July 22, 1924. 1,502,018

R. CHILTON

INTERNAL COMBUSTION ENGINE STARTER

Filed May 19, 1921

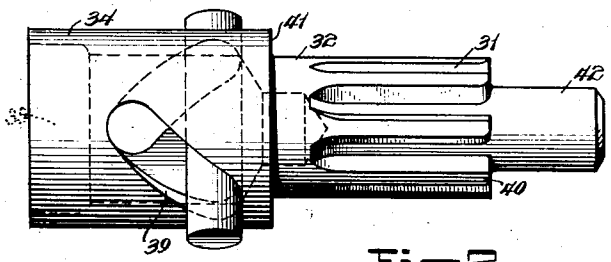

Fig. 2.

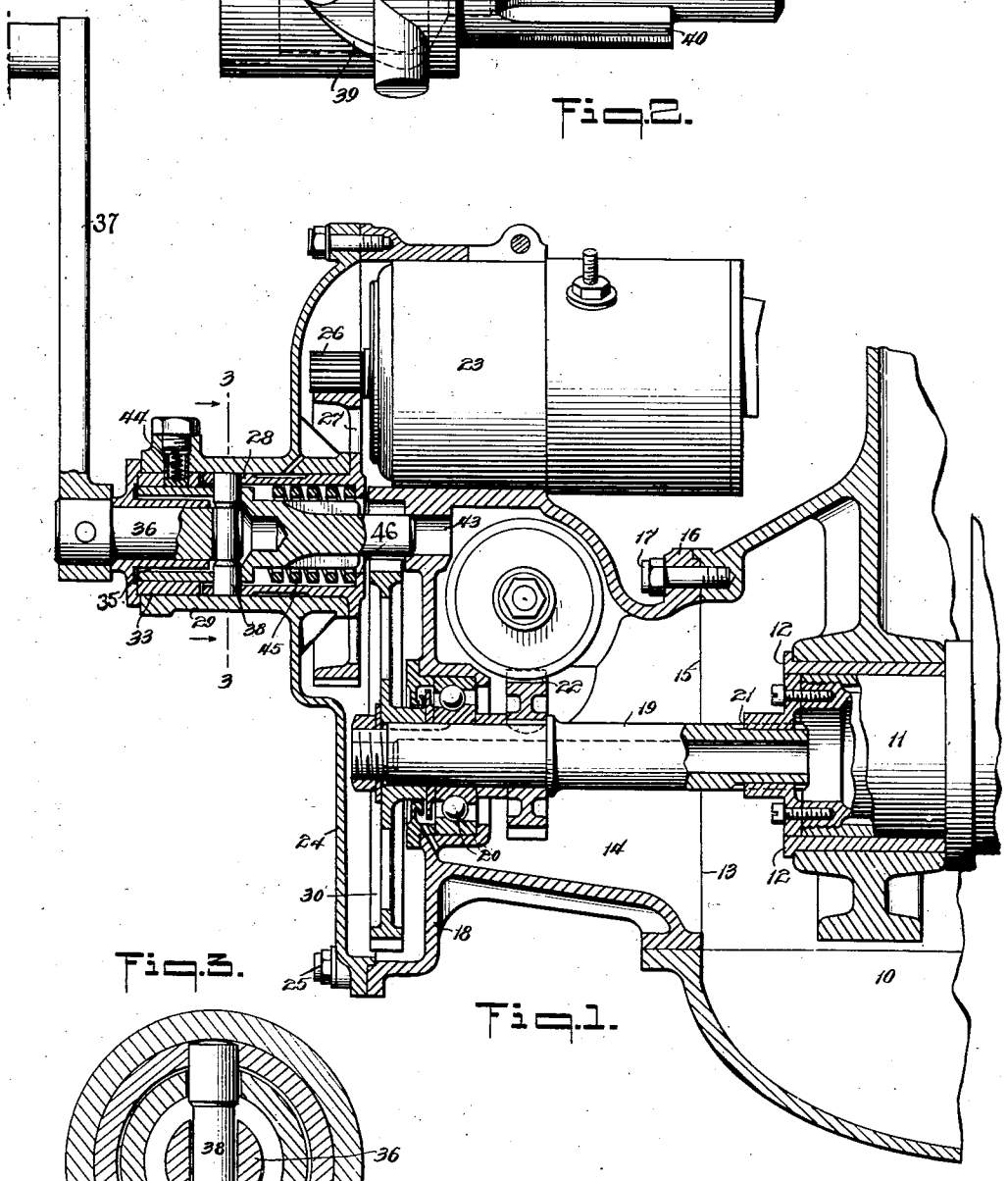

Fig. 3.

Fig. 1.

INVENTOR
Roland Chilton
BY
Warren S. Orton.
ATTORNEY

Patented July 22, 1924. 1,502,018

UNITED STATES PATENT OFFICE.

ROLAND CHILTON, OF KEYPORT, NEW JERSEY, ASSIGNOR TO AEROMARINE PLANE AND MOTOR COMPANY, A CORPORATION OF NEW YORK.

INTERNAL-COMBUSTION-ENGINE STARTER.

Application filed May 19, 1921. Serial No. 471,002.

To all whom it may concern:

Be it known that I, ROLAND CHILTON, a subject of the King of Great Britain, and resident of Keyport, in the county of Monmouth and State of New Jersey, have invented certain new and useful Improvements in Internal-Combustion-Engine Starters, of which the following is a specification.

The invention relates in general to an improved form of internal combustion engine starter of the type in which a motor acts through a reducing gear train to "turn over" the engine, and in which a small lagging pinion constituting one element of the gear train is shifted axially in one direction into operative position by the torque of the motor, and is shifted in the opposite direction and into an inoperative position automatically by the torque of the engine as it begins to "turn over" under its own power.

While the invention is of general application in any situation where a gear drive in one direction is designed to cause a completion of the driving connection and the drive in the opposite direction is caused to effect an interruption of such driving connection, the invention disclosed is particularly designed for use in starting aeroplane engines. In designing starter devices for such work it is vitally necessary to obtain a very large over all gear reduction but the mechanism to effect this large gear reduction must be light in weight and confined in the smallest possible space. This invention herein features a light construction of the starting motor, the reducing gear drive and associated parts while insuring a ruggedness having capacity to transmit the high torque necessary to turn over heavy duty engines of the type usually found in aeroplane construction.

