

[54] **INTERNAL COMBUSTION ENGINE
CRANKING MOTOR ENERGIZING
CIRCUIT**

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74/6

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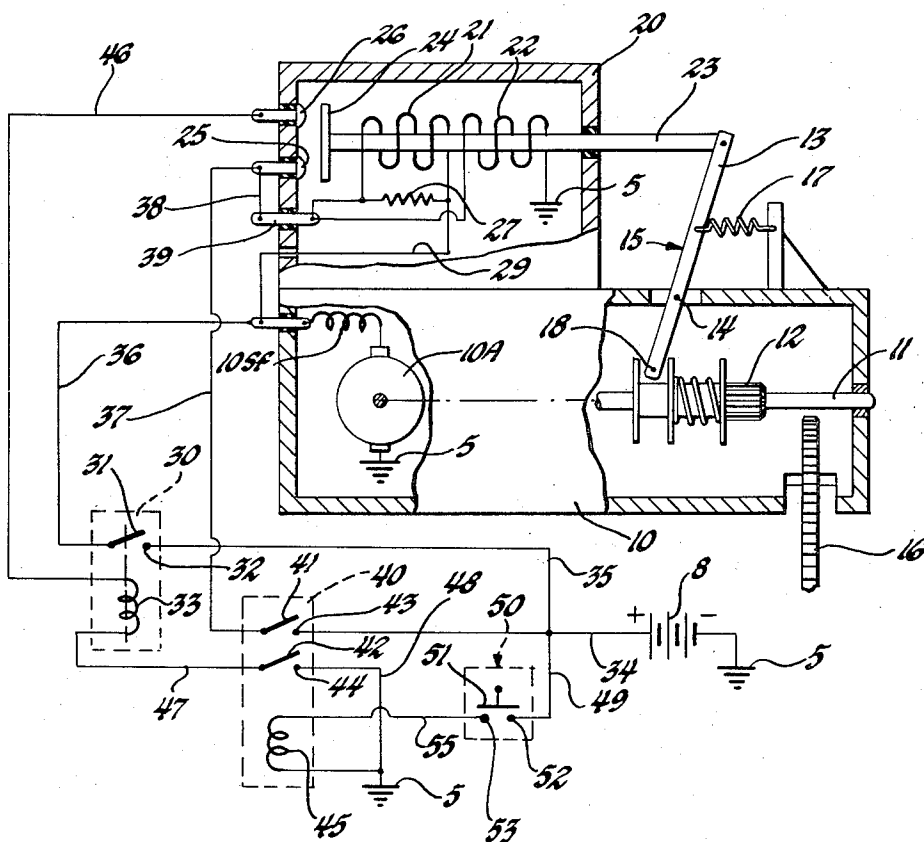
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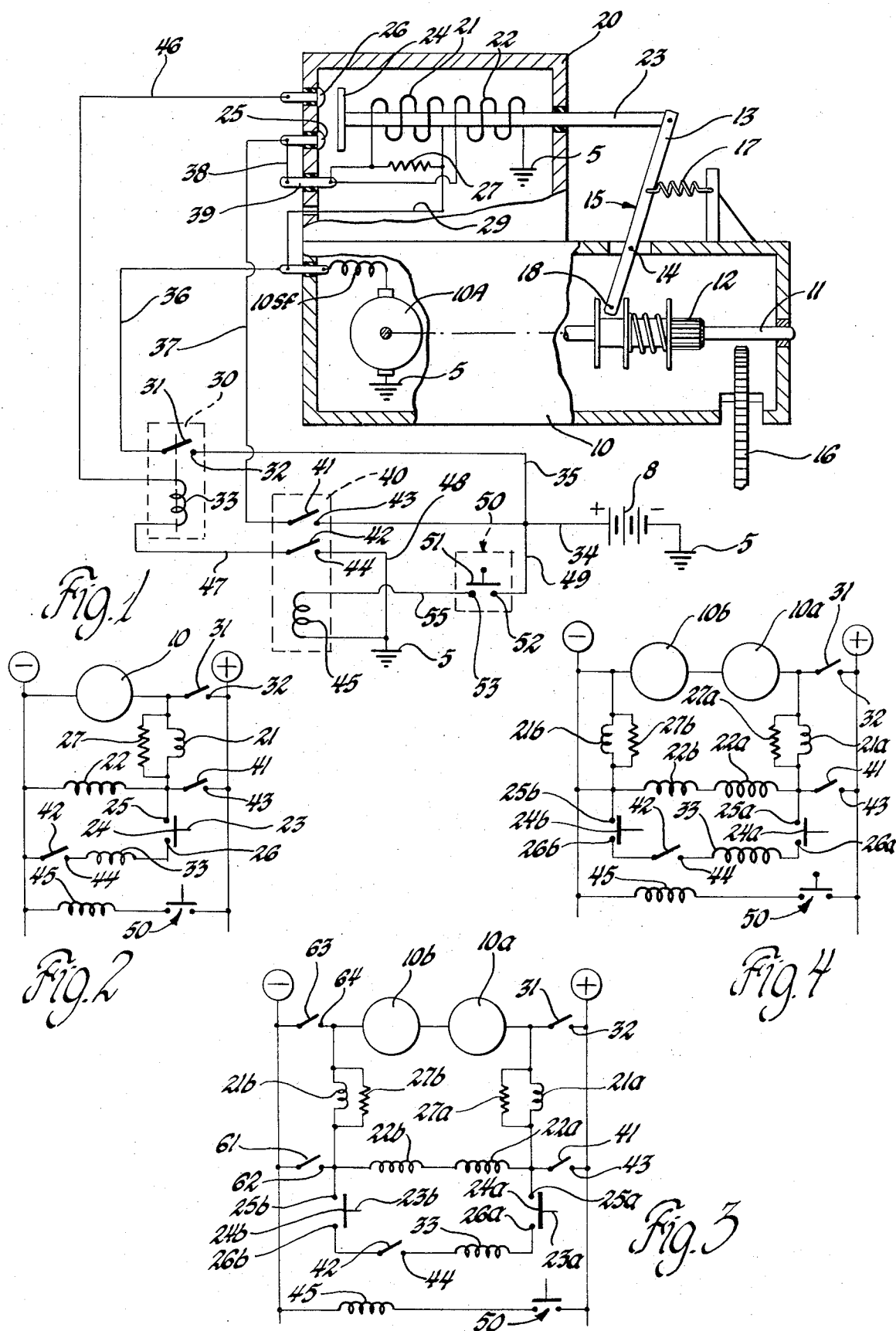
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[57] **ABSTRACT**

