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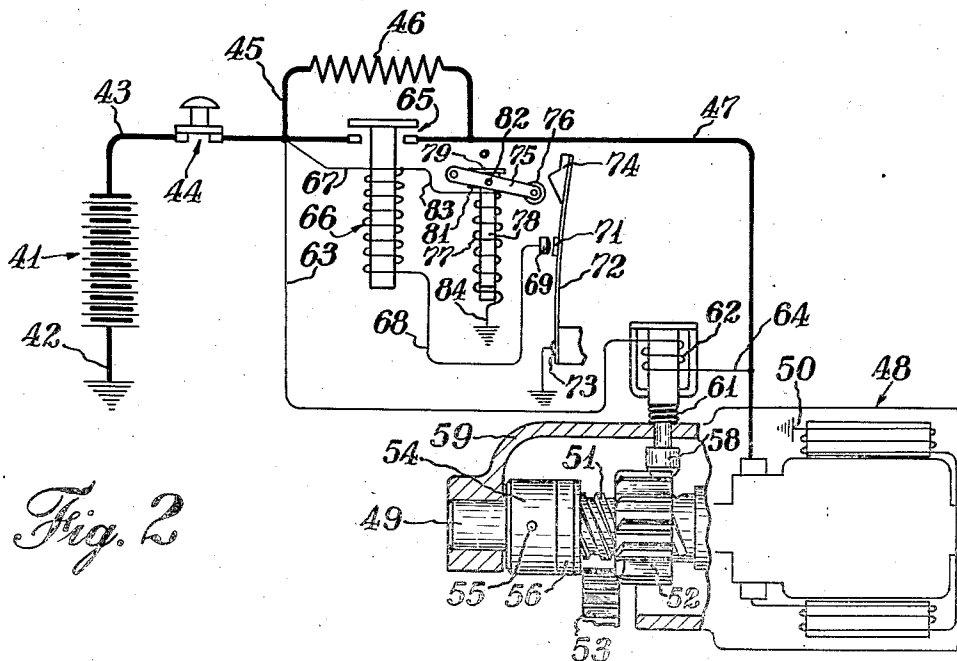
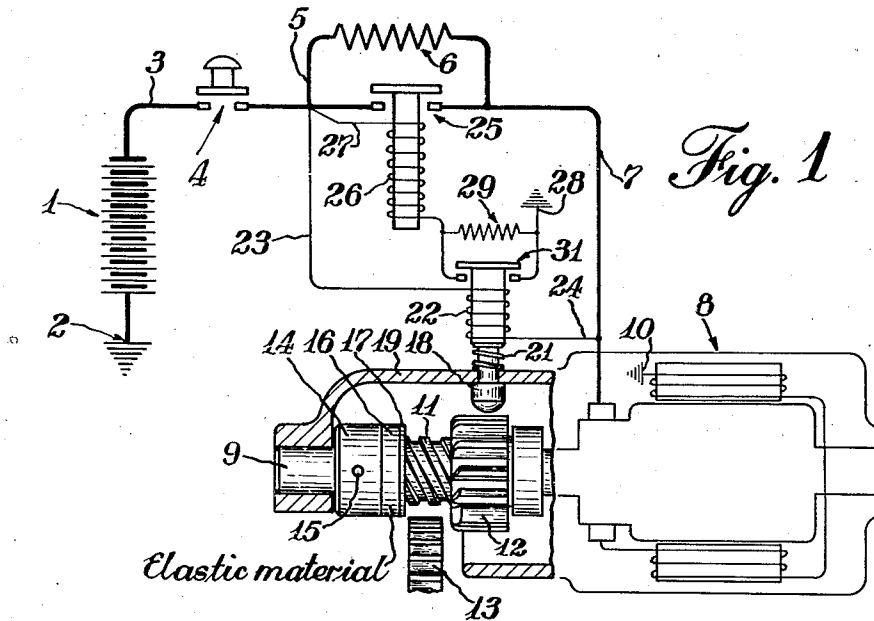
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2,233,595