One of the general objects of the present invention therefore is to provide a simple, light, rugged starter device for positively and efficiently inaugurating the rotation of a machine element and which preferably constitutes a readily removable attachment to an internal combustion engine of the aeroplane type.

One factor which contributes materially to the size and therefore weight of the reducing gear trains and housings usually employed in such devices is the size of the pinion which constitutes the shiftable element of the gear train. These pinions while designed as small as possible are mounted on shafts and must therefore have at least eleven teeth in order to provide sufficient root diameter to accommodate the necessary shaft. Accordingly, one of the vital features of this disclosure is to provide a gear train with the shiftable element having less than eleven teeth and preferably using a pinion of the smallest possible size which can be manufactured. Modern developments in the art of cutting gears have enabled pinions to be formed with as few as five teeth but such pinions could not be provided with the conventional screw shift automatic mesh devices known at present in similar constructions for a shaft having a diameter equal to the root diameter of even a seven tooth pinion would be inadequate to meet the strength requirements.

The present disclosure features the omission of the usual size pinion and its contained screw shaft and nut advancing organization. There is used instead a small compact, practically solid and therefore rugged, shiftable one-piece element with one portion cut to form a few teeth therein, preferably less than seven, and another portion extending integrally from the tooth portion formed cylindrical and of a diameter greater than the root diameter of the pinion to give adequate torsional strength to the element as a whole, to give a "shrouded" effect to one end of the pinion teeth to strengthen the same and to provide a massive journalled part to constitute an improved and powerful shifting device.

