United States Patent [19]

Carlson et al.

[11] **3,772,921**

[45] **Nov. 20, 1973**

[54] **ENGINE STARTER**

[75] Inventors: **John W. Carlson; Morris Esche; Steven E. Ferguson,** all of Anderson, Ind.

[73] Assignee: **General Motors Corporation,** Detroit, Mich.

[22] Filed: **Dec. 21, 1972**

[21] Appl. No.: **317,277**

[52] **U.S. Cl.** ..... **74/7 A**

[51] **Int. Cl.** **F02n 11/00,** F02n 11/08

[58] **Field of Search** ..... 74/6, 7 R, 7 A; 290/38 R, 38 A

[56] **References Cited**

UNITED STATES PATENTS

1,782,318	11/1930	Royle	290/38 A
3,124,694	3/1964	Seilly	290/38 R
3,686,961	8/1972	Campbell	74/7 R

FOREIGN PATENTS OR APPLICATIONS

833,537	7/1938	France	74/6
843,689	4/1939	France	74/6

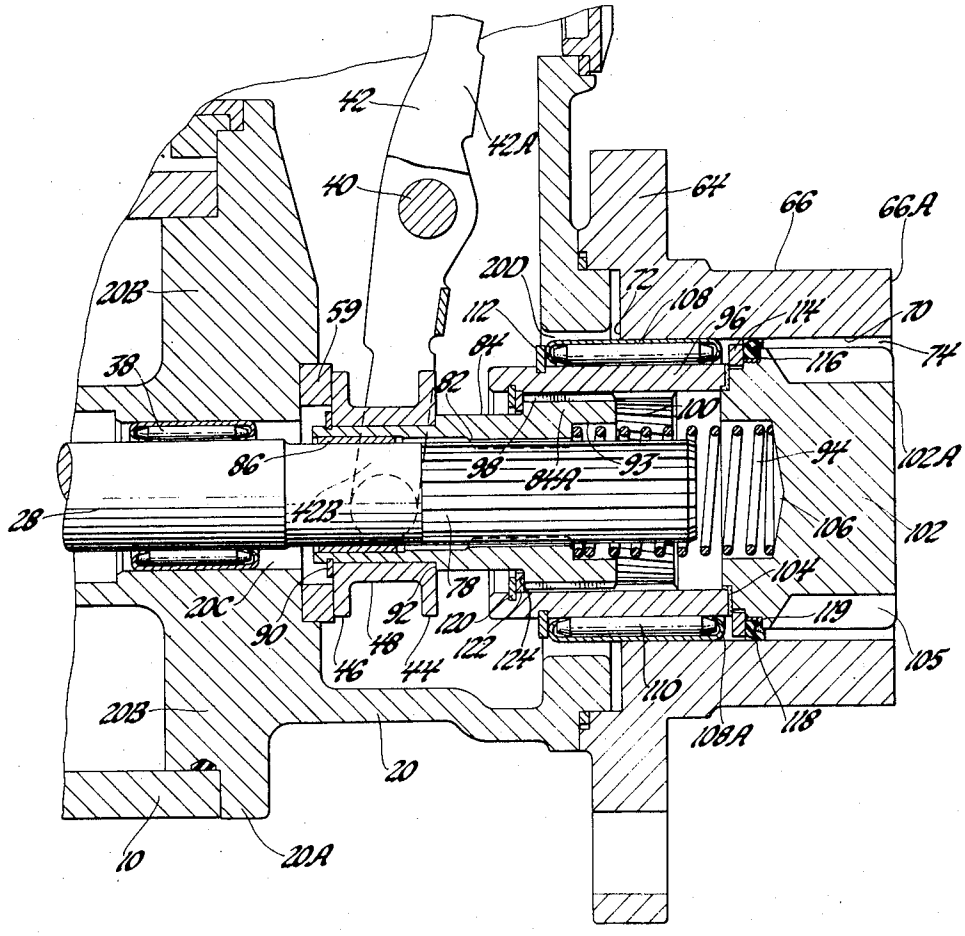
Primary Examiner—Allan D. Herrmann

Attorney—E. E. Christen et al.

[57] **ABSTRACT**

An engine starter for an internal combustion engine where a pinion can be moved into mesh with the ring gear of the engine and is driven by an armature of an electric motor. The starter includes a starter drive which does not have an overrunning clutch. The pinion is meshed with the ring gear of an engine by a solenoid and is automatically disengaged from the ring gear by a spring when a system that responds to cranking motor speed deenergizes the solenoid. The starter includes a nose housing having a tubular bore which receives a pinion that closes the open end of the tubular bore except for some clearance between the outside of the pinion and the bore. A seal encircles the solid pinion and the pinion and seal serve to prevent foreign material from entering the interior of the starter. The seal also serves to wipe the tubular bore of the nose housing during movement of the pinion. The pinion is supported at its exterior by a bearing interposed between the exterior of the pinion and the wall defining the tubular bore in the nose casting. The pinion assembly therefore receives its primary support at its exterior and the pinion assembly has an internal helical spline connected with a sleeve member which can be axially reciprocated and rotatably driven by an armature shaft.

