally similar starting system including an additional resistive circuit arranged in parallel with the solenoid and in series with the starting motor to slowly rotate the starting motor as it enters into meshing engagement with an engine to assure proper indexing for the gear train of the starting motor.

The present invention relates to solenoid-operated starting motors and more particularly to a solenoid circuit including means for maintaining the starting motor either in positive engagement or disengagement with an engine. More particularly, the solenoid of such a system includes an armature which is operated by both a pull-in coil and a hold-in coil for effecting engagement between the starting motor and an engine to be cranked by the starting motor. Shifting of the armature also preferably causes engagement between a movable contact plate and two contact points to close an additional electrical path for operating the motor. In such an arrangement, it has been found that reverse current flow through the pull-in coil causing a "chattering" effect with the armature rapidly shifting back and forth between its engaged and disengaged positions. This effect may lead to failure of the contact points or may cause the points to become welded to the contact point, either of which would make the starting motor inoperable. To overcome this problem, the present invention also contemplates the arrangement of diode means in series with the pull-in coil to prevent such current reversal.

Accordingly, it is an object of the present invention to provide a solenoid-operated starting motor including means for achieving positive engagement or disengagement of the starting with an engine to be cranked.

It is a further object of the invention to provide diode means in series with the pull-in coil for such a solenoid to prevent the development of counter magnetomotive forces within the pull-in coil and hold-in coil of the solenoid.

Other objects and advantages of the invention are made apparent in the following description having reference to the accompanying drawing.

In the drawing:

FIG. 1 is a generally schematic representation of a solenoid-operated starting motor, and

FIG. 2 represents an equivalent circuit for the arrangement of FIG. 1. The starting system illustrated in FIG. 1 represents a preferred embodiment constructed in accordance with the present invention. The system includes a starting motor **11** which is used to drive an engine gear component **12** for cranking an engine (not otherwise shown). The motor **11** is selectively coupled with the gear **12** by means of a movable pinion assembly **13**.

A solenoid **14** includes a pull-in coil **16** and a hold-in coil **17** arranged about a movable armature **18**. The armature **18** has an extension **19** pivoted to a member **21** which may be rotated about a pivot point **22** for engaging or disengaging the pinion assembly **13** with respect to the gear **12**.

An electrical source, such as the battery indicated at **23**, is effective to energize both the solenoid **14** and the starting motor **11** under the regulation of a control or starting switch **24**. Energization of the two coils **16** and **17** shifts the armature **18** to the left (as viewed in FIG. 1), thus causing the pinion assembly **13** to enter into engagement with the gear **12**.

Initial current for energizing the motor **11** passes through the pull-in coil **16**. However, an additional circuit is provided to supply current for energizing the motor **11** once the armature **18** is shifted to engage the pinion assembly with the gear **12**. For this purpose, a spring-loaded electrical contact plate **26** is arranged in spaced-apart relation from the left end of the armature **18**. A pair of electrical contact points **27** and **28** is then arranged behind the contact plate **26**. The battery **23** is connected in series across the switch **24** by means of an electrical conduit **29** with one end **16*a*** of the pull-in coil **16** and one end **17*a*** of the hold-in coil **17**. A parallel line **31** connects the source **23** with the electrical contact point **27**. The other end **16*b*** of the pull-in coil is connected in series with the electrical contact point **28** and the motor **11** to the other side of the battery **23** by means of electrical conduits **32** and **33**. The other end **17*b*** of the hold-in coil is connected with an electrical conduit **34** arranged in parallel with the electrical contact point **28** and the motor **11** to provide a return line between the hold-in coil and the source **23**.

In operation, closing of the switch **24** energizes both of the coils **16** and **17** with current for initially operating the motor **11** passing through the pull-in coil **16** and the conduits **32** and **33**. The pull-in coil **16** is effective to shift the armature **18** leftwardly for engaging the pinion assembly **13** with the gear **12**. Leftward movement of the armature also causes the contact plate **26** to engage both of the electrical points **27** and **28** providing an alternate circuit between the source **23** and motor **11** by means of conduits **31**, **32** and **33**. After the armature is shifted completely to the left and the pinion assembly is engaged with the gear **12**, this alternate circuit carries the current for energizing the motor **11** to cause rotation of the gear **12**.