The pull-in coil of a cranking motor solenoid, having pull-in and hold-in coils, and a resistor connected in parallel therewith are connected in series with the cranking motor of an internal combustion engine electrical cranking system. Upon the energization of the cranking motor solenoid, the solenoid armature is actuated in a direction to effect the operation, through a shift mechanism, of the cranking motor pinion gear, slidably mounted upon the cranking motor shaft, into engagement with the cranking gear of the engine. In the event of the abutment of the teeth of the pinion and cranking gears, the cranking motor is energized at low power through the parallel combination of the solenoid pull-in coil and resistor to provide sufficient torque to slowly rotate the pinion gear until the teeth thereof are in register with and, consequently, mesh with, the teeth of the cranking gear. Upon the meshing of the teeth of the pinion and cranking gears, the solenoid armature is actuated to the full extent of its travel to a position at which an electrically conductive member carried thereby bridges two electrical contacts located in the cranking motor solenoid housing to complete the energizing circuit of a power relay which connects the cranking motor directly across the direct current potential source.

7 Claims, 4 Drawing Figures





INTERNAL COMBUSTION ENGINE CRANKING MOTOR ENERGIZING CIRCUIT

This invention is directed to an internal combustion engine cranking motor energizing circuit and, more specifically, to an energizing circuit of this type which provides for improved engagement capability between the cranking motor driven pinion gear and the cranking gear of the associated internal combustion engine.

The internal combustion engine cranking system commonly employed for electrically cranking internal combustion engines includes an electric cranking motor having an extended shaft provided with a helical spline, a pinion gear slidably mounted upon and rotated by the extended motor shaft, a shift mechanism operable to axially slide the pinion gear in one direction to engage and in an opposite direction to disengage the pinion gear and the cranking gear of the associated internal combustion engine and an electrical solenoid having at least one operating coil and an armature actuated thereby in operative engagement with the shift mechanism. The armature of the solenoid is normally operated to a first position by a compression or tension spring to effect the disengagement of the pinion and engine cranking gears and is operated upon the energization of the solenoid, by a starting switch operable at volition, to a second position to effect the engagement of the pinion and engine cranking gears. When the meshing is nearly completed, the armature operates a master switching device which serves to connect the electric cranking motor across a source of direct current potential, such as a conventional storage battery. Internal combustion engine electrical cranking systems of this type are well known in the internal combustion engine art.