TWO-STAGE STARTER CONTROL

Filed Sept. 8, 1939

2 Sheets-Sheet 1



Witness:
Burn W. Jones

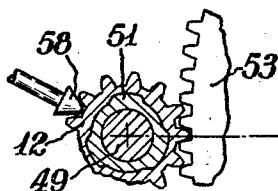
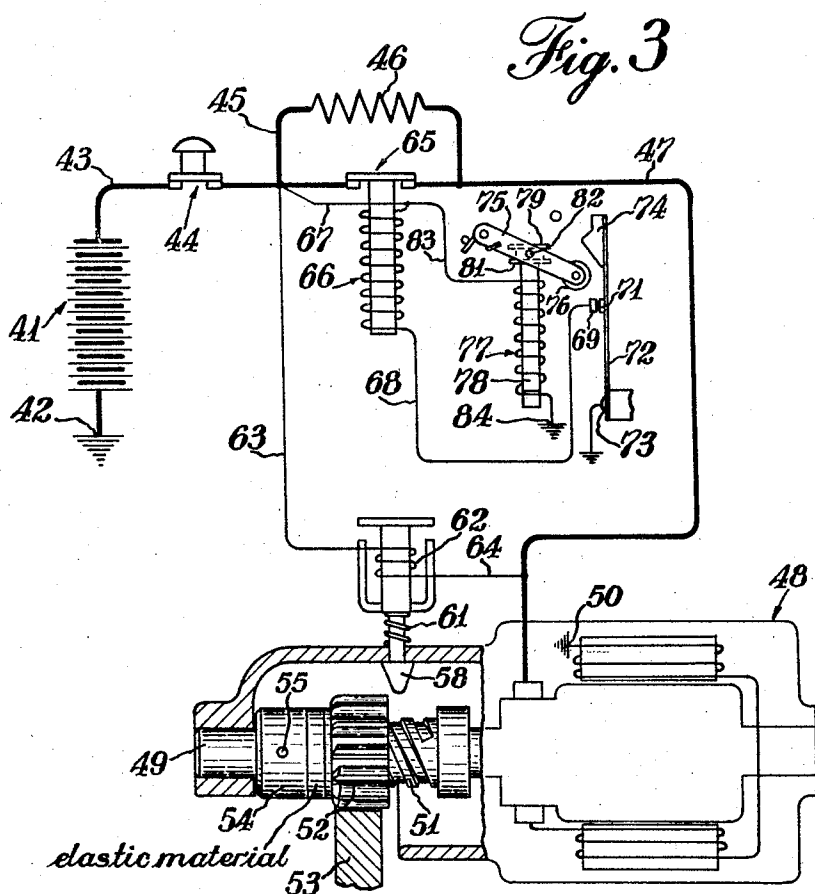
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,233,595

TWO-STAGE STARTER CONTROL

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7 Claims. (Cl. 290—38)

The present invention relates to a two-stage starter control for internal combustion engines and more particularly to a starting system in which engagement of the starting gearing is brought about by the partial energization of the starting motor at a low voltage, after which the starting motor is energized by the full battery voltage to crank the engine.

In installations of this character it has been proposed to use some form of detent to oppose rotation of the starting pinion during its engaging movement, in order to insure the desired longitudinal movement thereof under all operating conditions. Such detents as heretofore employed have generally been subject to rapid wear due to engagement with the pinion during the cranking operation, and/or have tended to cause the pinion to re-engage the engine gear immediately after being demeshed therefrom when the engine starts.

It is an object of the present invention to provide a novel two-stage engine starter control which is efficient and reliable in operation while being simple and economical in construction.

It is another object to provide such a device which incorporates automatically engaging gearing, and a detent for insuring proper engagement thereof during the first stage of operation of the device.

It is another object to provide such a device in which the detent is rendered operative only during the first stage of operation of the device, at all other times being inoperative and not subject to wear.

It is a further object to provide such a device in which means are provided for preventing the full energization of the starting motor until after the pinion has had time to mesh fully with the engine gear.

