

April 13, 1965

G. S. FARISON

3,177,228

GEARED STARTER

Filed July 1, 1960

5 Sheets-Sheet 1

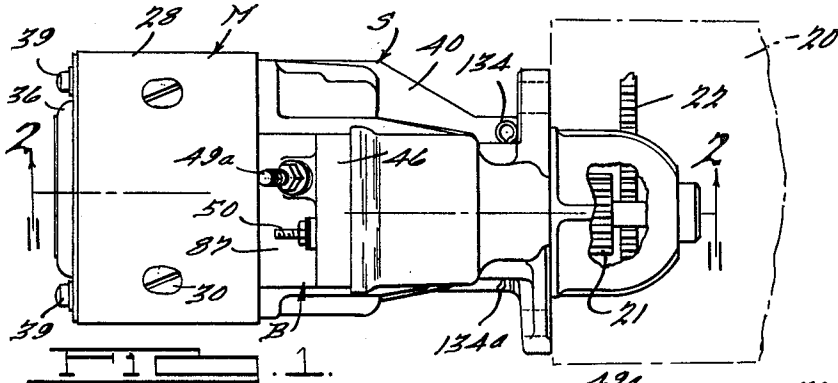


FIG. 1.

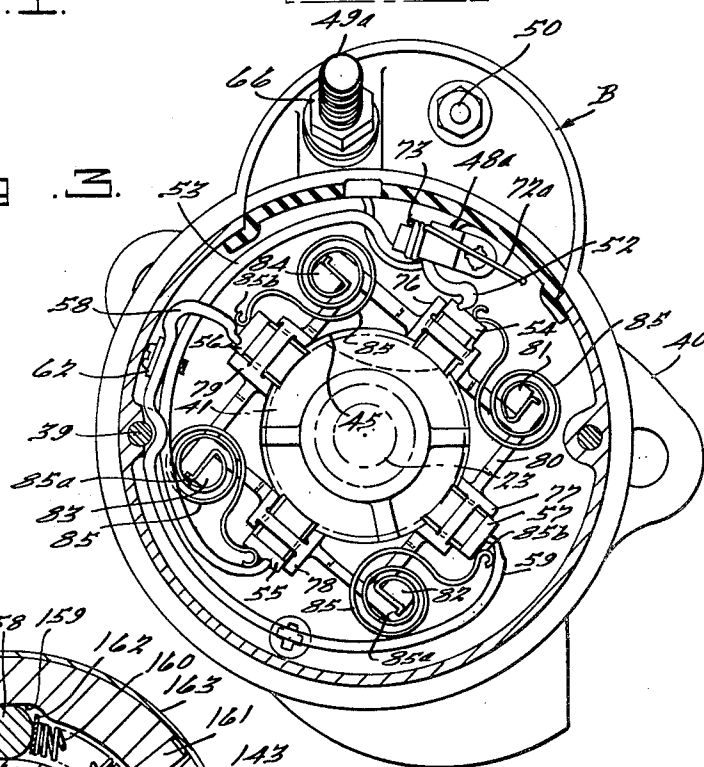
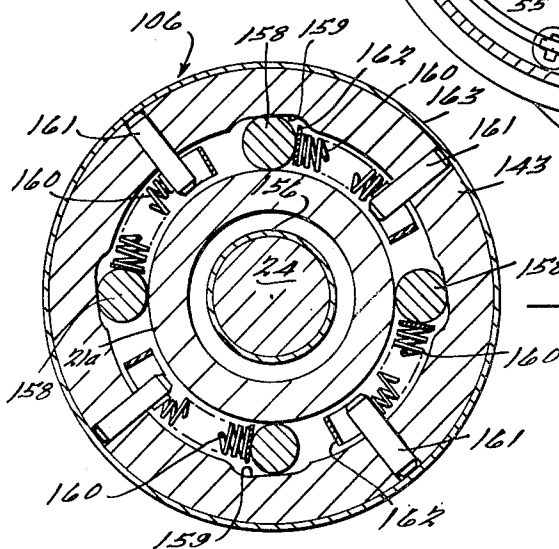


FIG. 3.

INVENTOR.
Glenn S. Farison.
BY
Harness and Harris
ATTORNEYS.