When the electrical engine cranking sequence is initiated upon the operation of the starting switch, the cranking motor solenoid is energized. Upon the energization of the cranking motor solenoid, the armature thereof is actuated and operates the shift mechanism to slide the pinion axially in a direction toward a meshing engagement with the internal combustion engine cranking gear. If the pinion and cranking gears properly engage, the solenoid armature will be actuated to the full extent of its travel and close contacts which actuate control circuits to energize the cranking motor directly across the associated direct current power supply or battery. This arrangement insures that power is not applied to the cranking motor until pinion gear-cranking gear mesh is realized. If tooth abutment occurs between the pinion and cranking gears, the spiral spline on the extended shaft of the cranking motor produces a rotation of the pinion gear which indexes this gear to a new position which permits proper meshing with the cranking gear. While this arrangement appears to be functional in theory, in actual applications in the field it has proven to be, in some instances, unsatisfactory. This arrangement relies upon the force of the cranking motor solenoid to produce an indexing rotation of the pinion gear in the event of pinion gear-cranking gear tooth abutment. A major portion of the solenoid force is used in overcoming the drive assembly return spring load, consequently, only the small remaining force is available for the actual indexing of the pinion gear. Consequently, a drop in supply potential or a heated solenoid from repeated cranking attempts results in a considerable lower available force for indexing the pinion gear as the return spring load remains

constant. The end result is that the solenoid force is incapable of overcoming the tooth surface friction and hence cannot index the pinion gear.

Since a successful indexing of the pinion gear upon encountering pinion gear-cranking gear tooth abutment determines whether or not pinion gear-cranking gear tooth mesh is obtained, a turning torque supplied by rotating the cranking motor armature is one method of indexing the pinion gear without total dependence upon solenoid force. Rotating the cranking motor armature simultaneously with the energization of the cranking motor solenoid, however, is hazardous since the armature obtains a high speed with full power to the motor and would damage the cranking gear of the engine in the process of mesh. Consequently, an arrangement to provide cranking motor armature rotation at low speed during the pinion gear-cranking gear engagement function while retaining the protective feature of providing full power to the cranking motor only when complete pinion gear-cranking gear engagement is obtained, is desirable.

It is, therefore, an object of this invention, to provide an improved internal combustion engine cranking system.

It is another object of this invention to provide an improved internal combustion engine cranking motor energizing circuit.

It is a further object of this invention to provide an improved internal combustion engine cranking motor energizing circuit which provides for the low power energization of the cranking motor simultaneously with the energization of the cranking motor solenoid whereby the cranking motor provides a torque which will index the pinion gear into a position in mesh with the cranking gear of the engine and prevents the application of full power to the cranking motor until complete pinion gear-cranking gear mesh is obtained.

In accordance with this invention, an improved internal combustion engine cranking motor energizing circuit is provided wherein the cranking motor is energized simultaneously with the cranking motor solenoid at low power through the parallel combination of the solenoid hold-in coil and a resistor whereby, in the event of pinion-cranking gear abutment, the motor provides torque to rotate the pinion gear into index with the cranking gear and a solenoid, energized only when complete pinion-cranking gear mesh is obtained, connects the cranking motor across a source of direct current potential.

For a better understanding of the present invention, together with additional objects, advantages and features thereof, reference is made to the following description and accompanying drawing in which:

FIG. 1 sets forth, partially in schematic form, the improved internal combustion engine cranking motor energizing circuit of this invention;

FIG. 2 is a schematic diagram of the electrical circuit portion of FIG. 1;

FIG. 3 is a schematic diagram of another embodiment of the internal combustion engine cranking motor energizing circuit of this invention for two cranking motors; and

FIG. 4 is a schematic diagram of another embodiment of the internal combustion engine cranking motor energizing circuit of this invention for two cranking motors.

As point of reference or ground potential is the same point electrically throughout the system, it has been illustrated in FIG. 1 by the accepted schematic symbol and referenced by the numeral 5.

In FIG. 1 of the drawing, the internal combustion engine cranking motor energizing circuit of this invention is set forth in combination with a cranking system including an electric cranking motor 10 having an extended shaft 11, a pinion gear 12 slidably mounted upon and arranged to be rotated by extended motor shaft 11 and a shift mechanism, generally shown at 15, operable to axially slide the pinion gear 12 in one direction to engage and in an opposite direction to disengage the pinion gear 12 and the cranking gear 16 of an associated internal combustion engine and a source of direct current potential, which may be a conventional storage battery 8. Electric cranking motors are usually of the series type, the series field and armature being shown in FIG. 1 and referenced by the characters 10SF and 10A, respectively.