Within such an arrangement, it has been found that once contact is made between the contact plate **26** and the electrical point **28**, reverse current flow often occurs within the pull-in coil **16** developing a magnetomotive force counter to the magnetomotive force developed by the hold-in coil **17** for maintaining the armature in its leftward position. This counter force may tend to shift the armature momentarily toward the right as viewed in FIG. **1**. Upon the resulting circuit break between the electrical points **27** and **28**, a positive force would again be developed by the pull-in coil rapidly shifting the armature again to the left. This sequence tends to occur very rapidly resulting in a "chattering" effect with the armature **18** rapidly shifting into and out of engagement with the contact plate **26** leading to possible failure of the starting motor in the manner described above. To prevent this effect, a diode **41** is arranged in series between the other end **16*b*** of the pull-in coil and the contact point **28** to prevent the occurrence of such reverse current flow.

The problem referred to above may be more clearly seen having reference to the equivalent circuit shown in FIG. 2. R_1 equals the circuit resistance of the switch **24** and R_2 equals circuit resistance between the battery **23** and the contact points **27** and **28**. The other components of the equivalent circuit in FIG. 2 are represented by the same numerals employed to designate those same components in FIG. 1.

During operation of the circuit, voltage achieved at the electrical point contact **28** is indicated as E_a and voltage occurring at the junction of coils **16** and **17** (where their one ends **16*a*** and **17*a*** join with the conduit **29**) is indicated by E_b. It may be noted that both of these voltages are developed after closing of the switch **24**. When R_1 is equal to R_2, and plate **26** abuts both the electrical points **27**, **28**, the voltage at E_1 is equal to the voltage at E_b. Accordingly, the pull-in coil **16** is shorted out and the hold-in coil **17** remains effective to restrain the armature **18** in its leftwardly shifted position. However, if circuit resistance should develop so that R_1 is greater than R_2 under the above conditions, E_a would also be greater than E_b because of the voltage drop across R_1. Such an occurrence would cause reverse current flow through the pull-in coil **16** developing a magnetomotive force in opposition to the magnetomotive force of the hold-in coil **17**. Because of the heavier construction of the pull-in coil **16**, the armature **18** would tend to momentarily shift to the right permitting the contact plate **26** to break engagement with the points **27** and **28**.

E_b would then become greater than E_a and the pull-in coil would again shift the armature **18** leftwardly with a rapid sequence of these events resulting to cause chattering of the armature **18**.

The arrangement of the diode **41** prevents the development of reverse current flow through the pull-in coil **16** under such circumstances. Accordingly, the "chattering" action of the armature is prevented and reliability of the solenoid circuit is substantially enhanced.

What is claimed is:

1. A solenoid circuit for a starting motor, the solenoid having a pull-in coil and a hold-in coil, both coils being operatively coupled with a solenoid armature which is effective to shift a pinion mechanism for accomplishing positive engagement and disengagement of the starting motor with a gear component of an engine in response to energization of the coils by electrical source means and switch means, the armature also being arranged for providing electrical continuity between two contact points electrically arranged in parallel with the switch means and solenoid coils for energizing the motor by the electrical source means, the circuit comprising a series connection between the source and one end of each coil through the switch, parallel connecting means between the opposite ends of the coils and the source, a diode being in series communication with the other end of the pull-in coil to prevent reverse current flow through the pull-in coil and the development of a magnetomotive force in the pull-in coil counter to the magnetomotive force of the hold-in coil which maintains the shifted position of the armature for operation of the starting motor.

2. A solenoid circuit for a starting motor, the solenoid having a pull-in coil and a hold-in coil, both coils being operatively coupled with a solenoid armature which is effective to shift a pinion mechanism for accomplishing positive engagement

and disengagement of the starting motor with a gear component of an engine in response to energization of the coils by electrical source means and switch means, the armature also being arranged for positioning a movable contact plate to provide electrical continuity between two contact points for operatively coupling the source with the starting motor, the circuit comprising a series connection between the source and one end of each coil through the switch, a connection between the source and one of the contacts, a series connection between the other end of the pull-in coil and the source through the other contact and the starting motor, a connection between the other end of the hold-in coil and the source in parallel with the series connection for the other end of the pull-in coil, the other contact and the motor and a diode arranged in the series connection for the other end of the pull-in coil to prevent reverse current flow through the pull-in coil and the development of a magnetomotive force in the pull-in coil in opposition to a magnetomotive force in the hold-in coil which maintains the shifted position of the armature for operation of the starting motor.

3. The circuit of claim 2 wherein the diode is arranged in the series connection between the other end of the pull-in coil and the other contact.