May 30, 1939. R. P. LANSING 2,160,479

ENGINE STARTER

Original Filed April 8, 1927 6 Sheets-Sheet 1

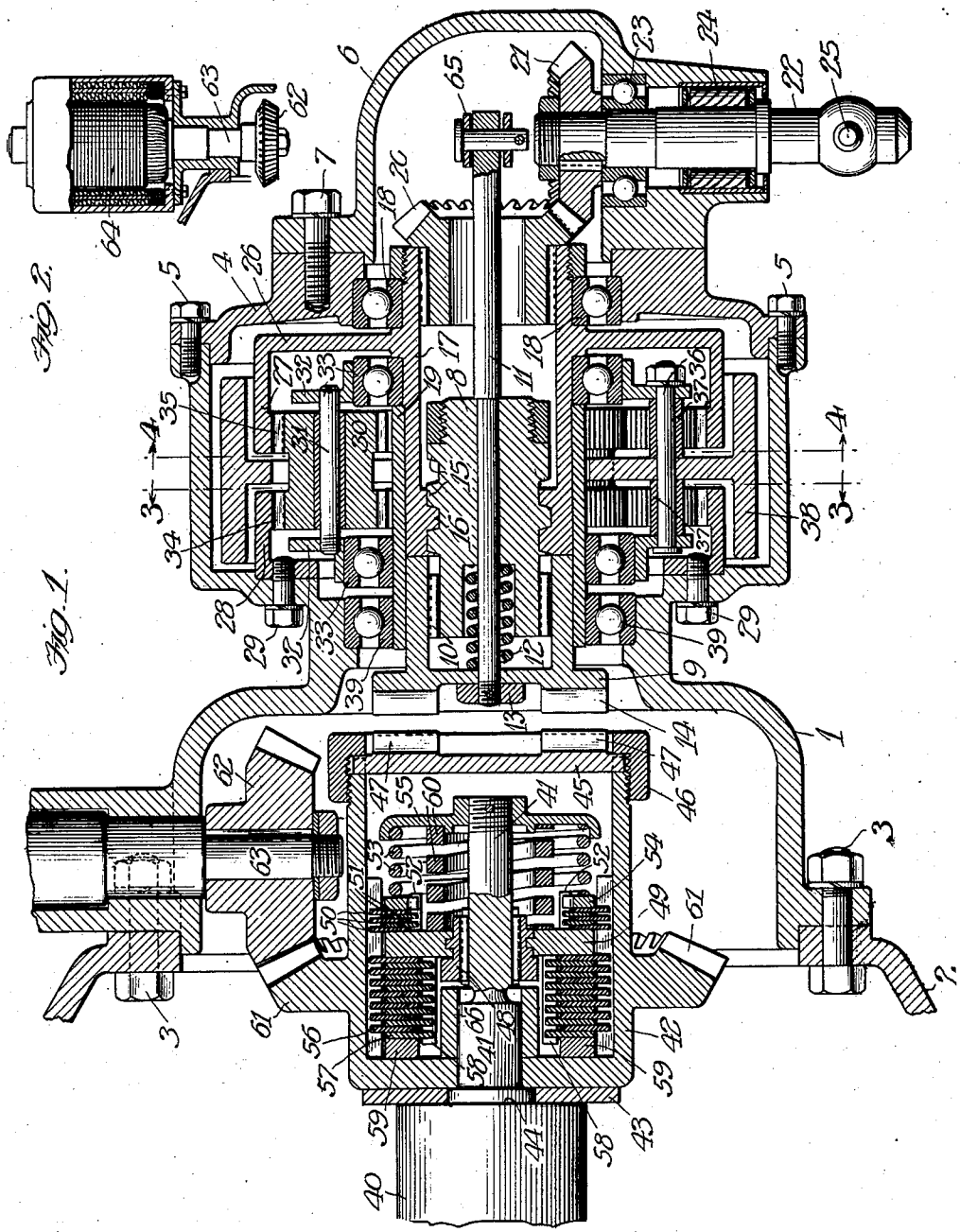


Fig. 2.

Fig. 1.

Witness
Martin H. Olsen.

Inventor
Raymond P. Lansing
By Rector, Hibben Davis & Macauley
His attys

May 30, 1939. R. P. LANSING 2,160,479

ENGINE STARTER

Original Filed April 8 ,1927 6 Sheets-Sheet 2

Fig. 4.

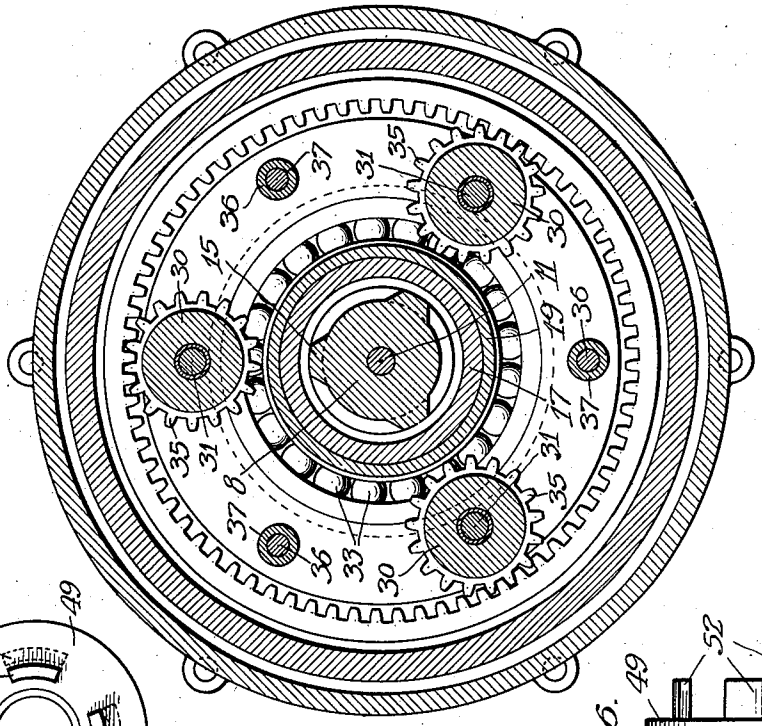


Fig. 5.