To operate the shift mechanism 15, an electrical solenoid 20 is provided. Electrical solenoid 20 has a pull-in coil 21, a hold-in coil 22, an armature member 23, an electrically conductive member 24 carried by armature 23 and a pair of electrical contacts 25 and 26. The armature member 23 is in operative engagement with shift mechanism 15. Armature 23 is operated to a first position by a spring 17, in which position it is indicated in FIG. 1, and to a second position upon the energization of pull-in coil 21 and hold-in coil 22 to effect, respectively, the disengagement and engagement of pinion gear 12 with cranking gear 16. When armature member 23 has been actuated to the full extent of its travel upon the energization of pull-in coil 21 and hold-in coil 22, electrically conductive member 24, which may be of copper or aluminum or any other electrically conductive material, bridges electrical contacts 25 and 26 to complete an electrical circuit thereacross. A resistor 27 is connected in parallel across pull-in coil 21.

Upon the energization of pull-in coil 21 and hold-in coil 22 of cranking motor solenoid 20, armature member 23 is actuated by the resulting magnetic flux in a direction horizontally to the left, as viewing the FIG. 1. This motion rotates lever arm 13 in a counterclockwise direction around pivot point 14 and the end 18 of pivot arm 13 slides pinion gear 12 in a direction toward cranking gear 16 in a manner well known in the internal combustion engine cranking system art.

The current carrying elements of an electrical switching device of the type having normally open current carrying elements operable to the electrical circuit closed condition in response to an electrical signal and cranking motor 10 are connected in series across a source of direct current potential. The electrical switching device may be a conventional electric relay 30 having a movable contact 31, a stationary contact 32 and an operating coil 33. The movable and stationary contact pair, 31-32, of relay 30 and cranking motor 10 are connected in series across battery 8 through a circuit which may be traced from the positive polarity terminal of battery 8, through leads 34 and 35, movable and stationary contact pair 31-32 of relay 30, lead 36, series field 10SF, motor armature 10A and point of reference or ground potential 5 to the negative polarity terminal of battery 8.

A relay 40 having two movable contacts 41 and 42 and two stationary contacts 43 and 44 and an operating coil 45 is also provided.

An energizing circuit including one of the movable and stationary contact pairs of relay 40 for each the pull-in coil 21 and parallel connected resistor 27 and the cranking motor 10 in series and the hold-in coil 22 may be traced from the positive polarity terminal of battery 8, through lead 34, movable and stationary contact pair 41-43 of relay 40, lead 37, stub lead 38, to terminal 39 of cranking motor solenoid 20 and thence through a first parallel circuit including pull-in coil 21 and parallel connected resistor 27, lead 29, and motor 10 in series and through a second parallel circuit through hold-in coil 22 and thence through point of reference or ground potential 5 to the negative polarity terminal of battery 8.

An energizing circuit including the same one movable and stationary contact pair of relay 40, the pair of electrical contacts 25 and 26 of cranking motor solenoid 20 and the other movable and stationary contact pair of relay 40 for operating coil 33 of relay 30 may be traced from the positive polarity terminal of battery 8, through lead 34, movable and stationary contact pair 41-43 of relay 40, lead 37, contacts 25 and 26 of cranking motor solenoid 20, lead 46, operating coil 33 of relay 30, lead 47, movable and stationary contact pair 42-44 of relay 40, lead 48 and point of reference or ground potential 5 to the negative polarity terminal of battery 8.

An energizing circuit for operating coil 45 of relay 40 may be traced from the positive polarity terminal of battery 8, through leads 34 and 49, the contacts of an electric crank switch 50, lead 55, operating coil 45 and point of reference or ground potential 5 to the negative polarity terminal of battery 8. Electric crank switch 50 may be any one of the several momentary contact electric crank switches well known in the art. The armature member 51 of an electrically conductive material may be operated into electrical engagement with stationary contacts 52 and 53 to provide an electrically conductive bridge thereacross in a manner well known in the art.

Upon the operation of crank switch 50 to the electrical circuit closed condition, the energizing circuit, previously described, for operating coil 45 of relay 40 is completed. Upon the energization of operating coil 45, movable and stationary contact pairs 41-43 and 42-44 are operated to the electrical circuit closed condition. With movable and stationary contact pairs 41-43 and 42-44 of relay 40 in the electrical circuit closed condition, the energizing circuit, previously described, for each pull-in coil 21 and parallel connected resistor 27 and cranking motor 10 in series and for hold-in coil 22 is completed. Upon the energization of pull-in coil 21 and hold-in coil 22, armature member 23 of cranking motor solenoid 20 is actuated to operate shift mechanism 15 to move pinion gear 12 axially in a direction into engagement with cranking gear 16. In the event of a mesh of the teeth of pinion gear 12 and the teeth of cranking gear 16, armature member 23 is actuated to the full extent of its travel where electrically conductive member 24 bridges contacts 25 and 26 to complete an electrical circuit thereacross. When electrically conductive member 24 bridges contacts 25 and 26, the energizing circuit, previously described, for operating coil 33 of relay 30 is completed. Upon the energization of

