

- [54] **STARTER MEANS FOR AN INTERNAL COMBUSTION ENGINE**

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Related U.S. Application Data

- [63] Continuation-in-part of Ser. No. 22,822, March 26, 1970, abandoned.

- [52] U.S. Cl..... 74/7 R

- [51] **Int. Cl.**..... **F02n 15/06**

- [58] **Field of Search** 74/7 A, 7 E, 7 R,
74/6

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[57] **ABSTRACT**

Starter means for an internal combustion engine including a pinion shaft having a pinion at one end and inserted into and in spline engagement with a hollow shaft which is driven by a starter motor, said pinion shaft being arranged to be moved to a projecting position in response to the initial operation of said starter motor, the spline portion between the hollow shaft and the pinion shaft being unexposed.

8 Claims, 6 Drawing Figures

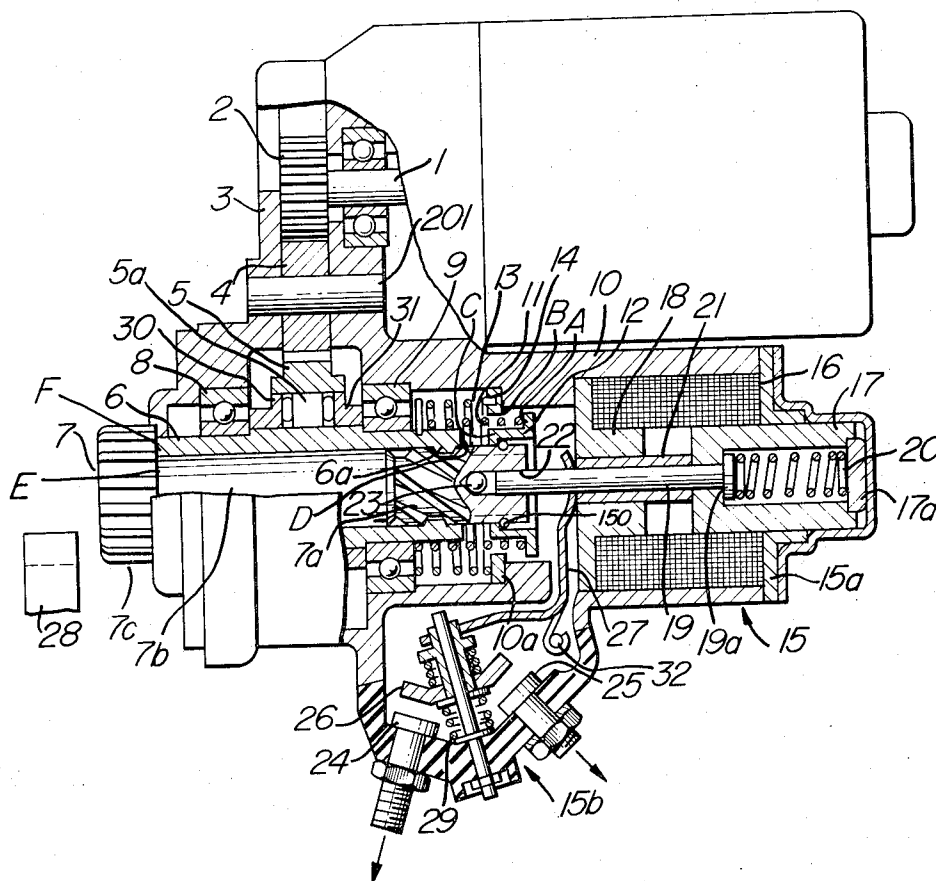


FIG. 1

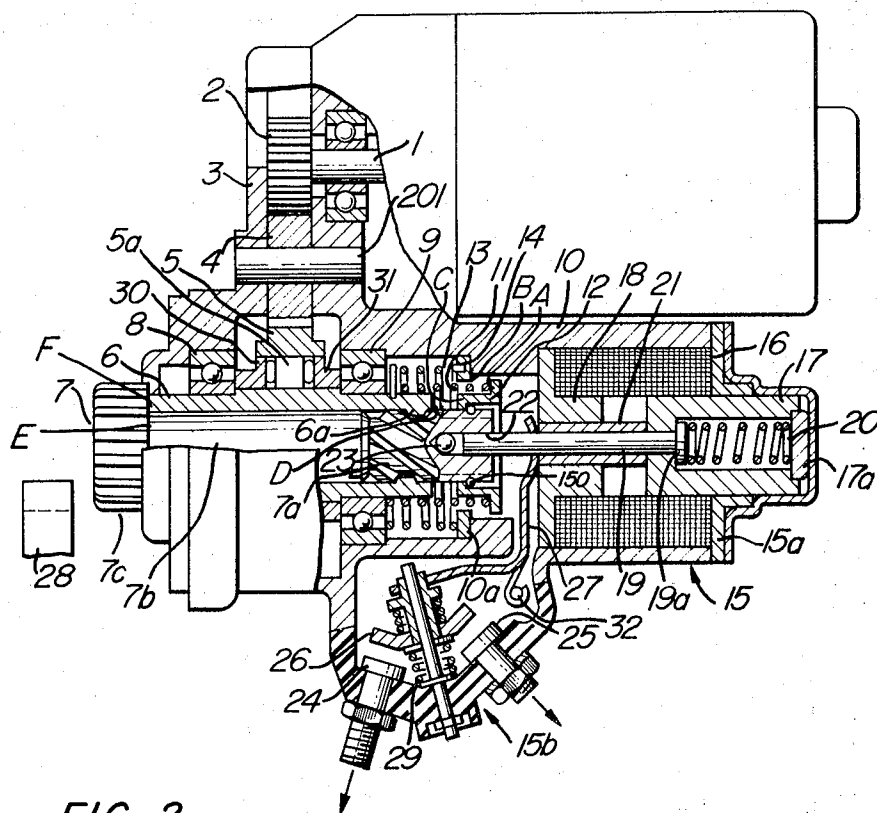


FIG. 2

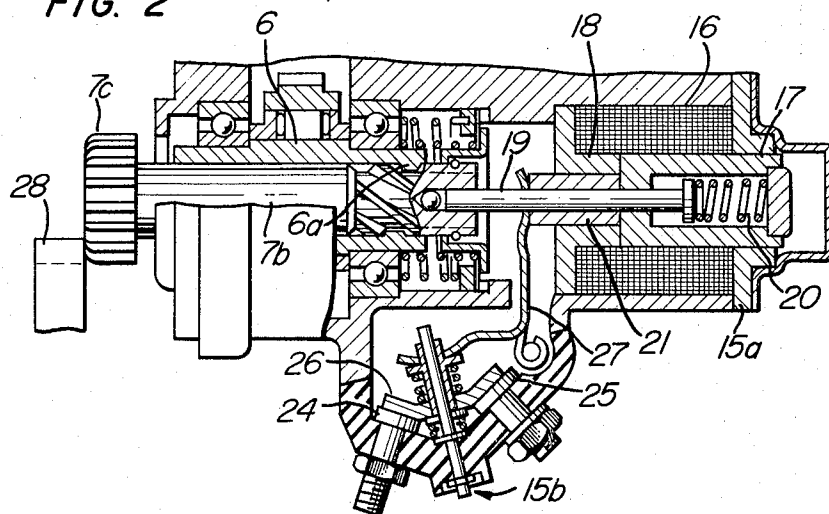


FIG. 3

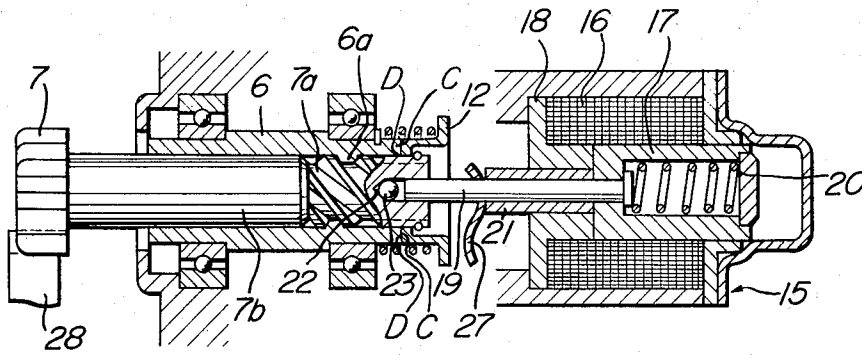
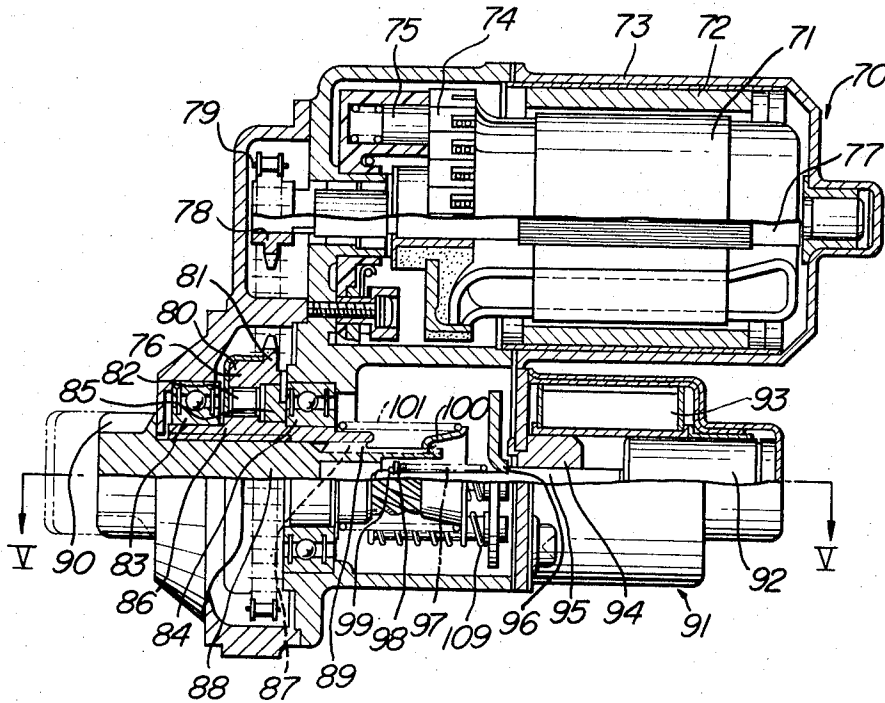


FIG. 4



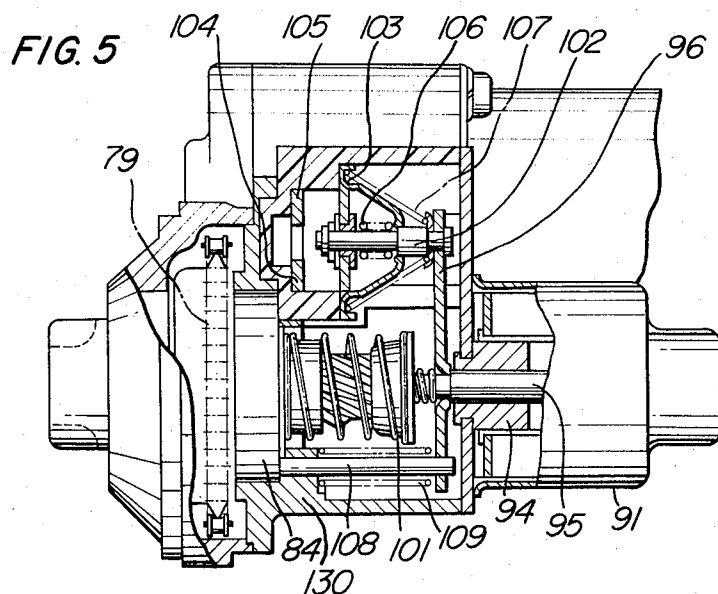
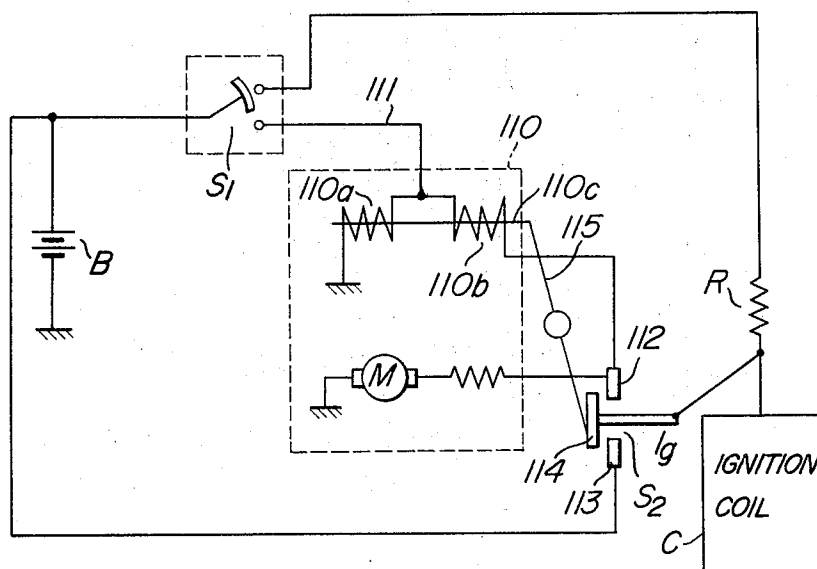


