Sept. 29, 1931. C. MARCUS 1,824,826

ENGINE STARTER

Filed May 18, 1925 3 Sheets-Sheet 1

Fig. 1.

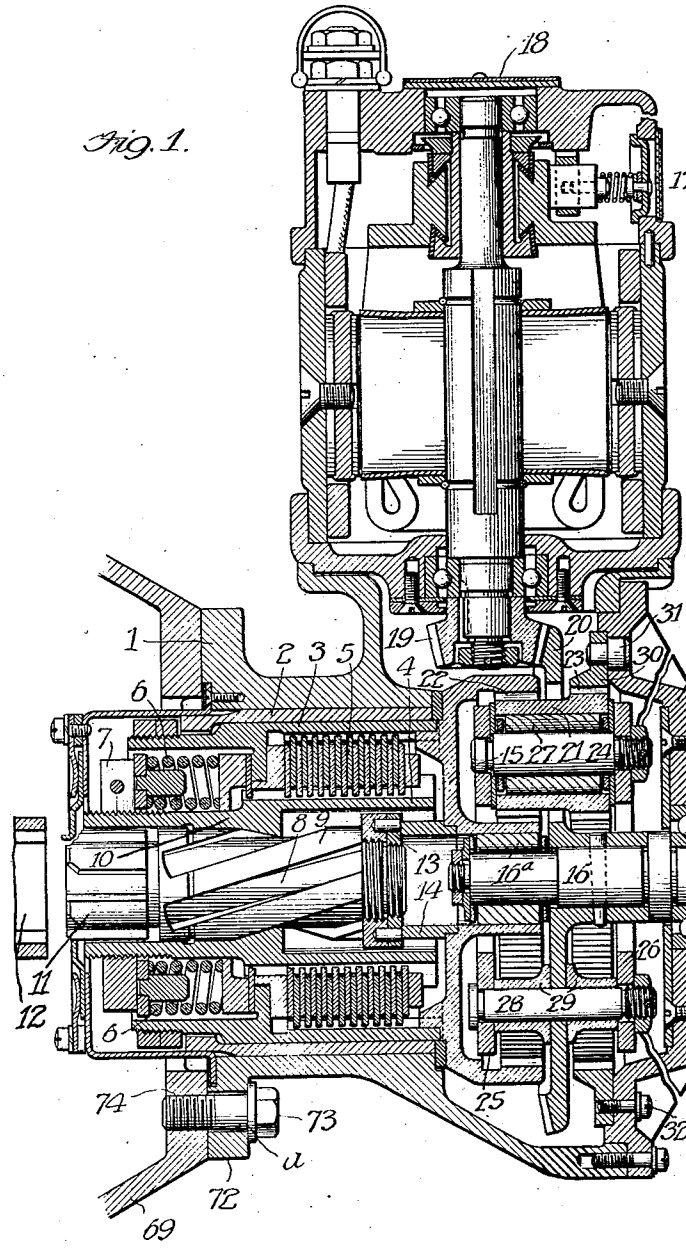
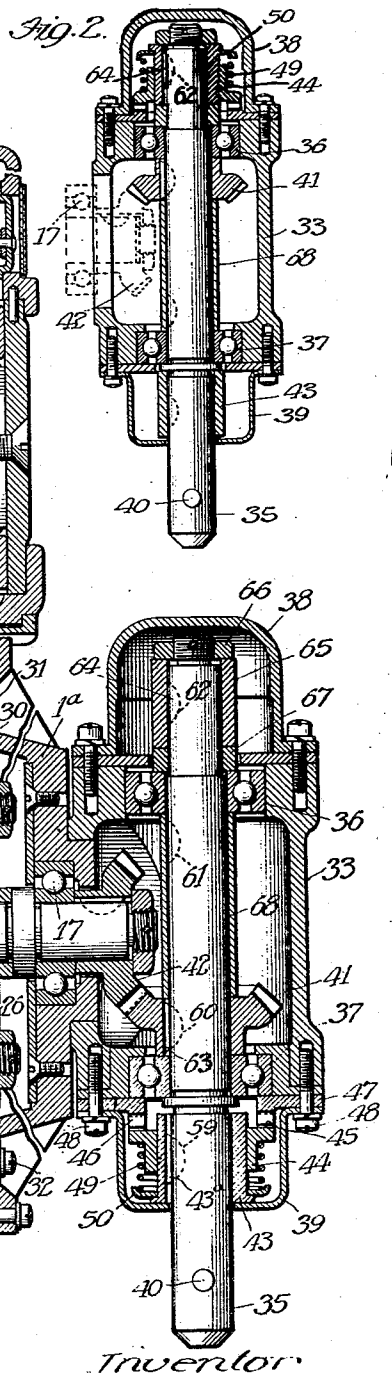


Fig. 2.



