March 28, 1939. H. WALTER 2,152,005

ENGINE STARTER

Original Filed July 30, 1936 3 Sheets-Sheet 1

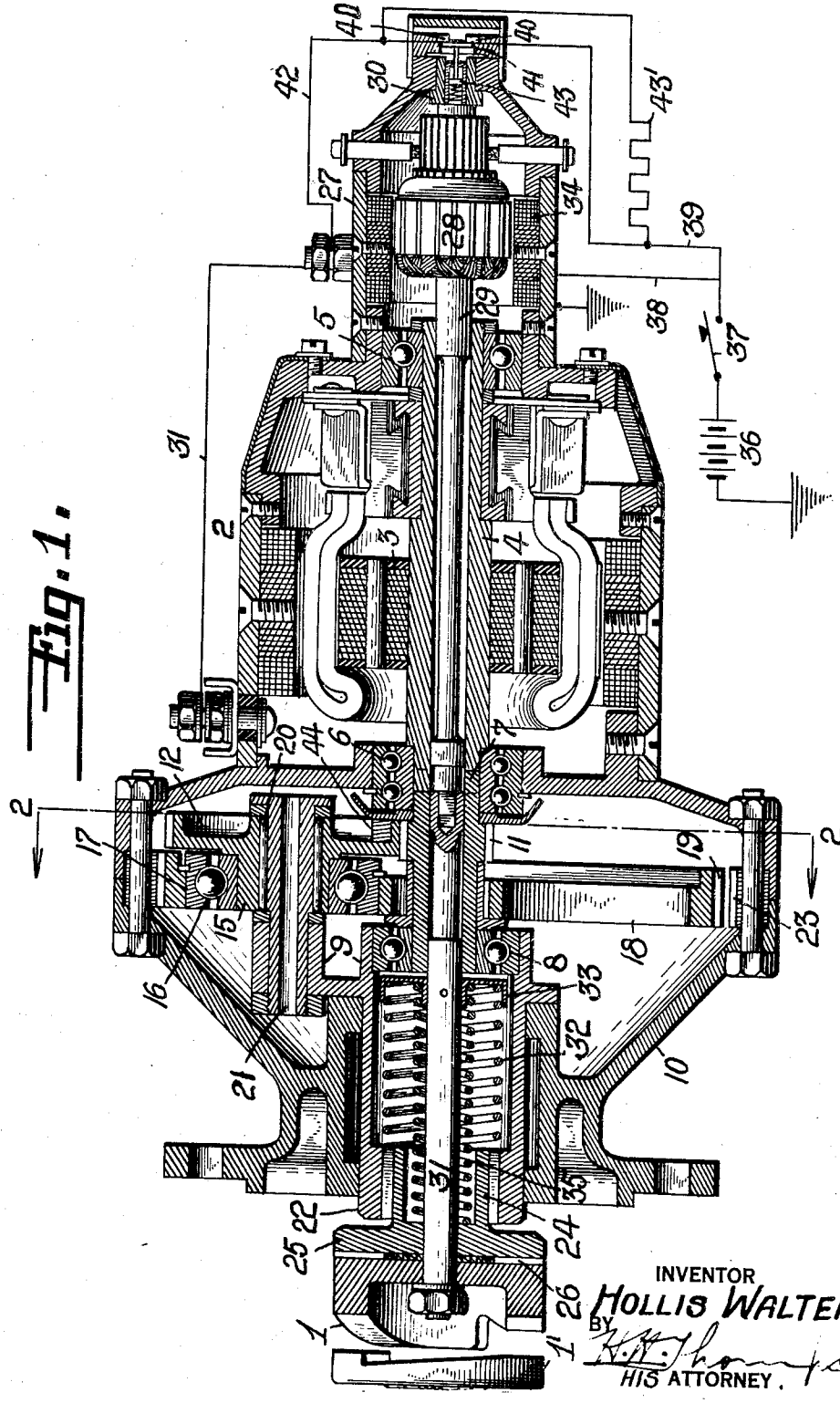

Fig. 1.

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Fig. 2.