April 13, 1965

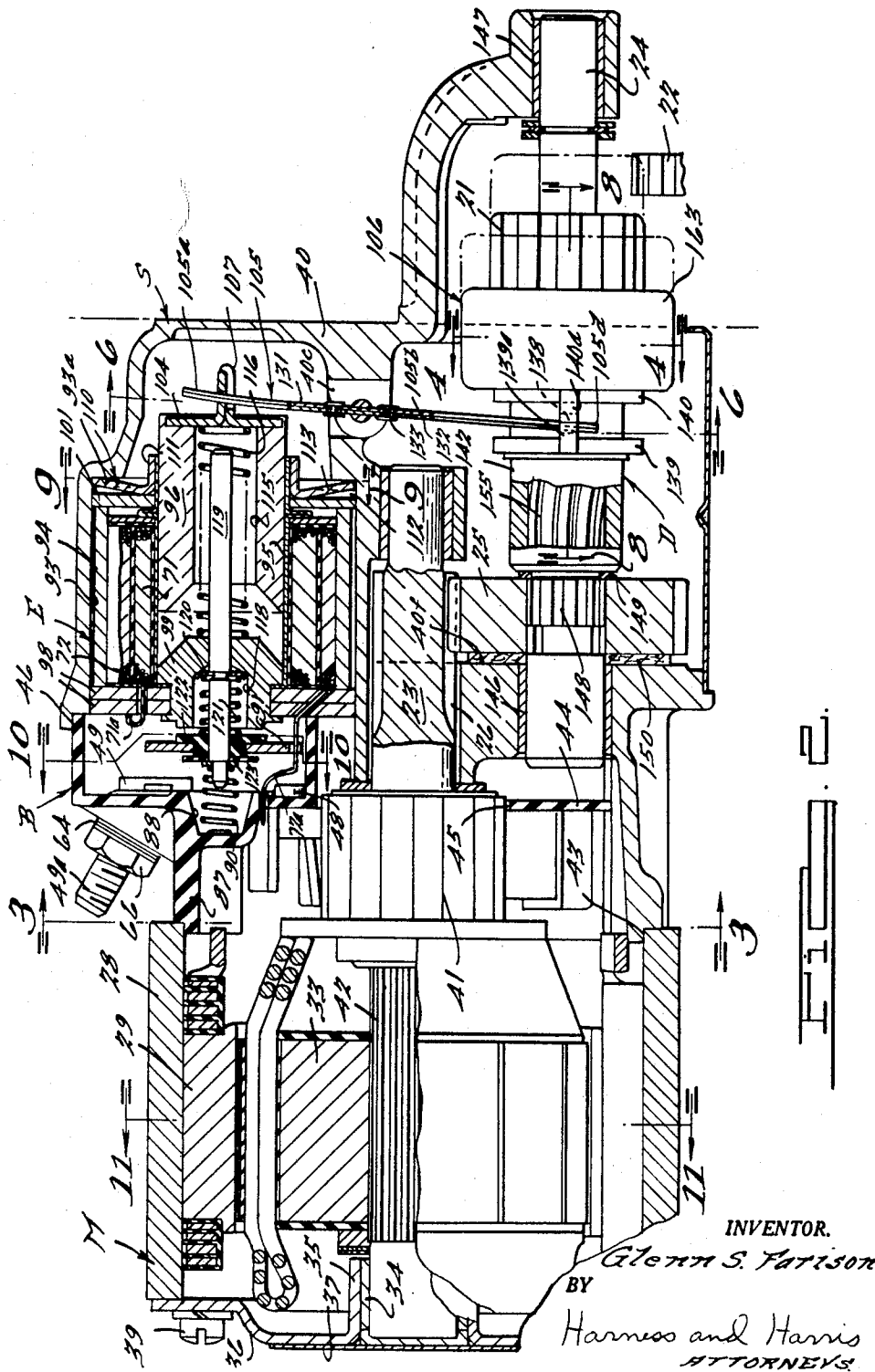
G. S. FARISON

3,177,728

GEARED STARTER

Filed July 1, 1960

5 Sheets-Sheet 2



April 13, 1965

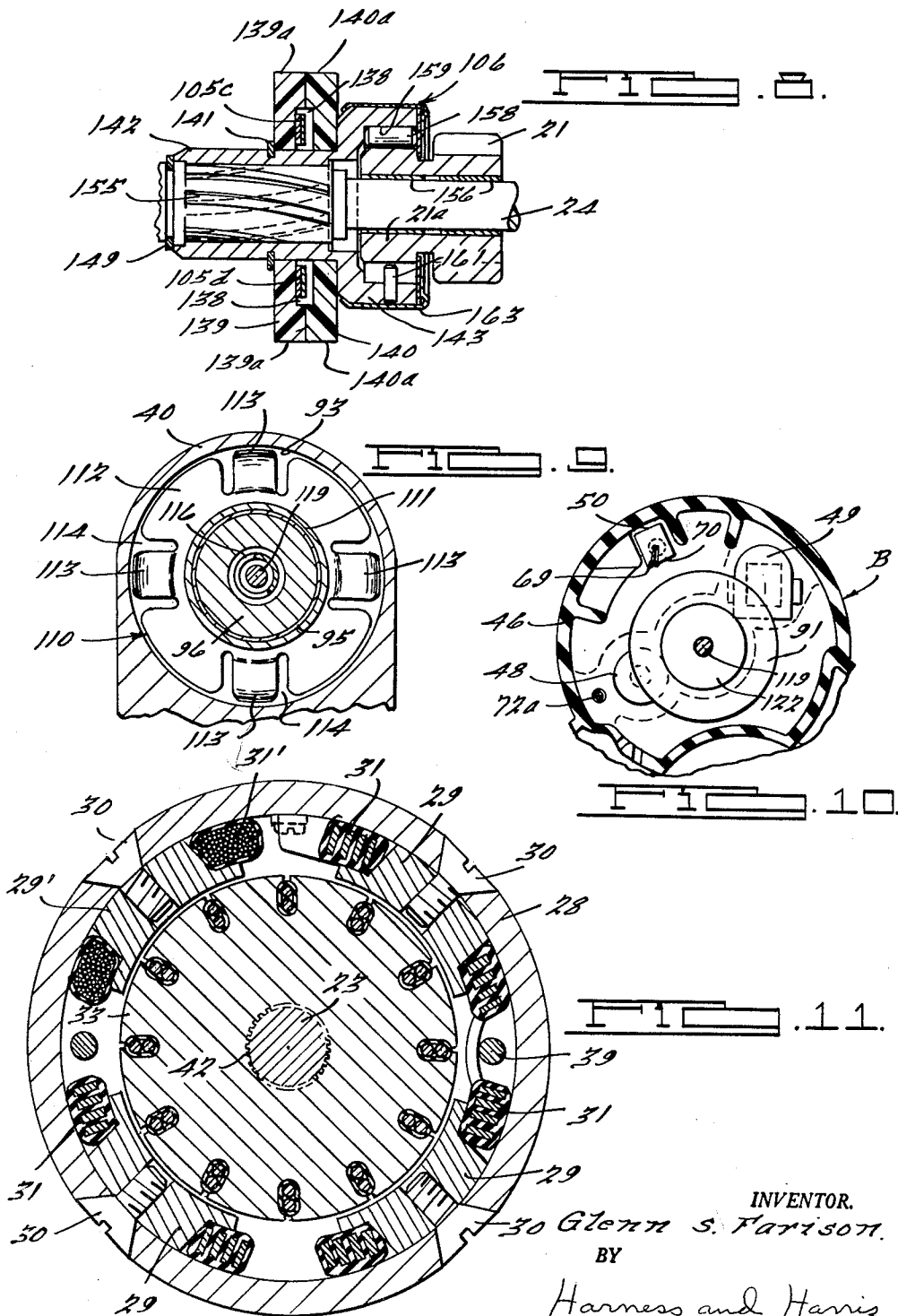
G. S. FARISON

3,177,728

GEARED STARTER

Filed July 1, 1960

5 Sheets-Sheet 4



INVENTOR.

Glenn S. Farison.