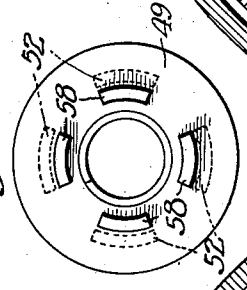


Fig. 6.

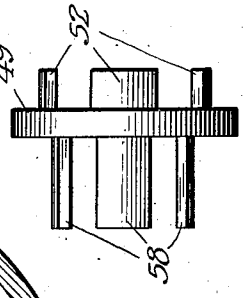
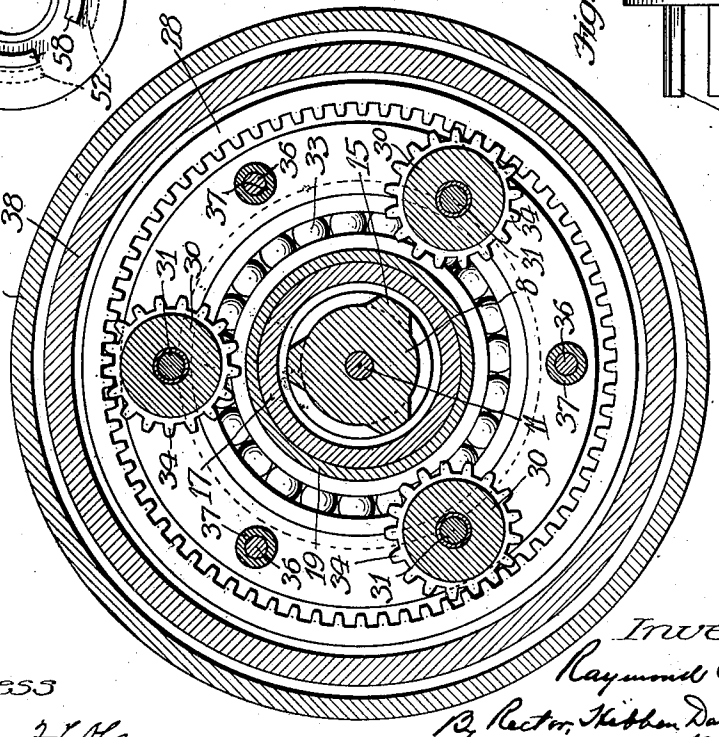


Fig. 3.



Witness
Martin H. Olsen.

