

Aug. 13, 1940.

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2,211,053

STARTING APPARATUS FOR INTERNAL COMBUSTION ENGINES

Filed Aug. 5, 1938

2 Sheets-Sheet 1

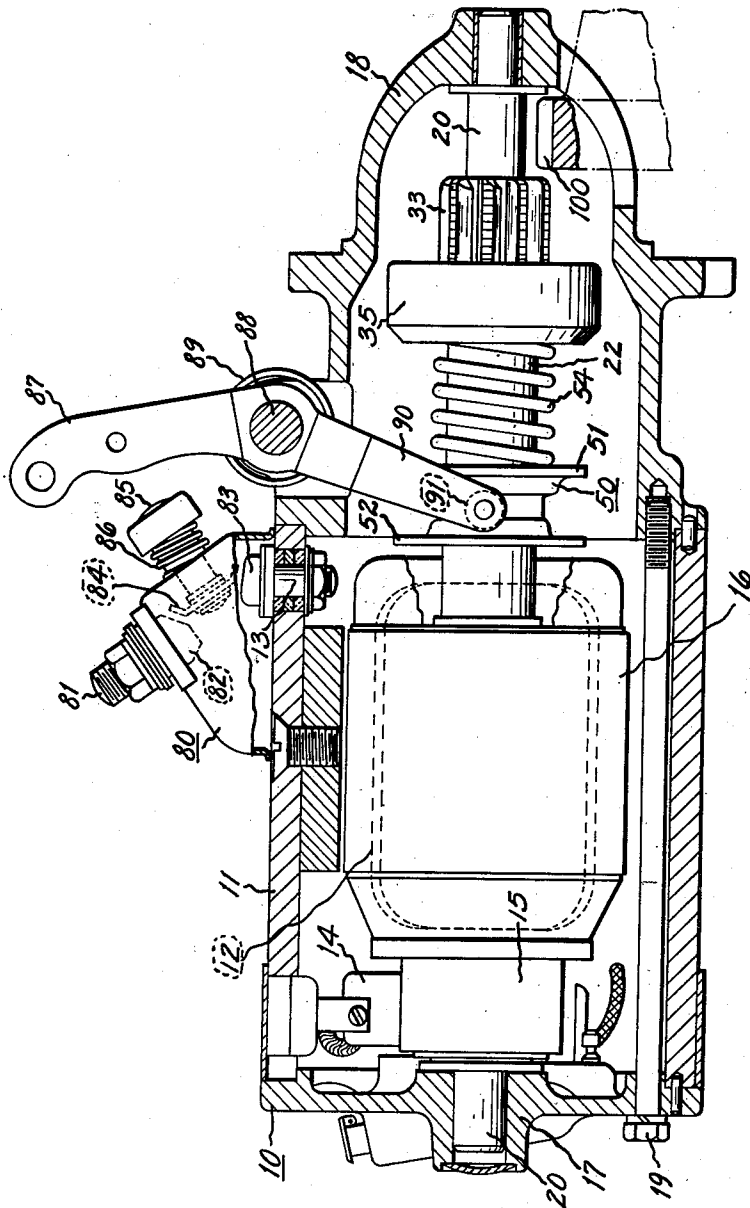


Fig. 1

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2 Sheets-Sheet 2

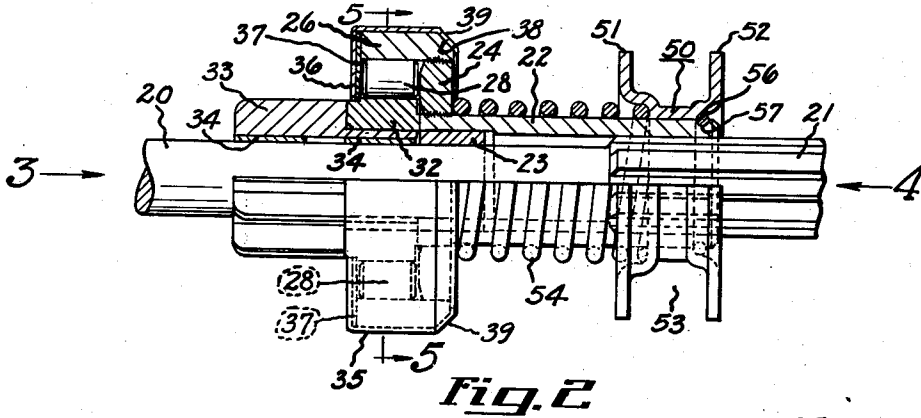


Fig. 2

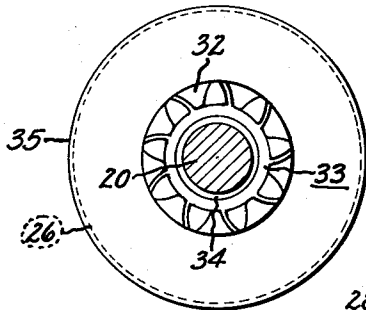


Fig. 3

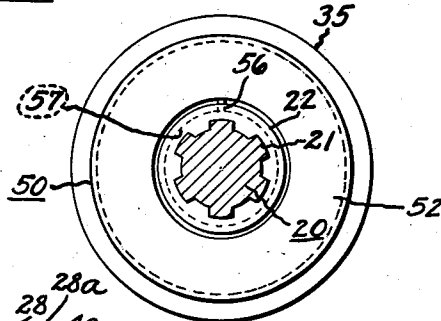


Fig. 4

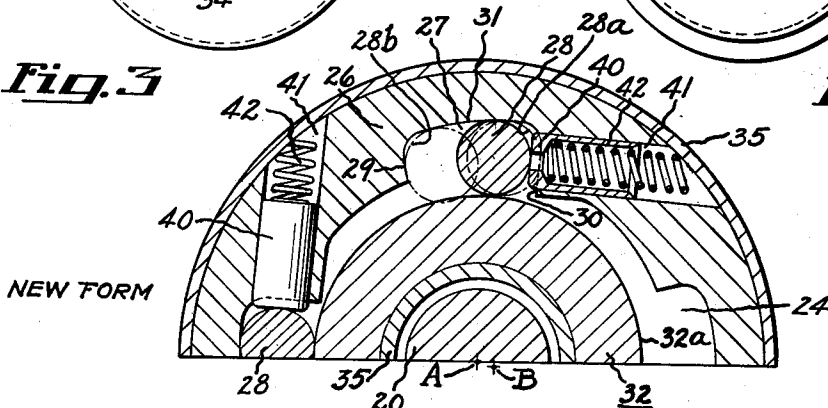


Fig. 5

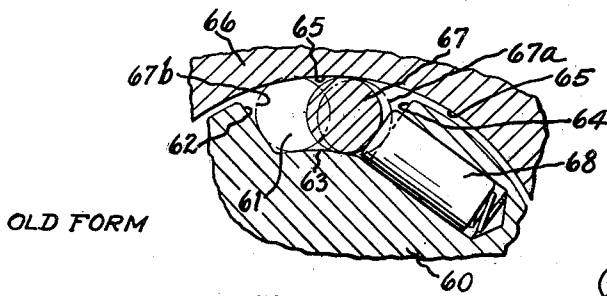


Fig. 6

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2,211,053

STARTING APPARATUS FOR INTERNAL COMBUSTION ENGINES

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2 Claims. (Cl. 74—6)

This invention relates to apparatus for starting internal combustion engines.

Engine starting apparatus in common use, particularly on automotive vehicles, comprises an electric motor operated by a storage battery or other source of direct current, a pinion shiftable into engagement with the flywheel gear of the engine to be started, and an overrunning clutch for connecting the electric motor with the pinion to crank the engine and for permitting the pinion to overrun the motor when the engine becomes self operative. The type of overrunning clutch which has been used with electrically operated engine starting apparatus is one which comprises a driven member connected with the pinion and being in the form of a shell having an internal cylindrical surface, and a driving member connected with the electric motor and located within the driven member and having roller camming surfaces, each of which cooperates with the cylindrical surface of the shell to provide a recess having converging walls between which a roller is urged, like a wedge, by a spring device whereby, normally, each roller is in position to transmit torque between the driving and driven members.

When the engine becomes self operative, the driven member is rotated faster by the engine than the driving member is rotated by the electric motor. Hence the driven member tends to overrun the driving member. Each roller tends to move toward the widest portion of its recess in opposition to the spring device which tends to urge each roller into the narrowest portion of its recess. Movement of each roller into the widest portion of its recess is limited by a stop surface which is provided by the driving member. This surface may be integral with the driving member or may be a part of a roller spacing cage articulated with the driving member through the spring device.