BY

Harness and Harris
ATTORNEYS

April 13, 1965

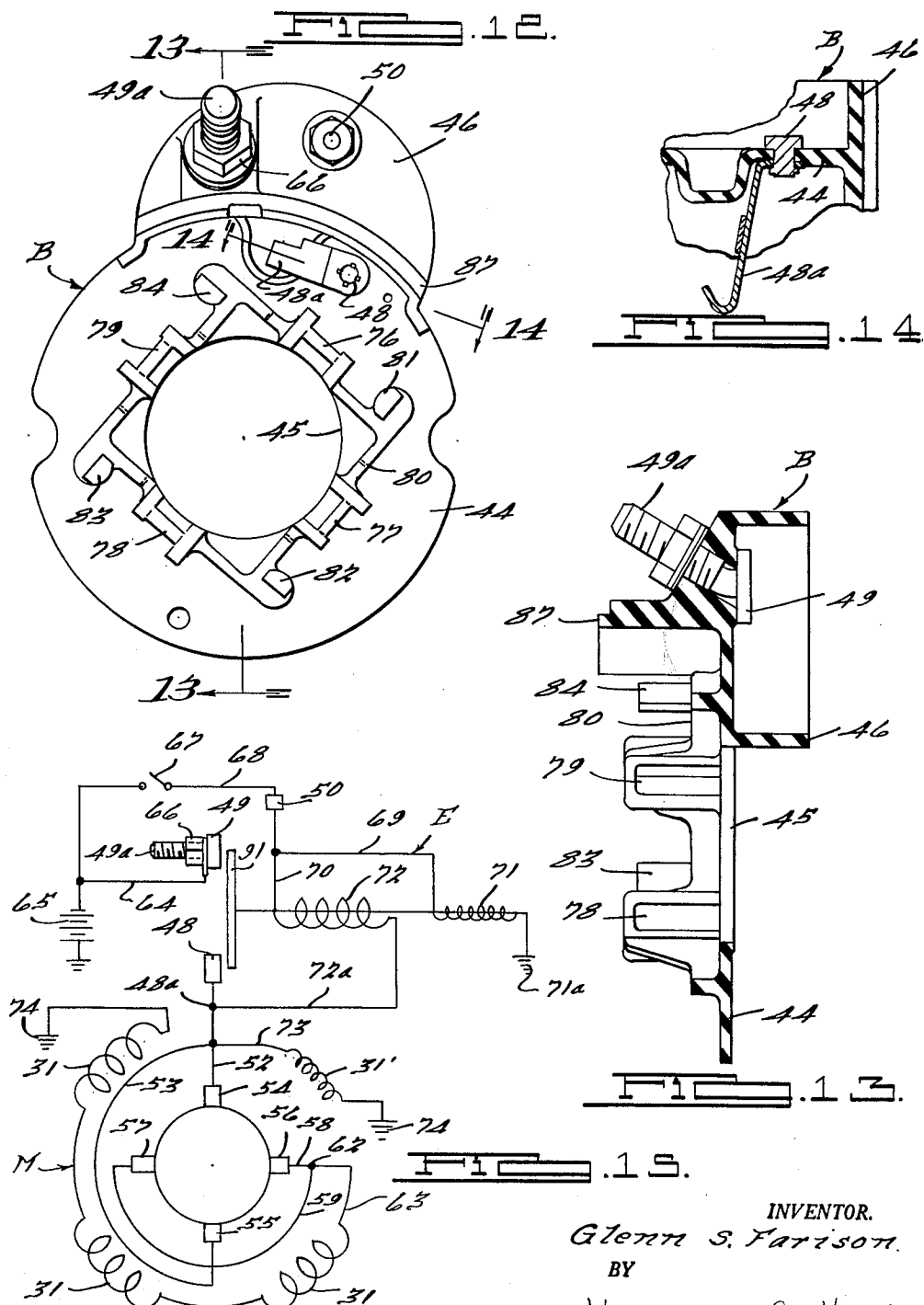
G. S. FARISON

3,177,728

GEARED STARTER

Filed July 1, 1960

5 Sheets-Sheet 5



INVENTOR.
Glenn S. Farison.
BY
Harness and Harris
ATTORNEYS.

1

3,177,728

GEARED STARTER

Glenn S. Farison, Southfield, Mich., assignor to Chrysler Corporation, Highland Park, Mich., a corporation of Delaware

Filed July 1, 1960, Ser. No. 40,359
20 Claims. (Cl. 74-7)

This invention relates to a solenoid actuated, gear transmitted, starter drive unit particularly adapted for starting the engine of a motor vehicle.

It is a primary object of this invention to provide an improved type of starter unit that will utilize less parts and smaller size parts to accomplish the starter drive function at a reduced cost and in an improved manner.

It is another object of this invention to provide a geared starter drive unit that permits utilization of a reduced size engine starter ring gear whereby a reduction in size of the vehicle passenger compartment tunnel hump may be accomplished.

It is still another object of this invention to provide an improved commutator and brush mount arrangement for an electric motor driven starter unit.

It is still another object of this invention to provide an improved type of solenoid unit and mounting means therefor in a starter drive unit.

It is still another object of this invention to provide an improved type of resiliently flexible actuating lever for interconnection of the starter drive unit solenoid and gear clutch.

It is a further object of this invention to incorporate a friction braking means in the gear train between the electric motor and the gear clutch to cushion clutch disengagement and cut down gear overrun.

Other objects and advantages of this invention will become readily apparent from a reading of the following description and a consideration of the related drawings wherein:

FIG. 1 is a top plan view of the geared starter drive unit embodying this invention;

FIG. 2 is an enlarged sectional elevational view taken along the line 2-2 of FIG. 1 showing the starter unit in de-energized condition;

FIG. 3 is a sectional elevational view taken along the line 3-3 of FIG. 2;

FIG. 4 is an enlarged sectional elevational view taken along the line 4-4 of FIG. 2;

FIG. 5 is a fragmentary sectional elevational view, similar to FIG. 2, but showing the solenoid and gear clutch elements immediately after energization of the solenoid unit;

FIG. 6 is a sectional elevational view taken along the line 6-6 of FIG. 2;

FIG. 7 is an enlarged fragmentary sectional elevational view taken along the line 7-7 of FIG. 6;

FIG. 8 is a sectional elevational view taken along the line 8-8 of FIG. 2;

FIG. 9 is a sectional elevational view taken along the line 9-9 of FIG. 2;

FIG. 10 is a sectional elevational view taken along the line 10-10 of FIG. 2;

FIG. 11 is a sectional elevational view taken along the line 11-11 of FIG. 2;

FIG. 12 is an end elevational view of the plastic brush mounting plate that is located intermediate the electric drive motor and the solenoid gear train housing;

FIG. 13 is a sectional elevational view taken along the line 13-13 of FIG. 12;

FIG. 14 is a fragmentary sectional elevational view taken along the line 14-14 of FIG. 12;

2

FIG. 15 is a schematic wiring diagram of the starter unit embodying this invention; and

FIG. 16 is a fragmentary sectional elevational view similar to FIGS. 2 and 5, but showing the solenoid unit after energization and movement of the associated drive pinion into engagement with the ring gear.

FIGS. 1 and 2 of the drawings show an electric motor driven geared starter drive unit S that is adapted to be bolted to the clutch housing cover 20 on the associated engine block of a vehicle drive train so that the drive pinion 21 of the starter unit S can be meshingly engaged with the toothed periphery of the engine flywheel 22. With the current trend to lower the height of motor vehicles and to also remove the objectionable drive shaft hump or tunnel that projects into the driver compartment of the vehicle body, it has been necessary to reduce the size of the engine flywheel that carries the engine cranking ring gear 22. Reduction in the size of the ring gear 22 has presented certain problems because the starter unit drive pinion 21 must now be moved to a new location so that it can be meshingly engaged with the reduced size flywheel ring gear 22. Change in position of the starter motor drive unit is a difficult and expensive change because it can involve change of both the engine block and the clutch or transmission housing as well as the steering linkage and other accessories located in the engine compartment. In order to provide for relocation of the starter unit drive pinion 21, without material change in location of the starter unit location in the engine compartment, the geared starter design herein disclosed has been developed. It will be noted that the drive pinion 21 is not mounted on the electric motor driven armature shaft 23 (FIG. 2) but instead is axially offset from the armature shaft 23 and carried by a pinion shaft 24 that is drivingly connected to the armature shaft 23 by the gear 25 that meshes with the gear teeth 26 formed integrally on the rear end of armature shaft 23. The use of a geared connection between the armature drive shaft 23 and the pinion shaft 24 is not per se new in this art but this specific design does provide extreme flexibility in location of the drive pinion 21 and also permits incorporation of a number of other novel features in this starter drive unit S.