4 Claims, 3 Drawing Figures



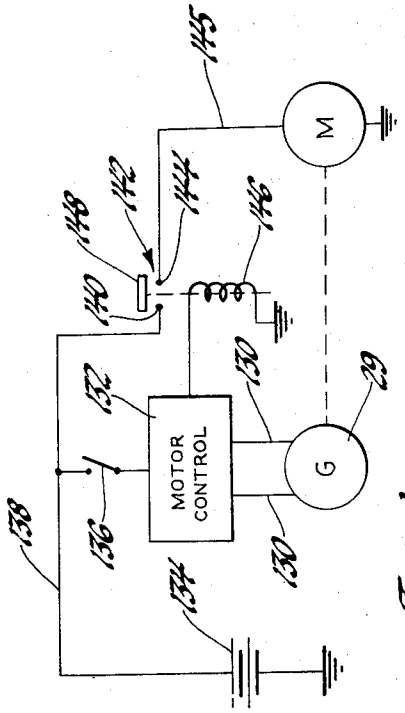


Fig. 1

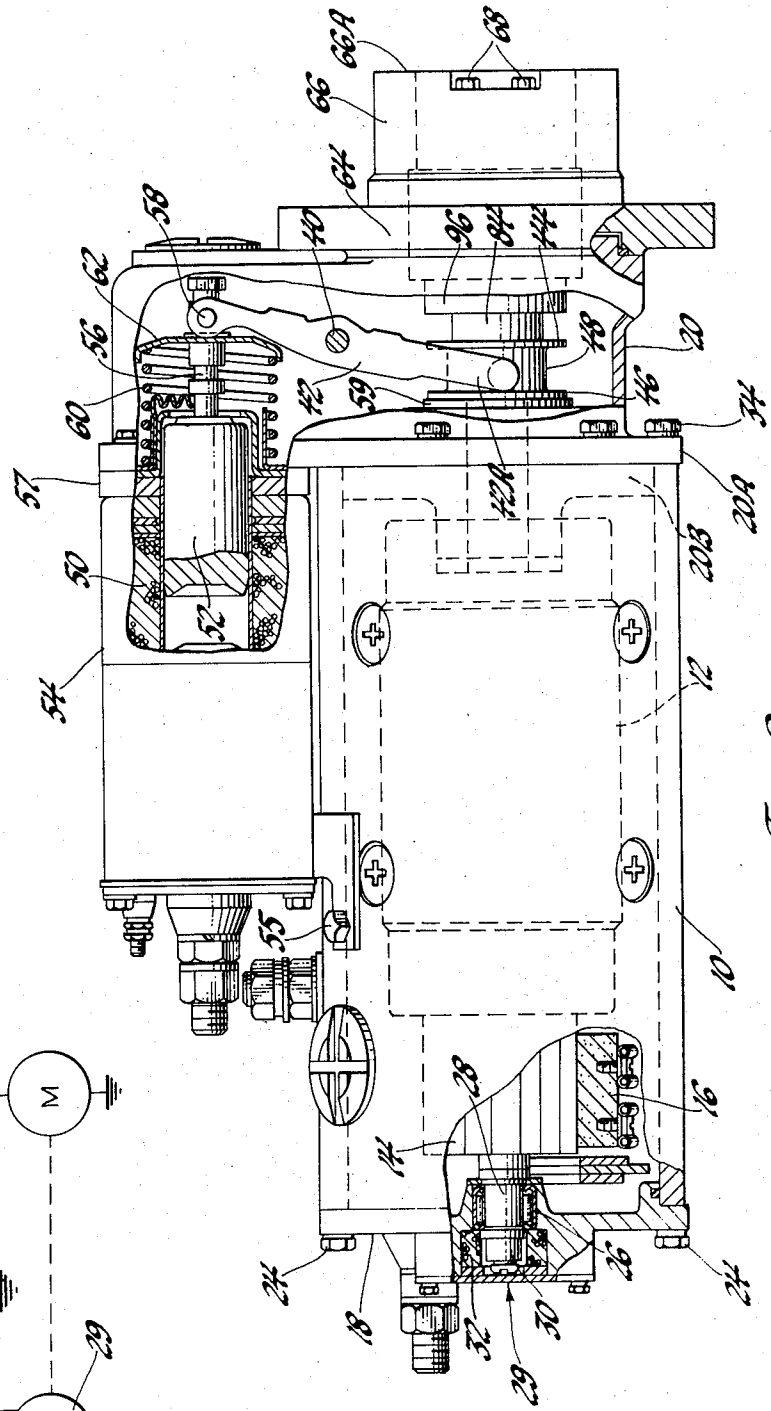


Fig. 2

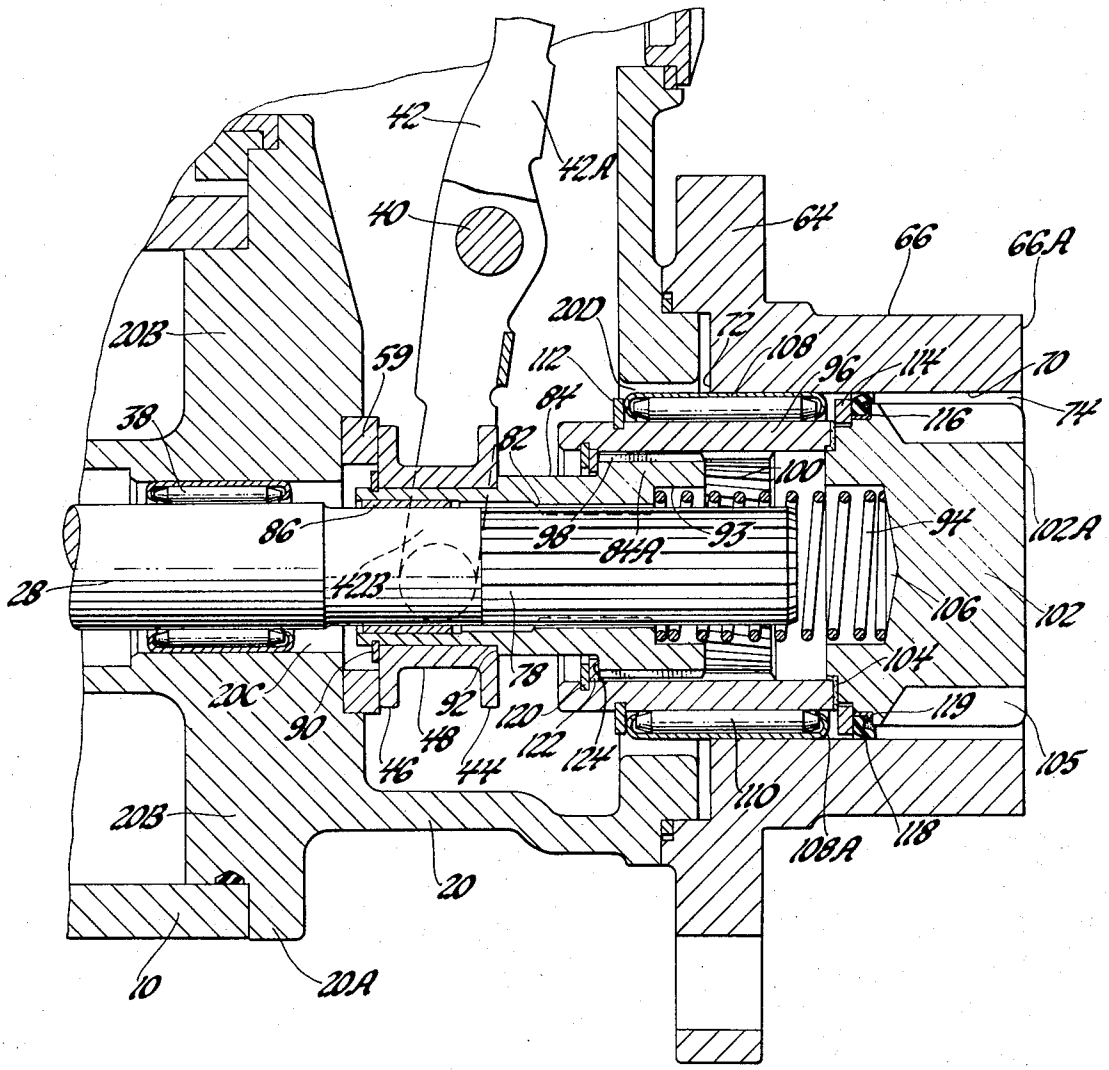

42
42A
40
64
66
66A
200
72
108
96
114
70
112
84
116
74
20B
59
38
82
100
86
98
84A
93
94
102A
28
42B
106
102
104
20C
78
92
120
119
90
48
122
124
105
46
44
110
108A
118
20B
20
10
20A

Fig. 3

ENGINE STARTER

This invention relates to starters for cranking internal combustion engines and more particularly to an electric starter where a pinion is driven by the armature shaft of an electric motor and where the pinion can be moved into and out of engagement with the ring gear of an engine.