Inventor
Raymond P. Lansing
By Rector, Hibben, Davis & Macauley
His Attys

May 30, 1939. R. P. LANSING 2,160,479

ENGINE STARTER

Original Filed April 8 ,1927 6 Sheets-Sheet 3

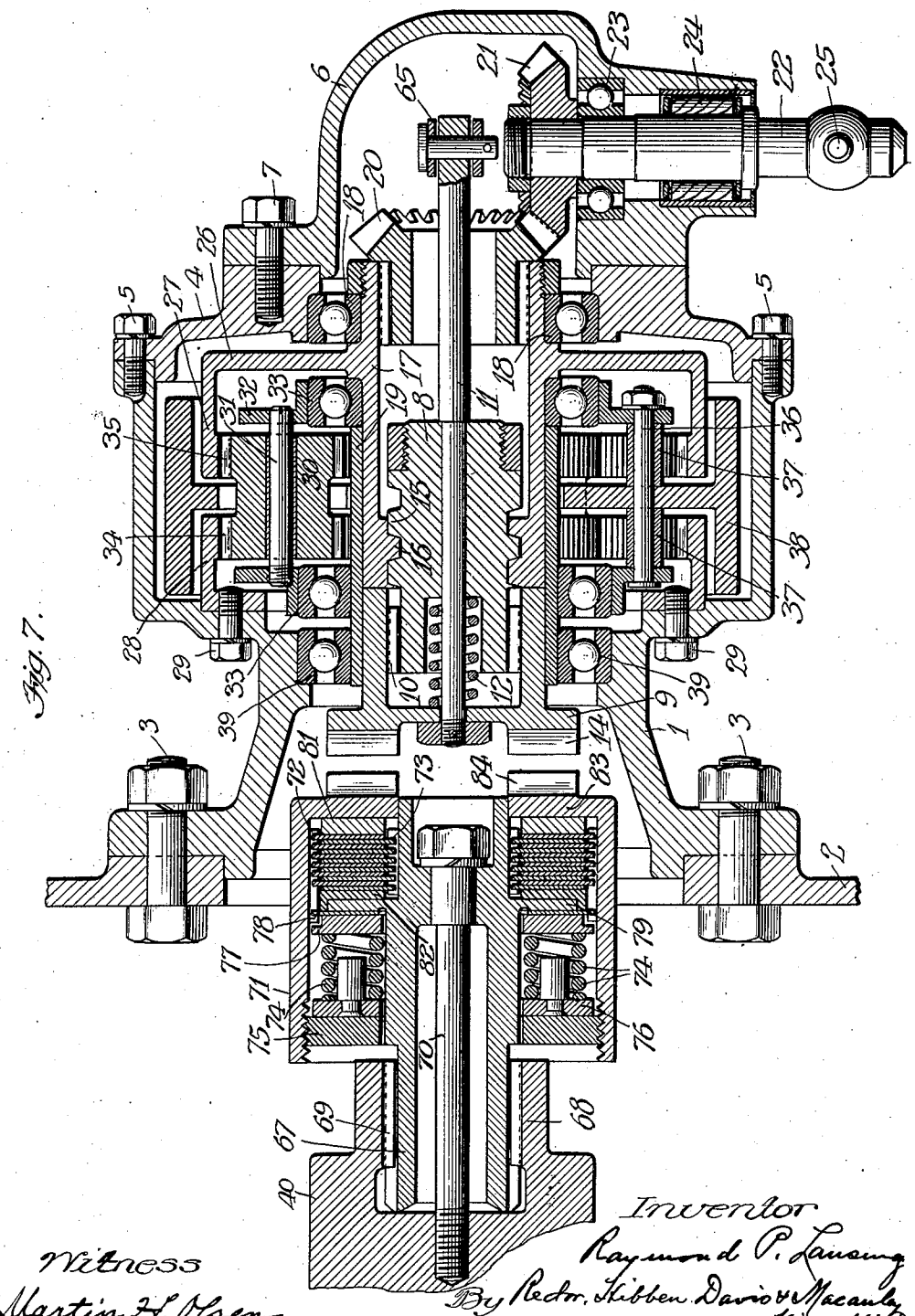


Fig. 7.

Witness
Martin H. Olsen.

Inventor
Raymond P. Lansing
By Redm. Gibbon Davis & Macaulay
His Attys.

May 30, 1939. R. P. LANSING 2,160,479

ENGINE STARTER

Original Filed April 8, 1927 6 Sheets-Sheet 4

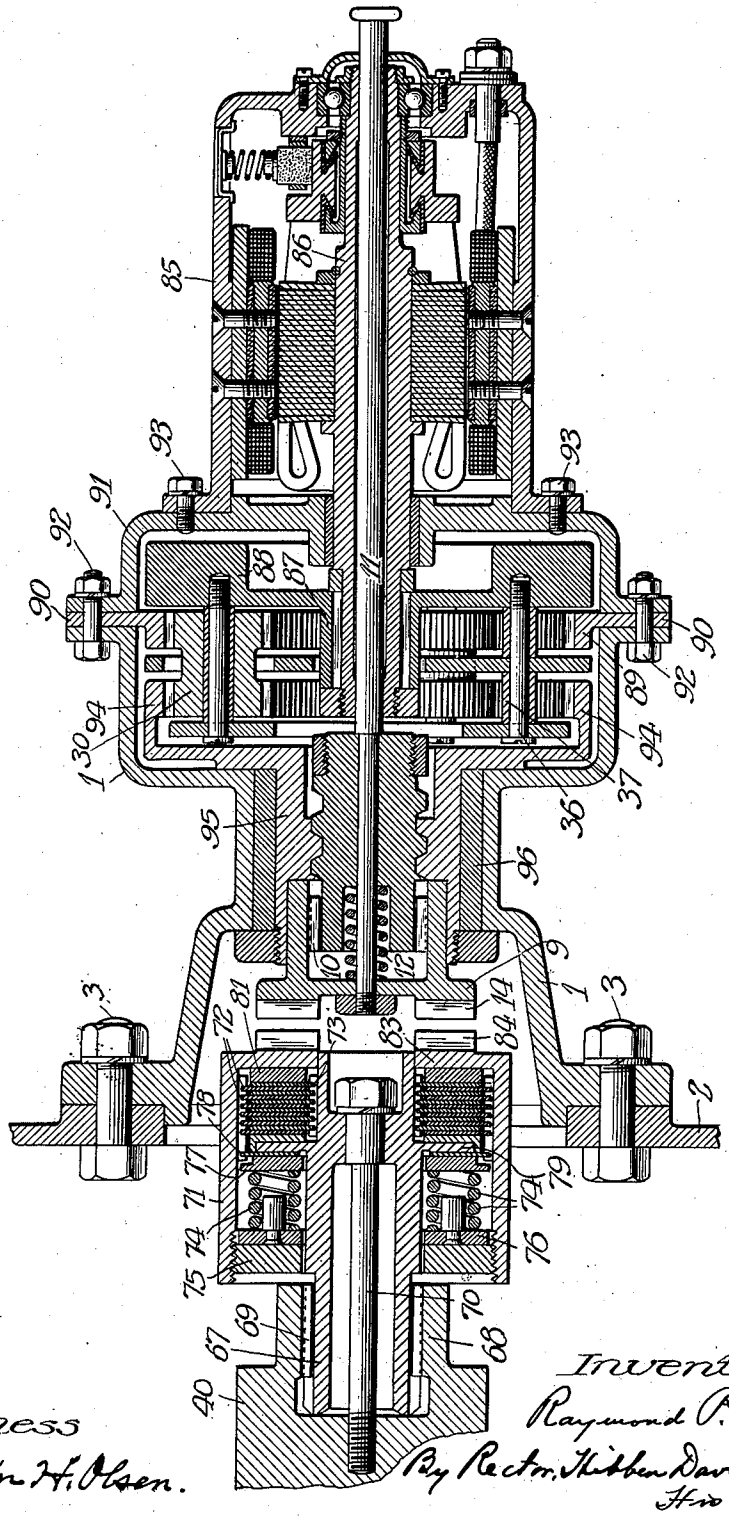


Fig. 8.

Witness
Martin H. Olsen.