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ENGINE STARTER

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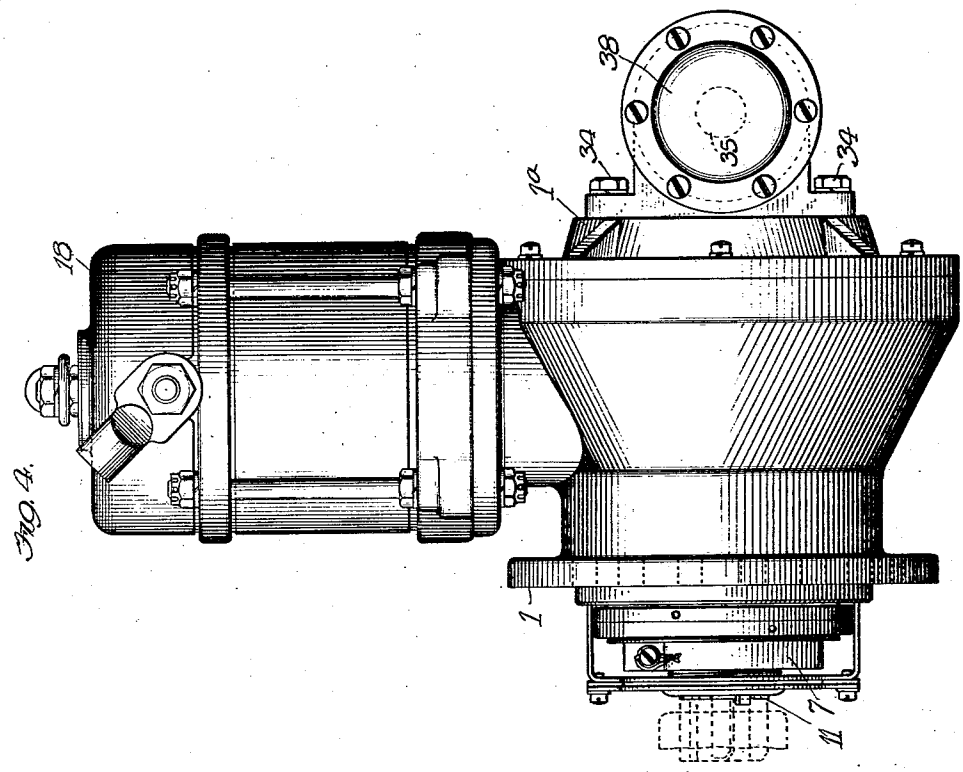

Fig. 4.

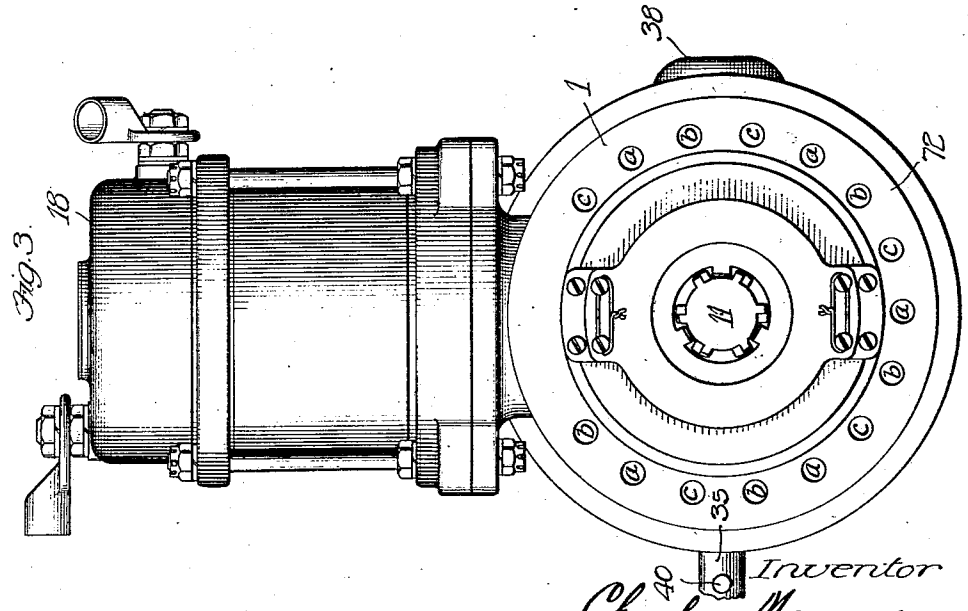

Fig. 3.