Starters for cranking internal combustion engines, which include a pinion driven by the armature of an electric motor and where the pinion is axially reciprocable by a solenoid and spring relative to the armature shaft, are well known in the art. In the past a majority of these devices have required some type of overrunning clutch connected between the armature shaft and the pinion to prevent high speed rotation of the armature shaft of the electric motor when the engine starts and while the pinion is still meshed with the ring gear of the engine. Because the overrunning cluth is a part which is subject to wear and adds to the number of parts required for the starter drive it has been proposed in the past to provide starting apparatus which does not require such a clutch. One example of such starting apparatus is disclosed in the U.S. Pat. to Kroeger No. 1,634,751 in which the pinion is demeshed from the ring gear when the speed of rotation of the electric cranking motor reaches a predetermined value thus obviating the need for the overrunning clutch.

It is one of the objects of this invention to provide an improved engine starter of the type that does not utilize an overrunning clutch. In carrying this object forward a starter drive assembly is provided which includes an annular member that is connected by straight splines with one end of an armature shaft. The annular member is connected by way of helical splines to a pinion assembly having a pinion movable within the tubular bore of a nose housing of the starting apparatus. The pinion has no openings extending therethrough and the pinion assembly is supported at its exterior by a bearing interposed between the exterior of the pinion assembly and the wall defining the tubular bore of the nose housing. The starting arrangement includes electronic circuitry for causing the pinion to be demeshed from the ring gear when the armature speed of the electric motor reaches a predetermined value as when the engine starts.

It is another object of this invention to provide starting apparatus for an internal combustion engine where the interior of the starting apparatus is protected from dirt and other foreign material. In this regard it has been common practice to provide a side opening in the nose casting of the cranking motor which permits the pinion to be meshed with the ring gear. An example of this is disclosed in the U.S. Pat. to Redick et al., No. 3,020,771. In contrast to starting arrangements of the type disclosed in the Redick et al. patent the present invention contemplates providing a nose casting which has an axially extending tubular bore which is only open at one end. The tubular bore is substantially closed by a non-apertured pinion which can be projected from a position within the bore to a position outside of the bore in mesh with the engine ring gear. In addition, the pinion is supported by a bearing that is slidable along the bore wall and the pinion is provided with a seal which wipes clean the wall of the tubular bore during operation of the starting device. In the arrangement that has just been described the armature shaft is not connected directly with the pinion nor is it necessary to axially reciprocate the armature shaft since the pinion assembly is supported at its exterior by the bearing member.

IN THE DRAWINGS

FIG. 1 is a schematic circuit diagram of a control system for the starting apparatus of this invention;

FIG. 2 is a plan view with parts broken away of an electric cranking apparatus made in accordance with this invention; and

FIG. 3 is an enlarged sectional view of a portion of the cranking motor illustrated in FIG. 2 and illustrating the starter drive assembly of this invention in detail.

Referring now to the drawings and more particularly to FIG. 2, the reference numeral **10** designates the annular frame of an electric cranking motor which is used to drive the pinion of the electric starter of this invention. The frame **10** carries the usual field coils which are not illustrated but which are of the type disclosed in the U.S. Pat. to Redick et al., No. 3,020,771. The electric cranking motor has an armature designated by reference numeral **12** having conductors connected with a commutator **14.** The commutator, in a conventional fashion, is engaged by brushes one of which is designated by reference numeral **16.**

The open ends of the tubular frame **10** are closed respectively by a commutator end frame **18** and by a lever assembly housing generally designated by reference numeral **20.** The commutator end frame **18** is secured to one end of the tubular frame **10** by a plurality of screws **24.** The commutator end frame supports a needle bearing **2** which rotatably supports one end of the armature shaft **28.** The armature shaft **28** forms a part of the armature **12** and supports the armature core and conductors in a known manner.