operating coil 33, movable and stationary contact pair 31-32 of relay 30 are operated to the electrical circuit closed condition. With movable and stationary contact pair 31-32 in the electrical circuit closed condition, an energizing circuit is completed for cranking motor 10 across battery 8 through a circuit which may be traced from the positive polarity terminal of battery 8, through lead 34, lead 35, movable and stationary contact pair 31 and 32, lead 36, series winding 10SF and armature 10A of cranking motor 10 and point of reference or ground potential 5 to the negative polarity terminal of battery 8. Consequently, cranking motor 10 is operated at full battery power to drive cranking gear 16 of the associated internal combustion engine through shaft 11 and pinion gear 12 in a manner well known in the internal combustion engine cranking system art.

In the event of tooth to tooth abutment between pinion gear 12 and cranking gear 16 when movable and stationary contact pairs 41-43 and 42-44 are initially operated to the electrical circuit closed condition, cranking motor 10 is energized at reduced power through a circuit which may be traced from the positive polarity terminal of battery 8, through lead 34, movable and stationary contact pair 41-43 of relay 40, leads 37 and 38, terminal 39, the parallel combination of pull-in coil 21 and resistor 27, lead 29, series field winding 10SF and armature 10A of cranking motor 10 and point of reference or ground potential 5 to the negative polarity terminal of battery 8. Resistor 27 is selected to be of an ohmic value which, with respect to the ohmic value of pull-in coil 21, will permit sufficient current to flow through cranking motor 10 to provide sufficient torque to rotate pinion gear 12 to a position in which the teeth thereof are in index with the teeth of cranking gear 16, at which time a mesh therebetween is obtained. At this time, armature member 23 is actuated to the full extent of its travel to complete the energizing circuit, previously described, through which cranking motor 10 is connected directly across battery 8 and is, therefore, energized by the full potential of battery 8.

FIG. 2 is a schematic diagram of the electrical portion of FIG. 1 which more clearly shows the detailed electrical circuit arrangement and connections. In FIGS. 1 and 2, like elements have been assigned like characters of reference.

FIG. 3 is a schematic diagram of another embodiment of the internal combustion engine cranking motor energizing circuit of this invention as applied to two cranking motors referenced by the numerals 10a and 10b. In a two-cranking motor system, there are two cranking motor solenoids and two associated shift mechanisms. In FIG. 3, the respective pull-in coils have been referenced by the numerals 21a and 21b, the respective hold-in coils have been referenced by the numerals 22a and 22b, the respective armature members have been referenced by the numerals 23a and 23b, the respective electrical conductive members have been referenced by the numerals 24a and 24b, the respective contacts have been referenced by the numerals 25a and 25b and 26a and 26b and the respective resistors connected in parallel with the respective pull-in coils have been referenced by the numerals 27a and 27b. With this embodiment, relay 40 has three movable and stationary contact pairs, the additional pair being referenced by the numerals 61 and 62, and relay 30 may have an additional movable and stationary contact pair

or, alternatively, a separate relay having a single movable and stationary contact pair may be employed. It is, however, believed to be preferable to have only one relay with two movable and stationary contact pairs.

Upon the operation of crank switch 50 of the embodiment of FIG. 3 to the electrical circuit closed condition, operating coil 45 of relay 40 is energized to operate the associated movable and stationary contact pairs 41-43, 42-44 and 61-62 to the electrical circuit closed condition. At this time, an energizing circuit is completed for the series combination of pull-in coil 21a and parallel connected resistor 27a, cranking motor 10a, cranking motor 10b, pull-in coil 21b and parallel connected resistor 27b and for the series combination of hold-in coil 22a and hold-in coil 22b through movable and stationary contact pairs 41-43 and 61-62. Upon the completion of this energizing circuit, respective armatures 23a and 23b are actuated in a direction which will cause the associated respective shift mechanisms to move the respective pinion gears of the respective cranking motors in the direction to engage cranking gear 16. If a mesh is obtained, respective electrically conductive members 24a and 24b bridge respective contacts 25a-26a and 25b-26b. At this time, an energizing circuit is completed for operating coil 33 of relay 30 to operate movable and stationary contact pairs 31-32 and 63-64 to the electrical circuit closed condition which connects cranking motors 10a and 10b in series across the source of direct current potential. In the event of tooth abutment upon the operation of crank switch 50 to the electrical circuit closed condition, cranking motors 10a and 10b are operated at low power supplied thereto through movable and stationary contact pair 41-43, the parallel combination of pull-in coil 21a and resistor 27a, cranking motor 10a, cranking motor 10b, the parallel combination of pull-in coil 21b and resistor 27b and movable contact pair 61 and 62. Consequently, cranking motors 10a and 10b provide torque to the respective pinion gears to revolve them to a position in which the teeth thereof are in register with the teeth of cranking gear 16. When a mesh between the respective pinion gears and cranking gear 16 is obtained, the respective armature members 23a and 23b are actuated to the full extent of their travel to complete the energizing circuit for operating coil 33 of relay 30 through movable and stationary contact pair 43, stationary contacts 25a and 26a and electrically conductive member 24a, operating coil 33, movable and stationary contact pair 42 and 44 of relay 40, stationary contacts 25b and 26b and electrically conductive member 23b and stationary and movable contact pair 61 and 62 of relay 40. Upon the completion of this energizing circuit, movable and stationary contact pairs 31-32 and 63-64 of relay 30 are operated to the electrical circuit closed condition to connect cranking motors 10a and 10b in series across the source of direct current potential. Consequently, these motors are energized by the full potential of the potential source.