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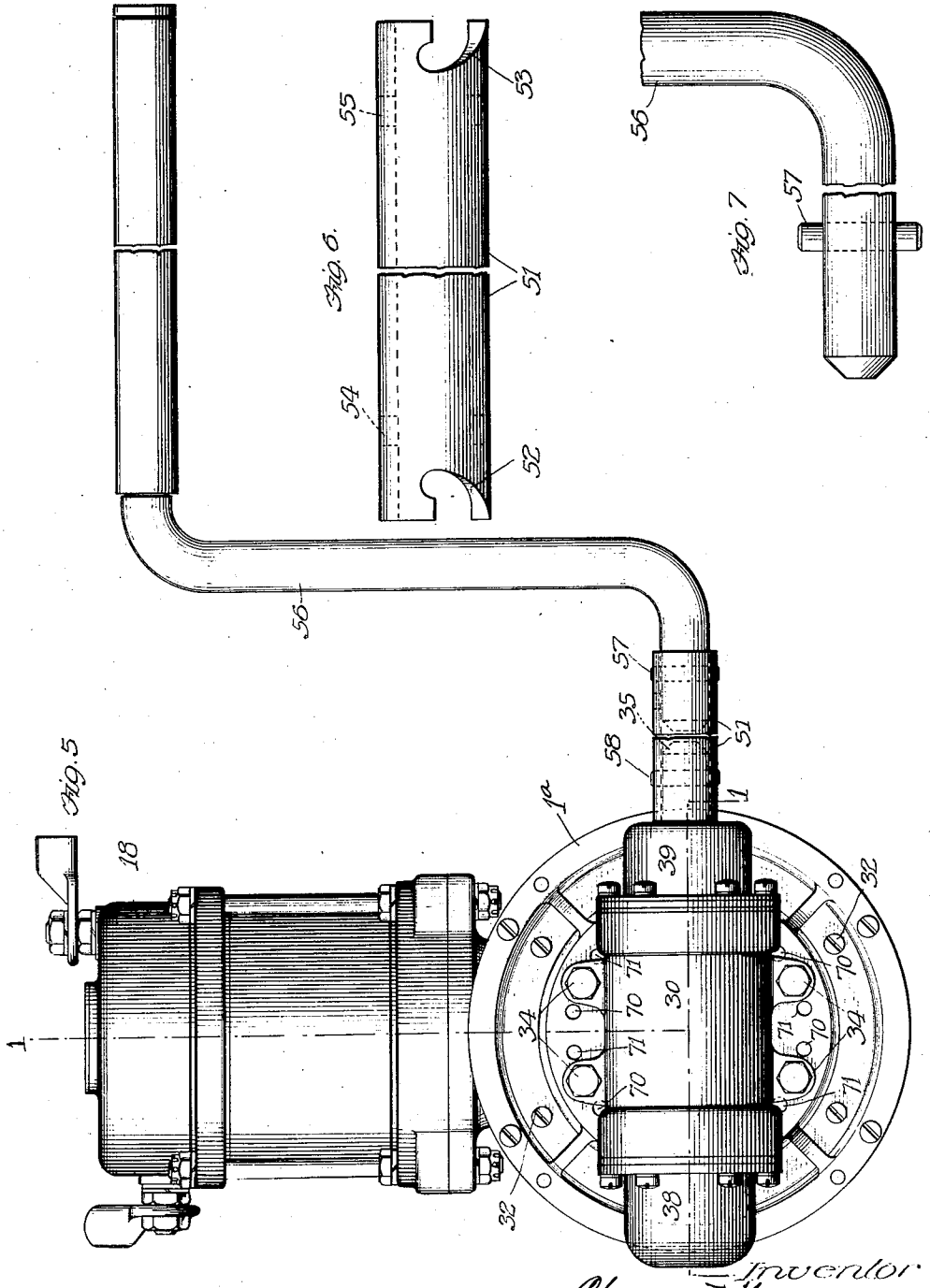

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UNITED STATES PATENT OFFICE

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ENGINE STARTER

Application filed May 18, 1925. Serial No. 30,917.