The commutator end frame **18** also supports a part of a small alternating current signal generator designated by reference numeral **29.** To this end a permanent magnet **30** is attached to the end of shaft **28** and rotatably driven thereby. The permanent magnet, during its rotation, generates an alternating current in the pickup coil **32** and the voltage generated therein has a frequency and an amplitude which are proportional to the speed of rotation of the armature **12.**

The lever assembly housing **20** has an annular portion **20A** which is bolted to the end of frame **10** by a plurality of screws or bolts **34.** This housing **20** has an integral center bearing section **20B** shown in dotted lines in FIG. **2** and in enlarged section in FIG. **3.** The center bearing section closes the open end of frame **10** and has a central opening **20C** which receives a needle bearing **38** that rotatably supports the armature shaft **28.** The lever housing **20** has an annular opening **20D** facing an opening formed in a nose housing **66** which is described in detail hereinafter. The lever housing **20** carries a pivot pin designated by reference numeral **40.** The pivot pin extends from one side wall of the lever housing to the other and this pivot pin pivotally supports a lever assembly designated in its entirety by reference numeral **42.** The lever assembly **42** can be like that disclosed in FIG. **3** of the above mentioned Redick et al. patent and has a forked end providing two spaced oppositely disposed arms **42A** and **42B** terminating in annular lugs located between the walls **44** and **46** of a shift collar generally designated by reference numeral **48** and shown in greater detail in FIG. **3.** As will be appreciated by those skilled in the art the pivoting of lever

42 about pivot point 40 will move the shift collar 48 axially with respect to the armature shaft in a manner more fully described hereinafter. The pivoting of the lever assembly 42 will cause the pinion of the starting mechanism to be engaged or disengaged from the ring gear of the engine.

The lever 42 is moved by a solenoid which is comprised of solenoid coil winding 50 and slidable armature 52. The coil winding 50 is located within a solenoid housing 54 which is secured to the frame 10 of the cranking motor by screws 55. The armature 52 passes through openings formed in part 57 and lever housing 20 and is connected with a rod 56 which in turn is pivotally connected to lever 42 by a pivot pin 58. The connection between rod 56 and armature 52 is a pivotal connection (not illustrated) but which may be of the type described in the U.S. Pat. to Hartzell et al., No. 2,839,935. The pivot connection 58 between lever 42 and rod 56 can take various configurations which form no part of the present invention but can be of the type disclosed in the U.S. Pat. to Redick et al., No. 3,020,771.

The armature 52 of the solenoid is biased to the position shown in FIG. 2 by a spring 60 interposed between a fixed part of the solenoid assembly and a spring retainer 62 supported by rod 56. The arrangement is such that the spring constantly urges the armature 52 out of the coil 50 and also applies a force to the top end of lever assembly 42 to spring bias it in a clockwise direction to therefore urge the shift collar 48 to a position where it engages brake washer 59 shown in FIG. 3. The spring 60 therefore moves the shift collar 48 in a direction to disengage the pinion of the cranking motor from the engine ring gear as will become more apparent hereinafter. When the solenoid 50 is energized the armature 52 is attracted to the left in FIG. 2 with the result that the lever 42 is pivoted counterclockwise about pivot pin 40 and with the further result that the shift collar 48 is moved to the right in FIGS. 2 and 3 to move a pinion into mesh with the ring gear of an engine.

The shift collar 48 forms a part of a starter drive which is generally designated by reference numeral 64. This starter drive is disclosed in detail in the sectional view of FIG. 3. The starter drive is partially positioned within the opening 20D in the lever housing 20 and partially positioned within a nose housing designated by reference numeral 66. The nose housing 66 is secured to one end of the lever assembly housing 20 by a plurality of screws 68 the heads of two of which are visible in FIG. 2. The screws 68 pass through openings in the nose housing 66 and are threaded into threaded openings in housing 20 with the heads engaging nose housing 66. It can be seen that the nose housing 66 has no side openings but rather has a tubular bore shown in FIG. 3 defined by a cylindrical wall designated by reference numeral 70. The cylindrical wall 70 extends entirely through nose housing 66 and ends in a cylindrical opening 72 facing opening 20D and a cylindrical opening 74 facing the exterior of the starter.

Referring now more particularly to FIG. 3, the starter drive assembly of this invention will be described in detail. As shown in FIG. 3 the armature shaft 28 is journaled for rotation in the needle bearing 38 and the end of the shaft is located within the nose housing 66. The end of the armature shaft 28, which drives the starter drive, has straight splines designated by reference numeral 78. The straight splines 78 fit within complementary straight splines 82 formed in the internal bore of an annular part or sleeve designated in its entirety by reference numeral 84. The annular member 84 carries a sleeve bearing 86 which is disposed about a smooth circular part of the armature shaft. One end of the annular member 84 has a reduced outer diameter and carries the shift collar 48 which is disposed between a retaining ring 90 and an annular wall 92 of the part 84. This of course means that as the shift collar 48 is moved axially it moves the annular part 84 therewith.

The annular part 84 has a counterbore 93 which forms a spring seat for one end of a spring 94.

The annular member 84 can be axially reciprocated by the lever 42 and rotatably driven by armature shaft 28 due to the straight spline connection between the part 84 and the armature shaft 28.