Inventor
Raymond P. Lansing
By Rector, Hibben, Davis & Macauley
His Attys

May 30, 1939. R. P. LANSING 2,160,479

ENGINE STARTER

Original Filed April 8, 1927 6 Sheets-Sheet 5

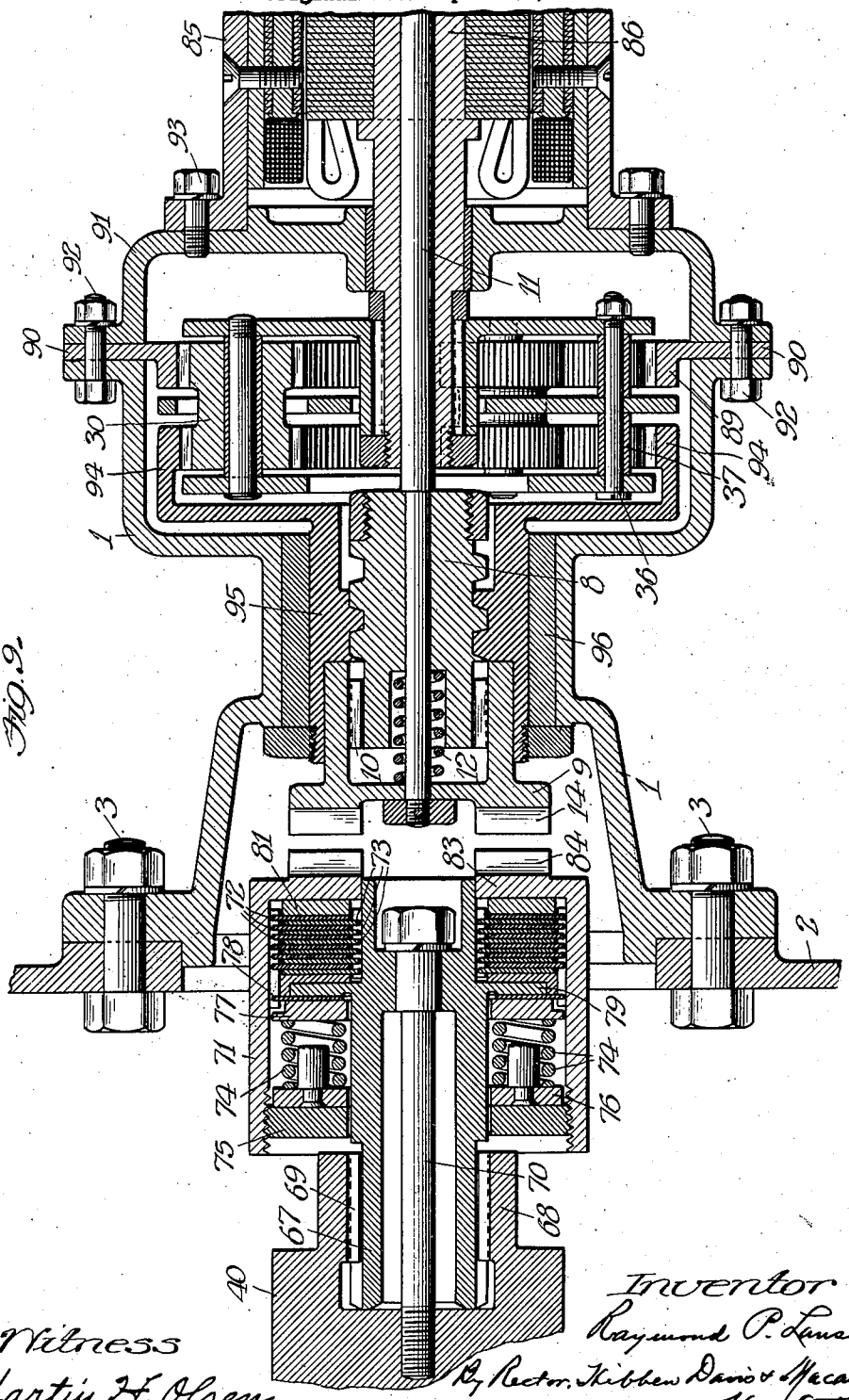


Fig. 2.

Witness
Martin H. Olsen.