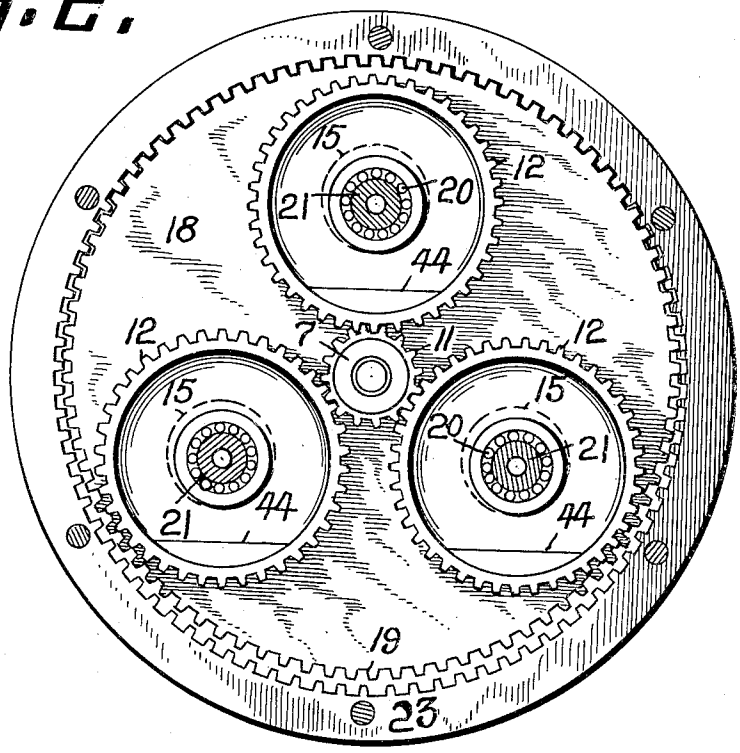

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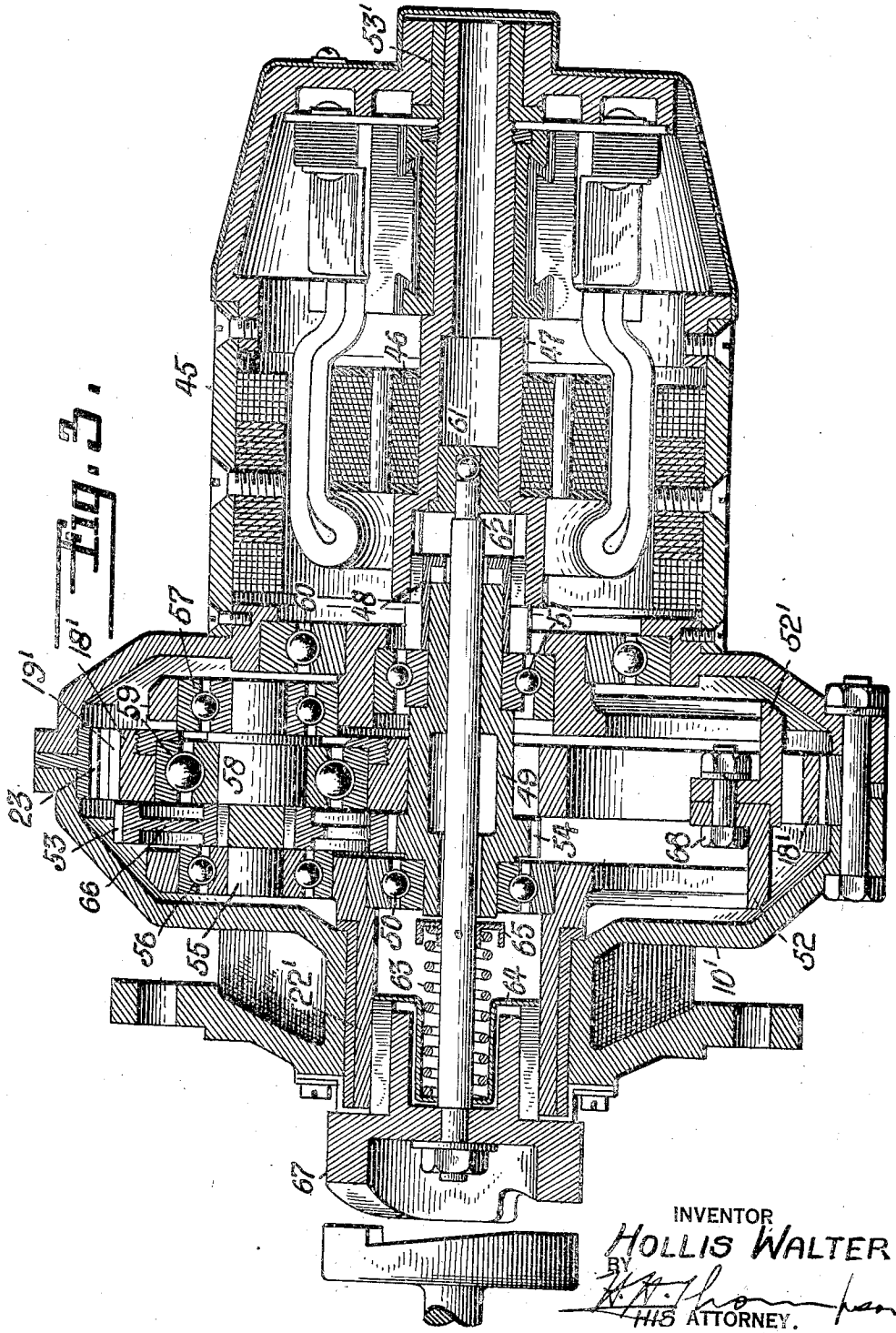
Fig. 5.