FIG. 6



STARTER MEANS FOR AN INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

The present application is a continuation-in-part of application Ser. No. 22,822, filed Mar. 26, 1970, now abandoned, and relates to a starter for an internal combustion engine.

In a conventionally known starter of the type having a pinion which is adapted to be put into engagement with a ring gear provided on an engine for starting the engine, the pinion is axially slidably mounted on an armature shaft of a starter motor through spline means, the pinion being moved along the spline by magnetic means into engagement with the ring gear. Further, such a type of starter that has a pinion mounted on an armature shaft of a starter motor through helical spline means for moving the pinion into engagement with an engine ring gear by the pinion inertia force during the initial rotation of the armature shaft has also been known. However, in such known structures, since the spline portions and the sliding surface for the position of the armature shaft of the starter motor and the pinion are exposed, they are often spattered with worn-off particles of clutch parts or mud with the result that the starter system often becomes inoperative.

Further, in a starter system for a large diesel engine, it has already been known to arrange in such a way that the pinion and the armature shaft are moved as a unit. In this arrangement, although the aforementioned disadvantages can be eliminated, it cannot be applied to a smaller starter system since it is difficult to obtain a sufficient thrust force for driving the armature assembly as a whole and moreover the mechanism for journaling the pinion shaft becomes complicated.

Still further, in each of these known starter systems, if the teeth of the pinion are not completely aligned with the valleys between the teeth of the engine ring gear, the pinion will possibly be damaged at its teeth when it is forced to engage with the engine ring gear.

SUMMARY OF THE INVENTION

The present invention is aimed to eliminate the above-mentioned disadvantages of conventional engine starters.

An object of the present invention is to provide an engine starter which is light in weight and compact, but can provide a large torque and has an increased durability.

Another object of the present invention is to provide a starter means in which the distance between the pinion of the starter means and the engine side wall can be reduced and the engine ring gear can also be made small, whereby the engine can be made compact as a whole.

A further object of the present invention is to provide a starter means which is free from malfunctions caused by foreign materials from outside.

A still further object of the present invention is to provide a starter means which can eliminate the possibility of the teeth of the pinion and those of the engine ring gear being damaged when they are put into engagement.

These and further objects and advantages of the present invention will become apparent from the following descriptions of preferred embodiments of the present

invention shown by way of examples in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of one embodiment of the present invention with a portion broken away in order to show the detail;

FIG. 2 is a sectional view with an enlarged scale of a portion of the starter means shown in FIG. 1;

FIG. 3 is a sectional view of the starter means with parts in operative positions;

FIG. 4 is a longitudinal sectional view showing a further embodiment of the present invention;

FIG. 5 is a sectional view taken along the line V—V of FIG. 4; and

FIG. 6 shows an example of the electric circuit of the starter means employing the principle of the present invention.

