

Nov. 21, 1944.

C. E. GOSSLING ET AL

2,363,412

ENGINE STARTING DEVICE

Filed Sept. 9, 1943

3 Sheets-Sheet 1

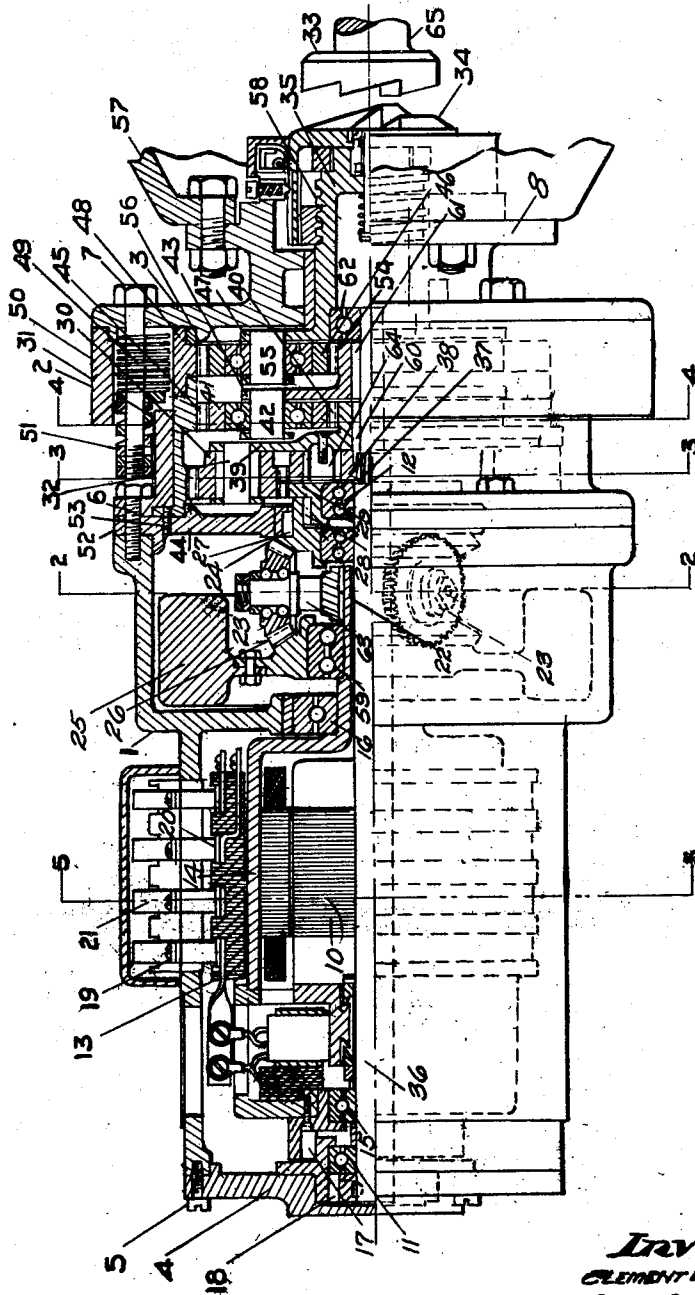


Fig. 1.

Inventors.
CLEMENT E. GOSSLING.
JOHN A. SMITH.
BY *Jm. J. Hardman*
ATTY

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3 Sheets-Sheet 2

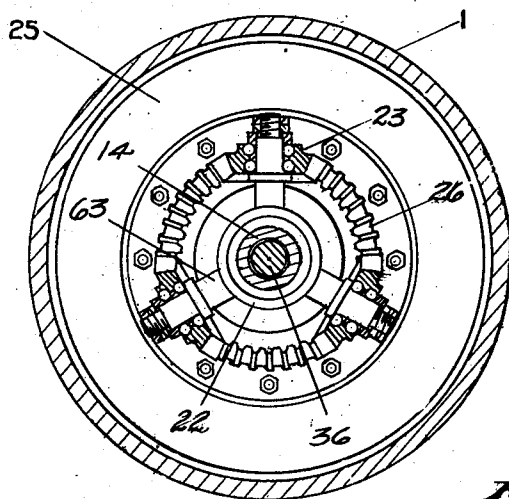


Fig. 2.