One of the primary objects of the invention is to provide a simplified form of automatic shift device for starter gears which can be used with the few teeth pinions herein featured and which can be accommodated within a smaller space than is occupied by similar devices now known and which at the same time will insure a positive actuation even when subjected to the distortional strains usual in heavy duty work. This phase of the invention is attained by compactly telescoping the massive cylindrical part of the shifter element in a driving sleeve and operatively connecting the same through the agency of a pin and helical slot form of drive.

It has been known in this art that there were advantages in using a very steep angle

of helix in similar devices which utilized a screw shifting mechanism to effect the desired meshing of the gears. An angle as high as 45° is preferred so as to avoid all possibilities of the teeth failing to mesh due to end to end contact, but difficulty has been experienced heretofore in producing a nut or internal screw with a thread as steep as 45°. In order to avoid end to end contact of the teeth complicated spring devices which would yield endwise in the event of end to end contact has been employed. Further in prior art devices where the weight of the pinion is carried on a screw thread the pinion is very apt to stick thus rendering the device inoperative as the pinion must be free to move axially.

Accordingly another object of the invention is to provide an automatic shift device which will eliminate the objectionable features inherent in the screw form of pinion shifting device and which will insure a positive intermeshing of the gear teeth while eliminating any incidental sticking between the pinion and its shifting element.

As very high tooth loads are encountered in a device of this type it is important to restrain the pinion from springing or tipping, even in a slight degree, for such action tends to throw all the load upon one corner of the meshing teeth with resulting tendency to breakage.

Accordingly, another object of the invention is to provide a form of bearing support which will maintain the pinion accurately in its requisite axial position, free from spring, canting or other distorting action.

I attain this phase of the invention by journalling the shiftable element in wide, spaced apart bearings provided on opposite sides of the pinion teeth.

Still another object of the invention is to provide a simple form of drive for actuating the starter mechanism manually at will utilizing the same reducing gear train and starter mechanism that is driven by the motor.

Various other objects and advantages of the invention will be in part obvious from an inspection of the accompanying drawings and in part will be more fully set forth in the following particular description of one form of mechanism embodying my invention, and the invention also consists in certain new and novel features of construction and combination of parts hereinafter set forth and claimed.

Referring to the accompanying drawings:—

Figure 1 is a view in vertical section showing a preferred embodiment of the invention in the form of an attachment mounted in operative engagement with an engine of the type usually found in aeroplane motive power constructions;

Figure 2 is an enlarged view in side elevation of the shiftable gear element shown in Figure 1; and

Figure 3 is an enlarged transverse sectional view taken on the line 3—3 of Figure 1 looking in the direction indicated by the arrows.

In the following particular description and in the claims, parts will be identified by specific names for convenience of expression but they are intended to be as generic in their application to similar parts as the art will permit.

In the drawings there is disclosed part of a conventional form of internal combustion engine 10 shown adjacent its crank shaft 11 which shaft is mounted in bearings 12 with an end of the shaft exposed through an opening 13 formed in the engine casing as is usual in a well known engine construction.

The device featured in this disclosure is in the form of an attachment and includes a mechanism containing hollow casing 14 having an exposed end 15 outlined by a flange 16 which is demountably secured to the open end 13 of the engine casing by means of bolts 17. The casing 14 includes an upstanding front wall 18 which provides the main support for the starter mechanism carried thereby. A main drive shaft 19 is journalled adjacent its forward end in antifriction bearings 20 formed in the wall 18 extends across the hollow casing and projects from the open end 15 so as to extend into the engine casing. The exposed end of the main drive shaft is secured by a spline 21 to the crank shaft and constitutes an extension of this shaft. The main drive shaft is provided within the casing with a worm gear drive 22 for driving the magneto (not shown). The casing is designed to provide a support for an electric starter motor 23 and it is a feature of this disclosure that the motor is of smaller size than is usually found in constructions of this character. The front of the casing extends forwardly from the front wall and is flanged to provide a support for a cover plate 24 demountably secured thereto by bolts 25. A gear train is housed between the wall 18 and the cover plate 24 and includes a relatively small motor pinion 26 in constant mesh with a relatively large first reduction gear wheel 27. The gear wheel 27 is provided with a hollow cylindrical barrel hub 28 which extends forwardly from the gear wheel proper and is journalled in a cylindrical bearing 29. This bearing constitutes an integral part of, and projects both rearwardly and forwardly through the cover plate 24. The main drive shaft is provided with a relatively large main driving gear wheel 30 which laps the lower part of the gear 27 and is operatively connected to and driven from the gear 27 by means of a small pinion 31