Inventor
Raymond P. Lansing
By Rector, Hibben, Davis & Macauley
His Attys

May 30, 1939 R. P. LANSING 2,160,479

ENGINE STARTER

Original Filed April 8, 1927 6 Sheets-Sheet 6

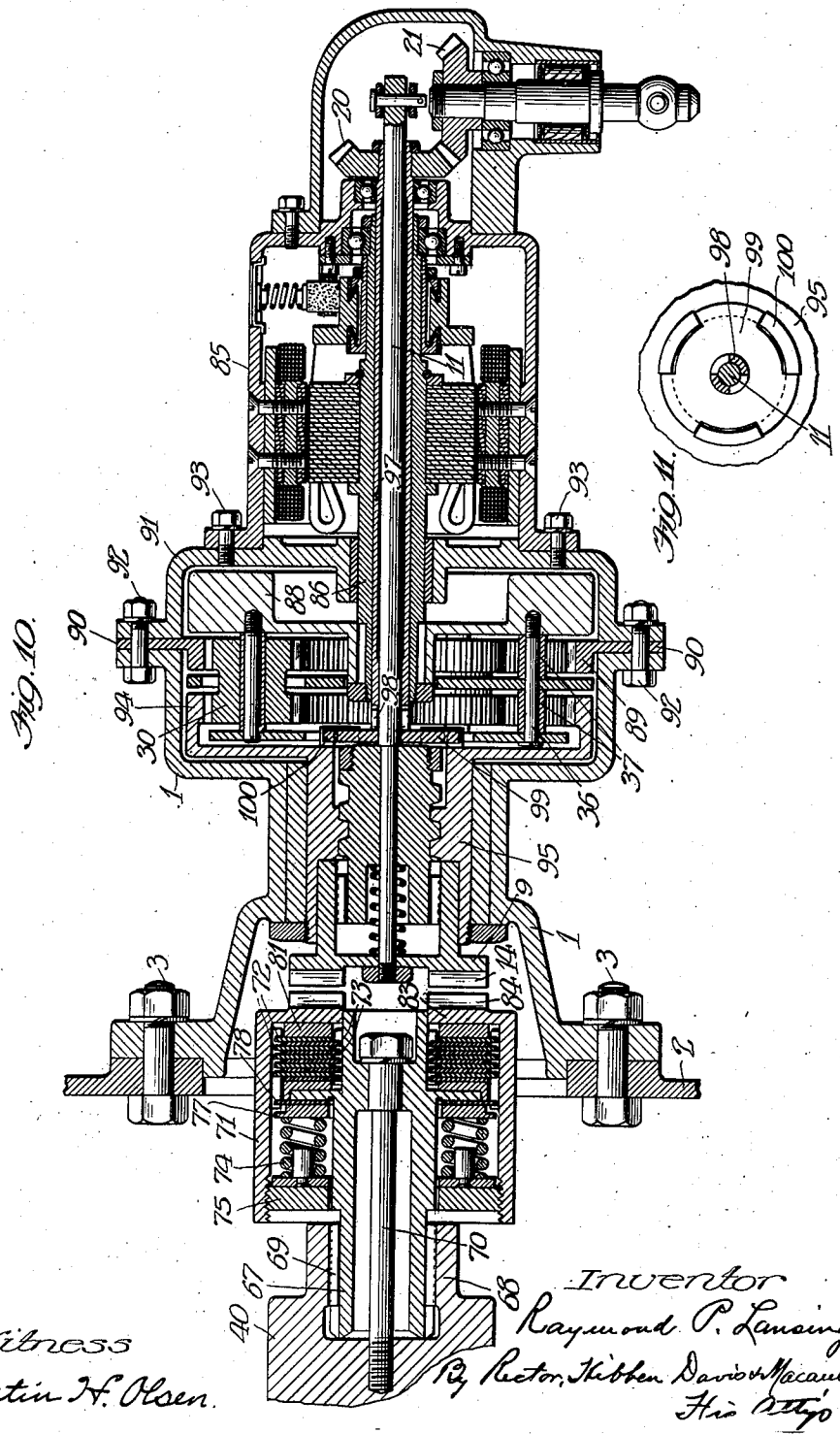


Fig. 10.

Fig. 11.

Witness
Martin H. Olsen.

Inventor
Raymond P. Lansing
By Rector, Hibben, Davis & Macauley
His Attys

Patented May 30, 1939

2,160,479

UNITED STATES PATENT OFFICE

2,160,479

ENGINE STARTER

Raymond P. Lansing, Montclair, N. J., assignor, by mesne assignments, to Bendix Aviation Corporation, South Bend, Ind., a corporation of Delaware

Application April 8, 1927, Serial No. 181,975
Renewed January 29, 1936

5 Claims. (Cl. 123—179)

My invention relates to engine starting apparatus for the starting of engines, such as internal combustion engines and more particularly, but not necessarily, airplane engines, and the object thereof is to provide a simple, efficient and reliable apparatus capable of either manual or power operation, or both, and characterized by the location and mounting of the yieldable driving mechanism of the starting apparatus substantially directly upon a rotatable part of the engine to be started, such as the crank shaft thereof, whereby such mechanism utilizes a space within the crank case or adjacent the crank shaft which space is not otherwise used, and whereby the driving apparatus itself which is attached to the crank shaft may be correspondingly shortened, as well as other advantages of structural and functional character which will be made apparent from the description hereinafter given. My invention in its more complete structure is also characterized by the employment of such mechanism as the connecting or driving mechanism between the engine and an electric generator, provision being preferably made in such mechanism for a different torque capacity in the direction for the cranking of the engine than in the opposite direction for the driving of the generator, the first named direction having the higher capacity for torque transmission. Also in the complete and present preferred structure of my apparatus I employ an inertia device which is combined and arranged in novel manner with certain mechanism of such starting apparatus, more particularly the reduction gearing employed by such inertia device, which feature and also the feature of the driving of a generator are not necessary or required in the broader aspect of my invention.

In the more complete and preferred embodiment of my invention as herein shown in Fig. 1, and selected for convenience in making disclosure thereof, my starting apparatus comprises a transmission or drive including a driving member adapted to crank a member of the engine to be started such as the crank shaft thereof, through the medium of a yielding driving connection which instead of being a part of the starter drive or transmission proper is mounted upon such engine member, and hand means and power means such as an electric motor for actuating the starting apparatus. The power means and the manual means may be combined in the same apparatus and usable separately or conjointly if desired, or the apparatus may be provided simply with either one of these two power means, all of these arrangements being shown in the drawings. Also such embodiment includes an inertia means such as the flywheel which in the present instance forms a part of the reduction gearing of the starting apparatus and such complete embodiment also includes the feature of the utilization of the yielding driving mechanism as the driving mechanism between the engine and the electric generator.

Insofar as my invention in its broader aspect is concerned, that is the provision of yielding driving mechanism upon the engine member adapted to function with the starting apparatus proper, the particular construction of such starter apparatus may be of any suitable character, but I prefer to employ the practical construction of apparatus as shown in the drawings and as hereinafter described in detail.

In the drawings, Figure 1 is a vertical section of my apparatus taken on an irregular section line in order to show the manual means on the same plane, whereas its position in practice is at right angles to the position shown; Fig. 2 is an elevation on a smaller scale illustrating the generator and associated parts; Figs. 3 and 4 are cross-sections on the corresponding section lines of Fig. 1 looking in the directions of the arrow; Figs. 5 and 6 detail views; Fig. 7 is a view similar to Fig. 1 but omitting the electric generator and the driving connection therefor; Fig. 8 is a view similar to Figs. 1 and 7 but illustrating power means for driving the apparatus and including the use of an inertia device; Fig. 9 is a view similar to Fig. 8 but on a larger scale and also omitting the inertia device; Fig. 10 is a view similar to Fig. 1 but illustrating a structure employing both the power means and the manual means in one apparatus; and Fig. 11 a detail view of a part in Fig. 10.

