

April 9, 1963

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3,084,561

COAXIAL SOLENOID FOR STARTER MOTORS

Filed May 19, 1960

4 Sheets-Sheet 1

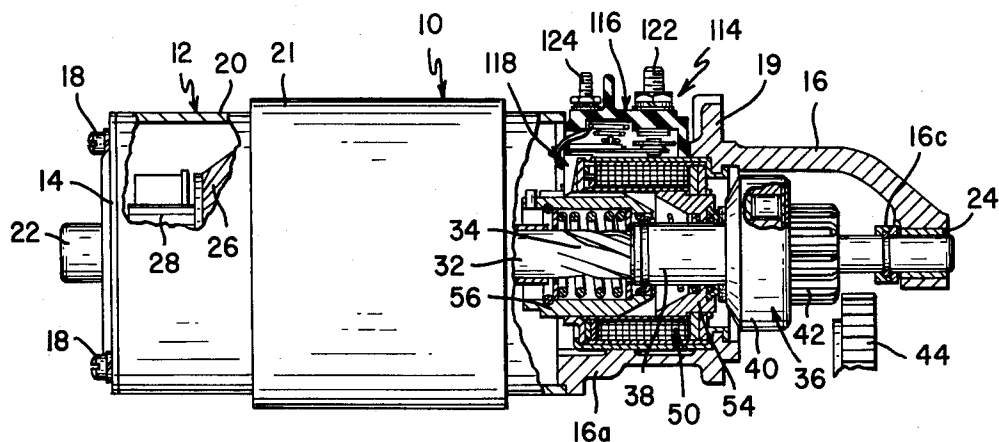


Fig. 1

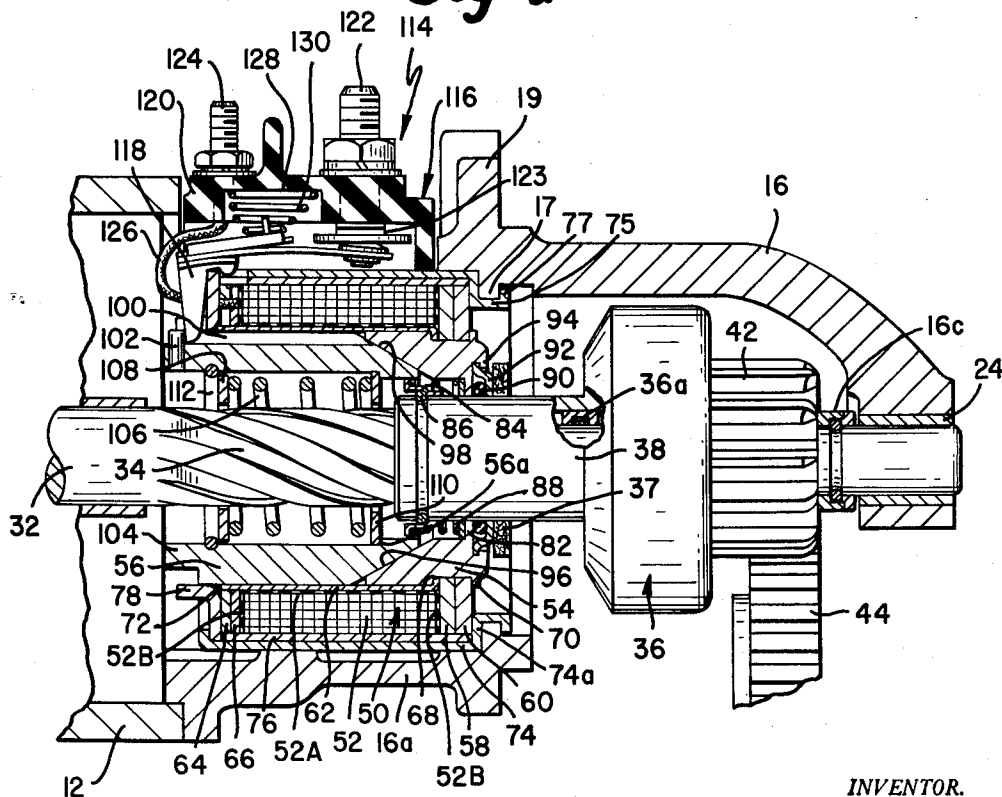


Fig. 2

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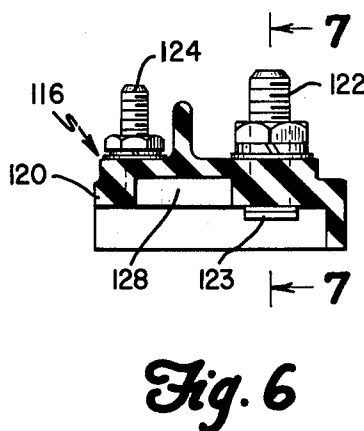
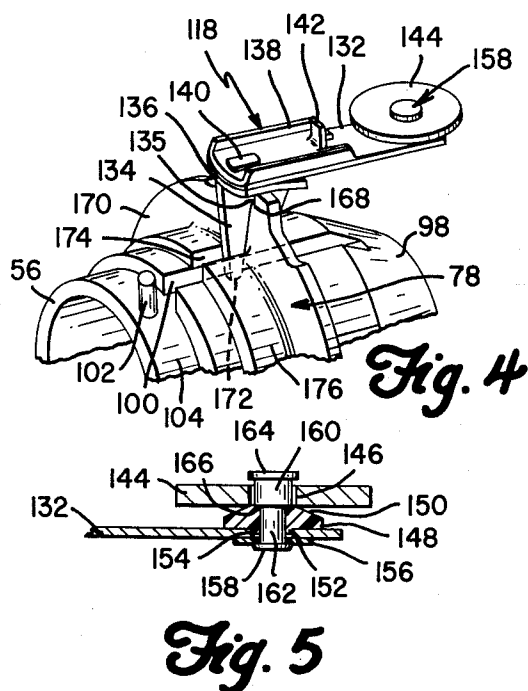
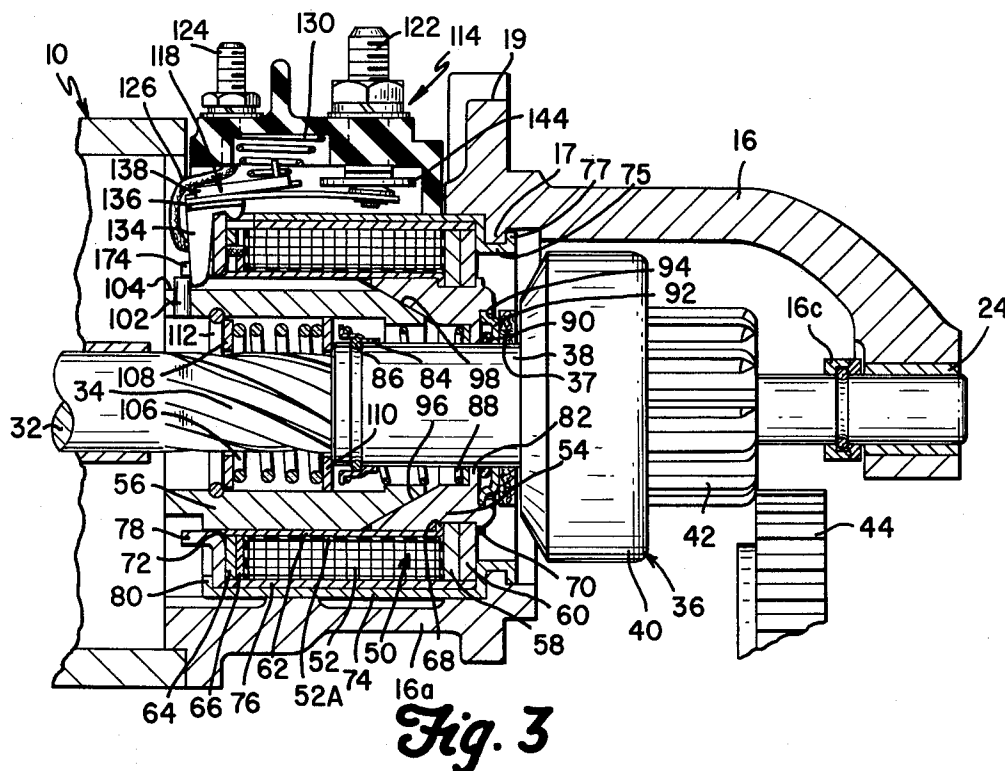