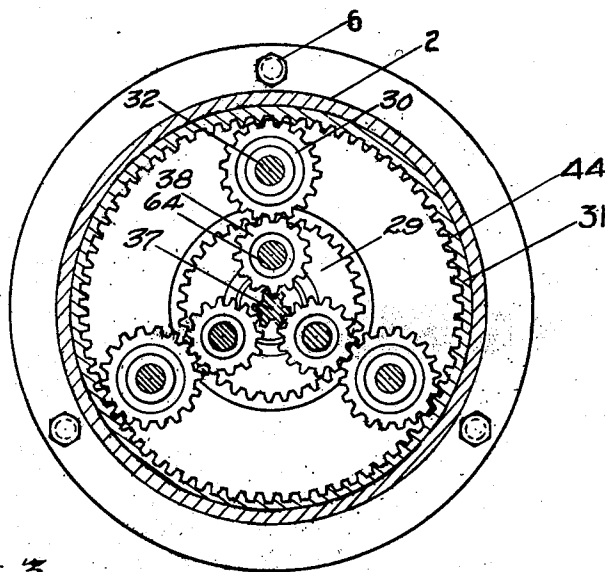


Fig. 3.

Inventors.
CLEMENT E. GOSSLING.
JOHN A. SMITH.
BY *J. Herdman*
ATTY.

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3 Sheets-Sheet 3

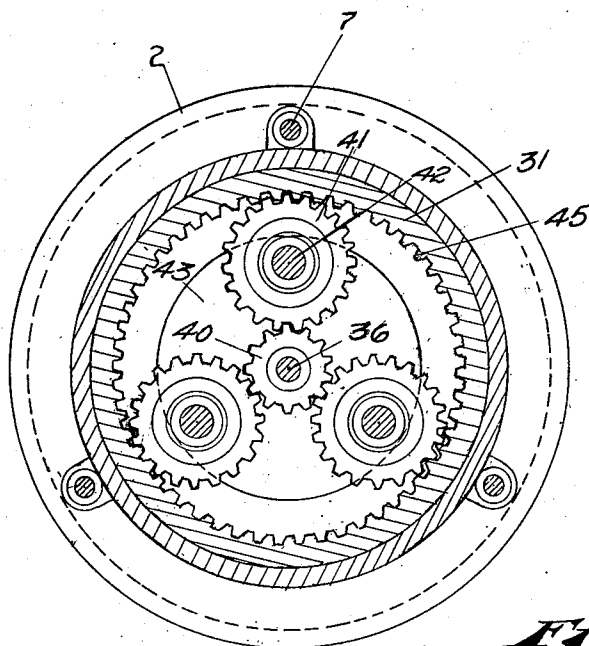


Fig. 4.

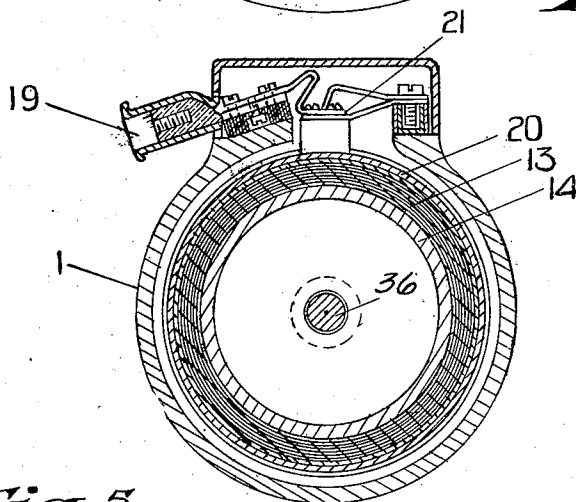


Fig. 5.

Inventors.

CLEMENT E. GOSSLING.

JOHN A. SMITH.

BY *Wm. J. Herdman*
ATTY.

UNITED STATES PATENT OFFICE

2,363,412

ENGINE STARTING DEVICE

Clement E. Gossling and John A. Smith, Toronto,
Ontario, Canada, assignors to Rogers Majestic
Corporation, Dover, Del., a corporation of Del-
aware

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4 Claims. (Cl. 123—179)

This invention relates to engine starting mechanisms suitable for internal combustion engines utilizing stored energy in an inertia element such as a fly-wheel, to give the engine an initial start, then continuing to crank the engine with the assistance of direct cranking action.

One object of this invention is to utilize all the stored energy in the inertia element, after which direct cranking action is brought into operation.