forming part of shifter device 32 particularly constituting the main element of novelty in this disclosure.

A bearing lining 33 is fitted within the cylindrical bearing 29 adjacent its outer end and provides a support for the outer end of the shifter member 32 which is in the form of an enlarged cylindrical portion 34. The enlarged portion 34 is provided with a blind hole 35 which extends into the same axially from the outer end and is fashioned to accommodate the shaft 36 of a manually actuated crank 37 of conventional form. A driving pin 38 extends diametrically across the hub 28 through the part 34 and has a length equal to the external diameter of the driving hub as shown in Figure 3. The pin is contained in a pair of helical slots 39 formed in the enlarged portion 34 adjacent the inner, closed end of the blind hole. It is a feature of this disclosure that the helical slots have a very steep angle of helix and in the disclosure this angle is about 45°. The central portion of the device 32, provided with the teeth 40 forming the pinion 31, is reduced from the large cylindrical portion 34 to form a rugged spring engaging shoulder 41 facing in the direction of movement of the device when effecting an intermeshing with the gear driven thereby. The teeth 40 are cut to the end of this reduced portion opposite the shoulder but are solidly connected at the end adjacent the shoulder giving the effect of a shrouded pinion. The opposite end of the member 32, that is, the end opposite the enlarged portion 34 is again reduced to form a long solid cylindrical extension 42. This extension has a sliding engagement in an outbearing 43 which is relatively long and formed in the inner wall 18 in position to be disposed as close as is physically possible to the periphery of the gear 30. It will be understood from this construction that the pinion is journalled at opposite ends in spaced apart bearings which are accurately machined so as to permit free end movement axially of the shifter device and which will defeat any tendency of this device from shifting out away from its axis of movement.

While it is possible that the shifted device will function by virtue of its inertia, the disclosure illustrates a precautional feature for insuring a resistance to any tendency of the device to rotate under the influence of its driving member. For this purpose there is illustrated a spring plunger 44 carried by the bearing 29 and which plunger extends through the sleeve 33 and bears in relatively light frictional engagement with the enlarged portion 34 of the shifter device.

A cushioning stop 45 is provided to take up the shock after the meshing action is complete and the driving commences between the pinion and gear 30. This stop is in the form of a spring located in the path of travel of the pinion, encircling the pinion and disposed between the shoulder 41 and a flange 46 defining the inner end of the hub. This flange is provided with an opening of a size to permit the pinion to pass there through.

In operation and assuming that the parts are in the position shown in Figure 1 and that it is desired to rotate the crank shaft 11. The starter motor is caused to rotate its pinion which in turn drives the first reduction gear 27. The turning of the gear 27 causes its hub 28 to rotate in the long bearing provided by the barrel 29 and the hub acts on the pin 38 at its ends to cause the same to turn over. As the pin revolves it bears adjacent its opposite ends against the inclined slots in the shifter device 32. This member will be held initially against rotation either by its own inertia or by the resistance to rotary movement imposed thereon by the plunger 44. Owing to the angularity of the helical slots there is produced an axial thrust on the shifter device which moves the pinion from the position shown in Figure 1 to the right and into mesh with the main driving gear 30 and therethrough power is transmitted through the main drive shaft 19 to the crank shaft.