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2,152,005

ENGINE STARTER

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Renewed July 7, 1938

11 Claims. (Cl. 290—38)

This invention relates to engine starters, and the invention has reference, more particularly, to a novel electric starting device for internal combustion engines wherein a jaw clutch of the electric starter is normally disengaged from a cooperating jaw clutch on the engine starter shaft, but is brought into engagement therewith at the time of starting.

Inasmuch as a comparatively small motor is used in starting and as a large gear reduction is provided between the motor and the jaw clutch of the starter, resulting in more or less lost motion, the motor may speed up to a high speed before full engagement of the meshing devices occurs, so that severe shock of engagement occurs in spite of the common use of spring cushioning devices in the driving mechanism. Such disadvantages are inherent in most prior starters and though a solution of the problem has been attempted by effecting a quick engagement of the jaw clutches, such devices are generally not successful. In the copending application of Albert S. Fink, Serial No. 74,415, there is disclosed a novel engine starter wherein quick engagement of the cooperating jaws is effected by the use of an independent motive means, which motive means during starting normally rotates at the slow speed of the jaws, that are driven through reduction gearing from the main motor.

One form of the present invention, like that of the Fisk application, also employs an independent or auxiliary motive means for causing a quick engagement of the cooperating jaw clutches, this form of the present invention incorporating certain modifications and/or improvements not present in the Fisk structure.

One feature of this form of the invention is the use of an independent auxiliary motive means having its armature displaced endwise with respect to its field when not in use, the endwise movement of the armature together with the rotation thereof, produced upon the energization of such motive means, serving to effect the rapid engagement of the starter jaw with the cooperating jaw of the engine starter shaft, thereby eliminating the engagement shock of most prior devices, said motive means serving to cause the starter jaw to follow up the engine starter shaft jaw during the entire starting period, thereby eliminating lost motion between the jaws and resulting shock of the starter mechanism.

Another feature of this novel form of the invention is the use of means for balancing the gyrating gear of the reduction gearing, thereby eliminating vibration ordinarily set up by the high speed motion of this gear.

Still another feature of this form of the invention is to provide means for inserting a resistance into the independent auxiliary motor circuit for cutting down the current consumption of this motor during normal operation of the starter, thereby obtaining a more efficient operation thereof.

In another form of the present invention, no independent motive means for obtaining the initial clutch jaw engagement is provided, but the main motive means has its armature displaced with respect to its field normally, so that upon energization of the motor, the endwise movement of the armature resulting from such energization produces a rapid and positive engagement of the cooperating jaw clutches, the said main motor thereafter acting through reduction gearing to drive the jaw clutches, and hence the engine crank shaft.

Other features and advantages will become apparent from the specification, taken in connection with the accompanying drawings, wherein the invention is embodied in concrete form.

In the drawings,

Fig. 1 is a vertical longitudinal sectional view of one form of the engine starter of this invention.

Fig. 2 is a sectional view taken along the line 2—2 of Fig. 1, looking in the direction of the arrows.

Fig. 3 is a vertical longitudinal sectional view of a somewhat modified form of the invention.

Similar characters of reference are used in all of the above figures to indicate corresponding parts.