It is another object to provide such a device in which the full energization of the starting motor is controlled by the detent so as to prevent such full energization until after the pinion is fully meshed.

It is another object to provide such a device in which the detent is arranged to position the pinion rotarily so as to facilitate its entry into mesh with the engine gear.

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

Fig. 1 is a semi-diagrammatic representation of a starting system involving a preferred em-

bodiment of the present invention, the parts being shown in idle or inoperative position;

Fig. 2 is a similar view of a second embodiment of the invention, the parts being shown in the positions assumed during the first stage of operation of the device;

Fig. 3 is a similar view of the embodiment of the invention illustrated in Fig. 2, showing the parts in the positions assumed during the cranking operation; and

Fig. 4 is a fragmentary detail showing the relationship of the pinion, the teeth of the fly-wheel gear and the positioning detent.

In Fig. 1 of the drawings there is illustrated a starting system 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 resistor 6 having a value sufficient to reduce the effective voltage of the battery 1 to a value suitable for meshing purposes. Resistor 6 is connected by a lead 7 to a starting motor indicated generally by numeral 8 which is grounded at 10.

Starting motor 8 is provided with an extended armature shaft 9 on which is mounted a screw shaft 11 carrying a pinion 12 threaded thereon for movement into and out of engagement with a member such as a flywheel gear 13 of an engine to be started. The operative position of the pinion 12 on the screw shaft 11 is defined by an abutment member 14 fixed to the screw shaft in any suitable manner as by means of a threaded connection locked by a pin 15. Preferably, a cushioning element such as a rubber block 16 with a metal face 17 is mounted on the screw shaft adjacent the abutment member 14 in order to cushion the engagement of the pinion.

Means for insuring the traversal of the pinion 12 into mesh with the flywheel gear 13 upon initial rotation of the starting motor is provided in the form of a detent 18 slidably mounted in the motor housing 19 in position to engage the teeth of the pinion 12, but normally held out of engagement therewith by means of a spring 21. An electromagnet 22 is provided for actuating the detent into operative position, which electromagnet is connected by a lead 23 to the starting circuit lead 5, and by the lead 24 with the starting circuit lead 7 so that the electromagnet is in effect bridged across the resistor 6.

Means for shunting out the resistor 6 in order to apply full battery voltage to the starting motor 8 is provided in the form of a bridging switch 25 which is shunted across the resistor 6 and is arranged to be actuated by an electro-

magnet 26. Electromagnet 26 is connected at one end by a lead 27 to the starting circuit lead 5, and its other end is grounded as indicated at 28 through a resistor 29 having a value sufficient to prevent closure of the bridging switch 25 when the starting switch 4 is originally closed, but permitting sufficient current to pass to hold the bridging switch 25 closed after it has been initially closed.

Means for short-circuiting the resistor 29 in order to secure initial closure of the bridging switch 25 is provided in the form of switch means 31 mounted on the detent 18 so as to be closed when said detent is fully depressed by the electromagnet 22. Detent 18 is so positioned in the motor housing 19 that when the pinion is in idle position, the detent engages between the teeth of the pinion to resist rotation of the pinion, and this engagement of the detent with the pinion prevents the detent from being fully depressed. When the pinion is traversed into engagement with the flywheel gear, however, it moves out from under the detent and permits it to be fully depressed by the electromagnet 22, thus causing closure of switch 31.

In the operation of this embodiment of the invention, starting with the parts in idle position as illustrated, closure of starting switch 4 causes current to flow through the resistor 5 to the starting motor, thus putting it into rotation at low speed. At the same time, current flows through lead 23 to electromagnet 22 and from thence through lead 24 to the starting motor lead 7, causing detent 18 to be pressed into engagement with the pinion 12, thus preventing rotation of the pinion and causing it to traverse into mesh with the flywheel gear 13. At this time current also flows through the lead 27 to electromagnet 26 and through the resistor 29 to the ground, but this current is so restricted by the resistor 29 as to prevent sufficient energization of the electromagnet 26 to effect closure of the bridging switch 25.