Looking particularly at FIG. 2, it will be noted that starter drive unit S comprises essentially four (4) basic units, namely, the motor M, the brush mount B, the solenoid or electromagnetic actuator E, and the drive transmitting gear and clutch assembly D. The motor unit M comprises a tubular cylinder 28 that provides the motor frame for journaling the armature 33 and mounting the interiorly positioned magnetizable pole shoes 29, 29'. From FIG. 11 it will be noted that there are three shoes 29 and one shoe 29' equally spaced circumferentially about and mounted on the interior side of the frame tube 28. Screws 30 bolt the shoes 29, 29' to the frame 28. Pole shoes 29 are encircled by series connected coil windings 31 whereas pole shoe 29' is encircled by a shunt coil 31' arranged in parallel with the field coils 31. The shunt coil 31' is arranged to prevent motor runaway of the series wound motor in the event of a circuit failure. This series shunt wound motor arrangement is common in starter motor drives and is not a part of this invention therefore further explanation thereof is not thought to be necessary. Journalled in the motor frame 28 by means of the armature shaft 23 is the motor armature 33 that is of more or less conventional construction. Armature shaft 23 has its left end journalled in a self-lubricating sleeve bearing 34 that is pressed in a sleeve-like formation 35 formed in the motor frame end plate 36. Bearing 34 is sealed

in end plate 36 by means of a cover plate 37. End plate 36 is connected to the right end of the tubular motor housing frame 28 by the through bolts 39 (see FIGS. 2, 3 and 11) that also connect the motor frame 28 to the housing 40 that contains the solenoid unit E and the gearing drive unit D.

The right end of the armature 33 (FIG. 2) is conductively connected to the motor commutator 41 by conventional means that do not involve this invention therefore a detailed description of the commutator 41 will be omitted. The commutator 41 as well as the armature 33 are each drivably connected to the armature shaft 23 by a press fit on the splined or ribbed formations 42 on shaft 23.

While the right end of the motor frame 28 (FIG. 2) matingly receives and seats the left end of the gearing and solenoid housing 40, as shown by the stepped connection 43, still, there is arranged between the motor M and the solenoid-gearing units E, D, the novel motor brush mount assembly B (see FIGS. 3, 10 and 12-14). Brush mount B is essentially an annular disc 44 of insulator material having a central opening 45 to receive the commutator 41. Projecting rearwardly or rightwardly from the upper portion of the disc 44 is a hollow, substantially cylindrical, portion 46 (see FIG. 10) that is adapted to mount the control contacts 48, 49 for the motor M as well as the terminal contact 50 for the solenoid E. Switch contact 48 has a flexible contact arm 48a, projecting forwardly from the front or left side of the disc 44 (see FIG. 3) that is connected by parallel conductor wires 52 and 53 to the pair of oppositely disposed commutator brushes 54 and 55 respectively. The other pair of commutator brushes 56 and 57 are connected in parallel by conductor wires 58 and 59 respectively to the connection screw clamp 62 that is also connected to the input lead 63 for the series arranged motor field coils 31. The field coils 31 as well as the shunt coil 31' are grounded to the motor frame 28 by a suitable connection 74. The complete electrical circuit and the operation of this starter unit will be explained in detail when the wiring diagram shown in FIG. 15 is subsequently explained.

The aforementioned contact 49 is the current lead in from the electrical energy source which may be the vehicle electrical system storage battery 65. Contact 49 has a threaded shank 49a that is adapted to be connected to a battery lead cable 64 by the nut 66.

The aforementioned terminal 50 is of the screw type also and is adapted to be connected by a conductor 68 (see FIG. 15) to the battery 65 through the starter switch 67. Terminal 50 has two conductors 69 and 70 extending therefrom in parallel with each of these conductors being connected to a different one of the two solenoid coils 71 and 72 respectively. One of these solenoid coils 71 is directly connected to ground by its end 71a through the casing 40. The other coil 72 is connected by its conductor 72a through the contact 48a to conductor wire 73 that extends to the shunt coil 31' and thence to ground at 74 (FIG. 15).

In addition to mounting the contacts 48, 49 and 50 the insulator disc 44 provides four integral commutator brush mounts 76-79 (see FIGS. 3, 12 and 13). Those brush mounts 76-79 are hollow rectangular frames with open bottom and top portions so that the brushes 54, 55 and 56, 57 can be slidably inserted therein with the brush bottom ends bearing on the outer periphery of the commutator 41 (see FIG. 3). The brush holder formations 76-79 are equally spaced around the periphery of the bore 45 in the brush mounting plate 44 and they are interconnected by a substantially rectangular wall formation 80. At the corners of the wall 80 are upstanding semi-cylindrical posts 81-84 which provide mounting supports for the coiled torsion springs 85. Springs 85 are each formed with a semi-cylindrical inner coil end 85a that non-rotatably seats upon one of the associated upstanding post elements 81-84. The outer free ends 85b of the

coiled torsion springs 85 are formed to provide fingers that each bear against one of the exposed outer ends of the several brush elements 54-57 to urge the brush elements into contact with the commutator 41. From the foregoing description it will be seen that the single plastic disc member 44 has integral formations which permit the snap-on mounting of the commutator brushes 54-57 and their associated springs 85. This particular brush mounting plate B has eliminated a large number of parts and a considerable amount of labor without in any way reducing the quality of this unit of the starter motor.

Projecting forwardly or towards the left from the main disc portion 44 of the brush mounting plate B is an arcuate portion 87 that extends along approximately the top quarter of the circumference of the annular disc 44 (see FIG. 12). A spring seat formation 88 is provided in the rear side of disc 44 to receive the compression spring 90 that urges the disc-like switch contact 91 into a rearward or disengaged position (FIGS. 2 and 5).

As can be clearly seen from FIG. 2, the insulated brush mounting plate B is sandwiched between the motor frame 28 and the gear box-solenoid casing 40. Except for the relatively small arcuate portions 87 and 46 at the top of the plate B all of the disc 44 is contained within the housing 40. The substantially cylindrical sleeve formation 46 on the rear side of the brush mounting plate B forms an end cover for a cylindrical bore 93 in the upper portion of the gear box-solenoid casing or housing 40. This bore 93 receives the solenoid unit E that controls actuation of the gear drive unit D as well as energization of the motor M.

The solenoid unit E that is mounted in casing bore 93 includes an outer tubular casing 94 that has an inside diameter of such size as to receive the associated solenoid double coil assembly 71, 72. The solenoid coil assembly has the pair of coil windings 71, 72 wrapped around the inner non-magnetizable sleeve 95. Coil 71 is the holding coil and coil 72 is a supplementary attracting coil that is shorted out after the solenoid armature 96 has been moved leftward sufficiently to cause the shiftable contact disc 91 to engage the switch contacts 48 and 49. The solenoid coil assembly 95, 71, 72, 94 is surrounded at one end by the magnetizable end discs 98 that also mount the fixed solenoid core piece 99.