Referring now to Figs. 1 and 2 of the drawings, the reference numeral 1 designates the engine starter jaw clutch that is normally disengaged from a complementary jaw clutch 1' provided on the engine crank shaft or engine starter shaft. The main power drive for the clutch 1 is provided by the starter motor 2 acting through a reduction gear train. The armature 3 of the motor 2 is shown mounted upon a tubular shaft 4 that is journaled in antifriction bearings 5 and 6 of the motor housing. The forward end portion of shaft 4 is keyed or splined to a tubular shaft 7 mounted in antifriction bearings 6 and 8, the bearing 8 being carried by a frame 9 having a sleeve projection 22 journaled in the starting engine housing 10.

The tubular shaft 7 is provided with pinion teeth 11 which mesh with and drive a plurality

of gears 12. Each of the gears 12 drives an eccentric, shown in the form of an eccentric hub 15 which is carried by an antifriction bearing 16 mounted in an aperture 17 within a large circular plate 18 provided with gear teeth 19 on its outer periphery. The gears 12 are each mounted by means of a long roller bearing 20 on a tubular shaft 21 secured to and carried by the frame 9.

The teeth 19 of circular plate or gyrating gear 18, as disclosed in the copending application of Fisk previously identified, have a pitch circle of somewhat less diameter than the pitch circle of an internal gear 23 fixed to the starter motor housing 10. Hence, in operation, the pinion 11 drives the three gears 12 at a reduced speed. The three eccentric hubs 15 thereon give an eccentric motion to the large gear 18, causing it to gyrate around within the internal gear 23 and to rotate very slowly on its own axis. The total throw of the eccentric hubs 15 should be equal to the difference in the pitch diameter of the gears 23 and 18. Since gear 23 is stationary, gear 18 is advanced that portion of a revolution during each gyration thereof, which is determined by the ratio of the total throw of an eccentric hub 15 to the pitch diameter of the internal gear 23. The gear 18, in so rotating, carries with it the frame 9 since this frame carries shafts 21, the frame 9 rotating in the same direction as the motor shaft 4.

This gear train, while very compact as is desired, gives the large ratio of 100:1 or more than is required. The gyrating gear 18 is highly satisfactory for this type of train since it provides a plurality of teeth in simultaneous engagement with gear 23.

Gyrating gear 18 is by nature out of balance and, when running at high speed, would tend to cause considerable vibration. In order to substantially eliminate this unbalance and obtain static balance of the gear 18, each of the gears 12 is provided with an unbalanced weight 44 equal to one third of the amount of total unbalance of the gyrating gear and eccentric hubs, each weight 44 being positioned on the side of its its respective gear opposite to the eccentric hub portion 15 thereof.

Sleeve projection 22 of frame 9 is splined upon a ratchet clutch sleeve 24 that is provided at its outer end with a ratchet clutch disc 25 having an annular series of fine ratchet teeth 26 arranged to engage a corresponding series of teeth provided on the rear side of engine engaging jaw 1.

The mechanism for quickly bringing the teeth of jaw clutch 1 into engagement with the cooperating engine jaw clutch teeth comprises a second or independent auxiliary electric motor 27, preferably having a small armature 28 of small inertia and wound for relatively low speed. The armature shaft 29 is journaled at its forward end within tubular shaft 4 and at its rear end within the bearing sleeve 30. Shaft 29 extends forwardly within tubular shaft 4 and has its forward end connected to a shaft 31 journaled in tubular shaft 7 and carrying the jaw clutch 1 at its forward end.

A coil compression spring 32 bears at one end against the sleeve projection 22 and at its other end against a collar 33 fixed on shaft 31, thereby urging shaft 31 and the connected shaft 29 rearwardly so that armature 28 is normally displaced rearwardly with respect to the field winding 34 of motor 27. A coil spring 35 bears at one end against ratchet clutch disc 25 and at its other end against collar 33, thereby urging the teeth 26 of clutch disc 25 into engagement with the corresponding teeth of jaw clutch 1.

The starter battery 36 is shown as adapted to be connected through switch 37 and lead 38 to the main motor 2 for operating this motor. When the switch 37 is first closed, the independent jaw clutch engaging motor 27 is adapted to be directly supplied from battery 36 by means of lead 39, cooperating stationary and movable contact means 40 and 41 and lead 42. The energization of this motor causes its armature to start to turn and simultaneously move forwardly against the tension of spring 32 so as to align itself with its field 34, thereby bringing the jaw clutch 1 into engagement with the cooperating engine jaw clutch 1', the turning of armature 28 serving to simultaneously bring the heavy jaw teeth on 1 into torsional engagement with the jaw teeth on the engine clutch jaw 1'. This engagement occurs very quickly due to the low inertia of the armature 28 and the fact that no gear reductions are employed.