Another object is to reduce to a minimum the slippage of the over-load clutch by initiating the transfer of energy to the cranking element, through a train of reduction gearing, at substantially zero rotary speed.

A further object is the elimination of much of the shock by engaging the starter and engine clutch jaws at a comparatively low rotary speed by means of the stored energy in the inertia element, then continuing by direct cranking action, to crank the engine.

A still further object of this invention is attained by the simplicity and compactness of design and construction, and the ease of manufacture by mass production methods. Furthermore, the dimensions of the motor or other prime mover are kept reasonably small.

Energy is imparted to the inertia element, or fly-wheel, by a prime mover which is shown in the embodiment being described as an electric motor. When the stored energy in the fly-wheel is released, giving the engine an initial start, the prime mover continues to crank the engine in the ordinary manner through appropriate reduction gearing.

The principle of a combined direct cranking and inertia engine starter is well known in the art and this invention relates to a novel method by which the above noted desired results are obtained.

The electric motor consists of an armature mounted on bearings and free to revolve within a normal field system. The novel feature of the field system is that it is also free to revolve coaxially with its own armature on suitable bearings.

It is quite evident that if, in the case of an electric motor, the armature be made to revolve, the reaction on the field system will tend to drive it in the opposite direction. It will be clear, therefore, that when both armature and field are free to revolve, the armature being held from rotation and the motor being excited, the field system revolving, say clockwise, then if this procedure be reversed, the field held and the arma-

ture allowed to revolve, the armature will also revolve clockwise.

The armature and the field in this invention are each restrained against rotation in one and the same direction by means of a free-wheel or ratchet gear of any well known type. In the case being described they are designed to permit of free rotation of either member in an anti-clockwise direction, when viewed from the left hand end of the drawing Fig. 1.

Due to the fact that the field system is free to revolve, current to energize the motor is introduced through the medium of a slip ring system.

When the motor is energized and connected so that the field revolves, then by reaction the armature will remain stationary, locked to the housing by a free-wheel or ratchet gear which will not permit it to revolve in the direction in which it is urged to revolve. The revolving field system mounted on a motor yoke will accelerate a fly-wheel to the same hand of rotation as that of the motor yoke through a system of differential or epicyclic planet bevel gearing which will be fully explained and described hereinafter in detail.

The motor yoke continuing to drive, will only accelerate the fly-wheel, but if the motor now be reversed, the armature will commence rotation in the same direction and the motor yoke will come to a standstill, being checked in the direction of its reaction by a free-wheel or ratchet gear. This reaction will slow up and bring to a stop the planet bevel gearing driving the fly-wheel but will permit the free rotation of the fly-wheel to continue in the same direction. This fly-wheel energy is transmitted through bevel gearing and a reduction gear system and will transmit the drive at reduced speed to the engine starting clutch jaw through jaw advancing mechanism of a well known kind.

As the fly-wheel energy is being expended, the armature shaft commences to crank the engine through a differential or epicyclic planet reduction gear system which will be hereinafter fully explained and described.

An overload clutch is provided and is shown in the drawings as the usual multi-plate friction clutch.

Referring to the drawings:

Fig. 1 is a longitudinal sectional elevation of the engine starting mechanism.

Fig. 2 is a cross section on the line 2—2, Fig. 1, showing the spider and planet bevel gearing accelerating the fly-wheel.

Fig. 3 is a cross section on the line 3—3, Fig.

1, showing the first stage in the epicyclic planet reduction gear.

Fig. 4 is a cross section on the line 4—4, Fig. 1, showing the second stage in the epicyclic planet reduction gear.

Fig. 5 is a cross section on the line 5—5, Fig. 1, with the armature details omitted, showing method of introducing current to energize the motor.

In the drawings forming a part of this specification like numerals of reference indicate corresponding parts in the different figures.

The engine starting mechanism shown in the accompanying drawings is enclosed in a housing which may be constructed in three sections. Housing section 1 houses the electric motor, the fly-wheel and the planet bevel gearing system accelerating the fly-wheel, and is provided with a detachably connected endplate 4 secured in place by studs 5. Housing section 2 houses an epicyclic planet reduction gear train and is detachably connected to section 1 by studs 6. The housing sections 1 and 2 are separated by a dividing wall or plate 52 supporting therein the bearing for the bevel gear 24. Section 3 houses the clutch jaw advancing mechanism 35 and is detachably connected to section 2 by the overload clutch bolts 7. Housing section 3 is provided with a flange 8 to receive bolts for securing the engine starting mechanism to the engine crank case 57.