FIG. 4 is a schematic diagram of another embodiment of the internal combustion engine cranking motor energizing circuit of this invention for two series connected cranking motors 10a and 10b. This circuit is similar to the circuit of FIG. 3 with the exception that movable contact pairs 61 and 62 of relay 40 and movable and stationary contact pair 63 and 64 of relay 30 are omitted.

In the embodiments of FIGS. 3 and 4, the cranking motors 10a and 10b are shown to be connected in series. It is to be specifically understood that cranking motors 10a and 10b may be connected in parallel with these two embodiments without departing from the spirit of the invention.

While a preferred embodiment of the present invention has been shown and described, it will be obvious to those skilled in the art that various modifications and substitutions may be made without departing from the spirit of the invention which is to be limited only within the scope of the appended claims.

What is claimed is:

1. An internal combustion engine cranking motor energizing circuit comprising in combination with a cranking system including an electric cranking motor having an extended shaft, a pinion gear slidably mounted upon and rotated by the extended motor shaft and a shift mechanism operable to axially slide the pinion gear in one direction to engage and in an opposite direction to disengage the pinion gear and the cranking gear of the associated internal combustion engine and a source of direct current potential: an electrical solenoid having a pull-in coil connected in series with said cranking motor, a hold-in coil, an armature member in operative engagement with said shift mechanism which is operated to a first position by a spring and to a second position upon the energization of said pull-in and hold-in coils to effect, respectively, the disengagement and engagement of said pinion and engine cranking gears, an electrically conductive member carried by said armature and a pair of electrical contacts bridged by said electrically conductive member when said armature is operated to said second position; a resistor connected in parallel across said pull-in coil; an electrical switching device of the type having normally open current carrying elements operable to the electrical circuit closed condition in response to an electrical signal; means for connecting said current carrying elements of said electrical switching device and said cranking motor in series across said source of direct current potential; a relay having two movable and stationary contact pairs and an operating coil; an energizing circuit including one of said movable and stationary contact pairs of said second relay for each said pull-in coil and parallel connected resistor and said cranking motor in series and said hold-in winding; an electrical circuit including said same one movable and stationary contact pair of said second relay, said pair of electrical contacts of said solenoid and the other said movable and stationary contact pair of said second relay through which an electrical signal may be supplied to said electrical switching device; an electric crank switch; and an energizing circuit including said electric crank switch for said operating coil of said second relay.

2. An internal combustion engine cranking motor energizing circuit comprising in combination with a cranking system including an electric cranking motor having an extended shaft, a pinion gear slidably mounted upon and rotated by the extended shaft and a shift mechanism operable to axially slide the pinion gear in one direction to engage and in an opposite direction to disengage the pinion gear and the cranking gear of the associated internal combustion engine and a source of direct current potential: an electrical solenoid having a pull-in coil connected in series with said cranking motor, a hold-in coil, an armature member in

operative engagement with said shift mechanism which is operated to a first position by a spring and to a second position upon the energization of said pull-in and hold-in coils to effect, respectively, the disengagement and engagement of said pinion and engine cranking gears, an electrically conductive member carried by said armature and a pair of electrical contacts bridged by said electrically conductive member when said armature is operated to said second position; a resistor connected in parallel across said pull-in coil; a first relay having a movable and stationary contact pair and an operating coil; means for connecting said movable and stationary contact pair of said first relay and said cranking motor in series across said source of direct current potential; a second relay having two movable and stationary contact pairs and an operating coil; an energizing circuit including one of said movable and stationary contact pairs of said second relay for each the series combination of said pull-in coil and parallel connected resistor and said cranking motor and for said hold-in coil; an energizing circuit including said same one movable and stationary contact pair of said second relay, said pair of electrical contacts of said solenoid and the other said movable and stationary contact pair of said second relay for said operating coil of said first relay; an electric crank switch; and an energizing circuit including said electric crank switch for said operating coil of said second relay.