My invention relates to engine starting apparatus for the starting of internal combustion engines, more particularly the engines of airplanes, and the object thereof is to provide a simple, efficient and reliable apparatus of this character for either power or manual operation or both combined, the apparatus, in its preferred form being such that the manually operated mechanism may be readily applied to and detached from such apparatus and may moreover be reversed in position thereon. The various features of advantage and utility in the construction and operation of my apparatus will be apparent from the description hereinafter given.

In the drawings, Fig. 1 is a sectional elevation of my apparatus with both the power and the manual mechanisms embodied therein, such section being taken on the irregular line 1—1 of Fig. 5; Fig. 2 a section of the manually operated mechanism showing change in relative position of certain of the parts thereof for reversal of direction of engine rotation with the same direction of rotation of the hand crank, or for the same direction of engine rotation with either direction of rotation of the hand crank, the view being on a smaller scale than Fig. 1; Fig. 3 an end elevation of the apparatus viewed at the engine engaging end thereof; Fig. 4 a side elevation of such apparatus; Fig. 5 an elevation of the other end of the apparatus; Fig. 6 an elevation of the cranking tube or extension; and Fig. 7 an elevation of a portion of the hand crank.

Inasmuch as my invention concerns the manually operated mechanism as the source of power or the addition thereto, if desired, of a starting motor as the source of power and also concerns the provision of means for locking the driving connections against backward rotation, such as occurs when the engine back-fires, the particular construction of the drive or transmission for engagement with and disengagement from the member of the engine to be started is immaterial, and therefore, any suitable construction of drive may be employed. However, I prefer to employ the particular drive or transmission illustrated in the drawings, especially in view of the employment therein of a friction clutch which cooperates with the locking means above referred to in case of backfire, such drive being made the subject matter of a co-pending application.

First describing the automatic drive or transmission which is here selected and illustrated in Fig. 1, the same is located in a casing 1 within which is preferably provided a bushing 2. Within this bushing, there rotates a barrel 3 and a shell 4 concentrically arranged therewith and providing a considerable annular space between them in order to receive a yieldable driving connection which is here in the form of a friction clutch 5. The sets of plates of this friction clutch are splined respectively to the interior of the barrel and the exterior of the shell. The proper spring pressure is provided for the friction plates by means of a series of springs 6 which are located in such annular space between the barrel and shaft. The necessary spring tension is provided by the adjustable nut 7 which is threaded onto the outer end of the shell. Within the shell there is mounted a screw shaft 8 having long lead threads 9 which are threaded to the internally threaded or nut portion 10 of the shell. This shaft is provided at its outer end with a driving member which is here in the form of a splined portion 11 adapted when moved longitudinally to engage a rotatable member of the engine to be started, such as the crank shaft 12 thereof which is here provided with internal splines.

When the barrel is rotated in the manner hereinafter explained, such rotation is imparted to the shell 4 through the friction clutch with the result that by reason of the threaded connection between such shell and shaft, the latter is moved outwardly that is, to the left in Fig. 1, and the splined portion 11 thereof is engaged with the engine member and the engine is thereupon cranked. When the engine starts on its own power, such splined portion is automatically demeshed and the same together with its shaft is restored to normal position, as shown in Fig. 1, at which time the abutment nut 13 of the shaft is in contact with the bushing 14 of the main drive wheel 15 of the apparatus.

The operating connections between the starting motor and the manually operated mechanism comprise said main driving wheel 15 in combination with planetary gearing in order to provide a considerable reduction, such as is required in the cranking of airplane engines, in practice the same being a total reduction of 100 to 1 from the motor armature shaft to the driving wheel 15. This main drive wheel 15 is in the form of an internal gear and is mounted to rotate by reason of its connection with the barrel. The main drive shaft 16 which is arranged in line with the screw shaft 8 is journalled within the hub of the drive wheel 15 by means of the roller bearing 16[a] and also in the cover 1[a] of the main casing 1 by means of the ball bearings 17. The electric motor and the manually operated mechanism are respectively operatively connected with this drive shaft 16 in the manner now to be described.