A novel means is used to mount the solenoid assembly 94, 71, 72, 98, 95, 101 in the casing bore 93. From FIGS. 2 and 9 it will be noted that there is a flanged washer 110 mounted adjacent the outer side of the end disc 101 of the solenoid assembly. This washer 110 has a central axially extending collar 111 that seats on the solenoid inner tube 95. The radially extending body portion 112 of the washer 110 that abuts the outer face of disc 101 is radially slotted at 114 so as to provide a group of circumferentially spaced fingers 113. These fingers 113 are bent outwardly or rearwardly so that they provide spring fingers that press against the end wall 93a of the bore 93 in casing 40 and urge the solenoid assembly 94, 98, 95, 101 leftwardly against the brush mount plate B. The spring finger washer 110 thus provides for take-up of any variation in manufacturing tolerances and assures a rigid mounting of the solenoid assembly 94, 98, 95, 101 in the bore 93 of the housing 40 regardless of size variations within specified limits.

Shiftable mounted in the bore of tubular sleeve 95 is the solenoid armature 96. Armature 96 has a longitudinally extending central bore 115 that receives a compression spring 116. Spring 116 has its left end seated against the fixed solenoid core 99 and its right end seated against the armature end plate 104 so that it continuously urges the armature 96 towards the right.

Extending through the fixed core 99 of the solenoid unit is a stepped bore 118 that receives a shiftable thrust rod 119. Fixed on the thrust rod 119 is a collar 120 that is adapted to provide a seat for the right end of compression spring 121. The left end of spring 121 bears against

5

an insulator washer 122 that abuts the right side of the conductor switch disc 91. Disc 91 is movable towards the right along rod 119 upon compression of the spring 121. This movement is advantageous when the thrust rod is shifted to the left to bring the disc 91 into contact with the spaced contacts 48, 49. The contact 91 and insulated washer 122 are prevented from moving towards the left along the thrust rod 119 by the anchored washer 123.

Extending between the anchored washer 123 and the bottom of the spring seat formation 88 in the right side of the brush mount plate B is the compression spring 90. Spring 90 continuously urges the thrust rod 119 rightwardly tending to hold the contact disc 91 out of engagement with the spaced contacts 48, 49.

From the foregoing description it is thought to be clear that the parts of the solenoid unit E take the relative positions shown in FIG. 2 when the coils 71, 72 are de-energized. However, after the solenoid coils 71, 72 are energized the solenoid parts move through the positions shown in FIG. 5 to the positions shown in FIG. 16. A further description of the operation of the solenoid on energization thereof is given in connection with the flexible gear shifting lever 105.

From FIGS. 2, 5-7 and 16 it will be noted that the right end of the solenoid armature 96 has a plate member 104 fixed thereto. Plate 104 has a projection 107 thereon that is slotted at 108 to provide a means for attaching the solenoid armature 96 to the upper end 105a of the resilient shift lever 105. Shift lever 105 is essentially a two-piece flexible strip of inverted Y-shaped configuration. The two strips 131 and 132 that form the body of the lever 105 are connected together by a pair of spaced rivets 133. It will be noted from FIG. 7 that the rivet receiving holes 132a in the strip 132 are larger than the holes in strip 133 and also larger than the rivet shanks. This arrangement permits a slight amount of relative movement between the strips 131, 132 during flexing thereof. This gives improved bending action. The strips 131, 132 have tapered end portions 105a and 105b to facilitate uniform bending of lever 105 during shift of the clutch mechanism 106 and drive pinion 21 by the armature 96. Lever 105 is pivotally mounted on the casing 40 by means of the pivot shaft 134 that extends transversely across the strip receiving slot 40c in the casing 40. Pivot shaft 134 can be a cotter pin as shown in FIG. 1 having the free end of one leg bent over as at 134a.

The lower end 105b of lever 105 flares out into a bifurcated formation providing a pair of spaced fingers 105c and 105d. These fingers 105c and 105d straddle the drive shaft 24 and seat in slots 138 (see FIGS. 2, 6 and 8) formed between the pair of shaft encircling nylon collars 139, 140. Collars 139, 140, that are substantially diamond-shaped in side elevation (see FIG. 8), have end edge portions 139a and 140a that slidably seat in opposed guideways 40e in the housing 40. Collars 139, 140 are anchored to the stepped sleeve 142 of the clutch mechanism 106 (see FIG. 6) by the snap ring 141 that holds the collars 139, 140 against the left end of the enlarged cup portion 143 on the sleeve 142. With the connection of the lever lower end fingers 105c and 105d in the slots 138 of the collars 139, 140 that are fixed to the sleeve 142, it is thought to be obvious that actuation of the armature 96 will effect shift of the sleeve 142 along the drive shaft 24.

From FIGS. 2 and 8 it is clear that drive shaft 24 is rotatably supported at its opposite ends in the casing 40 by means of the sleeve bearings 146 and 147 that are preferably of self-lubricating material. Drivably connected to drive shaft 24 by the splines 148 is the gear 25. Gear 25 is locked against axial movement on the shaft 24 by the snap ring 149. Interposed between the gear 25 and the housing face 40f is a friction braking washer 150. This washer 150 acts to prevent overrun of the gearing 25, 26 and the motor shaft 23 when the engine has been

6

started and the pinion 21 is withdrawn from the ring gear 22. Washer 150 also cushions the return of the gear 25 to its retracted position against the casing face 40f.

It will be noted that the stepped sleeve 142 is drivably connected to the drive shaft 24 by the spiral splines 155. These spiral splines rotate the drive pinion 21 relative to shaft 24 as the pinion 21 is being moved rightward to engage ring gear 22. This rotation of pinion 21 facilitates meshing engagement of the gears 21, 22.

As can be seen from FIGS. 4 and 8 in particular, the enlarged cup 143 of sleeve 142 houses the one-way or overrunning clutch construction 106. This overrunning clutch 106 permits the drive pinion 21 to overrun the shaft 24 when the engine starts. Pinion gear 21 is journaled on shaft 24 by the bearings 156. Gear 21 has a forwardly or leftwardly extending (FIG. 8) hub sleeve 21a that forms the inner race for the rollers 158 of the overrunning clutch 106. The sleeve cup 143 forms the outer race for the clutch 106 and its interior surface is grooved to provide the rollers ramps 159. Springs 160 anchored to the cup 143 by pins 161 exert a force against the shoes 162 that press the rollers 158 towards the drive engaging ends of the ramp surfaces 159. A sheet metal rim 163 encloses the outer side of the cup 143 and retains the pins 161.