Movable contact means 41 is shown carried by a spring pressed plunger 43 mounted in shaft 29 so that at about the time the jaw clutches engage, the contact 41 will disengage stationary contacts 40, thereby insering a resistor 43' in the circuit of motor 27 so that thereafter this motor draws but little current, as is desired. After the jaw clutches once engage, the motor 27 serves to retain the clutch jaw teeth in mutual cooperative engagement so that the jaw 1 always follows the engine jaw 1' regardless of overrunning of the engine with respect to the low speed power drive, the cooperating ratchet teeth 26 permitting jaw 1 to advance adhead of disc 25 driven from the main motor 2, whereby lost motion and resulting jarring of the starter mechanism is eliminated. Furthermore, since no slip clutch is employed or needed in the power drive for the jaw 1, the motor 2, due to the large gear reduction, acts to pull the engine through any back fire that may occur so that, in effect, the engine is not allowed to back fire, which action heretofore has often resulted in injury to ordinary starter mechanisms and required the same to employ expensive and inefficient friction clutches.

By employing separate electric motors for causing the clutch engagement and for supplying the power to rotate the clutch after engagement, I not only avoid the difficulties of the prior art, but my construction provides for the engagement of the clutch appreciably ahead of the cranking operation, thereby eliminating initial shock or jar of the clutch jaws.

Fig. 3 illustrates a somewhat simpler arrangement wherein the main starter motor is used alone, the said motor being arranged to normally have its armature rearwardly offset from its field winding so that the energization of the motor results in forward movement of its armature, which movement is employed for effecting the meshing of the jaw clutches. In this figure, the motor 45 has its armature 46 provided with a hollow armature shaft 47 that is journaled at its rear end in a bearing 53' and is splined at its forward end upon a sleeve 48 which, in turn, is splined to a tubular shaft 49 that is journaled in anti-friction bearings 50 and 51. Bearings 50 and 51 are respectively mounted in apertures provided in the two parts 52 and 52' of a two part frame that serves the function of the frame 9 in the form

of the invention shown in Figs. 1 and 2. Parts 52 and 52' are secured together as by bolts 68.

Tubular shaft 49 is provided with pinion teeth 54 that mesh with a drive a plurality of gears 53 that are disposed around the pinion 54 in the same manner as gears 12 of Figs. 1 and 2. Gears 53 are keyed upon stub shafts 55 that are carried by antifriction bearings 56 and 57 mounted in apertures provided in the frame parts 52 and 52', respectively. Stub shafts 55 are provided with eccentrics 58 that carry antifriction bearings 59 mounted in apertures provided in a circular plate or gyrating gear 18', similar to gear 18 of Figs. 1 and 2. The teeth 19' of gyrating gear 18' mesh with the teeth of an internal gear 23' fixed to the starter motor housing 10'.

Frame part 52' is journaled in an antifriction bearing 60 mounted in housing 10', while frame part 52 is provided with a sleeve projection 22' that is journaled in the forward part of housing 10'. Sleeve projection 22' is splined upon the hub portion of starter motor jaw clutch 67.

Armature shaft 47 carries a thrust bearing 61 that engages the rear end of a longitudinally extending shaft 62 which projects through the tubular shaft 49 and has its forward end attached to jaw clutch 1'. A coil compression spring 63 bears at one end against a seat 64 carried by sleeve projection 22' and at its other end against a seat 65 fixed on shaft 62, thereby urging shaft 62 and hence armature 46 rearwardly into the positions shown in Fig. 3.

In use, upon the energization of motor 45, armature 46 advances while rotating, thereby acting through thrust bearing 61 to move shaft 62 quickly forwardly against the tension of spring 63 and effecting the quick meshing of jaw clutch 1 with the engine jaw clutch. Thereafter, continued rotation of armature 46 effects, through the action of the reduction gearing, the rotation of sleeve projection 22' and hence rotation of jaw clutch 1', thereby bringing the jaw clutches into torsional engagement, whereupon the engine crank shaft is driven from the starter.

While this form of the invention does not provide for rotational follow-up of the engine jaw clutch by the starter jaw clutch, yet, on the other hand, this form of the invention does provide for quick engagement of the clutch jaws and, furthermore, the same is of simple construction and exceedingly compact in nature.