3. An internal combustion engine cranking motor energizing circuit comprising in combination with a cranking system including two electric cranking motors, each having an extended shaft, a pinion gear slidably mounted upon and rotated by the extended shaft of each motor and a shift mechanism for each motor operable to axially slide the corresponding pinion gear in one direction to engage and in an opposite direction to disengage the pinion gear and the cranking gear of the associated internal combustion engine and a source of direct current potential: an electric solenoid corresponding to each of said cranking motors, each of said solenoids having a pull-in coil, a hold-in coil, an armature member in operative engagement with the said shift mechanism for the motor to which it corresponds which is operated to a first position by a spring and to a second position upon the energization of said pull-in and hold-in coils to effect, respectively, the disengagement and engagement of the corresponding said pinion gear and engine cranking gear, an electrically conductive member carried by said armature and a pair of electrical contacts bridged by said electrically conductive member when said armature is operated to said second position; a resistor connected in parallel across the said pull-in coil of each of said electric solenoids; a first relay having a movable and stationary contact pair and an operating coil; means for connecting said movable and stationary contact pair of said first relay and said two cranking motors across said source of direct current potential; a second relay having two movable and stationary contact pairs and an operating coil; an energizing circuit including one of said movable and stationary contact pairs of said second relay for each the series combination of said pull-in coil and parallel connected resistor of one of said solenoids, said two cranking motors and said pull-in coil and parallel connected resistor of said second solenoid and the series combination of said hold-in coil of both said solenoids; an energizing circuit including said same one of said

movable and stationary contact pairs of said second relay, said pair of electrical contacts of both said solenoids and the other said movable and stationary contact pair of said second relay for said operating coil of said first relay; an electric crank switch; and an energizing circuit including said electric crank switch for said operating coil of said second relay.

4. An internal combustion engine cranking motor energizing circuit comprising in combination with a cranking system including two electric cranking motors, each having an extended shaft, a pinion gear slidably mounted upon and rotated by the extended shaft of each motor and a shift mechanism for each motor operable to axially slide the corresponding pinion gear in one direction to engage and in an opposite direction to disengage the pinion gear and the cranking gear of the associated internal combustion engine and a source of direct current potential: an electric solenoid corresponding to each of said cranking motors, each of said solenoids having a pull-in coil connected in series with the said cranking motor to which it corresponds, a hold-in coil, an armature member in operative engagement with the said shift mechanism for the motor to which it corresponds which is operated to a first position by a spring and to a second position upon the energization of said pull-in and hold-in coils to effect, respectively, the disengagement and engagement of the corresponding said pinion gear and engine cranking gear, an electrically conductive member carried by said armature and a pair of electrical contacts bridged by said electrically conductive member when said armature is operated to said second position; a resistor connected in parallel across the said pull-in coil of each of said electric solenoids; a first relay having a movable and stationary contact pair and an operating coil; means for connecting said movable and stationary contact pair of said first relay and said two cranking motors in series across said source of direct current potential: a second relay having two movable and stationary contact pairs and an operating coil; an energizing circuit including one of said movable and stationary contact pairs of said second relay for each the series combination of said pull-in coil and parallel connected resistor of one of said solenoids, said two cranking motors and said pull-in coil and parallel connected resistor of said second solenoid, in that order, and the series combination of said hold-in coil of both said solenoids; an energizing circuit including said same one of said movable and stationary contact pairs of said second relay, said pair of electrical contacts of both said solenoids and the other said movable and stationary contact pair of said second relay for said operating coil of said first relay; an electric crank switch; and an energizing circuit including said electric crank switch for said operating coil of said second relay.

5. An internal combustion engine cranking motor energizing circuit comprising in combination with a cranking system including two electric cranking motors, each having an extended shaft, a pinion gear slidably mounted upon and rotated by the extended shaft of each motor and a shift mechanism for each motor operable to axially slide the corresponding pinion gear in one direction to engage and in an opposite direction to disengage the pinion gear and the cranking gear of the associated internal combustion engine and a source of direct current potential: an electric solenoid corresponding to each of said cranking motors, each of said