Describing the particular embodiment of my invention as herein shown in Figs. 1 to 6, and first referring to the starter drive proper, the same is located within a main casing 1 which is suitably supported as by being detachably connected with the crank case 2 of the engine in suitable manner as by means of the bolts 3. This casing is provided with an end plate 4 secured thereto by screws 5 and containing bearings for rotating parts as hereinafter described, and also supporting an extension casing 6 secured to the plate 4 by the screws 7 and forming a bearing and enclosure for parts of the manual means.

The driving member proper of the starter apparatus comprises a rotatable and longitudinally movable shaft 8 and also a clutch member 9

mounted on one end thereof for longitudinal movement thereof and rotary movement therewith as by means of splines 10. A manually operated rod 11 extends centrally through the shaft 8 and clutch member 9 and is operatively connected thereto but provision is made whereby the clutch member may have a relative independent movement upon its shaft 8 and the rod 11 against the tension of the coil spring 12. A nut on the outer end of the rod 11 limits the outward movement of the clutch member, this nut being designated by the reference character 13 in Fig. 1, but not so designated in Figs. 7, 8, 9 and 10, although therein shown as applied to the same purpose. This clutch is in the form of a dog clutch with jaws 14 on its outer face.

In the present instance the shaft 8 has screw thread action with respect to its cooperating parts of the transmission and to this end such shaft is a screw shaft provided with external threads 15 which engage corresponding screw threads 16 in the interior of a sleeve 17 acting as a nut therefor which nut is capable of rotary movement but incapable of longitudinal movement. This sleeve is mounted to rotate within anti-friction bearings 18 mounted in the central bore of the plate 4 and also within a bushing 19.

The sleeve 17 is drivingly connected at its outer end with a bevel gear 20 which is adapted to be driven by suitable manually operated means which here comprises a corresponding bevel gear 21 secured to a cranking shaft 22 bearing in the casing 6 by means of the bearings 23 and 24 and extending laterally of the apparatus whereby any suitable hand crank may be applied by the operator to engage the crank pins 25 and thereby rotate the cranking shaft 22 and eventually the driving member 8 and its clutch member 9.

This embodiment is provided with an inertia device and also with reduction means, the sleeve 17 here constituting a component part thereof for compactness and solidity. As shown this sleeve is provided towards its outer end with a peripheral flange 26 and a marginal flange 27 provided internally with teeth to form a rotatable internal gear which is a part of the reduction gearing of the apparatus. A stationary internal gear 28 is secured within the casing 1 by screws 29, the same being of approximately the same diameter as the gear 27 but spaced apart therefrom. This reduction gearing is of the planetary type, being provided with a series of planetary pinions 30 mounted on studs 31 which in turn are mounted in a cage formed by the two parallel plates 32 which are mounted on bearings 33. These pinions have two sets of peripheral gear teeth 34 and 35 which teeth are of different numbers, the left-hand set of teeth 35 having one more tooth than the set 34 for the proper reduction purposes, there being a corresponding difference in the number of the teeth of the two internal gears. The plates 32 are held in proper spaced relation by bolts 36 and spacers 37, such bolts passing through the web of an inertia device herein shown in the form of a flywheel 38 and being thereby secured thereto. This web is positioned centrally with respect to the internal gears 27 and 28 and also concentrically of the reduction gearing, as well as the driving member. This flywheel is thus locked by means of the spacers 37 bearing on opposite sides of the web as shown in Fig. 1. In addition to the anti-friction bearings described I also provide another bearing 39 which is interposed between the central opening of the casing 1 and the bushing 19.

Next describing the yielding driving mechanism which is mounted upon the engine member, such engine member in the present instance is the crank shaft 40 which has a reduced central extension 41 on which such mechanism is mounted and to which it is operatively connected. This mechanism as herein shown comprises a rotatable barrel 42 which is closed at its inner end except for the central opening through which such shaft or extension 41 passes. A washer 43 is preferably interposed between the end of the barrel and a shoulder 44 of the crank shaft. The other end of the barrel is closed by a plate 45 interlocked therewith and held in place by a clamping ring 46 screwing on the outer end of the barrel. This plate 45 constitutes a clutch member and the same is provided on its outer face with clutch jaws 47 complementary to and adapted to be engaged by the clutch jaws 14 of the starter apparatus proper.

The yielding driving mechanism further comprises a screw sleeve 48 which is mounted on the shaft 41 for rotary movement therewith and a slight longitudinal movement thereof as by being splined thereto. This sleeve is externally screw threaded to cooperate with a nut 49. At its outer side this nut cooperates with a friction clutch of constant torque transmitting capacity. In the present instance this clutch comprises two sets of friction plates 50 and 51 which are operatively connected respectively to the interior of the barrel 42 and to an extension or series of tongues 52 on the nut as by being splined thereto. This clutch is of the present type and is always subjected to an engaging pressure the pressure on the plates being obtained through the spiral spring 53 bearing against the ring 54 and consequently against the plates 50 and 51 and also against the abutment plate 55 which is secured to the outer end of the shaft or stud 41.

Another friction clutch is interposed between the nut and the barrel the same comprising two sets of plates 56 and 57 which are splined respectively to the interior of the barrel and to an extension or a series of tongues 58 on the left hand side of the nut, Fig. 1. These friction plates bear at one end against one face of the nut and at the other end against a spacing ring 59 interposed between such clutch and the inner end of the barrel. A rather heavy compression spring 60 is interposed between the abutment 55 and the nut 49.

When the driving mechanism above described is employed as the driving connection from the engine to an electric generator the barrel 42 is provided with a separate or integral bevel gear 61 adapted to mesh with a corresponding bevel gear 62 secured to and driving the extended armature shaft 63 of the generator 64. This armature shaft may have its bearing in the casing 1 as herein shown and be conveniently removable therewith from the crank shaft when the starter apparatus is removed, and the same is likewise assembled under the same condition.