Description of the Preferred Embodiments

Referring first to FIG. 1, reference numeral 2 designates a pinion integrally mounted on the shaft 1 of a starter motor and rotatable incident to the rotation of said starter motor. Reference numeral 4 designates an idle gear rotatably mounted by means of a pin 201 which is fixed to a housing 3 and a housing 10. This idle gear 4 serves to transmit the rotation of the pinion 2 through a clutch, including an outer race 5, clutch rollers 5a, and bushings 30 and 31, to a spline shaft 6. The clutch transmits the driving power of the starter motor to the spline shaft 6 but does not in any case transmit the rotation of the spline shaft 6 to the pinion 2 through the idle gear 4. Namely, the clutch is the so-called one way clutch. The spline shaft 6 is provided substantially axially with a spline 6a which is slightly twisted radially and in meshing engagement with a spline 7a provided on a pinion shaft. The rotation of the spline shaft 6 is transmitted to the pinion shaft 7b through the gearing engagement of these two splines 6a and 7a. Fixedly mounted on an end extremity of the pinion shaft 7b is a pinion 7 which is in engagement with a ring gear 28 when driving an engine. The starter means of the present invention is characterized by the construction of the clutch. Namely, the outer periphery of the spline shaft 6 provides a rolling surface for the clutch roller and the rotation of the outer race 5 is transmitted to the spline shaft 6 through the roller 5a. The bushings 30 and 31 merely provide a space for receiving the rollers 5a and do not directly contribute the transmission of rotation. Of course, the spline shaft 6 is rotatably and not slidably mounted in the housings 3 and 10 through bearings 8 and 9 respectively. A stopper 12 is provided on the spline 7a of the pinion shaft 7b. A stopper ring 150 is secured around the spline 7a thereby restricting the movement of the stopper 12 to the right. A return spring 11 is disposed between the inner race of the bearing 9 and the flange of the stopper 12, and a spring 13 is disposed between the inner race of the bearing 9 and a braking member 14 which is urged to the annular shoulder 10a of the housing 10.

One hooked end of the spring 13 is inserted in a hole formed on the spline shaft 6, and the other hooked end is inserted in a hole formed on the brake member 14. The spline shaft 6 and the pinion shaft 7b mesh in the splines (6a and 7a). However when the end face C of the stopper 12 abuts on the end face D of the spline shaft 6, the pinion shaft 7 stops its axial movement. In

this condition the rotation of the starter motor is transmitted through the pinion 2, the idle gear 4, the outer race 5, the clutch rollers 5a, the spline shaft 6, the spline 6a, the spline 7a, the pinion shaft 7b and the pinion 7.

The pinion shaft 7b is pushed by a rod 19 and slides forward along the spline 6a of the spline shaft 6.

Further, the starter means made in accordance with the present invention includes a magnetic switch generally designated by the reference numeral 15. This magnetic switch comprises an electrical solenoid section 15a and a switch section 15b. The solenoid section 15a includes a solenoid coil 16 and a movable and a stationary core 17 and 18, respectively, which are disposed inside the coil 16. A rod 19 is axially slidably disposed through the movable core 17 and the stationary core 18. The rod 19 has an end flange 19a in the form of a circular disc provided at the right end, the end flange 19a being adapted to abut an annular shoulder formed on the inner surface of the movable core 17. Further, the rod 19 is biased leftwardly as seen in FIG. 1 by means of a compression coil spring 20 acting between the end flange 19a and an end plate 17a secured to the right end portion of the movable core 17. The rod 19 is inserted at its left end into an axial bore 22 formed at the right end of the piston shaft 7b, and abuttingly engages with the pinion 7b through a ball 23. Further, at the left side of the movable core, there is disposed a cylindrical slide bush 21 which is made of non-magnetic material and encircling the rod 19. The right end of the bush 21 abuttingly engages with the left end of the movable core 17.