Describing the operating connections between the electric starting motor 18 and the drive shaft 16, such motor which is vertically disposed is provided at the lower end of its armature shaft with a bevel pinion 19 which meshes with a large bevel gear 20 secured to the shaft 16. The bevel gear 20 forms a spider for carrying a set of preferably three planetary gear units each of which comprises a hub 21 having a gear 22 cut thereon at one end and a gear 23 at the other end, the number of the teeth of the gear 22 being less than that of the gear 23. Three equidistant openings are provided in the web of the gear 20 through each of which extends one of such planetary units, each being mounted in place by means of a bolt 24 passing transversely through the spider plates 25 and 26 and secured thereto and having mounted thereon a roller bearing 27 about which the gear hub 21 may rotate. These spider plates 25 and 26 are spaced apart by means of the bolts 28 and the spacer collars 29.

Cooperating with the set of gears 23 is a stationary internal gear 30 which is secured to the interior of the casing 1[a] in a suitable manner as by means of the dowels 31 and the screws 32. The main drive wheel 15, which preferably has a somewhat lesser number of teeth than the gear 30, meshes with the set of planetary gears 22 and the web thereof is secured to the rotatable barrel 3 of the drive or transmission proper. Obviously, when the starting motor is energized the drive will be actuated in the manner hereinbefore described through the planetary gearing by means of which the considerable reduction is accomplished.

Next describing the manually operated mechanism for cranking the engine, such mechanism is contained substantially within and supported by the casing 33 which is secured in a suitable manner as by means of the screws 34 Fig. 5 to one end of the casing cover 1[a] of the apparatus. These screws are so arranged and located that the entire casing 33 together with its contained mechanism may be turned end for end as desired, or as required by the exigencies of the situation, particularly in the event that the apparatus is used on an airplane engine. Extending longitudinally or axially through this casing 33 is a cranking shaft 35, the same being journaled in suitable bearings 36 and 37 arranged within such casing. This cranking shaft extends beyond both ends of the casing proper and is enclosed at one end by an end cap 38 and extends through the center of the end cap 39 at the opposite end of such casing, the same thus protruding from the casing and end cap as shown in Fig. 1 and being thereat provided with suitable crank engaging means, such as the pin 40, adapted to cooperate with the hand crank or an intermediate cranking tube hereinafter explained. The cranking shaft 35 is provided intermediate its length with a bevel pinion 41 keyed thereto and adapted to mesh with a corresponding bevel pinion 42 which is keyed to the end of the shaft 16 which projects through the casing cover 1[a] and into the interior of the casing 33.

Contained within the end cap 39 and cooperating with the cranking shaft is a means for locking such shaft against backward rotation, such as occasioned by back-fire of the engine. The means herein shown comprise a bushing or sleeve 43 which is keyed to the shaft 35 by means of the key 43[a] and in which is adapted to slide the movable member of a sleeve 44 of a ratchet clutch, the same having on its inner face ratchet teeth 45 adapted to cooperate with complementary ratchet teeth 46 on the outer face of a plate 47 clamped by the screws 48 between the end cap 39 and the end of the casing 33 as shown in Fig. 1. The movable ratchet member is normally held in engagement with the stationary member by means of a spring 49 interposed between such movable member and a spring keeper or abutment 50 at the outer end of the end cap 39 and in the interior thereof.

In the event that my engine starting apparatus is used on an airplane, selection is made as to the position of the casing 33 on the apparatus, such casing being capable of being turned end for end thereby permitting assembly to be made for cranking the engine in the same direction but offering a choice of the direction of rotation of the hand crank. The desired selection is made depending upon the accessibility of the hand crank for the operation, particularly in view of the attachment of the wings, struts and so forth of the airplane. The arrangement and relative position of these members of the plane make it impossible with some types of planes to crank on but one side of the hand crank, and inasmuch as it is easier and more

convenient for the operator to push the hand crank handle away from him at the top of the stroke, provision must be made so that when the starting motor is assembled in the plane, the rotation most desirable for the hand crank operation may be selected.