Describing a cycle of operation and beginning with the parts in their normal position shown in Fig. 1, and describing of course the complete apparatus as therein shown, the operator applies the hand crank and rotates the cranking shaft 22 whereupon the sleeve 17 will be rotated through the bevel gears 21 and 20. Likewise the planetary gearing will be rotated and the inertia flywheel will be rotated and thereupon accelerated as the cranking operation continues. When the flywheel has been sufficiently accelerated

the operator will thrust the rod 11 inwardly, that is towards the left in Fig. 1 through operating connections not shown except for the shifting fork 65, whereupon the driving member will be shifted to the left inasmuch as the threads 15 and 16 have a long lead which action is assisted by the rotation of the sleeve 17. The clutch jaws 14 which are now being rotated by the energy stored up in the flywheel will be brought into engagement with the jaws 47 of the yielding driving mechanism. Consequently the barrel 42 will be rotated, and also the nut 49 through the medium of both of the friction clutches which now act conjointly in transmitting the considerable torque of the starting apparatus. The direction of the threads of the nut 49 and sleeve 48 are such that a slight rotation of the nut will cause such sleeve to move to the right and away from the spacing sleeve 66 whereupon the pressure of the spring 60 is caused to bear upon the nut and the friction plates 56 and 57. Consequently, both of the friction clutches are now in action and torque is transmitted through both of them and through the nut and thence to the sleeve 48 and shaft 41 and consequently to the engine which is thereby cranked.

When the engine has started on its own power and thereby becomes the driver instead of the driven member, the excess speed of rotation imparted to the starter apparatus will cause the driving member thereof to be automatically disconnected from the yielding mechanism of the engine through the screw thread action of the shaft 8 and sleeve 17 whereupon the parts will resume their normal position shown in Fig. 1.

Assuming that the yielding driving mechanism is utilized to drive an electric generator, when the barrel 42 is rotated, as by the engine when in operation, such barrel will be rotated by the engine and the torque thereof will be transmitted through the bevel gears 61 and 62 to the generator for the purpose of generating current for any desired purpose, as for instance charging any batteries that may be carried on the airplane or for furnishing ignition and lights either direct thereto or indirectly through the battery. Thus the battery (not shown) may be in multiple relationship, electrically, with the generator 64, whereby the generator will assist the battery by supplementing, or "boosting" the current supplied to the ignition and lighting units by the battery, and thereby furnish ignition and lights either direct thereto or through the battery. Inasmuch as the engine acceleration is considerable and sudden and the weight of the armature is considerable, it is necessary to provide means for limiting the amount of torque transmitted from the engine to the generator. To this end, I make provision for disabling the larger friction clutch composed of the plates 56 and 57 and utilizing merely the lower value clutch composed of the plates 51 and 52 so that when the generator is driven the torque is transmitted merely through the low value clutch. When the engine becomes the driver the rotation of the shaft 41 causes a rotation of the sleeve 48 and as the nut 49 remains in substantially the same plane longitudinally the screw action between these parts will move the sleeve 48 slightly to the left and towards the ring 66 so that the pressure of the heavy spring 60 will be relieved from the larger friction clutch and transferred to the relatively rigid abutment 66 and the torque will then be transmitted from the shaft 41 through the sleeve 48 and nut 49, lower capacity clutch and thence to the barrel 42 and eventually to the generator.

In Fig. 7 I have shown another construction or embodiment of my invention similar to that of Fig. 1 but modified as to the specific construction of the yielding driving mechanism which is mounted upon and drivingly connected to the engine member or crank shaft, and also omitting the generator drive feature. The starter apparatus and the manual means are the same and need not be described but corresponding reference numerals are applied.

Referring to the modified driving mechanism shown in Fig. 7, the same comprises a central shaft 67 which is detachably connected to the central bore 68 of the crank shaft 40 as by means of the splines 69. This shaft is secured to the crank shaft by the central screw 70. A barrel 71 is drivingly connected with the shaft 67 by a yielding driving connection comprising the two sets of friction disks or plates 72 and 73 operatively connected or splined respectively to the interior of the barrel and the exterior of the shaft 67. These friction plates are held in contact with a yielding pressure by means of the series of coiled springs 74 and such pressure is adjusted or predetermined by means of the nut 75 screwing into the inner end of the barrel. These springs bear against a ring 76 interposed between the inner ends thereof and the nut 75, and at the other end against a ring 77 which in turn bears against a washer 78 and thence against a flange 79 of the shaft 67. By preference the clutch plates bear at opposite ends against rings 81 and 82. The ring 81 is interposed between the right hand end of the friction clutch and the inner end of the end flange 83 of the barrel. This flange is provided with clutch jaws 84 complementary to the jaws 14 of the starter apparatus and cooperating in the same manner as the clutch jaws 14 and 47 of the structure of Fig. 1.

The operation of the starter apparatus of Fig. 7 is the same as that of Fig. 1 and with respect to the yielding driving mechanism the torque or energy which had been stored up in the inertia device is transmitted to the clutch jaws 14 and 84, whereupon the barrel 74 will be rotated. The torque is transmitted from the barrel through the friction clutch and thence to the shaft 67 and consequently to the crank shaft of the engine. When the engine starts on its own power the starter apparatus is disconnected in the manner already explained.

In Fig. 8 I have shown another embodiment of my invention similar to that of Fig. 7 with the exception that power means such as an electric motor 85 is substituted for the manual means and a different construction and arrangement of inertia device is provided. In other respects the structure is the same as that of Fig. 7 and corresponding reference numerals are therefore employed and a complete detailed description is unnecessary.

According to Fig. 8 the starting motor 85 has a hollow armature shaft 86 through which the elongated manually operating rod 11 passes and projects beyond the outer end thereof whereby the same may be operated by the hand of the operator or through any suitable linkage or connections, not shown. The projecting end of this armature shaft is drivingly connected by means of splines to the hub 87 of the inertia device or flywheel 88. This flywheel constitutes one of the side members of the cage of the planetary gearing, taking the place of one of the plates 32 of the structure of Fig. 1. The planetary pinions

and the spacing means are the same as hereinbefore described but the internal gears are somewhat differently constructed and arranged. The stationary internal gear 89 is provided with a marginal flange 90 which is clamped between the main casing 1 and a supplemental casing 91 by means of the bolts 92, the motor 85 being detachably connected with the casing 91 by means of the screws 93. This casing 91 also constitutes an end plate or closure for the motor and a bearing for the armature shaft.