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COAXIAL SOLENOID FOR STARTER MOTORS

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4 Sheets-Sheet 4

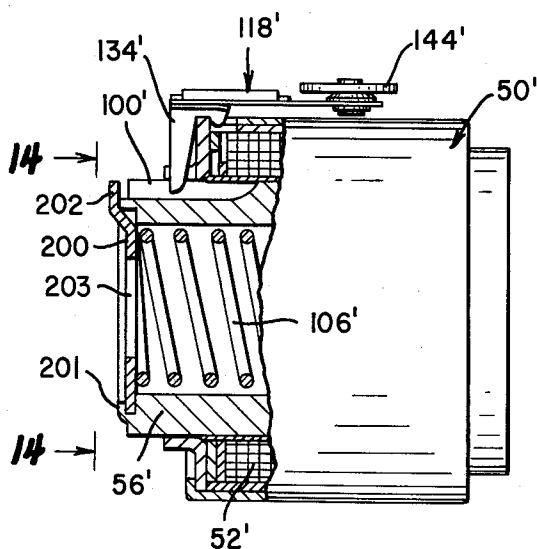


Fig. 13

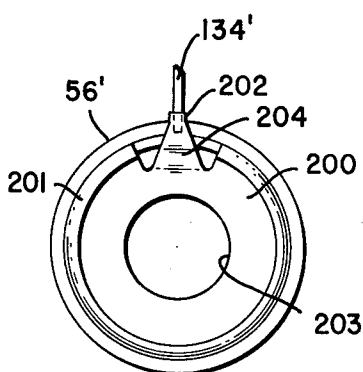


Fig. 14

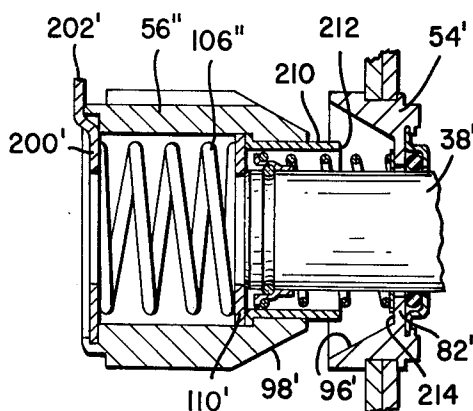


Fig. 15

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COAXIAL SOLENOID FOR STARTER MOTORS