My construction and attachment of the manually operated mechanism, together with the provision of the cranking tube, attain these advantageous features. This cranking tube 51 which is shown by Fig. 7 and which in practice is about eighteen inches or so in length, is provided at its ends with oppositely directed spiral slots 52 and 53 and also with transverse holes 54 and 55. A suitable hand crank 56 shown particularly in Fig. 7 is provided with a cranking pin 57 and is adapted to engage one or the other of the spiral slots 52 or 53, according to whichever one is presented thereto. Only one of the spiral slots 52 and 53 is actually utilized when cranking, such active slot being the one in engagement with the pin 57 of the crank 56, the purpose of which slot being to throw the handle out of engagement when the engine starts. This cranking tube or crank extension is used when the apparatus is applied to an airplane engine in which event such tube is passed through a suitable opening in the side of the fuselage of the airplane whereupon its outer end will be convenient for application of the crank thereto. This cranking tube is passed through either one or the other side of the fuselage according to whichever is the more convenient for the desired direction of rotation of the crank. The end of the tube which cooperates with the cranking shaft 35 is rigidly pinned to such shaft by means of a pin 58 which is passed through either the hole 54 or 55 according to whichever end of such tube is presented to the shaft 35. The spiral slot of the inner end of the tube is not at this time utilized. If the opposite direction of rotation is desired, it is merely necessary to turn this tube end for end, no other change being necessary. As a result, the manufacturer is enabled to carry in stock only one part which may be used for either direction of cranking.

Moreover, the manually operated mechanism is so made with interchangeable parts that the cranking shaft may be turned end for end or such shaft left in its original position and the bevel pinion and other parts changed in position on the shaft so that such pinion will mesh at the other side of the pinion 42, thereby giving a reverse direction of rotation with the same direction of rotation of the hand crank. Such changed position of parts is illustrated in Fig. 2 according to which the bevel pinion 41 has been shifted along and reversed in position on the cranking shaft 35 so as to mesh on the other side of the pinion 42, and the locking mechanism for the shaft 35 has been shifted to the other end thereof.

As shown, the shaft 35 is provided along its length with four keyways 59, 60, 61 and 62. In the structure of Fig. 1 all of these keyways are active except keyway 61, the keyway 59 receiving the key 43^a of the bushing 43, the keyway 60 receiving the key 63 of the pinion 41, and the keyway 62 receiving the key 64 of the spacer collar or bushing 65. This collar is held onto the shaft 35 by a nut 66 and together with the ring 67 occupies the space between this nut and the bearing 36. According to the structure of Fig. 2, the bevel pinion 41 is reversed on the shaft and the spacer sleeve 68 is changed in position so as to be between this pinion and the bearing 37. The key of the pinion then utilizes the previously inactive keyway 61 while the keyway 60 now becomes inactive. The locking mechanism is shifted to the outer end of the shaft 35 and the key 43^a of its bushing 43 then utilizes the keyway 62 and the spacer collar 65 and ring 67 are shifted so that the key 64 of such collars utilizes the keyway 59.

In addition to the provision of means whereby the entire casing 33 and its contained parts may be turned or adjusted 180° as hereinbefore stated, I prefer to make provision of angular adjustments thereof of different degrees and also to make provision of angular adjustment of the entire assembly of starter drive with respect to that part 69 of the engine crank case to which such assembly is attached. Moreover by the combination of both adjustments, various different degrees of adjustment may be obtained as the resultant.

To these ends, the casing cover 1^a is provided with the two pairs of holes 70 and the two pairs of holes 71, Fig. 5 such holes in the present instance being located 15° away from the mid-position holes in which the screws 34 are shown in the drawings. By utilizing the pairs of holes 71, for example, a clockwise angular adjustment of the casing 33 of 15° is obtained.

Referring next to the adjustment of the entire starter assembly on the crank case 69, the flange 72 of the casing 1 is provided in the present instance with fifteen holes in three groups of five holes each lettered respectively *a*, *b*, and *c* which holes are equidistantly located and spaced 20° apart in their occupied circumference of 300°. Through a group of these holes, as selected, are passed the five fastening screws which screw into five tapped holes in the crank case 69, one of which screws and holes is shown at 74 in Fig. 1. In the present instance the group of holes *a* are the ones utilized when the starter assembly is in vertical position as shown in the drawings. By utilizing the group of holes *b*, the starter assembly will be given an anticlockwise (Fig. 3) angular adjustment which

in the present case is 20°. By utilizing the group of holes *c*, the starter assembly will be given a clockwise (Fig. 3) angular adjustment of 20°.