Power may be furnished by an electric motor 9 consisting of an armature 10 mounted on bearings 11 and 12, and a field system 13, mounted on a yoke 14 that is free to revolve coaxially with the armature 10 on bearings 15 and 16. The armature 10 and the field 13 of this motor are both restrained against rotation in a clockwise direction, when viewed from the left hand end of the drawing Fig. 1, by means of free-wheel or ratchet gears 17 and 18. Current to excite the motor 9 is introduced at 19 through the medium of a slip ring system 20 as shown in Fig. 5. In the case of a direct current motor this will require four brush connections 21, as shown in the drawings, if one set of field coils is used, as series wound motors are essential for such traction duty; reversal being effected by transposing armature brush connections externally with respect to the electrical direction of the field. Should two sets of field coils be employed, three brushes only need be used as the common end of the two sets of fields would be brought to one brush, the other two then representing the armature connections.

When the motor 9 is excited and connected so that the field 13 revolves, then by reaction the armature 10 will remain stationary, locked to the housing section 1 by the free wheel or ratchet gear 18 which will not permit it to rotate in the reaction direction. The field system 13 mounted on the yoke 14 rotates a spider 22. This spider 22, which is keyed to the yoke 14, has a plurality of arms 63, radially disposed, each arm carrying a bevel pinion 23. These bevel pinions 23 rolling on a bevel gear 24 will accelerate the fly-wheel 25 which rotates on a suitable bearing 59 in the same direction as that of the yoke 14, through the bevel gear 26 which forms an integral part of the fly-wheel 25. The reaction load on bevel gear 24 on which the bevel pinions 23 roll, tends to cause it to rotate, but the rotation in that direction is checked by means of a free-wheel or ratchet gear 27 locking it firmly to the housing dividing plate 52.

If the bevel gears 24 and 26 are of equal size the ratio between the yoke 14 and the fly-wheel

25 will be that of two to one irrespective of the size of the bevel pinions 23. By making the bevel gears 24 and 26 to different sizes and inclining the connecting bevel pinions 23 accordingly, various ratios can be adopted if considered desirable.

During the period of fly-wheel acceleration, the reduction gear train is stationary and the starter clutch jaw does not rotate; therefore, the yoke 14, continuing to drive, will only accelerate the fly-wheel 25. After the proper fly-wheel speed has been obtained and the motor reversed by any suitable circuit arrangement, the armature 10 will commence to revolve in the same direction and the yoke 14 will come to a standstill, being checked in the direction of its reaction by the free-wheel or ratchet gear 17. This reaction will slow up and bring to a stop the spider 22. The stored energy in the fly-wheel 25 will, however, through the bevel gear 26, continue to revolve the bevel pinions 23 in the same direction, but as the spider 22 is now stationary, or approaching that condition, the energy of the fly-wheel 25 will, through the bevel gear 26 and the bevel pinions 23, reverse the bevel gear 24, the free-wheel or ratchet gear 27 permitting of free rotation in this direction. This energy is transmitted through the bevel gear 24 to an epicyclic sun pinion 29, the direction of rotation of which is controlled by a free-wheel or ratchet gear 28. The epicyclic sun pinion 29 engaging a plurality of planet pinions 30 mounted on a pinion gear plate 39, against an outer internal gear ring 31, which is fixed to the housing dividing plate 52 by studs 53, will transmit the drive at a reduced speed, through further reduction gearing to the starter jaw 34. Through jaw-advancing mechanism 35 of any suitable type, the advancing rotating starter clutch jaw 34 engaging with the starting clutch jaw 33 on the engine crank shaft 65 will crank the engine.

As the energy of the fly-wheel 25 becomes expended, the armature shaft 36, which is revolving at the opposite hand to that of the bevel gear 24, commences to crank the engine, by means of a pinion 37 through the epicyclic planet reduction gear system. The correction for this reversal of motion is obtained through the use of planet idler pinions 38 of which there is a plurality, these in turn, mesh with the planet pinions 30 in the same manner as the epicyclic sun pinion 29 previously described.