The larger diameter portion 84A of the annular member 84 is disposed within a tubular part designated by reference numeral 96. The exterior of portion 84A of part 84 is provided with helical splines 98 which mate with complementary internal helical splines 100 formed on the inner bore of the tubular part 96. By way of example, the helical spline 100 may have a helix angle of 35°, RH, and a diametral pitch of 24/48. The end of tubular part 96 is welded or otherwise secured to a pinion designated by reference numeral 102 over an annular area 104. The annular part 96 and the pinion 102 may therefore be considered a one-piece pinion assembly.

The pinion 102 has a plurality of teeth 105 disposed evenly about its outer periphery, for example, eleven teeth. These teeth mesh with the ring gear of the engine (not shown) to be cranked whenever the pinion 102 is moved into mesh with the ring gear. It is pointed out that the pinion 102 has no central opening passing therethrough and in fact is a solid piece substantially filling the tubular bore 70 of the nose housing 66. The pinion 102 has a counterbore 106 forming another spring seat for the spring 94.

The annular part 96 carries a needle bearing comprised of an outer race 108 and a plurality of rollers 110 which engage the outer cylindrical surface of part 96. The cylindrical outer wall of the outer race 108 engages the cylindrical wall 70 of the nose housing 66. The outer race 108 of the bearing will slide along the wall 70 as the starter drive is moved axially in a manner to be more fully described. Located at one end of the outer race 108 is a retaining ring 112 disposed within an annular slot in the outer periphery of part 96. Located adjacent the opposite end of the outer race 110 is a washer 114. Disposed between the washer 114 and an annular wall 116 of pinion 102 is an annular lip seal designated by reference numeral 118 which is formed of a resilient material such as an oil resistant rubber. The seal has an annular steel support plate 119 and the seal moves axially with the starter drive assembly to wipe clean the cylindrical wall 70 when the starter is being used.

In order to prevent relative axial movement between parts 84 and 96 in one direction by the force of spring 94 a retaining ring 120 and a washer 122 are provided. The retaining ring 120 fits within an annular slot formed in part 96 and abuts the washer 122 which in turn abuts the annular wall 124 of the part 84. With this arrangement part 96 cannot move to the right relative to part 84 when washer 122 engages wall 124.

The starter drive assembly, which has been described, is illustrated in FIG. 3 in its non-cranking or at rest position. In this position the shift collar **48** is in engagement with brake washer **59** and is being held in this position by the spring **60.** In this position it is seen that the outer race **108** of the bearing is partially disposed within the tubular bore **70** and it can be seen that the end wall **102A** of pinion **102** is substantially in alignment with the annular end wall **66A** of the nose housing **66.** It will be observed that in this position the contact between the bearing race **108** and the tubular wall **70** and the contact between the seal **118** and the tubular wall **70** substantially prevent the entry of foreign material into the interior of the lever housing **20.** In addition, it can be seen that the pinion **102** substantially fills the tubular bore **70** and since it is fully retracted the pinion is protected by the nose housing.

When it is desired to crank an internal combustion engine the solenoid coil **50** is energized causing the lever **42** to pivot counterclockwise to therefore move the shift collar **48** to the right in FIG. **3.** As the shift collar **48** moves to the right it moves the part **84** with it. As the part **84** is moved to the right in FIG. **3** it moves the part **96** and the pinion **102** to the right through the drive connection provided by the helical spline connection **98** and **100** between parts **84** and **96.** During this movement the part **96** and attached pinion **102** are both translated axially and rotated slightly due to the helical spline connection and the outer race **108** of the roller bearing slides axially along bore **70.** In addition, the seal **118** is translated and rotated along bore **70** to wipe it clean. The pinion **102** is eventually meshed with the ring gear (not shown) of an internal combustion engine. In the fully extended position (solenoid armature **52** pulled in) the pinion **102** is projected out of the nose housing **66** and in this fully extended position the seal **118** is located just within the end **74** of the bore **70.** In this fully extended position the right end **108A** of the bearing race is therefore not projected out of housing **66** with the result that the outer race **108** is positioned entirely within the tubular bore **70** during engine cranking. It will be appreciated that snap ring **112** and washer **114** serve to move outer race **108** axially depending upon the direction of movement of the pinion assembly comprised of parts **96** and **102.**

In the event of end tooth abutment between the teeth **105** of the pinion **102** and the ring gear, which would tend to prevent meshing of the pinion with the ring gear, the jump spring **94** will be compressed as the part **84** is moved axially. As is known to those skilled in the art the contacts (not illustrated) for energizing the cranking motor are operated by movement of the armature **52** and are closed after the armature is fully pulled in. One example of such switch contacts is the arrangement shown in the U.S. Pat. to Schneider No. 2,670,444. In the case of end tooth abutment the movement of part **84,** lever **42** and armature **52** can still take place due to the compression of the jump spring **94** and eventually the motor is energized to rotate the pinion **102** into engagement with the ring gear. The compressed spring **94** drives the pinion into mesh with the ring gear as the pinion is rotated into mesh with the ring gear.