The other or rotatable internal gear 94 is formed as a shell extension portion of the screw sleeve 95 which is similar to the sleeve 17 of Fig. 1 but differently shaped and positioned. This sleeve bears in a bushing 96 in the central opening of the main casing 1.

Describing a cycle of operation the electric motor is energized through electrical connections and a switch (not shown) and the flywheel 88 is thereupon rapidly rotated. When the acceleration of this flywheel has reached a predetermined point the current to the motor may or may not be interrupted and the operator will then force the rod 11 inwardly to connect the clutch jaws 14 and 84 in the manner and with the result above explained, whereupon, the energy stored in the flywheel will be transmitted to the engine for cranking the same, after which the starter apparatus will be automatically disconnected when the engine starts on its own power.

In Fig. 9 I have shown a construction similar to that of Fig. 8 except that the flywheel 88 is dispensed with and no provision made for inertia action wherefore the electric motor will drive the driving member and the yielding driving mechanism through the reduction gearing and the screw sleeve. In other respects the operation is the same as that above explained.

In Fig. 10 I have shown another modified form of construction characterized by the provision in one apparatus of power means and manual means which may be operated separately or conjointly. This structure in all of its parts with the exception of the power means and manual means is the same as that of Fig. 8, and hence no further description of such common parts is necessary, but corresponding reference numerals are applied thereto.

In the structure of Fig. 10 the electric motor 85 has its armature shaft 86 made hollow and connected with the hub of the flywheel 88 as in Fig. 8, but interposed between the manually operated rod 11 and such armature shaft there is provided an elongated sleeve 97 to whose right hand end the bevel pinion 20 of the manual means is drivingly connected. The inner or left hand end of this sleeve has interlocking driving connection at 98 with a circular plate 99 which in turn is drivingly interlocked at 100 with the sleeve 95. The described driving connections are formed as interlocks for the purpose of ready assembly and disassembly of the parts. When the motor is operated as the actuating means the operation is the same as explained in connection with Fig. 8. When the manual means is operated the torque is transmitted through the bevel gears 21 and 20, through sleeve 97 and thence to the sleeve 95 and through the reduction gearing to the flywheel 88 after which the mode of operation is the same as above described.

The structures embodying my invention possess numerous practical and functional advantages besides those set forth in the preamble hereof, among which may be stated the following:

By the locating and mounting of the yielding driving mechanism upon the engine member or crank shaft it is possible to make the starter apparatus proper much shorter inasmuch as such driving mechanism no longer constitutes a part of the starter apparatus proper but is removed therefrom and placed in a space not otherwise utilized. Also, this enables the diameter of the pilot mounting of the apparatus to be made smaller and enables the driving member support bearings and the openings in the supplemental casing to be made of smaller diameter which is of advantage in that standard sizes of bearings can be used. Furthermore, by my construction and arrangement the clutch in the yielding driving mechanism and asociated parts are not limited as to radial dimensions as when forming a part of the starter apparatus proper. In addition my construction provides compactness and solidity of parts not only by reason of the structure and arrangement above described, but also by connecting the screw sleeve directly to the reduction gearing and the bevel gear and in fact in making the same a part of such gearing.

I claim:

1. In an engine starting apparatus, the combination, with a rotatable member of the engine to be started, of yielding driven means constantly connected with said engine-member, a central driving member adapted to engage said driven means and crank the engine member, and actuating means therefor including reduction gearing comprising a stationary internal gear, a parallel rotatable internal gear having a hub which is operatively connected with the driving member to rotate it unyieldingly, pinions and a cage therefor, a driving member operatively connected with said hub and adapted to engage and crank the engine member, and driving means connected directly with said cage.

2. An improved crankshaft drive comprising a member extending from the crankshaft and drivably connected thereto to rotate in unison therewith, a friction disc clutch mechanism engageable with said member near the end remote from said crankshaft, a driving member normally out of, but movable into driving relation to said clutch mechanism, resilient means mounted adjacent said member in a position intermediate said clutch mechanism and the crankshaft end of said member to render the latter operative as a driving connection between said driving member and said crankshaft.

3. An engine starting apparatus comprising a planetary gearing including a combined internally toothed and internally threaded member, a threaded driving member cooperating with said internally threaded member, a yielding clutch continually connected with a member of the engine to be started, a second normally disengaged clutch interposed between said driving member and said first named clutch, and means responsive to axial movement of said driving member for engaging said second named clutch for transmission of starting torque from said planetary gearing to said engine member.

4. An engine starting apparatus comprising an internally threaded sleeve and reduction gearing of which such sleeve forms a rigidly driven part, a driving member engaging said threaded sleeve and reduction gearing, a friction clutch continually connected with a member of the engine to be started, a second normally disengaged clutch interposed between said driving

member and said friction clutch, and means responsive to axial movement of said driving member for engaging said second named clutch for transmission of starting torque from said threaded sleeve and reduction gearing to said engine member.

5. An engine starting apparatus comprising reduction gearing including a stationary internally toothed gear and a rotatable internally toothed gear, the latter having an internally threaded hub, a driving member engaging said internally threaded hub and reduction gearing, a yielding clutch continually connected with a member of the engine to be started, a second normally disengaged clutch interposed between said driving member and said first named clutch, and means responsive to axial movement of said driving member for engaging said second named clutch for transmission of starting torque from said threaded hub and reduction gearing to said engine member.

RAYMOND P. LANSING.