When the pinion 12 is fully meshed with the flywheel gear, it moves out from under the detent 18, thus permitting electromagnet 22 to close the switch 31. Electromagnet 26 is thereby fully energized, causing closure of the bridging switch 25 whereby full battery voltage is applied to the starting motor 8 to crank the engine. Closure of bridging switch 25 short-circuits the electromagnet 22 whereby the detent 18 is returned by the spring 21 to its normal position, thus opening the switch 31. Bridging switch 25 is maintained closed, however, by the current traversing the resistor 29 as long as the starting switch 4 is held closed.

When the engine starts, the pinion 12 is traversed back to its normal position by the overrunning action of the engine gear, and upon opening of the starting switch 4, the starting motor is deenergized and the bridging switch 25 opens.

In the embodiment of the invention illustrated in Figs. 2 and 3, the full energization of the starting circuit is controlled by a time delay mechanism independently of the pinion detent.

Referring to Fig. 2, battery 41 grounded at 42 is connected by a lead 43 to a starting switch 44 which is connected by a lead 45 to a resistor 46 of suitable value for restricting the energization of the starting motor during the meshing operation. Resistor 46 is connected by a lead 47 to starting motor 48 which is grounded at 50. The extended armature shaft 49 of the

starting motor carries suitably fixed thereon a screw shaft 51 on which is threaded a pinion 52 for automatic traversal into and out of engagement with an engine flywheel gear 53, the engaging position of the pinion being defined by an abutment 54 suitably fixed to the screw shaft as indicated at 55, cushioning means 56 being preferably interposed between the pinion and abutment.

A detent 58 is slidably mounted in the motor housing 59 in position to engage the teeth of pinion 52 when projected into operative position to thereby insure traversal of the pinion 52 by initial rotation of the screw shaft 51.

Detent 58 is normally held out of engagement 15 with pinion 52 by means of a spring 61. An electromagnet 62 is arranged when energized to move the detent into operative position, and is connected by a lead 63 to the starting circuit lead 45 and by a lead 64 to the starting motor lead 47.

Means for short-circuiting the resistor 46 is provided in the form of a bridging switch 65 arranged to be actuated by a solenoid 66. Solenoid 66 is connected by a lead 67 to the starting circuit lead 45 and by a lead 68 to a fixed contact 69. A mating contact 71 is mounted on a pendulous spring strip 72 which is anchored and grounded at 73 and has at its free end a bob 74.

Means are provided for normally holding contacts 71, 69 open in the form of a pivoted arm 75, the free end of which carries a roller 76 arranged to engage the bob 74 and bend the spring strip 72 backward. A solenoid 77 is arranged to actuate a plunger 78 having flanges 79 and 81 arranged to engage a pin 82 on the arm 75 and thereby move the arm into and out of operative position. Solenoid 77 is connected by a lead 83 with the lead 67 of solenoid 66, and is grounded at 84. When the swinging arm 75 is moved by the solenoid 77 out of engagement with the bob 74, it is arranged to set the spring strip 72 in pendulous vibration whereby effective closure of contacts 69, 71 is delayed for a predetermined time interval.

In the operation of this embodiment of the invention, closure of the starting switch 44 causes energization of the starting motor 48 at low voltage by virtue of the resistor 46 in the starting circuit, whereby the starting motor rotates slowly. At the same time the electromagnet 62 is energized, causing detent 58 to engage between the teeth of pinion 52, thus resisting rotation thereof and causing it to traverse into engagement with the engine gear. At this time solenoid 77 is also energized, causing the arm 75 to swing down to the position illustrated in Fig. 2, thus freeing the bob 74 and setting the pendulum 72 in vibration.

After a predetermined time interval, contact 71 comes to rest against contact 69, thus causing energization of solenoid 66 to close the bridging switch 65. Starting motor 48 is thereupon fully energized to crank the engine, and at the same time electromagnet 62, being short-circuited by the bridging switch 65, is deenergized and the detent 58 is returned to idle position by the spring 61, the parts then assuming the positions illustrated in Fig. 3.