It will of course be appreciated that whenever the solenoid is deenergized the spring **60** immediately operates to return the starter drive mechanism to its retracted position illustrated in FIG. **3.**

From an inspection of FIG. **3** it will be evident that the starter drive has no overrunning clutch and the starter drive is withdrawn from the ring gear automatically by a system to be described hereinafter. It should also be observed that the nose housing **66** is not provided with the usual bearing for supporting the armature shaft **28** since with the arrangement of this invention the end of the shaft **28** is axially spaced from the solid pinion **102.** The reason that no bearing is required for the armature shaft in the nose housing is the fact that the pinion assembly **96** and **102** is externally supported by the needle bearing **108** and **110** which is slidable in the tubular bore **70.** It should be appreciated by those skilled in the art that the support for the pinion assembly **96** and **102** is substantially entirely provided by the needle bearing rather than supporting the pinion on the motor shaft as for example in the Redick et al. U.S. Pat. No. 3,020,771. It will also be appreciated that this external support for the pinion assembly has been provided without requiring any axial movement of the armature shaft **28** as for example in starter arrangements disclosed in the U.S. Pat. to Rushmore No. 1,235,162 and Lee No. 2,425,946.

As previously mentioned the starter drive of this invention has no overrunning clutch. In order to prevent the ring gear from driving the motor armature at high speed through the pinion once the engine starts the starter arrangement of this invention automatically causes the pinion to be disengaged from the ring gear when the engine starts. This is accomplished by the system illustrated in FIG. **1** where the motor M corresponds to the cranking motor shown in FIG. **2.** As previously explained, the commutator end of the cranking motor has an AC tachometer generator **29,** the rotor **30** of which is driven at armature speed. This generator is designated by the letter G and the reference numeral **29** in FIG. **1** and is shown mechanically connected to the cranking motor M. The generator G has output lines **130** connected to a motor control **132** illustrated as a block. The motor control **132** is connected to a battery **134** by a starter switch **136** through positive power line **138.** The positive power line **138** is also connected with one fixed contact **140** of a relay or magnetic switch designated by reference numeral **142.** The other fixed contact **144** of the relay is connected to the cranking motor M through conductor **145.** The relay **142** has a relay coil **146** connected with motor control **132** which shifts a movable contact **148** into engagement with fixed contacts **140** and **144** when the relay coil **146** is energized.

The system is arranged such that when switch **136** is closed the motor control **132** energizes relay coil **146** to electrically energize the cranking motor M. The conductor **145** is actually connected with the solenoid coil **50** which in turn, in a conventional manner, causes the motor M to be energized by switch contacts closed by movement of armature **52** after the solenoid pulls in.

The motor control **132** is further arranged such that when the pinion is meshed with the ring gear of the engine and the engine starts a speed responsive voltage of a predetermined magnitude is generated in generator **29** and applied to motor control **132** to cause a deenergization of relay coil **146.** The ultimate effect of this is to deenergize the solenoid coil **50** with the result that the spring **60** immediately retracts the pinion **102** from the ring gear of the engine. Thus, no overrunning clutch is required since the system automatically disen-

gages the pinion from the ring gear when the engine starts.

Although the motor control **132** could take a wide variety of forms it preferably has the same circuit for deenergizing the cranking motor when cranking motor speed reaches a predetermined value as that disclosed in the U.S. Pat. to Cummins et al., No. 3,628,041. Thus, the generator **29** of this invention corresponds to the generator **56** disclosed in the Cummins et al. patent and as disclosed in this patent the relay **25** corresponds to relay **142** of this invention.

The electronic circuitry provided by the motor control **132** can be supported by the cranking motor and may, if desired, be built into the solenoid housing **54** or other parts of the cranking motor.