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6 Claims. (Cl. 74-6)

This invention relates to a dynamo-electric starter mechanism and more particularly to starter motors for internal-combustion engines wherein engagement between the starter motor pinion and the flywheel ring gear of the engine to be started is accomplished with a co-axial solenoid type shift mechanism.

Heretofore starting motors of the so-called piggy-back type (i.e. a shifting solenoid mounted on the outside of the motor housing) have been used extensively in the automotive and allied industries for starting internal combustion engines. Due to space limitations on the present day equipment, this type of engine starter is not entirely satisfactory because of the space the piggy-back solenoid occupies. Also, in the manufacturing of engine starters it is desirable, from a mass production standpoint, to produce a starter housing that is easily adaptable to the mounting positions required to satisfy a number of engine types. By eliminating the solenoid from the outside of the motor housing, not only is a saving of space accomplished, but, more important, a given motor housing may be mounted in any desirable position without special consideration being given to the shifting solenoid or related parts, so that the advantages of the positively shifting solenoid for starting motor engagement can be retained without special consideration being given to mounting restrictions. This ultimately means that a given starter motor can be manufactured to satisfy the various mounting requirements for the various types of internal combustion engines, thereby eliminating the need of manufacturing several types of motor housings.

Co-axial shift solenoid type starters, as such, are not new in the art but starters of this type suggested in the past have not proven entirely satisfactory for present day use for various reasons. They either were unreliable in service over an extended period of time or were too expensive to manufacture. Many problems are presented in the production of this type of starter such as the provision of suitable electrical characteristics of the solenoid and accompanying parts, the provision of suitable on-and-off switching for the dynamo-electric starting motor, the provision of a demeshing mechanism for the starter pinion and the reduction of overall manufacturing costs, all of which heretofore have not been completely or satisfactorily solved.

The invention contemplates the provision of a starter motor mechanism for internal combustion engines wherein an overrunning roller-type clutch with its pinion is moved in one direction by the combination of a co-axial solenoid and a helically-splined motor armature shaft to engage the starter pinion with the internal combustion engine ring gear, and then traversed in the opposite direction after the engine starts, when the speed of rotation of the ring gear overruns the speed of rotation of the starting motor causing the roller clutch to overrun which reacts with the helical splines to cause a retraction of the assembly to a position in which the pinion is disengaged. The pinion is capable of being held in engagement by the energization of the solenoid, thereby preventing false starts from causing disengagement of the pinion.

The invention further contemplates the provision of a shifting and switching mechanism for a starting motor comprising a simplified arrangement of a co-axial solenoid and an externally-mounted starting motor control switch, the individual components of which can be adapted

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for a plurality of sizes of starting motors that are manufactured for use with the various types of internal combustion engines.

The invention contemplates the provision of a starting motor assembly having a pinion housing suitable for mounting in several positions, including a co-axial shift mechanism and related parts, all suitable for use on various types of internal combustion engines, which is reliable in service and economical to produce in mass production manufacturing and readily serviceable in the field.

It is, therefore, a principal object of this invention to provide a co-axial type solenoid for starter motors for automobiles which is reliable in operation, economical to manufacture on a mass production basis, and easily adapted to various engines and their mounting requirements.

It is another object to provide a starting motor including a co-axial shifting mechanism wherein the pinion and overrunning clutch assembly is moved into operative position by a co-axially-mounted solenoid prior to closing the motor power switch, the pinion being driven into full driving relationship by the combined action of a meshing spring and the thrust developed by a helically-splined shaft due to motor torque.

It is another object to provide a simplified switch mechanism for a starting motor having a rapid make and break action when actuated by the movable armature of a co-axial solenoid to energize the dynamo-electric starting motor, which is also constructed in such a way as to be easily accessible for servicing or replacement.

Another object is to provide a starting motor having a co-axial solenoid shift mechanism wherein the number of parts is reduced to a minimum and all of the parts are designed so as to be readily produced on a mass production basis.

A further object is to provide an electro-magnetic coil for a co-axial solenoid to be used in a starter motor shift mechanism which has a single actuating coil.

It is another object to provide a co-axial type starting motor having engine mounting means that is readily adaptable for various types of internal combustion engines, and which may be readily sealed from atmospheric conditions.

It is a further object to provide a starting motor having a simplified electrical circuit wherein the connections are reduced to a minimum to minimize the possibility of faulty construction during manufacture.