When the engine starts, pinion 52 is traversed back to idle position by the overrunning action of the engine gear. Opening of the starting switch 44 by the operator thereupon deenergizes the solenoid 66, thereby permitting bridging switch 65 to open, and deenergizes solenoid 77, 75

thus permitting arm 75 to open contacts 69, 71.

In Fig. 4 of the drawings there is illustrated an arrangement whereby the pinion detent is used to so define the rotary position of the pinion as to facilitate its entry into mesh with the engine gear without tooth interference. It has been found in practice that in most starting installations, abutment of the pinion teeth against the ends of the flywheel teeth occur more frequently in certain relative positions of the pinion than in others. Thus, tooth abutments between a single tooth of the pinion and a single tooth of the flywheel may under some circumstances be considerably less troublesome than abutment of two teeth of the pinion with two teeth of the flywheel. By suitably positioning the detent 58, the pinion may be arranged to always present a single tooth to the flywheel gear, or the pinion may be so positioned that a tooth space of the pinion is bisected by the line joining the axes of the pinion and flywheel gear whereby two teeth of the pinion are caused to simultaneously engage with the engine gear, or any intermediate position found to be advantageous may be chosen. Another advantage of the use of the detent is that since the traversal of the pinion is assured thereby irrespective of the slowness of rotation of the motor shaft, the resistor 6 or 46 may have such a value as to cause the initial rotation of the starting motor to be quite slow whereby very little kinetic energy is stored up in the rotating parts during the meshing operation, and very little, if any, yielding buffer arrangement is required to cushion the impact of the pinion against the abutment 9 or 59.

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

What is claimed is:

1. In a two-stage starting system for internal combustion engines, a starting circuit including a battery, a starting switch, a starting motor and a resistor in series therewith for reducing the voltage of the battery initially applied to the motor, starter gearing for connecting the motor to a member of the engine to be started including a pinion movable longitudinally into engagement with the engine member by initial rotation of the motor, a detent for opposing rotation of the pinion to insure its traversal into operative position, means normally maintaining the detent in retracted position, a solenoid connected in shunt with said resistor for moving the detent into

operative position upon closure of the starting switch, and means including a bridging switch for short-circuiting the resistor and solenoid after the pinion has moved into engagement with the engine member.

2. A two-stage starting system as defined in claim 1 in which the means for short-circuiting the resistor and detent solenoid includes a solenoid controlled by the starting switch for closing the bridging switch, and means for delaying energization of the switch solenoid.

3. A two-stage starting system as defined in claim 1 in which the means for short-circuiting the resistor and detent solenoid includes a solenoid controlled by the starting switch for closing the bridging switch, and means for preventing effective closure of the switch solenoid for a predetermined time after closure of the starting switch.

4. A two-stage starting system as defined in claim 1 in which the means for short-circuiting the resistor and detent solenoid includes a solenoid controlled by the starting switch for closing the bridging switch, and a switch actuated by the detent when the pinion is fully engaged with the engine member for actuating the bridging switch solenoid.

5. A two-stage starting system as defined in claim 1 in which the means for short-circuiting the resistor and detent solenoid includes a solenoid controlled by the starting switch for closing the bridging switch, a switch actuated by the detent when the pinion is fully engaged with the engine member for actuating the bridging switch solenoid, and means for maintaining energization of the bridging switch solenoid to hold the bridging switch closed irrespective of opening of the detent switch.

6. A two-stage starting system as defined in claim 1, in which the detent is arranged to so position the pinion rotarily as to facilitate the entry of the teeth thereof into engagement with the engine member.

7. In a starting system for internal combustion engines, a starting circuit including a battery, a starting switch, a starting motor, gearing for connecting the motor to an engine to be started including an engine gear, a pinion movable longitudinally into engagement with the engine gear by initial rotation of the motor, and a detent for opposing rotation of the pinion to insure its traversal into operative position, said detent being arranged to so position the pinion rotarily as to facilitate the entry of the teeth thereof into the tooth spaces of the engine gear.

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