The spring 45 is so proportioned in its length and tension that the pinion is in position meshing with the main driving gear before the shoulder 41 engages the left end of the spring. When the pinion and gear are fully engaged the spring acts as a yielding abutment and cushions the shock as it arrests the end movement of the pinion. The helical slots are preferably made long enough so that the cross pin does not reach the end of the slot until the spring is sufficiently compressed to hold the pinion from further end movement, after which the driving connection is effected.

As the crank shaft begins to turn under its own power it overruns the electric motor and acts through the shifter device to reverse the direction of twist between the shifter and the hub 28. There is thus produced a reaction between the helical slots and the cross driving pin which acts to withdraw the pinion from its meshing engagement with the gear wheel 30.

By means of a device of the character disclosed it is possible to use a pinion with as few as five teeth and at the same time provide a connection with its shifting and driving members capable of transmitting the powerful torsional forces necessary to start aeroplane engines.

As the driving shaft is integral with the pinion and has a diameter even greater than the diameter of the pinion there is

provided all the desired torsional strength while shrouding the pinion teeth. Incidentally the small size of pinion used permits the use of a small electric motor while giving a larger gear reduction than has been possible heretofore and thus further contributing to the desideratum of light weight and compactness of parts.

The present disclosure eliminates certain disadvantages which have been inherent in similar devices using screw forms of shifting mechanism. A 45° helical slot can readily be formed in the shifter device with an end mill even in the blind hole disclosed, thus eliminating end jamming without the necessity of providing cushioning devices for this purpose.

As the action of devices of this character depend upon the lagging of the pinion behind the member that drives it, any sticking of the pinion which would retard its end movement renders the device inoperative and this is especially true where the weight of the pinion is carried on a screw thread. In the present disclosure the pinion is carried on stationary bearings independent of the driving element and has no other contact with the element that drives it except the contact of the cross pin which fits freely in the helical slots. As the pinion and its driving sleeve are formed in one piece and journalled at spaced apart points there is avoided any sticking between the mesh pinion and the sleeve which drives it. The helical slot construction permits the surfaces, which coact to produce automatic mesh and which have to take the driving loads, to be disposed at relatively great radius. As the shoulder which engages the cushioning spring is formed integral with the pinion and with the sleeve which drives it, it can be made rugged and thus absorb the considerable loads and impacts to which it is subjected in operation. The rigid bearings provided on opposite sides of the pinion prevents the pinion from springing or tipping and thus eliminates the throwing of the loads on one corner of the teeth with resulting danger of breaking. The cross pin which engages the helical slot forms a convenient point for actuating the device manually by the engagement therewith of a manually actuated crank thus utilizing the same reducing gear train to effect the turning over of the engine by hand as that through which it is driven by the motor.

Having thus described my invention, I claim:

1. In an engine starter, the combination with a casing provided with means at one end for securing the same to the engine to be started, said casing including a pair of parallel walls defining its opposite end, a driving shaft journalled adjacent one end in one of said walls and having its other end projecting from the casing and fashioned to engage a movable element of the engine, a motor carried by the casing as a part thereof, and a reducing gear train contained within the casing and operatively connecting the motor and the driven shaft, said train disposed between the parallel walls and including a sliding gear element journalled at two spaced apart points in both walls.

2. In an engine starter, the combination with a casing provided with means for securing the same to the engine to be started, said casing including a pair of parallel walls, a driving shaft journalled adjacent one end in one of said walls and having its other end fashioned to engage a movable element of the engine, a motor carried by the casing as a part thereof, a reducing gear train operatively connecting the motor and the driven shaft, said train disposed between the parallel walls and including a sliding meshing gear journalled at two spaced apart points in both walls, whereby the sliding gear is carried by two stationary bearings.

3. In an engine starter, the combination of a hollow casing opened at one end and provided adjacent said open end with means for mounting the same on the engine to be started, starter mechanism housed within the casing and including a driving shaft extending through said open end, and provided with means for connecting the same directly to a revolving element of the engine, a motor carried by the casing and a reduction gear train for driving the shaft from the motor, said train including an element provided with means controlled by the torque of the shaft for moving one element of the train into an inoperative position and controlled by the torque of the motor for moving said element into an operative position, said element having one end exposed and adapted to be engaged by a manually actuated member for operating the starter mechanism manually.