Now considering FIGS. 2, 5, 15 and 16 in particular, operation of this geared starter motor will be explained. When the starter switch 67 is open (FIG. 15) the starter drive unit components are in the relative positions shown in FIG. 2. On closing the starter switch 67 the parallelly arranged holding and attracting or pull in coils 71, 72 are each energized by the parallel circuits that are grounded at 71a and 74 respectively. Energization of the two coils 71, 72 produces a sufficient magnetic field to cause movement of the solenoid armature 96 towards the left (see FIG. 5). Initial leftward movement of the armature 96 does not cause any material rightward movement of the clutch and gear drive unit 106 because the flexible lever 105 is first bent to the arcuate shape shown in FIG. 5 during the initial leftward movement of the armature 96. As the clutch and gear unit 106 does not have to be moved by the armature during initial movement of the armature as it is pulled leftward towards the fixed core piece 99, it is possible to use smaller size coils 71, 72 than would be the case if the clutch and drive unit 106 had to be actuated on initial leftward movement of armature 96. The bending of the flexible lever 105 to the shape shown in FIG. 5 stores up potential energy that is subsequently released to push the pinion 21 into meshing engagement with the ring gear 22. After the armature 96 moves leftward past the position shown in FIG. 5, then subsequent leftward movement shifts the pinion gear drive unit 106 rightward to meshingly engage the pinion 21 with the ring gear 22 as shown in FIG. 16. As previously pointed out the rightward movement of the drive unit 106 by the armature 96 also causes a rotation of the pinion 21 on the shaft 24 because of the helical splined connection 155 of the sleeve 142 to the shaft 24. The rotation of pinion 21 on shaft 24 assists in engaging the gears 21, 22 which may also be formed with beveled ends to further assist the engaging action of gear 21 with gear 22. The pinion gear 21 is usually engaged with the ring gear 22 before the armature 96 reaches its extreme leftward position as shown in FIG. 16 and this is important because it assures engagement of the gears 21, 22 before the motor unit M is energized to rotate the pinion 21. From FIG. 16 it will be noted that at the completion of leftward shift of the armature 96 the armature actuator switch contact 91 now bridges contacts 48, 49 and thereby connects the battery 65 to the contact 48, 48a. Contact 91 now completes a circuit through the contact 48a and the field and shunt coils 31, 31' to ground at 74 that energizes the motor M which through the gears 26, 25 rotatably drives the shaft 24. Rotation of shaft 24 rotates the sleeve 142 because of the splines 155 and the cup por-

tion 143 of one-way clutch 106 drives the pinion gear sleeve 21a through the rollers 153 (see FIGS. 4 and 8). When the pinion gear 21 has turned the ring gear 22 sufficiently to start the associated engine then the ring gear will drive the pinion gear at an increased speed. The increased speed of the pinion 21, when engine driven, is not transmitted to the drive shaft 24 or to the connected gearing 25, 26 and motor armature 33 because of the overrunning or one-way clutch rollers 153. While a specific type of one-way clutch is shown, still other well known types of one-way clutches can be substituted for the specific construction shown. It is thought to be clear from the wiring diagram in FIG. 15 that when contact 91 bridges the contacts 48, 49 that then the pull-in coil 72 is shorted out. The additional coil 72 is not needed when the armature 96 has been moved near to its extreme leftward position because the coil 71 is then quite capable of completing the movement of the armature into engagement with and holding the armature 96 against the stationary core piece 99.

When the engine has been started by operation of this starting gear unit S the switch 67 is then opened and this deenergizes the armature holding coil 71 and permits the compressed spring 116 to shift the armature 96 rightwardly. Initial rightward movement of the armature 96 flexes the lever so as to bend its upper end 105a towards the right and also breaks the contact between the disc 91 and the switch contacts 48, 49 so as to open the motor circuit. Thereafter further rightward movement of the armature 96 withdraws the pinion gear 21 from engagement with ring gear 22 and impells the drive unit clutch and gear unit 106 towards the left along the drive shaft 24. As the left end of clutch sleeve 142 engages the snap ring 149 the gear 25 is pressed into frictional engagement with the braking washer 150 that is compressed against the casing wall portion 40f. This frictional engagement of the gear 25 with the braking washer 150 prevents unnecessary drive of the gearing 25, 26 and also cushions the retraction of the drive unit 106 upon disengagement of gears 21, 22. The braking washer also brakes the rotation of the pinion gear drive sleeve 143 so that the pinion 21 will not spin unnecessarily and interfere with subsequent starting operations.

From the foregoing description of the starter drive unit S it is thought to be clear that new and old components have been combined in a novel manner to produce a low cost, minimum size, highly efficient, rugged, fool-proof starter drive unit that lends itself particularly to current and future motor vehicle design and use. The use of a geared drive 25, 26 also permits the motor M to be run at about twice the speed of a direct drive starter unit and accordingly a much smaller size motor M can be used that is light in weight and less expensive than the motor used with a direct drive starter unit. The location of the commutator 41 and the brush mount B intermediate the motor M and solenoid unit E has permitted some overlapping of commutator, solenoid and gearing parts so as to reduce the overall length of the starter unit S. The geared drive 25, 26 has also permitted some length reduction without any material increase in cross sectional area of the starter drive unit. The flexible shift lever 105 which permits some initial movement of the solenoid armature 96 towards its fixed core piece 99 prior to shift of the drive unit 106 allows slightly smaller solenoid coils 71, 72 to be used than would otherwise be the case. The plastic brush mount B that is a unitary plate with a number of preformed formations to receive snap-on brushes, springs, and the like, is a labor saving, low-cost, component of minimum size that is quite advantageous in a starter drive unit. The flanged spring plate washer 110 that mounts the solenoid coil assembly in the bore 93 of housing 40 and automatically takes up variations in tolerances of parts is another component that reduces the rejection of components because of size variations and thus tends to reduce the cost of the starter unit.

I claim:

1. An engine electric motor starter unit comprising an electric motor having a rotatable motor shaft, means for energizing said motor including a switch operated by an electrically operated reciprocable plunger, a drive shaft axially offset from and drivingly connected by gearing to said motor shaft, a pinion gear rotatably mounted on said drive shaft and shiftable axially therealong for movement into and out of mesh with a gear drivingly connected to the engine to be started, a one-way clutch drivingly connecting said pinion gear to said drive shaft for drive transmission in one direction of rotation, and a motion transmitting pivotally mounted, flexible, resilient leaf spring link connected between said plunger and said pinion gear providing the sole means to transmit reciprocation of said plunger into axial movement of said pinion gear along said drive shaft, flexing of said link on initial movement of said plunger permitting some initial relative movement between said plunger and said pinion gear prior to conjoint movement thereof.

2. An engine electric motor starter unit comprising an electric motor having a rotatable motor shaft, means for energizing said motor including a switch operated by an electrically operated reciprocable plunger, a drive shaft axially offset from and drivingly connected by gearing to said motor shaft, a pinion gear rotatably mounted on said drive shaft and shiftable axially therealong for movement into and out of mesh with a gear drivingly connected to the engine to be started, a one-way clutch drivingly connecting said pinion gear to said drive shaft for drive transmission in one direction of rotation, and a motion transmitting pivotally mounted, flexible, bifurcated, resilient link connected between said plunger and said pinion gear providing the sole means to transmit reciprocation of said plunger into axial movement of said pinion gear along said drive shaft, flexing of said link on initial movement of said plunger permitting some initial relative movement between said plunger and said pinion gear prior to conjoint movement thereof, said link comprising a pivotally mounted yoke member having the stem end connected to said plunger and the other bifurcated end straddling and connected to the one-way clutch associated with the pinion gear.