Other objects and advantages of this invention relating to the arrangement, operation and function of the related elements of the structure, to various details of construction, to combinations of parts and to economies of manufacture will be apparent to those skilled in the art upon consideration of the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

Referring to the drawings:

FIG. 1 is an elevational view with sections broken away showing in a non-operative position a starting motor embodying the invention;

FIG. 2 is an enlarged sectional elevation of one end of the starting motor showing the movable parts in their operative positions;

FIG. 3 is a view similar to FIG. 2 showing the movable parts in their respective positions when tooth abutment occurs;

FIG. 4 is an isometric view showing, in part, the parts of a switch-actuating system;

FIG. 5 is a sectional elevation through the center of the conducting contact disc assembly shown in FIG. 4;

FIG. 6 is a sectional elevation of an insulating cover for the switch assembly;

FIG. 7 is a view taken on line 7—7 of FIG. 6;

FIG. 8 is an isometric view showing in part a conducting element shown in FIG. 7 and its related parts;

FIG. 9 is a view similar to FIG. 7 showing an alternate contact arrangement of the switch;

FIG. 10 is a view similar to FIG. 8 showing a part of the contact arrangement of FIG. 9;

FIG. 11 is a bottom view taken on line 11—11 of FIG. 7;

FIG. 12 is a schematic diagram of connections of a typical starting motor;

FIG. 13 is an elevational view, partly in section, of a modification of the invention;

FIG. 14 is a view taken along the line 14—14 of FIG. 13; and

FIG. 15 is a sectional elevation of a portion of the mechanism showing another modification.

Referring to the drawings, and particularly to FIGS. 1, 2, and 3, a dynamoelectric starting motor unit 10 is shown comprising a two-piece frame member 12, end heads 14 and 16, and through bolts 18 to hold the housing in assembled relation. The two-piece frame member 12 consists of a thin inner tubular member 20 and a relatively thicker outer member 21 providing the magnetic path for the flux-traversing pole pieces of the dynamo-electric motor. The invention is not to be limited to the use of a two-piece motor frame member as any conventional frame member could be used without departing from the invention.

End head members 14 and 16 are provided with bearing assemblies 22 and 24 for rotatably mounting a conventional armature 26 having a commutator 28 at one end in electrical contact with current-conducting brushes 30 which are also conventional. The armature 26 has a shaft 32 provided with helical splines 34 which transmit rotational and longitudinal motion to a conventional roller type overrunning clutch assembly 36 mounted thereon.

The clutch assembly 36 consists of a tubular body member 38 integrally connected to an enlarged clutch housing 40 in which is mounted a driving pinion 42 for rotation in one direction in a driving relation with the clutch mounted in the housing 40. Pinion 42 provides a driving connection between the dynamo-electric starting motor and the flywheel ring gear 44 of an engine to be started. The tubular body member 38 of clutch 36 is provided with internal helical splines (not shown) which mesh with the helical splines 34 on the shaft 32 providing a portion of the thrust for longitudinal movement of the clutch assembly when moving the pinion 42 to engaged position with the ring gear. The initial activating thrust to engage is provided by a novel solenoid assembly which will now be described. Concentrically mounted in the end head member 16 is a solenoid assembly 50 comprising three main components, a single electro-magnetic actuating coil 52, a stationary magnetic core member 54, and a movable magnetic core member or armature 56. The solenoid assembly includes a pair of magnetic metal end rings 58 and 60, an inner tubular coil-retaining member of brass 62, magnetic metal end retaining members or rings 64 and 66, coil 52, and the stationary magnetic core member 54.

The inner tubular member 62 is provided with an outwardly-rolled lip 72 to locate the end rings 64 and 66. The opposite end of tube member 62 is provided with an inwardly-rolled lip 68 which is clamped between the shoulder on the stationary core member 54 and the end rings 58 and 60 when the parts are fastened in permanent assembly by stakes 70. The solenoid coil 52 is wound on this assembly with an insulation sleeve 52A and end washers 52B separating the windings from the mechanical parts of the assembly.

Before the sub-assembly is placed in the pinion housing 16, a tubular magnetic member 74 is inserted in the housing, so that an integral shoulder 74A of the tubular member is in contact with the internal flange 17 of the pinion housing 16. A reduced end section 75 of the tubular member 74 is rolled over to form a lip 77 embracing the flange 17 to thereby maintain the tubular member 74 in a permanent position. A second tubular spacer member 76, also of magnetic material, and the solenoid sub-assembly are placed in tubular member 74 positioning the end rings 58 and 60 and the spacer 76 against the internal shoulder 74A of member 74. A flanged member 78 is then placed in position against the end ring 64, after which an end portion of member 74 is turned inwardly to provide a lip portion 80 locking the complete stationary solenoid assembly 50 in the pinion housing 16. A combination of slots and projections (not shown), commonly used in assemblies of this kind, prevent the individual parts from relative rotation as a result of vibration.