The switch section 15b of the magnetic switch 15 includes a contact 24 which is adapted to be connected with an electric power source such as a battery (as shown in FIG. 6) and another contact 25 which is connected with the starter motor. A switch element 26 is provided for connecting the contacts 24 and 25 with each other. The switch element 26 is held in a normal open position by means of a spring 29. The means for actuating the switch element 26 to close the switch includes an actuating lever 27 pivotally mounted at 32. The actuating lever 27 has one end disposed to engage the left end of the slide bush 21 of the solenoid section 15a whereby, when the slide bush is displaced toward left as seen in FIG. 2, the actuating lever 27 is pivotally moved counterclockwise about the pivot pin 32 and actuates the switch element to the close position by its other end. In the drawing, the reference numeral 28 shows an engine ring gear with which the pinion 7 engages when the latter is moved toward left.

The starter means of the present invention as constructed above will operate as follows. First of all, the solenoid coil 16 of the solenoid section 15a in the magnetic switch 15 is energized to draw the movable core 17 toward the stationary core 18. The movement of the core 17 is transmitted through the spring 20 to the rod 19 to displace the rod 19 toward left. The movement of the rod 19 is in turn transmitted through the ball 23 to the pinion 7 to bring it into engagement with the ring gear 28 so that the sliding surface of said pinion shaft is exposed. At the same time, the slide bush 21 is pushed by the movable core 17 toward left and moves in turn, by its left end, the corresponding end of the switch actuating lever 27 toward left so as to cause counterclockwise rotation of the lever 27 about the pivot pin 32. As the result, the switch element 26 is

caused to move into the close position to connect the contact 24 and 25 with each other, whereby the starter motor is started to operate. As the pinion 7 is moved toward left as explained above, the brake member 14 is also caused to move toward left away from the annular shoulder 10a of the housing 10 by the flange of the stopper 12 against the action of the spring 13, so that the braking effort applied from the brake member 14 to the spline shaft 6 is released. Thus, the spline shaft 6 is driven by the starter motor through the gears 2, 4 and 5 and the one way clutch.

When the pinion is moved as described above, if the teeth of the pinion 7 is not in alignment with those of the engine ring gear 28, they will fail to mesh with each other. In this case, the leftward movement of the pinion 7 is stopped half way of its travel, however, even in this circumstance, the movable core 17 continues to move toward left against the force of the spring 20 to cause the slide bush 21 to move toward left. Thus, the switch element 26 is moved into the close position to close the contacts 24 and 25 (FIG. 2). As the result, the starter motor is put into operation and, as the pinion 7 rotates slightly, it comes to a position where it can engage with the engine ring gear 28. Even when the brake member 14 is moved away from the annular shoulder 10a of the housing 10, by the front annular surface A of the stopper faces to the rear annular face B of the brake member 14, the braking effort is retained so that a sudden rotation of the spline shaft 6 will be prevented. According to the arrangement of the present invention, the rod 19 for driving the pinion 7 is not secured to the movable core 17 but connected through the spring 20, so that the switch in the starter motor circuit can be closed by the movement of the movable core 17 irrespective of the movement of the rod 19. Therefore, an extremely smooth operation can be obtained. Further according to the arrangement of the present invention, the rod 19 drives the pinion shaft portion 7b of the pinion 7 through the ball 23 whereby a sliding friction between the bottom of an axial bore 22 of the pinion shaft portion 7b and the left end face of the rod 19 can substantially be reduced.

When the engine is started and begins to run by itself, the coil 16 of the magnetic switch 15 is de-energized. Thus, the movable core 17 is returned by the force of the spring 29 toward right and, at the same time, the pinion 7 is also returned under the influence of the return spring 11 and the rear end E of the pinion is faced to the front end F of the spline shaft, consequently the sliding surface of the pinion shaft is covered up. Further, the switch element 26 is simultaneously moved apart from the contacts 24 and 25 by the spring 29, so that the electric power supplied to the starter motor is interrupted. In this instance, since the brake member 14 is forced under the action of the spring 13 into contact with the annular shoulder 10a of the housing 10, the rotation of the spline shaft 6 is immediately restricted by the friction between the brake member and the annular shoulder. According to this arrangement of the present invention, the spline shaft 6 can be stopped immediately after the engine is started so that, even in case where the engine failed to start, a second starting procedure can immediately be made without a danger of forcing the rotating pinion 7 into engagement with the ring gear 28.