3. An engine electric motor starter unit comprising an electric motor having a rotatable motor shaft, means for energizing said motor including a switch operated by an electrically operated reciprocable plunger, a drive shaft axially offset from and drivingly connected by gearing to said motor shaft, a pinion gear rotatably mounted on said drive shaft and shiftable axially therealong for movement into and out of mesh with a gear drivingly connected to the engine to be started, a one-way clutch drivingly connecting said pinion gear to said drive shaft for drive transmission in one direction of rotation, and a motion transmitting pivotally mounted, flexible, resilient link connected between said plunger and said pinion gear providing the sole means to transmit reciprocation of said plunger into axial movement of said pinion gear along said drive shaft, flexing of said link on initial movement of said plunger permitting some initial relative movement between said plunger and said pinion gear prior to conjoint movement thereof, said link comprising a pivotally mounted leaf spring yoke member of inverted Y-shape having the stem end connected to said plunger and the other bifurcated end straddling and connected to the one-way clutch associated with the pinion gear by means of a self-lubricating, sound absorbing, connection.

4. An engine electric motor starter unit comprising an elongated housing, an electric motor mounted in one end of said housing having a rotatable motor shaft positioned interiorly of and extending longitudinally of the housing towards the other end thereof, a rotatable drive shaft mounted in the other end of the housing and extending longitudinally thereof in axially offset relation

commutator means surrounding said motor shaft and located therealong intermediate the two pieces of the housing between said motor and said gear means, an electromagnetically operated starter switch unit for said motor mounted in a switch unit bore in the said other end of the housing with the switch unit arranged in transversely stacked relation to the said gear means, and means for fixedly mounting said switch unit in said switch unit bore irrespective of variations in relative sizes of the switch unit and its bore comprising a plate type washer seated in one end of the switch unit bore between the adjacent switch unit bore end wall and the contiguous end wall of the switch unit, said washer having angularly offset spring fingers that compressively engage the said adjacent switch unit bore and wall and fixedly force the switch unit against the other end wall of the switch unit bore.

12. In an engine electric motor starter unit comprising an electric motor driven rotatable drive shaft, a pinion gear drivingly connected to said drive shaft and axially shiftable therealong for movement into engagement with and disengagement from a driven gear, an electromagnetic switch unit for control of said motor having a reciprocable plunger to operate the switching unit and to shift the pinion gear along the drive shaft including a pivotally mounted leaf spring lever operatively connected at its opposite ends to said plunger and said pinion gear and providing the sole means for transmission of motion therebetween, said lever being flexible about its intermediate pivot axis to permit some relative movement between said plunger and pinion gear prior to conjoint movement thereof, said lever comprising a plurality of flexible, resilient, laminates connected together for limited relative movement.

13. In an engine electric motor starter unit comprising an electric motor driven rotatable drive shaft, a pinion gear drivingly connected to said drive shaft and axially shiftable therealong for movement into engagement with and disengagement from a driven gear, an electromagnetic switch unit for control of said motor having a reciprocable plunger to operate the switching unit and to shift the pinion gear along the drive shaft including a pivotally mounted leaf spring lever operatively connected at its opposite ends to said plunger and said pinion gear and providing the sole means for transmission of motion therebetween, said lever being flexible about its intermediate pivot axis to permit some relative movement between said plunger and pinion gear prior to conjoint movement thereof, said lever comprising a plurality of flexible, resilient, laminates connected together for limited relative movement, and having a stem-like upper end connected to a slot in said plunger and a bifurcated yoke-like lower end connected to slotted portions carried by said pinion gear.

14. An engine electric motor starter unit comprising an elongated two-piece housing unit including a first tubular housing section providing the frame for an electric motor having a motor shaft arranged concentrically therein and extending axially of the tubular frame with the motor shaft projecting axially beyond the inner end of the tubular housing section and mounting a drive gear, a commutator mounted on said inwardly projecting motor shaft, a commutator brush mounting plate surrounding said commutator and having integral brush mounting supports thereon, a second housing section having a tubular inner end formation that matingly engages the tubular inner end of said first housing section with the commutator brush mounting plate sandwiched therebetween, said second housing section having a cylindrical bore therein extending longitudinally thereof that receives an electromagnetically operated switch unit having contact means for controlling energization of said motor, said switch unit including a reciprocable armature unit to actuate the motor controlling switch contact

means, portions of said switch contact means being formed as integral parts of said commutator brush mounting plate, said commutator brush mounting plate also having portions that close one end of the housing bore that receives said switch unit, a rotatable drive shaft journaled in the second housing section and positioned in axially offset relation to the interiorly projecting motor shaft, a reduction gear drivingly mounted on said drive shaft and arranged in meshing engagement with the motor shaft mounted drive gear, a one-way drive clutch mechanism drivingly connected to said drive shaft and shiftable axially thereof, said clutch mechanism carrying a pinion gear adapted to be shifted axially along said drive shaft to be engaged with and disengaged from a driven engine gear, and pivotally mounted lever means interconnecting the armature and the one-way drive clutch to transmit motion therebetween but arranged to permit relative axial movement between the armature and clutch mechanism prior to conjoint movement thereof.

15. In an engine electric motor starter unit as set forth in claim 14 wherein the lever interconnecting the armature and the one-way drive clutch is resiliently flexible about the lever pivot axis to permit some relative movement between the armature and one-way drive clutch before conjoint movement thereof.

16. In an engine electric motor starter unit as set forth in claim 14 wherein resilient means are mounted in the cylindrical bore in the second housing section at the other end thereof to urge the switch unit therein against said brush mounting plate to provide a clearance take-up mounting means for said switch unit in the housing bore.

17. An engine electric motor starter unit comprising an elongated sectional housing unit including a first tubular housing section providing the frame for an electric motor having a motor shaft arranged concentrically therein and extending axially of the tubular frame with the motor shaft projecting axially beyond the inner end of the tubular housing section and mounting a drive gear, a commutator mounted on said inwardly projecting end of said motor shaft, a commutator brush mounting plate surrounding said commutator and having integral commutator brush mountings thereon and integral motor control contact means, a second housing section having a tubular inner end formation that matingly engages the tubular inner end of said first housing section with the commutator brush mounting plate sandwiched therebetween, said second housing section having a cylindrical bore therein extending longitudinally thereof that receives an electromagnetically operated switch unit having motor control contact means engageable with the commutator plate mounted motor control contact means for controlling energization of said motor, said switch unit including a reciprocable armature unit to actuate certain of the motor controlling switch contact means, said commutator brush mounting plate also having portions that close one end of the housing bore that receives said switch unit, a rotatable drive shaft journaled in the second housing section and drivingly engaged with the inwardly projecting end of said motor shaft, a clutch mechanism drivingly connected to said drive shaft and shiftable axially thereof, said clutch mechanism carrying a pinion gear adapted to be shifted axially along said drive shaft to be engaged with and disengaged from a driven engine gear, and pivotally mounted, resilient, lever means interconnecting the armature and the clutch to transmit axial motion therebetween.

18. An engine electric motor starter unit as set forth in claim 17 wherein said electric motor has a plurality of series wound field coils and a parallel arranged shunt coil to control operation thereof.