Stationary core member 54 is provided with an inwardly-projecting annular flange 82 which forms a base for a return spring 88 acting against a collar 84 positioned on the tubular portion 38 of the overrunning clutch being held in position thereon by a snap ring 86 positioned in an annular slot in the end of the tubular portion 38. The opposite side of the annular flange 82 forms a seat for an O ring 90 which is held in position thereagainst by a retainer ring 92 which is mounted on the stationary core member 54 by cooperating with an inturned lip 94 formed as an outer extremity for a recess in the member 54. The O ring 90 seals with the tubular portion 38. An additional seal with the shaft 32 is provided internally of the tubular portion 38 by a retainer ring including a second O ring 36A as shown in FIG. 2. These O ring sealing assemblies 90 and 36A are provided to prevent oil in the casing of so-called "wet-clutch" transmissions in which the ring gear 44 is mounted, from entering into the housing of the starter motor or the solenoid assembly. In all engine installations, the use of these seals is not necessary and in the most common engines, the use of a fiber washer 37 cooperating with the exterior surface of the tubular portion 38 of the overrunning clutch 36 is sufficient to protect the actuating elements of the solenoid as well as the rotating parts of the starter motor. The fiber washer also acts as a brake to decrease the time of coasting of the motor armature.

The movable magnetic core member or armature 56 of the solenoid, which slides inside of the brass tube 62, is provided with an outer conical surface 98 at its forward end to cooperate with an inner mating conical surface 96 of the stationary core member 54. The outer surface of armature 56 is also provided with a longitudinal slot 100 which is blocked at its rear end by a pin 102 press-fitted into an aperture in an annular recessed section 104 at the rear of the armature 56 (FIGS. 3 and 5). Slot 100 and pin 102 cooperate with a switch actuator to be described further hereinafter. In the bore of armature 56, a compression spring 106 is provided, acting between retaining washers 108 and 110, the former being held in position by a snap ring 112 to maintain the parts in assembled relation in the bore. Washer 110 seats against the end of the tube 38 of the overrunning clutch 36, so that the bias of the spring 106 may act against it. This cooperation, however, is limited by the washer 110 contacting a stop 56a in the bore of the armature as is best seen in FIG. 2. This action will be described in further detail hereinafter.

A switch unit 114 is provided on the starting motor comprising a pair of sub-assemblies, an insulating cover assembly 116 including contacts and a movable switch actuating unit 118. The cover assembly 116 (FIGS. 6 and 7) consists of a molded insulating base member 120 having mounted therein a terminal post 122 for a battery cable (not shown), which, through contacts, to be described

further hereinafter, conducts the electrical power to the starting motor. A second terminal post 124, also mounted in the insulating cover 120, provides the connection for a control circuit including a manually operable switch (not shown) for actuating the solenoid 50. The insulating cover is also provided with an annular recess 128 on its lower side to retain in position and anchor the larger end of a conically-shaped coil spring 130 cooperating with the switch assembly 118.

The switch actuating unit 118, best seen in FIG. 4, comprises a flat steel spring member 132, a pivoting trigger member 134, a lower spring-retainer plate 136, and a channel-shaped spring anchor plate 138, all permanently held together by riveting a projecting transverse portion 140 of the trigger member 134. Spring-anchor plate 138 is provided with an upturned lug 142 cooperating with the lower end of the conically-shaped spring 130 which is anchored in the recessed area 128 on the lower side of the molded cover 120 to thereby retain the spring in operating relation between the cover assembly 116 and the switch actuator 118 to bias the actuator to open position.

The leaf spring 132 is provided at its free end with a disc-shaped contact member 144 (FIG. 5) having a central aperture 146 loosely fitting a headed stud 160 which is insulated from and mounted on the spring 132 by an insulating member 148 having an upper conical surface 150 contacting the lower side of the contact member 144 and a downwardly extending tubular section 152, which projects into an aperture 154 in spring 132, and cooperates with an insulating washer 156 on the lower side of the spring to insulate therefrom the stud 160 and the contact member 144. The stud is riveted in position on the spring with the insulating members as shown in FIG. 5. This method of mounting allows the contact member 144 to move freely to adjust itself to the fixed contacts and to revolve between actuations so as to change the contact surface on successive closures.

Another important feature of the switch actuating unit 118 is its ability to provide a quick make and break of the conducting contacts which also tends to increase the life of contacting surfaces for reasons obvious to those experienced in the art. In the operation of the actuating unit 118, trigger member 134 is provided with a forward extension having a notch 135 which engages with a notch 168 in the upper peripheral edge of annular flange 170 on member 78 above the slot 100 providing a pivot point for the switch unit 118. When armature 56 is drawn toward pinion-engaging position, pin 102 closing the slot 100 will contact the edge of the lower end 172 of trigger member 134, pushing it forward to move the unit 118 in substantially a counter-clockwise direction about its pivot point. To prevent the unit 118 from tipping out of its pivoted position, the lower end of trigger member 134 is guided in slot 100 and aligning slot 174 provided in a tubular projection 176 of member 78.

The quick make and break of the contact surfaces of the switch assembly is accomplished through a favorable combination of lever ratios of the actuating parts resulting in an amplified action of both the scope of movement and the speed of movement of the contact disc 144 in both the closing and opening of the switch. The length of the trigger member 134 in contact with the armature of the solenoid is approximately half the length of the spring member 132 on whose distal end the contact disc 144 is mounted. The contact disc 144 in the closing phase, therefore, moves at least twice as fast as the moving core element of the solenoid. On opening, the spring plate 138, being shorter than the main spring member 132, and also the fact that the switch-actuating elements including the trigger member 134 are free from the armature of the solenoid when the circuit is to be broken, tends to develop a reverse movement in the already-flexed main spring member 132, so that when the contact disc 144 begins to move to open position, an acceleration of its movement is rapid resulting in a quick break of the contact surfaces.