The arrangement of the present invention is also advantageous in that the force of axial thrust produced

during engine starting will scarcely be applied to the bearings 8 and 9 jouralling the spline shaft 6. As shown in FIG. 3, during the operation, the end surface D of the stopper 12 is in abutting engagement with the end surface C of the spline shaft 6, and the spline portion 7a of the shaft 7b is subjected to an axial thrust acting toward the left. On the other hand, the spline shaft 6 is subjected to a reaction force, due to the axial component of the thrust produced at the helical spline 6a, which serves to urge the stopper 12 toward the right. Therefore, the axial force component of the thrust produced by the helical spline engagement between the spline portion 7a of the pinion 7b and the spline shaft 6 is shared by the spline shaft 6 and the stopper 12 and will not be transmitted through the bearings 8 and 9 to the side wall of the housing 10. Thus, according to the arrangement of the present invention, energy loss due to the axial force component produced during engine cranking can be substantially eliminated and the engine side wall can be protected from wear.

A further embodiment of the present invention is shown in FIGS. 4 and 5. A starter motor generally designated by the reference numeral 70 has an armature 71 and a permanent magnet 72, both enclosed in a motor housing 73. The armature 71 is provided integrally therewith a commutator 74 which cooperate with a rectifying brush means 75. The armature 71 further has a drive shaft 77 having a chain sprocket 78 at one end. A chain 79 passing around the sprocket 78 also passes around a sprocket 76 which is larger in diameter than the sprocket 78. The sprocket 76 has a hub portion 80 and sprocket teeth 81 for engagement with the chain 79 and is mounted through rollers 82 on a sleeve member 86 which is in turn rotatably supported on the housing by means of bearings 83 and 84. Within the sleeve member 86, there is inserted a pinion shaft 88 having a pinion 90 at its one end. The sleeve member 86 and the pinion shaft 88 are connected together through the splines 87 and 89 respectively formed on the member sleeve 86 and the shaft 88. The inner surface of the hub portion 80 of the chain sprocket 76, the roller 82 and the outer surface of the sleeve member 86 together constitute a one-way clutch of known type. The reference numeral 85 shows a member for supporting the sprocket 76 on the sleeve member 86.

Means for causing the axial movement of the pinion shaft 88 includes electrical solenoid means 91 comprising a solenoid coil 93, a movable core 92 and a stationary core 94. The movable core 92 has a rod 95 extending axially toward the pinion shaft 88 and is inserted at its free end into an axial bore formed in the adjacent end of the pinion shaft 88. The rod 95 carries a driving plate 96 slidably mounted thereon and a second driving plate 98 which is also slidably mounted thereon. A spring 97 is disposed between the driving plates 96 and 98 to urge these plates from each other. A stop ring 99 is provided on the rod 95 adjacent to its end for limiting the leftward movement of the driving plate 98, so that the spring 97 serves to push the driving plate 98 onto the stop ring 99 and the driving plate 96 onto an annular shoulder formed on the rod 95. Therefore, when the magnetic means 91 is energized, the movable core 92 is caused to move toward left so as to displace the rod 95 toward left. Thus, the driving plate 96 is also driven toward left. This movement is transmitted through the spring 97 to the second driving plate 98 which in turn pushes the pinion shaft 88 toward left by engaging with

an annular shoulder formed on the axial bore of the pinion shaft 88. When the magnetic means 91 is de-energized, the movable core 92 is retracted toward right, so that the rod 95 and the driving plates 96 and 98 mounted thereon are also moved toward right. Then, the pinion shaft 88 is returned toward right by means of a return spring 101 acting on a flange 100 mounted on the right end thereof.