The inclusion of these planet idler pinions 38 will not change the ratio of the first gear train in any way, merely changing the hand of rotation. The ratio between the pinion 37 and the epicyclic cage is exactly as it would be were the outer internal gear ring 31 and the pinion 37 spanned by one larger planet gear wheel.

The planet pinions 30 and the idler planet pinions 38 rotate on stub-shafts 32 and 64 respectively, which are mounted on a pinion gear plate 39. This pinion gear plate 39 is designed with an extending hub which forms a sun pinion 40.

The outer internal gear ring 31 being held stationary with the housing 2 by the studs 53, and the planet pinions 30 which mesh with the outer internal gear ring 31 being rotated on an orbital track 44, the pinion gear plate 39 will revolve around the armature shaft 36 on its bearing 60, completing the first stage of the epicyclic planet reduction gear system as shown in Fig. 3.

In the second stage of the epicyclic planet reduction gear system, the sun pinion 40 engages a plurality of planet pinions 41 which rotate on stub shafts 42 mounted on a second pinion gear plate 43. The planet pinions 41 being driven by the

sun pinion 46 against the fixed outer internal gear ring 31 on a second orbital track 45, the second pinion gear plate 43 will, in a manner similar to that of the first pinion gear plate 39, revolve around the armature shaft 36 on its bearing 61 completing the second stage of the epicyclic planet reduction gear train as shown in Fig. 4.

The second pinion gear plate 43 is designed with an extending hub which forms a sun pinion 54. This sun pinion 54 engages the planet pinions 46 in the final stage of the epicyclic planet reduction gear train. The planet pinions 46 are rotatably mounted on stub-shafts 55 carried on the inner flange 47 of the jaw-advancing mechanism 35. The planet pinions 46 engage a final fixed outer internal gear ring 48. The final outer internal gear ring 48 is held stationary with the housing 2 by the overload clutch bolts 7 and the planet pinions 46, which mesh with the fixed outer internal gear ring 48 on an orbital track 56, being rotated, the flange 47 on which the planet pinions 46 are mounted will revolve on its bearing 62. The rotating flange 47, by means of the screw 58 of the jaw-advancing mechanism 35, will drive forward the rotating starter clutch jaw 34 until it engages in the usual manner with the starting jaw 33 on the engine crank shaft 65 thereby cranking the engine.

The overload clutch incorporated in this design is indicated as a multi-plate friction clutch 49 of a well known type, which consists of a series of plates 50, some of which are keyed to the housing 2 and others keyed to the final outer internal gear ring 48. These plates 50 are clamped to one another under the pressure of a series of springs 51.

It should be noted that when the fly-wheel has been accelerated and its energy is being expended in rotating the starter clutch jaw through the train of epicyclic planet reduction gearing, that it does not rely for its transmission upon anything, excepting the reaction of the planet pinions 30 against the fixed outer internal gear ring 31. This fact is stressed as the revolution of the armature pinion 37 does not distract from this movement in any way, but merely serves to augment it if the speeds fall to that point where they become coincidental when referred to the pitch line speeds of the armature pinion 37 and the planet pinions 38.

During the period of deceleration of the fly-wheel 25, the speed of the armature shaft pinion 39 will approach, and eventually pass that of the sun pinion 29, continuing to rotate the starter jaw 34 while utilizing all inertia energy of the fly-wheel 25 until it is completely expended. This inertia energy being amplified by the direct cranking action will tend to overcome, to a great extent, any tendency to clutch slippage, thereby increasing the efficiency of the starter.

The starter clutch jaw 35 engaging the starting clutch jaw 33 of the engine at substantially zero speed, the torque value of the starter member will be below the slipping value of the overload clutch 50 and will prevent clutch slippage and reduce shock when the members engage.

The drawings show the field system as driving the fly-wheel and the armature as driving the direct cranking mechanism, but this procedure may be reversed without affecting the principle of operation, to suit the convenience of the individual design.

While there is herein illustrated and completely described, by way of example only, one complete embodiment of the invention, it will be ap-

parent that many changes may be made therein without departing from the intended scope and spirit of the invention.