As is well known, a quick break of the contacts at the time a circuit is to be opened reduces the erosion of the contact surfaces due to the sparking occurring at that time.

Returning to the fixed contact elements of the switch, cooperating with the moving switch element or disc 144 (FIGS. 7, 8, and 11), a conducting block 180, preferably of copper, is provided having a projecting contact surface 182 integral therewith, which is positioned in the insulating base 12 to cooperate with the contact disc 144. A slot 184 is also provided in block 180 for connecting to the bared end of a lead 186 projecting from a field coil 187 either by soldering or wedging. On the upper surface of block 180 (FIG. 7) an elongated projection 188 is provided which fits into a cavity 190 molded in the cover member 120 to hold the block in position. This arrangement is desirable from an economic point of view since a minimum number of parts are used and the parts can easily be assembled in a mass production operation.

An alternate method of forming one of the fixed contacts is shown in FIGS. 9 and 10, wherein the flat copper strip 192 used to wind a field coil terminates in an end portion 194 which is formed so as to project into the insulating switch housing 120 through a suitable aperture. The rigidity of the strip material 192 is sufficient to maintain end 194 of the strip in the desired position to provide a fixed contact cooperating with the disc 144, shown in phantom in FIG. 9.

All of the individual parts and the sub-assemblies described hereinbefore are designed to be of universal use insofar as they may be assembled, in operative relation in various selected radial positions in the end head member 16. The end head member 16 is also designed to be adaptable to various engine mounting pads and with relation to the co-axial shifting mechanism and its related switch unit, in that a planar surface may be milled off of the circumference of the tubular housing portion 16a of the end head in the area between an engine mounting flange 19 and the end of the motor frame at any desired radial location, providing the mounting for the switch assembly 114. It being possible to locate the switch assembly at any radial position on the starting motor, a plurality of motor-mounting positions are possible for any given internal combustion engine or for the mounting requirements of various types of engines, without it being necessary to provide several different castings for the different engines. The advantages of this type of construction are obvious to those skilled in the art in view of the present day economic factors and the limitations of mass production facilities.

In the operation of the starting motor (FIGS. 2, 3 and 12), when manual switch 196 is actuated, the solenoid winding 52 is energized from a source of power such as battery B which draws armature 56 to the right, as viewed in the drawings. When the solenoid armature assembly 55 moves washer 110, through the action of the compression spring 106 anchored to the armature by washer 108, it contacts the end surface of the tubular member 38 of the clutch assembly 36, forcing the clutch assembly and pinion 42 in the same direction, causing the pinion 42 to mesh with flywheel ring gear 44 (FIG. 2). When pinion 42 is fully meshed with the engine ring gear 44, the conical surfaces 96 and 98 of the armature and the stationary core 54 are in contact with each other, with the return spring 88 maximumly compressed. The pinion is arrested by a stop 16c mounted on the shaft 32.

Coincident with the meshing of the pinion and ring gear, the pin 102 on armature 56 moves the trigger 34 inwardly to move the switch-actuating unit 118 in a counterclockwise direction about its pivot causing the contact disc 144 to bridge the contact surface 123 of terminal 122 and the contact surface 182 of conducting block 180 (FIG. 7). This energizes the starting motor, causing rotation (FIG. 2) of shaft 32, thereby imparting rotative effort and thrust to the pinion 42 through the mechanical drive connection between the helical splines

34 of the shaft 32 and the internal splines in the tube 33 of the clutch assembly 36. This rotative effort also urges the pinion 42 into complete engagement with the ring gear until the thrust is taken by the stop 16c on the shaft as shown in FIG. 2.

When the engine starts, the operator will release the manual switch 196, breaking the power circuit from the battery to the solenoid coil 52 which will terminate the magnetic attraction of the coil for the armature 56. The switch element 118 then opens immediately under the combined action of spring member 132 and the coil spring 130. As soon as the contact disc 144 is moved a sufficient distance to break its bridging relation with reference to the fixed contact surfaces 123 and 182, the power circuit to the starting motor is broken, which will immediately cease to apply rotative effort to the driving shaft 32. As the engine begins to rotate, the ring gear 44 will tend to rotate the pinion 42 of the overrunning clutch at a speed which causes the clutch 36 to overrun, which, combined with the decreasing speed of rotation of the motor shaft 32, causes the helical splines 34 to create a retractive thrust which tends to move the clutch assembly including the pinion to the left (FIG. 2) to disengage the pinion from the ring gear 44. This action is assisted by the spring 88 which also tends to move the overrunning clutch in the same direction, having been compressed when the pinion 42 is in engagement with the ring gear. When the pinion 42 is completely disengaged, with the power circuit to the starting motor having been opened, the parts will return to their original positions as shown in FIG. 1. The parts will remain in this position until a new starting cycle is initiated by the manual operator by the operator of the switch 196.