As shown in FIG. 5, a switch actuating member 102 is carried on the driving plate 96. The switch actuating member 102 in turn carries a switch element 103 at its end. The reference numerals 104 and 105 show contacts arranged in an electric circuit for the engine starter motor. These contacts are arranged to be closed by the switch element 103. The reference numeral 106 shows a spring arranged between the switch actuating member 102 and the switch element 103 for yieldably urging the switch element 103 toward left. The reference numeral 107 shows a return spring which urges the driving plate 96 toward right. Therefore, when the magnetic means 91 is energized and thus the driving plate 96 is moved toward left as described above, the switch element 103 is also moved toward left to close the contacts 104 and 105. The reference numeral 108 shows a guide member fixed to the housing 130 for the driving plate 96, and 109 a return spring which urges the driving plate 96 toward the right. The arrangement shown in FIGS. 4 and 5 has all of the advantageous features of the aforementioned embodiments and further as an advantage that the speed reduction mechanism between the starter motor 70 and the pinion shaft 88 can be made compact. has

A typical electric circuit for an engine starter system embodying the principle of the present invention is shown in FIG. 6. An electric power source or a battery B is connected on one hand through a main switch S₁ with an ignition coil C and on the other hand with a starter solenoid 110. The starter solenoid 110 has a coil 110a which is connected at its one end with the line 111 from the main switch S₁ and grounded at its other end, and a coil 110b which is connected at its one end with the line 111 and at its other end with the contact 112 of a starter switch S₂. The contact 112 is further connected directly with the starter motor M. A second contact 113 is provided for cooperation with the contact 112, the two contacts 112 and 113 being closed by a switch element 114. The switch element 114 is actuated by a link 115 connected with a movable core 110c. The switch element 114 is further connected with a coil resistance R in the circuit of the ignition coil C. Therefore, when the main switch S₁ is closed, the solenoid 110 is energized and thus the motor M is started to operate. At the same time, the switch element 114 closes the contacts 112 and 113 whereby the engine is cranked.

The present invention has thus been described with reference to the illustrated embodiments, however, the present invention is in no way limited to the details thereof, and it should be noted that several changes and modifications can be made within the scope of the invention.

What is claimed is:

1. An automatic engine starter system comprising: a starter motor having an output shaft with a first pinion mounted for rotation incident to rotation of the starter motor;

a spline shaft being provided with a first spline and sliding surface;
 a stationary housing and bearing means for supporting the spline shaft in the stationary housing rotatably and not slidingly,
 a speed reduction means for reducing and transmitting the rotation from the starter motor to the spline shaft,
 a pinion shaft being provided with a second spline and sliding surface for engaging with the first spline and sliding surface and inserted into the spline shaft, so that the pinion shaft is housed substantially in the spline shaft when it is not operated and slid forward along the first spline when it is operated,
 means for pushing forward the pinion shaft,
 a second pinion secured on the front end of the pinion shaft for engaging with a ring gear of the engine for cranking it, whereon, the pinion shaft is installed fully in the spline shaft while the automatic engine starter system is not in operation.

2. An automatic engine starter system as in claim 1 wherein the first and second splines being helical and further comprising:
 a stopper being provided at the rear end of the pinion shaft opposite to the pinion so as to determine the maximum displacement of the pinion shaft.

3. An automatic engine starter system as in claim 1 further comprising one-way clutch means provided be-

tween the speed reduction means and the spline shaft.

4. An automatic engine starter system as in claim 1, wherein the means for pushing forward the pinion shaft comprises:

5 a movable core,
 an axially movably rod for pushing forward the pinion shaft,
 a magnetic coil for making the movable core to be pushed forward.

10 5. An automatic engine starter system as in claim 4 further comprising a ball being installed in a bore of the pinion shaft so that the axially movable rod engages with the pinion shaft through the ball.

15 6. An automatic engine starter system as in claim 4 further comprising brake means for braking the rotation of the pinion when the pinion is at the retracted position, and the brake means being released only when the pinion engages with the engine ring gear.

20 7. An automatic engine starter system as in claim 4 further comprising:

a compression coil spring provided between an end flange of the rod and an end plate secured to the movable core for urging the rod.

25 8. An automatic engine starter system as in claim 4 further comprising a cylindrical slide bush, a switch means being actuated by the slide bush which is moved by the movable core.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,771,372 Dated November 13, 1973

Inventor(s) Taro Asahi and Tatuo Doi

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Heading

Item (30) Foreign Application Priority Data

October 29, 1969	Japan	102697/69
October 29, 1969	Japan	102698/69
October 29, 1969	Japan	102700/69
October 29, 1969	Japan	102701/69

Signed and sealed this 9th day of April 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

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Commissioner of Patents