We do not, therefore, desire to limit ourselves to the foregoing except as may be pointed out in the appended claims in which we claim and desire to secure by United States Letters Patent the following:

1. An engine starter comprising, a first driving member, a second driving member, separate means for constraining each of said members to rotate in one and the same direction only, an energy storing member, a step-up gearing associating said first driving member with said energy storing member, an engine starting clutch jaw, means for advancing said jaw to engine engaging position, reducing and reversing gearing, and means whereby when said driving members are energized said first driving member is rotated causing said second driving member to be held from rotation against its said associated restraining member to permit said energy storing member to be rotated through said step-up gearing by said first driving member, and further means whereby when said driving members are energized in reverse order said second driving member is rotated to hold said first driving member from rotation against its said restraining member to free said energy storing member to rotate to impart, through said reducing and reversing gearing, motion to said engine starting clutch jaw advancing means to advance said jaw to engine engaging position and said second driving member is rotated to, through said reducing gearing, assist said energy storing member to rotate said engine starting clutch jaw.

2. An engine starter comprising, an electric motor, the field and armature members of which are each free to rotate, and means associated with said field and further means associated with said armature for respectively restraining both said field and armature to rotate in one direction only, a fly-wheel, a step-up gearing associating one of said motor members with said fly-wheel, an engine starting clutch jaw, means for advancing said jaw to engine engaging position, reducing and reversing gearing and means whereby when said electric motor is energized, the motor member associated with said fly-wheel is rotated causing the other motor member to be held by its associated restraining means from rotation to permit said fly-wheel to be rotated through said step-up gearing by said motor member associated with said fly-wheel and further means whereby when said electric motor is energized in reverse order the other motor member is rotated to operate the restraining means associated with said first mentioned motor member to restrain said first mentioned motor member from rotation to free said fly-wheel to impart, through said reducing and reversing gearing, motion to said engine starting clutch jaw advancing means to advance said jaw to engine engaging position and the second mentioned motor member continues to rotate to, through said reducing gearing, assist said fly-wheel to rotate said engine starting clutch jaw.

3. An engine starter comprising, a first driving member, a second driving member, separate means constraining each of said members to rotate in one direction only, an energy storing member, reversing gearing, and an engine starting clutch jaw, means for advancing said jaw to engine engaging position, an epicyclic gear train of three members, a first member of said gear

train being fixed in relation to and rotating with said first driving member, a second member of said gear train being associated with and adapted to rotate with said energy storing member and a third member of said gear train being associated with said second driving member and adapted to operate said engine starting clutch jaw advancing means through said reversing gearing, and means whereby when said driving members are energized said first driving member is rotated causing said second driving member by its associated restraining means to be restrained from rotation to hold said third member of said gear train stationary and rotating said first gear train member to rotate said second gear train member to impart stepped-up rotation to said energy storing means and when said driving members are energized in reverse order said second driving member is rotated to operate the restraining means associated with said first driving member to restrain said first driving member from rotation to hold said first member of said gear train stationary to permit said energy storing member to rotate said second gear train member to, through said first gear train member, rotate said third gear train member at reduced speed to cause said engine starting clutch jaw advancing means through said reversing gearing to advance said jaw to engine engaging position and said second driving member continues to rotate to assist, through said third gear train member, said energy storing member in rotating said engine starting clutch jaw.

4. An engine starter comprising, a first driving member, a second driving member, separate means constraining each of said members to rotate in one and the same direction only, an energy storing member, reversing gearing, and

an engine starting clutch jaw, means for advancing said jaw to engine engaging position, a bevel differential or epicyclic gear train of three members, a first member of said gear train being fixed in relation to and rotating with said first driving member, a second member of said gear train being associated with and adapted to rotate with said energy storing member and a third member of said gear train being associated with said second driving member and adapted to rotate said engine starting clutch jaw advancing means through said reversing gearing, and means whereby when said driving members are energized said first driving member is rotated causing said second driving member to be restrained by its associated restraining member from rotation to hold said third member of said gear train stationary and rotating said first gear train member to rotate said second gear train member to impart stepped-up rotation to said energy storing means and when said driving members are energized in reverse order said second driving member is rotated to restrain through its associated restraining member said first driving member from rotation to hold said first member of said gear train stationary to permit said energy storing member to rotate said second gear train member to, through said first gear train member, rotate said third gear train member at reduced speed to rotate said engine starting clutch jaw advancing means through said reversing gearing to advance said jaw to engine engaging position and said second driving member continues to rotate to assist, through said third gear train member, said energy storing member in rotating said engine starting clutch jaw.

CLEMENT E. GOSSLING.
JOHN A. SMITH.