Fiber washer 37, described hereinbefore as a dust seal, also serves as a braking element for the overrunning clutch, thereby retarding the rotation of the motor armature and the clutch after disengagement of the pinion from the ring gear.

In the event tooth abutment occurs (FIG. 3) between the pinion and the ring gear, the armature 56 of the solenoid will continue to move into the coil 52, compressing the spring 106 until the conical surfaces 96 and 98 are in engagement. This allows the switch actuator 116 to move its full distance to close the power circuit to the motor causing rotation of shaft 32. As shaft 32 starts to rotate to abate the abutment relation of the teeth, the force developed by the compression spring 106 will assist the thrust created by the helical splines to force the pinion 42 into mesh with ring gear 44.

If, for some reason, the engine will not start immediately and the operator releases the manual switch 196, the magnetic force of the coil 52 ceases and the solenoid armature 56 retracts, so that the holding pin 102 acting against the trigger member 134 will also be retracted, allowing spring 130 to break the circuit to the starting motor. When the engine finally starts, the pinion will be disengaged from the ring gear in the normal manner described. In the event of a false start, the clutch and pinion assembly and the shifting mechanism will remain in their normal operative position as long as the operator keeps the solenoid switch closed.

In FIG. 13, a solenoid assembly 50' is shown incorporating an alternate method of triggering the switch actuating unit 118'. The solenoid assembly 50' is similar to the assembly 50 described hereinbefore except for the armature member 56'. The mounting member 74', coil 52', spring 106', and other related parts are the same. The switch actuating unit 118' with its trigger member 134' and contact disc 144 is also the same. The difference in the armature is an end member 200 having an integral projecting tab 202, which actuates the trigger 134', in place of the pin 102 shown in FIG. 4. Member 200 (FIGS. 13 and 14) is a stamped metal member permanently mounted in one end of armature 56' by rolling over an integral annular projection on said armature as

shown at 201. An aperture 203 is provided in member 200 through which the starting motor shaft (not shown) projects. The rolled portion 201 does not completely encircle member 200, as shown in FIG. 14, allowing an integral tongue portion 204 of member 200 to extend out and above the end of the armature. The portion 204 terminates in the tab 202 which contacts the trigger 134'. The operation of the arrangement just described is the same as the arrangements using the pin 102 and, therefore, will not be described further.

FIG. 15 shows an alternate arrangement of parts whereby a more rapid break is provided between the switch contact members. It has been found that a quicker circuit breaking action is desirable in heavy equipment such as trucks, tractors, etc. This is accomplished by providing additional longitudinal movement of armature 56', which, through the action of a movable sleeve 210 provides additional compression in spring 106'. The increase in over-all travel distance of the armature is provided by decreasing the thickness of the magnetic core member 54', as can be seen by comparing with member 54 described hereinbefore. Member 54' is the same in all other respects including the integral flange portion 82'. When the armature 56' is moved toward the magnetic core member 54', the end surface 212 of sleeve 210 will abut surface 214 of flange 82'. After this abutment occurs, the armature will continue to travel until conical surfaces 96' and 98' are in contact. This additional travel of the armature will provide increased compression in spring 106' through the action of sleeve 210, member 110', and member 200'. When the magnetic action of the solenoid is discontinued, the spring 106', having increased compression, will cause the armature to rapidly accelerate toward its inactive position. It is easy to see that the quicker the armature returns, the quicker the switch actuating mechanism is freed, breaking the power circuit to the starting motor.

It is to be understood that the above detailed description of the present invention is intended to disclose an embodiment thereof to those skilled in the art, but that the invention is not to be construed as limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings since the invention is capable of being practiced and carried out in various ways without departing from the spirit of the invention. The language used in the specification relating to the operation and function of the elements of the invention is employed for purposes of description and not of limitation, and it is not intended to limit the scope of the following claims beyond the requirements of the prior art.

What is claimed:

1. In a starter drive, a starter motor including a rotatable armature having a shaft provided with driving splines, an overrunning clutch assembly including a driving pinion engaging said splines in a driving relation movable along said shaft to mesh the pinion with a ring gear of an engine to be started by transferring driving torque from said motor to the engine ring gear, a solenoid assembly including a magnetic circuit positioned in coaxial relation with reference to the armature shaft having an armature resiliently engaging the clutch assembly to move the clutch assembly toward the ring gear to mesh the pinion with the ring gear, a manual switch to control the energization of the solenoid, a normally-open second switch capable of being actuated by the solenoid armature to control the energization of the starter motor, and pivoted means movable by the solenoid armature in a direction to close the second switch.

2. In a starter drive, a starter motor including a rotatable armature having a shaft provided with helical driving splines, an overrunning clutch assembly including a driving pinion engaging said splines in a driving relation movable along said shaft to mesh the pinion with a ring gear of an engine to be started by transferring rotatable torque

from said motor to the engine ring gear, a solenoid sub-assembly including a magnetic circuit positioned in coaxial relation with reference to the armature shaft having an armature resiliently engaging the clutch assembly to move the clutch assembly toward the ring gear to mesh the pinion with the ring gear, deformable flange means on the solenoid sub-assembly to hold it in fixed coaxial relation on a portion of the motor, a manually operable switch to control the energization of the solenoid, a normally-open switch cooperating with the solenoid armature adapted to be moved thereby to closed position only to control the energization of the starter motor and a pivoted member having arms of unequal length to actuate the normally-open switch to closed position.