What is claimed is:

1. A starting apparatus for an internal combustion engine comprising, frame means, a nose housing supported by said frame means, said nose housing having an internal axially extending cylindrical wall defining a tubular bore extending therethrough that has an open end facing the exterior of said starting apparatus, a shaft supported for rotation by said frame means adapted to be rotatably driven by a power source, one end portion of said shaft disposed within said tubular bore and terminating in a first end face located within said tubular bore, a sleeve member disposed about said shaft having a straight splined connection with said one end portion of said shaft whereby said sleeve member can move axially of said shaft and is rotatably driven thereby, a pinion assembly comprising an annular member and a pinion member extending axially therefrom, said pinion member having a plurality of external teeth and having an imperforate end wall facing the said first end of said shaft and spaced therefrom, bearing means disposed between said annular member and said cylindrical wall in said nose housing for rotatably supporting said pinion assembly, means connecting said bearing means and said annular member such that said bearing means is shiftable axially along said cylindrical wall when said annular member is moved axially, means providing a helical splined connection between the interior of said annular member and the exterior of said sleeve member, a spring interposed between said sleeve member and said pinion assembly for axially shifting said pinion assembly relative to said shaft when said sleeve member is shifted axially, and means for shifting said sleeve member axially in opposite directions relative to said shaft, said pinion member being projected from a position within said tubular bore to a position at least partially outside of said tubular bore for engagement with an engine ring gear.

2. An engine starter for an internal combustion engine comprising, an electric cranking motor having a frame means, an armature including an armature shaft rotatably supported by said frame means, a nose housing supported by one end of said frame means, said nose housing having an axially extending internal cylindrical wall defining a tubular bore extending through said nose housing, one end of said tubular bore defining a cylindrical end opening facing the exterior of said nose housing, one end portion of said armature shaft located at least partially within said tubular bore with the end face of said one end portion of said shaft spaced inwardly from said cylindrical end opening, a sleeve member supported by said one end of said shaft having internal straight splines mating with external straight splines formed on the exterior of said one end of said armature shaft, whereby said sleeve member can move axially relative to said armature shaft and is rotatably driven thereby, a pinion assembly having an annular portion and an imperforate pinion portion extending axially therefrom, said pinion portion having outer circumferentially spaced teeth and having an inner end face spaced from said end face of said armature shaft, a bearing having an outer annular part engaging said cylindrical wall formed in said nose housing and having means engaging said annular portion of said pinion assembly to rotatably support said pinion assembly, said bearing being axially movable with said annular part by sliding movement of said outer part of said bearing along said cylindrical wall, means providing a helical splined connection between the interior of said annular member and the exterior of said sleeve member, a compression spring interposed between said sleeve member and said pinion assembly, and means for shifting said sleeve member axially of said shaft for meshing said pinion portion with the ring gear of an engine.

3. A starter drive for cranking an internal combustion engine adapted to be driven by a shaft and adapted to be supported at its exterior by a tubular wall of a housing comprising, an annular axially extending sleeve member having internal splines adapted to mate with external splines of a shaft, a shift collar secured to one end of said sleeve member and disposed about the outer periphery thereof, the opposite end of said sleeve member having external helical splines, a pinion assembly having a tubular portion and an imperforate pinion portion extending axially therefrom, said pinion portion having external teeth adapted to mesh with the teeth of an engine ring gear, said tubular portion of said pinion assembly disposed about a portion of said sleeve member and having internal helical splines mating with said external helical splines on said sleeve member, a compression spring interposed between said sleeve member and said pinion portion of said pinion assembly urging said sleeve member and pinion assembly away from each other, abutment means operative to limit relative axial movement between said sleeve member and pinion assembly by the force of said spring, a bearing having a plurality of rollers engaging the outer periphery of said tubular portion of pinion assembly and an outer cylindrical race, said outer race adapted to engage the tubular bore of a housing, and abutment means carried by said pinion assembly located adjacent opposite ends of said outer race.

4. An engine starter comprising, a power source having a frame means, a shaft rotatably driven by said power source, a nose housing supported by one end of said frame means, said nose housing having an axially extending internal cylindrical wall defining a tubular bore extending through said nose housing, one end of said tubular bore defining a cylindrical end opening facing the exterior of said nose housing, one end of said shaft disposed within said tubular bore, an imperforate pinion member having a plurality of outer circumferentially spaced teeth, a bearing including an outer race and rollers disposed between said outer race and said pinion member, said outer race engaging said cylindrical wall in said nose housing whereby said pinion member is supported for rotation at its exterior by said bearing, means connecting said pinion member and bearing such that said bearing moves axially when said pinion

member is shifted axially, said outer race sliding along said cylindrical wall in said nose housing during said axial movement of said pinion, means providing a straight splined connection between said shaft and said pinion member whereby said pinion member can be shifted axially with respect to said shaft and is rotatably driven thereby, means for shifting said pinion axially from a position disposed within said tubular bore to a projected position at least partially outside of said bore for engagement with the ring gear of an engine, and an annular seal carried by said pinion member engaging said cylindrical wall in said nose housing located between one end of said outer race and said cylindrical end opening of said tubular bore, said seal operative to wipe said cylindrical wall during axial movement of said pinion member.

* * * * *