19. An engine electric motor starter unit as set forth in claim 17 wherein said electromagnetically operated switch unit includes a solenoid unit having an armature

to said motor shaft with portions thereof overlapping said motor shaft, gear means within and intermediate the ends of the housing drivingly interconnecting said overlapping portions of said shafts, a pinion gear axially shiftable on and drivingly connected to said drive shaft, and motor commutator means surrounding said motor shaft and located therealong between said motor and said gear means, said commutator means comprising a plate member having brush means and motor control switch means thereon, and an electromagnetically operated starter switch unit for energizing said motor mounted on the other end of said housing in transversely stacked relation to said shafts.

5. An engine electric motor starter unit comprising an elongated housing, an electric motor mounted in one end of said housing having a rotatable motor shaft positioned interiorly of and extending longitudinally of the housing towards the other end thereof, a rotatable drive shaft mounted in the other end of the housing and extending longitudinally thereof, gear means within and intermediate the ends of the housing drivingly interconnecting said shafts, a pinion gear axially shiftable on and drivingly connected to said drive shaft, and motor commutator means surrounding said motor shaft and located therealong between said motor and said gear means, and an electromagnetically operated starter switch unit for energizing said motor mounted on the other end of said housing in transversely stacked relation to said shafts including a reciprocable armature element connected to said pinion gear for shiftable actuation thereof along said drive shaft by means of a resilient, flexible interconnecting link pivotally mounted on said housing and providing the sole motion transmitting means between the armature and the pinion gear, said link being arranged so that initial movement of said armature element bends said link prior to effecting shifting movement of the connected pinion gear.

6. An engine electric motor starter unit comprising an elongated housing, an electric motor mounted in one end of said housing having a rotatable motor shaft positioned interiorly of and extending longitudinally of the housing towards the other end thereof, a rotatable drive shaft mounted in the other end of the housing and extending longitudinally thereof, gear means within and intermediate the ends of the housing drivingly interconnecting said shafts, a pinion gear axially shiftable on and drivingly connected to said drive shaft, and motor commutator means surrounding said motor shaft and located therealong between said motor and said gear means comprising a disc of insulator material mounted on and extending transversely of the housing intermediate its ends having an aperture surrounding said commutator with integral formations thereon to movably support the commutator brush assemblies.

7. An engine electric motor starter unit comprising an elongated housing, an electric motor mounted in one end of said housing having a rotatable motor shaft positioned interiorly of and extending longitudinally of the housing towards the other end thereof, a rotatable drive shaft mounted in the other end of the housing and extending longitudinally thereof, gear means within and intermediate the ends of the housing drivingly interconnecting said shafts, a pinion gear axially shiftable on and drivingly connected to said drive shaft, and motor commutator means surrounding said motor shaft and located therealong between said motor and said gear means comprising a disc of insulator material mounted on and extending transversely of the housing intermediate its ends having an aperture surrounding said commutator with integral formations thereon to movably support the commutator brush assemblies including snap-on spring receiving posts and channel-type brush receiving frames.

8. An engine electric motor starter unit comprising an elongated housing, an electric motor mounted in one end of said housing having a rotatable motor shaft positioned

interiorly of and extending longitudinally of the housing towards the other end thereof, a rotatable drive shaft mounted in the other end of the housing and extending longitudinally thereof, gear means within and intermediate the ends of the housing drivingly interconnecting said shafts, a pinion gear axially shiftable on and drivingly connected to said drive shaft, motor commutator means surrounding said motor shaft and located therealong between said motor and said gear means, and an electromagnetically operated starter switch unit for energizing said motor mounted on the other end of said housing in transversely stacked relation to said shafts, said motor commutator means including a disc of insulator material mounted on and extending transversely of said housing having an aperture therein surrounding said commutator with integral formations thereon to movably support the brush assemblies for said commutator means.

9. An engine electric motor starter unit comprising an elongated housing, an electric motor mounted in one end of said housing having a rotatable motor shaft positioned interiorly of and extending longitudinally of the housing towards the other end thereof, a rotatable drive shaft mounted in the other end of the housing and extending longitudinally thereof, gear means within and intermediate the ends of the housing drivingly interconnecting said shafts, a pinion gear axially shiftable on and drivingly connected to said drive shaft, motor commutator means surrounding said motor shaft and located therealong between said motor and said gear means, and an electromagnetically operated starter switch unit for energizing said motor mounted on the other end of said housing in transversely stacked relation to said shafts, said motor commutator means including a disc of insulator material mounted on and extending transversely of said housing having an aperture therein surrounding said commutator with integral formations thereon to movably support the brush assemblies for said commutator means, said disc also mounting the switch contacts for control of said motor which contacts are controlled by the operation of said electromagnetically operated switch unit.

10. An engine electric motor starter unit comprising an elongated housing, an electric motor mounted in one end of said housing having a rotatable motor shaft positioned interiorly of and extending longitudinally of the housing towards the other end thereof, a rotatable drive shaft mounted in the other end of the housing and extending longitudinally thereof, gear means within and intermediate the ends of the housing drivingly interconnecting said shafts, a pinion gear axially shiftable on and drivingly connected to said drive shaft, motor commutator means surrounding said motor shaft and located therealong between said motor and said gear means, and an electromagnetically operated starter switch unit for energizing said motor mounted on the other end of said housing in transversely stacked relation to said shafts, said motor commutator means including a disc of insulator material mounted on and extending transversely of said housing having an aperture therein surrounding said commutator with integral formations thereon to movably support snap-on brush assemblies for said commutator means, said disc also mounting the switch contacts for control of said motor which contacts are controlled by the operation of said electromagnetically operated switch unit with the disc also providing one end wall for said electromagnetically operated switch unit.

11. An engine electric motor starter unit comprising an elongated two-piece housing, an electric motor mounted in one end of said housing having a rotatable motor shaft positioned interiorly of and extending longitudinally of the housing towards the other end thereof, a rotatable drive shaft mounted in the other end of the housing and extending longitudinally thereof, gear means within and intermediate the ends of the housing drivingly interconnecting said shafts, a pinion gear axially shiftable on and drivingly connected to said drive shaft, motor

13

attracting coil and an armature holding coil arranged in parallel.

20. An engine electric motor starter unit as set forth in claim 19 wherein said armature attracting coil is shorted out after said armature has been moved to a position to actuate the motor control contact means.

References Cited by the Examiner

UNITED STATES PATENTS

1,563,945	12/25	Apple	-----	310—83	10
2,302,687	11/42	Dyer.			
2,354,844	8/44	Thornburg	-----	74—7	

14

2,923,830	2/60	Merriam et al.	-----	290—38
2,934,656	4/60	Seilly	-----	290—38

FOREIGN PATENTS

688,973	5/30	France.
904,851	3/45	France.
903,051	2/54	Germany.
923,883	2/55	Germany.
939,846	3/56	Germany.
631,580	11/49	Great Britain.
297,139	5/54	Italy.

BROUGHTON G. DURHAM, *Primary Examiner.*