3. In a starter drive, a starter motor including a rotatable armature having a shaft provided with helical driving splines, an overrunning clutch assembly including a driving pinion engaging said splines in a driving relation movable along said shaft to mesh the pinion with a ring gear of an engine to be started by transferring rotatable torque from said motor to the engine ring gear, a solenoid sub-assembly including a magnetic circuit positioned in coaxial relation with reference to the armature shaft having an armature resiliently engaging the clutch assembly to move the clutch assembly toward the ring gear to mesh the pinion with the ring gear, deformable flange means on the solenoid sub-assembly to hold it in fixed coaxial relation on a portion of the motor, a manually operable switch to control the energization of the solenoid, a normally-open switch cooperating with the solenoid armature to be moved thereby to closed position only to control the energization of the starter motor, and a pivoted member for actuating the normally-open switch to closed position pivoted on a portion of the solenoid sub-assembly, having a short arm contacting the armature of the solenoid when the armature moves to cause the pinion to mesh with the ring gear and a long arm to actuate the switch closing element.

4. In a starter drive, a starter motor including a rotatable armature having a shaft provided with driving splines, an overrunning clutch assembly including a driving pinion engaging said splines in a driving relation movable along said shaft to mesh the pinion with a ring gear of an engine to be started by transferring rotatable torque from said motor to the engine ring gear, a solenoid assembly including a magnetic circuit positioned in coaxial relation with reference to the armature shaft having an armature assembly resiliently engaging the clutch assembly including a concentric slidable sleeve projecting forwardly of the armature, said armature assembly being adapted to move the clutch assembly toward the ring gear to mesh the pinion with the ring gear, said concentric slidable sleeve being engageable with a fixed portion of the solenoid assembly to increase the resilient bias between the armature and the overrunning clutch assembly when the pinion is engaged with the ring gear, means to mount the solenoid assembly in its fixed coaxial relation on a portion of the motor, a manually operable switch to control the energization of the solenoid, a normally open switch cooperating with the solenoid armature to be moved thereby to closed position only to control the energization of the starter motor, said normally open switch being capable of being mounted in the motor housing from the exterior thereof, and a pivoted member movable on a portion of the solenoid assembly for actuating the normally open switch to closed position when the armature moves the pinion into meshed relation with the ring gear.

5. In a starter drive, a starter motor including a rotatable armature having a shaft provided with driving splines, an overrunning clutch assembly including a driving pinion engaging said splines in a driving relation

movable along said shaft to mesh the pinion with a ring gear of an engine to be started by transferring rotatable torque from said motor to the engine ring gear, a solenoid assembly including a magnetic circuit positioned in coaxial relation with reference to the armature shaft having an armature assembly resiliently engaging the clutch assembly including a concentric sleeve slidable in one direction projecting forwardly of the armature, said armature assembly being adapted to move the clutch assembly toward the ring gear to mesh the pinion with the ring gear, said sleeve being engageable with a fixed portion of the solenoid assembly to slide in a direction to increase the resilient bias between the armature and the overrunning clutch assembly when the armature is home, means to mount the solenoid assembly in its fixed coaxial relation on a portion of the motor, a manually operable switch to control the energization of the solenoid, a normally open switch cooperating with the solenoid armature to be moved thereby to closed position only to control the energization of the starter motor, said normally open switch being capable of being serviced in the motor housing from the exterior thereof, and a pivoted member having unequal arms movable on a portion of the solenoid assembly for actuating the normally open switch to closed position when the armature moves the pinion into meshed relation with the ring gear.

6. In a starter drive, a starter motor including a rotatable armature having a shaft provided with driving splines, an overrunning clutch assembly including a driving pinion engaging said splines in a driving relation movable along said shaft to mesh the pinion with a ring gear of an engine to be started by transferring rotatable torque from said motor to the engine ring gear, a solenoid sub-assembly including a magnetic circuit positioned in coaxial relation with reference to the armature shaft having an armature resiliently engaging the clutch assembly including a concentric slidable sleeve projecting forwardly of the armature, said armature being adapted to move the clutch assembly toward the ring gear to mesh the pinion with the ring gear, said slidable sleeve being engageable with a fixed portion of the solenoid assembly to increase in one extreme position the resilient bias between the armature and the overrunning clutch assembly, deformable flange means to mount the solenoid assembly in fixed coaxial relation on a portion of the motor, a manually operable switch to control the energization of the solenoid, a normally open switch cooperating with the solenoid armature to be moved thereby to closed position only to control the energization of the starter motor, said normally open switch being capable of being mounted in the motor housing from the exterior thereof outside of the solenoid assembly adjacent the deformable flange means, and a pivoted member movable on a portion of the solenoid assembly for actuating the normally open switch to closed position when the armature moves the pinion into meshed relation with the ring gear.

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