In this form of the invention the gears 53 are preferably suitably weighted at 66 to statically balance the eccentrics 58 and gyrating gear 18', thereby reducing vibration to a minimum. Although in this form of the invention I have employed relative displacement of the motor armature and field winding to effect longitudinal movement of shaft 62 and hence jaw clutch 67 when starting, it is to be understood that I may use other electromagnetic means for this purpose, if desired.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In an engine starter of the jaw clutch type, an engine engaging jaw, motive means for driving said jaw at relatively slow speed during the starting period, and additional motive means directly connected to said jaw for effecting the rapid longitudinal and rotational engagement of said jaw with the engine at the initiation of said starting period.

2. In an engine starter of the character described, an engine engaging member, an electric motor connected to said member and having its armature axially displaced with respect to its field winding when deenergized, the energization of said motor resulting in relative movement of its armature and field winding, causing said member to be quickly advanced into engagement with the engine, and gear reduction means for thereafter effecting the rotational drive of said member at relatively low speed.

3. In an engine starter, an engine engaging member, an electric motor, reduction gearing included between said motor and said member for rotating said member relatively slowly and with large available torque, and a second electric motor having its armature displaced with respect to its field winding when deenergized, said second motor being connected to said member, whereby upon the energization of said second motor, the resultant relative movement of the armature and field winding thereof causes said member to quickly move into engagement with the engine while turning, to thereby effect torsional engagement of said member and engine.

4. In an engine starter of the jaw clutch type, an engine engaging jaw, a main electric motor, reduction gearing driven from said main motor and connected for driving said jaw at reduced speed, and an auxiliary motor directly connected to said jaw for effecting longitudinal engaging and rotational follow-up movements of said jaw with respect to the engine.

5. In combination, an engine clutch jaw and a starter having a clutch jaw for driving the same, said starter comprising an electric motor with axially movable armature and field windings, said motor being connected to said starter clutch jaw for effecting longitudinal engaging movement of said jaw with respect to said engine clutch jaw, and means including reduction gearing connected to said starter clutch jaw for effecting the power drive of the same.

6. In combination, an engine clutch jaw and a starter having a clutch jaw for driving the same, said starter comprising an electric motor with axially movable armature and field windings, said motor being connected to said starter clutch jaw for effecting longitudinal rapid engaging and rotational follow-up movements of said jaw with respect to said engine clutch jaw, and means including another electric motor and reduction gearing connected thereto and to said starter clutch jaw for effecting the power drive of the same.

7. In an engine starter of the character described, an engine engaging member, reduction gearing connected to said member, a source of current, a main electric motor supplied from said source and connected to said gearing for driving said member at relatively slow speed during the starting period, an auxiliary electric motor supplied from said source and directly connected to said member for effecting the rapid longitudinal and rotational engagement of said member with the engine at the initiation of said starting period, and means for reducing the supply of electric current from said source to said auxiliary motor upon the engagement of said member with the engine, said auxiliary motor serving thereafter during the starting period to cause

said member to follow the engine regardless of engine overrun of said main electric motor drive.

8. In an engine starter of the character described, an engine engaging member, an electric motor connected to said member and having its armature axially displaced with respect to its field winding when deenergized, the energization of said motor, resulting in relative movement of its armature and field winding, causing said member to be quickly advanced into engagement with the engine, and gear reduction means for thereafter effecting the rotational drive of said member at relatively low speed, said gear reduction means including a gyrating gear and means for statically balancing said gyrating gear.

9. In an engine starter, an engine engaging member, an electric motor, reduction gearing included between said motor and said member for rotating said member relatively slowly and with large available torque, said electric motor having axially movable armature and field elements, and a direct connection between one of said motor elements and said member for effecting the rapid engagement of said member with the engine upon the energization of said motor.

10. In an engine starter, an engine engagi member, an electric motor, reduction gearing i cluded between said motor and said member f rotating said member relatively slowly and wi large available torque, said reduction geari including weighted gears driven from said m tor, eccentrics fixed to and driven from sa gears, a gyrating gear driven from said ecce trics, said weighted gears serving to statical balance said gyrating gear, a fixed gear mesh ing with said gyrating gear, and a frame carr ing said gears and connected in driving relati to said member.

11. In an engine starter of the character d scribed, an engine engaging member, moti means for driving said member at relatively slo speed during the starting period, additional m tive means directly connected to said memb for effecting the rapid longitudinal and rot tional engagement of said member with the e gine at the initiation of said starting perio and means for reducing the supply of current t said additional motive means after the initiatir of said starting period.

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