4. In an engine starter, the combination of a hollow casing having an open end provided with means for mounting the starter on the engine to be started and provided at the opposite end with an end wall having means for receiving a cover plate, a driving shaft journalled in said end wall extending through said casing and projecting exteriorly of the casing through the open end to engage a rotatable element of the engine, a motor carried by the casing, a reducing gear train connecting the motor and driving shaft and including an automatically shiftable meshing gear and a cover plate engaging the end wall for housing the gear train and providing a support for the shiftable meshing gears of the gear train.

5. In a device of the class described, the combination which includes a pair of lapping gears, a member mounted for rotary movement about the axis of one of the gears and shiftable axially, a part of said member provided with teeth to form a small pinion in one position meshing with the other of said gears to form therewith a reducing gear train, another part of said member being cylindrical, a bearing for said cylindrical part and a pin and slot connection between the first named gear and said cylindrical part for transmitting torque forces from one to the other, said connection being fashioned for shifting the member axially as the cylindrical part is rotated.

6. In a device of the class described, the combination of a plurality of gears and a connecting pinion coacting to form a reducing gear train, said pinion having a cylindrical end portion formed with a diameter substantially equal to the diameter of the teeth thereby to give the effect of a shrouded pinion and a pin and slot shifting device operatively engaging said cylindrical end portion for shifting the pinion axially.

7. In a device of the class described, the combination of a pinion having a cylindrical end portion formed with a diameter substantially equal to the diameter of the teeth thereby to give the effect of a shrouded pinion, means including a pin extending diametrically through said cylindrical end portion for shifting the pinion axially and means engaging the pinion on opposite ends of the tooth containing portion for journalling the same at spaced apart points.

8. In a gear drive, the combination with a driving member provided with a hollow cylindrical hub, a cross pin extending diametrically across said hub, a shifter device provided with spiral slots containing said pin and also provided with teeth cut thereon to form a pinion adapted to be driven by the pin and a two point fixed support for said shifter device.

9. In a gear drive, the combination with a driving member provided with a hollow cylindrical hub, a cross pin extending diametrically across said hub, a shifter and driving device provided with spiral slots containing said pin and adapted to be rotated thereby and also provided with teeth cut therein to form a pinion, and a fixed bearing for said shifter device.

10. In a device of the class described, a gear train including a large gear having a hollow barrel hub, a cross pin extending diametrically across the hub, a bearing for said hub, a shifter device provided with a gear train connecting pinion, said device being slidably mounted in said bearing and extending axially through said hub, said device provided with a spiral slot containing said pin and means for retarding the rotary movement of the shifter device whereby the rotation of the large gear will act on the shifter device to move the same axially along said bearing and cause the pinion to complete the gear train.

11. In a device of the class described, a gear train including a large gear having a hollow barrel hub, a cross pin extending diametrically across the hub, a bearing for said hub, a shifter device provided with a gear train connecting pinion, said device extending axially through said hub, and provided with a spiral slot containing said pin, means for retarding the rotary movement of the shifter device whereby the rotation of the large gear will act on the shifter device to move the same axially along said bearing and cause the pinion to complete the gear train and means housed within the hub for cushioning the movement of the shifter device.

12. In a device of the class described, the combination of a hollow driving hub, having a pin extending into the same, a shifter device mounted for axial movement in the hub provided with a helical slot containing said pin and with a reduced portion forming a shoulder, said reduced portion cut to form a pinion adapted to mesh with a driven member, means engaging the shifter device and tending to resist rotary movement while permitting axial movement thereof, a spring disposed between the shoulder and the hub and acting to resist the axial movement of the shifter device into its pinion meshing position.