By adjustments of the entire assembly and of the casing 33, different resultants of angular adjustment may be obtained. For instance, the entire assembly may be adjusted clockwise 20° (Fig. 3) by utilizing the holes *c* and the casing 33 may be adjusted or rotated anti-clockwise (still looking at the engine engaging end of the assembly or clockwise in Fig. 5) and the holes 71 utilized, whereupon the resultant will be an adjustment of 5° clockwise (Fig. 5) of the cranking shaft 35 with respect to the crank case 69. In like manner an adjustment of 5° may be made in the opposite direction.

I claim:

1. An engine starter including a driving member adapted to engage and drive a member of the engine to be started but normally out of engagement therewith, means for actuating the driving member in its engaging and driving movements, a driving element operatively connected with said actuating means, a main casing which substantially encloses and supports said member and element and through which a gear part of such element extends, a second casing removable over said gear-part detachably secured to the main casing, and manually operated means mounted in the second casing and operatively connected with the extending part of said element.

2. An engine starter including a driving membed adapted to engage and drive a member of the engine to be started but normally out of engagement therewith, means for actuating the driving member in its movements, a driving element operatively connected with said actuating means, a main casing which substantially encloses and supports said member and element and beyond which a gear part of such element extends, a second casing detachably secured to the main casing at different predetermined angular positions, and manually operated means mounted in such second casing for reversal of its parts to be operated from either end and adapted to be operatively connected with the extending part of said element when cranking from either end.

3. An engine starter including a driving member adapted to engage and drive a member of the engine to be started but normally out of engagement therewith, means for actuating the driving member in its movements, a driving element operatively connected with said actuating means, and manually operated means detachably connected with said driving element and including reversible driving connections cooperating with such element for changing the direction of rotation of the latter.

4. An engine starter including a driving member adapted to engage and drive a member of the engine to be started but normally out of engagement therewith, means for actuating the driving member in its movements, a driving element operatively connected with said actuating means, and manually operated means detachably connected with said driving element and including a cranking shaft and a gear drivenly connected therewith and adjustable and reversible in position thereon for changing the direction of rotation of such driving element.

5. An engine starter including a driving member adapted to engage and drive a member of the engine to be started but normally out of engagement therewith, means for actuating the driving member in its movements, a driving element operatively connected with said actuating means, and manually operated means detachably connected with said driving element and including a cranking shaft, a gear drivenly connected therewith and a device for locking the shaft against backward rotation, said shaft having provisions whereby said gear may be detachably connected therewith at different and reversing positions.

6. An engine starter including a driving member adapted to engage and drive a member of the engine to be started but normally out of engagement therewith, means for actuating the driving member in its movements, a driving element operatively connected with said actuating means, and manually operated means detachably connected with said driving element and including a cranking shaft, a gear drivenly connected therewith and a device for locking the shaft against backward rotation, and keys for detachably connecting said gear and device to the shaft, said shaft having a series of keyways to accommodate said keys according to different adjusted positions of said gear and said device thereon.

7. An engine starter including a driving member adapted to engage and drive a member of the engine to be started but normally out of engagement therewith, means for actuating the driving member in its movements, a driving element operatively connected with said actuating means, an electric motor operatively connected with the driving element, a main casing which supports said member, motor and element and through which a part of such element extends, and manually operated means cooperating with such extending part of said element and mounted on said casing for adjustment to different predetermined angular positions.

8. An engine starter including a driving member adapted to engage and drive a member of the engine to be started but normally

out of engagement therewith, means for actuating the driving member in its movements, a driving element operatively connected with said actuating means, an electric motor operatively connected with the driving element, a main casing which supports said member, motor and element and through which a part of such element extends, a second casing mounted on the first casing for adjustment to different predetermined angular positions, and manually operated means cooperating with such extending part of said element and mounted on said casing for adjustment to different predetermined angular positions.

9. An engine starter including a driving member adapted to engage and drive a member of the engine to be started but normally out of engagement therewith, means for actuating the driving member in its movements, a driving element operatively connected with said actuating means, and manually operated means comprising a cranking shaft operatively connected with such driving element, and a cranking tube having at opposite ends crank engaging means, one end of such tube being secured to the cranking shaft.

10. An engine starter including a driving member adapted to engage and drive a member of the engine to be started but normally out of engagement therewith, means for actuating the driving member in its movements, a driving element operatively connected with said actuating means, and manually operated means comprising a cranking shaft operatively connected with such driving element, and a cranking tube having at opposite ends spiral slots and transverse pin holes, one end of such tube being secured to the cranking shaft by pin and hole connection.

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