solenoids having a pull-in coil connected in series with the said cranking motor to which it corresponds, a hold-in coil, an armature member in operative engagement with the said shift mechanism for the motor to which it corresponds which is operated to a first position by a spring and to a second position upon the energization of said pull-in and hold-in coils to effect, respectively, the disengagement and engagement of the corresponding said pinion gear and engine cranking gear, an electrically conductive member carried by said armature and a pair of electrical contacts bridged by said electrically conductive member when said armature is operated to said second position; a resistor connected in parallel across the said pull-in coil of each of said electric solenoids; a first relay having a movable and stationary contact pair and an operating coil; means for connecting said movable and stationary contact pair of said first relay and said two cranking motors across said source of direct current potential: a second relay having three movable and stationary contact pairs and an operating coil; an energizing circuit including two of said movable and stationary contact pairs of said second relay for each the series combination of said pull-in coil and parallel connected resistor of one of said solenoids, said two cranking motors and said pull-in coil and parallel connected resistor of said second solenoid and the series combination of said hold-in coil of both said solenoids; an energizing circuit including said same two of said movable and stationary contact pairs of said second relay, said pair of electrical contacts of both said solenoids and the other said movable and stationary contact pair of said second relay for said operating coil of said first relay; an electric crank switch; and an energizing circuit including said electric crank switch for said operating coil of said second relay.

6. An internal combustion engine cranking motor energizing circuit comprising in combination with a cranking system including two electric cranking motors, each having an extended shaft, a pinion gear slidably mounted upon and rotated by the extended shaft of each motor and a shift mechanism for each motor operable to axially slide the corresponding pinion gear in one direction to engage and in an opposite direction to disengage the pinion gear and the cranking gear of the associated internal combustion engine and a source of direct current potential: an electric solenoid corresponding to each of said cranking motors, each of said solenoids having a pull-in coil connected in series with the said cranking motor to which it corresponds, a hold-in coil, an armature member in operative engagement with the said shift mechanism for the motor to which it corresponds which is operated to a first position by a spring and to a second position upon the energization of said pull-in and hold-in coils to effect, respectively, the disengagement and engagement of the corresponding said pinion gear and engine cranking gear, an electrically conductive member carried by said armature and a pair of electrical contacts bridged by said electrically conductive member when said armature is operated to said second position; a resistor connected in parallel across the said pull-in coil of each of said electric solenoids; a first relay having two movable and stationary contact pairs and an operating coil; means for connecting one of said movable and stationary contact pairs of said first relay, said two cranking motors and the other one of said movable and station-

any contact pairs of said first relay across said source of direct current potential: a second relay having three movable and stationary contact pairs and an operating coil; an energizing circuit including two of said movable and stationary contact pairs of said second relay for each the series combination of said pull-in coil and parallel connected resistor of one of said solenoids, said two cranking motors and said pull-in coil and parallel connected resistor of said second solenoid and the series combination of said hold-in coil of both said solenoids; an energizing circuit including said same two of said movable and stationary contact pairs of said second relay, said pair of electrical contacts of both said solenoids and the other said movable and stationary contact pair of said second relay for said operating coil of said first relay; an electric crank switch; and an energizing circuit including said electric crank switch for said operating coil of said second relay.

7. An internal combustion engine cranking motor energizing circuit comprising in combination with a cranking system including two electric cranking motors, each having an extended shaft, a pinion gear slidably mounted upon and rotated by the extended shaft of each motor and a shift mechanism for each motor operable to axially slide the corresponding pinion gear in one direction to engage and in an opposite direction to disengage the pinion gear and the cranking gear of the associated internal combustion engine and a source of direct current potential: an electric solenoid corresponding to each of said cranking motors, each of said solenoids having a pull-in coil connected in series with the said cranking motor to which it corresponds, a hold-in coil, an armature member in operative engagement with the said shift mechanism for the motor to which it corresponds which is operated to a first position

tion by a spring and to a second position upon the energization of said pull-in and hold-in coils to effect, respectively, the disengagement and engagement of the corresponding said pinion gear and engine cranking gear, an electrically conductive member carried by said armature and a pair of electrical contacts bridged by said electrically conductive member when said armature is operated to said second position; a resistor connected in parallel across the said pull-in coil of each of said electric solenoids; a first relay having two movable and stationary contact pairs and an operating coil; means for connecting one of said movable and stationary contact pairs of said first relay, said two cranking motors and the other one of said movable and stationary contact pairs of said first relay in series across said source of direct current potential, in that order; a second relay having three movable and stationary contact pairs and an operating coil; an energizing circuit including two of said movable and stationary contact pairs of said second relay for each the series combination of said pull-in coil and parallel connected resistor of one of said solenoids, said two cranking motors and said pull-in coil and parallel connected resistor of said second solenoid, in that order, and the series combination of said hold-in coil of both said solenoids; an energizing circuit including said same two of said movable and stationary contact pairs of said second relay, said pair of electrical contacts of both of said solenoids and the other said movable and stationary contact pair of said second relay for said operating coil of said first relay; an electric crank switch; and an energizing circuit including said electric crank switch for said operating coil of said second relay.

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