13. In a device of the class described, the combination with a driving sleeve, a shifter device free to move axially in said sleeve, means providing bearings encircling the device at opposite ends thereof for supporting the device entirely free of the driving sleeve thereby to minimize sticking action between the sleeve and device and means between the sleeve and device for shifting the device axially as it is held by its inertia from rotary movement with the sleeve.

14. In a device of the class described, the combination which includes a driving sleeve, a member provided with a blind hole at one end and mounted for axial movement in said sleeve, the part of the member provided with the blind hole having a helical slot in the side thereon, a pin drive between the sleeve and slot, the portion of the member beyond the blind hole being solid and provided with teeth to form a pinion and a crank adapted to fit in said blind hole and to engage said pin to turn the sleeve.

15. In a device of the class described, the combination with a gear, of a shiftable integral member having a pinion on one part and a helical slot, a rotating pin engaging in said slot rotating and shifting the member as a whole to bring the pinion into mesh-

ing engagement with the gear, one end of said shiftable member being open to provide access to the pin, thereby to permit the actuation of the member by a crank engaging the pin, and a resilient abutment for bringing the member to rest when the meshing action is complete.

16. In an engine starter, the combination which includes a one-piece shiftable gear train element with one part cut to form a pinion solid between the roots of its teeth, with another part enlarged from the pinion forming part to form a spring abutting shoulder, with an end part coacting with said last named part to form a pair of spaced apart journals, fixed bearings for supporting said journals, and means for driving and shifting said one-piece element.

17. In a device of the class described, the combination of an open end driving sleeve mounted for rotary movement and having a pin extending across the same adjacent the open end, a shifter device having a helical slot for containing the pin, said pin providing a means adapted to be engaged by a manually actuated member inserted through the open end of the sleeve for actuating the shifter device manually.

18. In a device of the class described, the combination of a gear, a pinion mounted for axial movement to and from a meshing engagement with the gear, a fixed support for each end of the pinion, means for shifting the pinion, one of said pinion supports containing said shifting means.

19. In a device of the class described, the combination of two telescoping barrels, a cross pin engaging the outer barrel, the inner barrel having a helical slot in which said pin is mounted, means for supplying power to one of the barrels and means for taking power off the other barrel, the central portion of the pin being exposed through an end of the inner barrel to permit the engagement therewith of a supplemental power means.

20. In an engine starter, the combination with a driving member, a driven gear and automatically actuated shiftable means for driving the gear from the driving member, said means including a one piece axially shiftable pinion having a relatively small pitch diameter with less than eleven and more than four teeth, provided on opposite sides of the tooth portion with smooth cylindrical portions constituting journals formed integral with the tooth portion and the tooth portion being solid between the roots of the teeth to obtain adequate strength and fixed bearings for said cylindrical journal portions.

21. In an engine starter, the combination with a driving and a driven gear, of a driving connection therebetween including an axially shiftable pinion having less than eleven and more than four teeth, said pinion being solid between the roots of the teeth and provided on one side of the tooth portion with means integral therewith providing bearings for supporting the same and tending to reinforce the teeth containing portion and means operatively connected with said integral means for shifting the pinion.

22. In a device of the class described, the combination which includes a driving gear, a driven gear, a mesh pinion coaxial with the driving gear, journals on each side of the mesh pinion, a fixed bearing for each journal, and automatic meshing means for driving the pinion from the driving gear.

23. In a device of the class described, the combination with a driving sleeve, a shifter device free to move axially in said sleeve, actuating means between the sleeve and device for shifting the device automatically and fixed means for supporting the device entirely free of the driving sleeve thereby to minimize sticking action between the sleeve and device, said means supporting the shifter device directly at spaced points and independent of the actuating means.

24. In an engine starter, the combination with a driving element provided with a hub, a cross pin extending diametrically across said hub, an axially shiftable pinion provided with a spiral slot containing said pin and adapted to be rotated thereby, said pinion provided with teeth cut therein and a fixed bearing for said pinion.

Signed at Keyport, in the county of Monmouth and State of New Jersey, this 13th day of May, A. D. 1921.

ROLAND CHILTON.