Overrunning clutches of the type referred to, when used with electric motor operated engine starters, do not always release and overrun when the engine becomes operative. I attribute the failure of this type of clutch to release to the fact that the clutch rollers are subjected to relatively high centrifugal force when the engine becomes self-operative.

When the driven member first speeds ahead of the driving member thus relieving the load on the electric motor, the motor speed may increase to as much as 7000 R. P. M. The rollers will then be subjected to a relatively high centrifugal force and will exert considerable pres-

sure against the internal cylindrical surface of the driven member of the clutch. The driven member drags the rollers with it so that they are urged against their respective stop surfaces provided by the driving member with the result that the driving member is dragged along with the driven member. In other words, the conventional clutch which was intended to overrun becomes, at high speed, a friction clutch by which a torque is transmitted from the member, normally the driven member, to the member, normally the driving member. I have observed that, even though a driving member having the roller stop surfaces integral therewith is hardened, that these stop surfaces are actually worn by the rollers, each surface having a groove of substantial depth due to the failure of the clutch to overrun, and the tendency of the clutch to operate as a friction clutch in the manner referred to.

The object of the present invention is to remedy this defect. Therefore, I associate with an electric starting motor and a pinion shiftable into mesh with a gear of the engine to be started, an overrunning clutch in which the cylindrical surface is provided by the inner member of the clutch (instead of by the outer member as has been the case of clutches used with electric engine starters) and in which the outer member is provided with the roller camming surfaces and the roller stop surfaces. Since the outer member of the clutch provides the roller camming surface and roller stop surfaces, when the engine becomes self operative the forces operating upon the rollers urge them only toward surfaces of the outer clutch member and away from surfaces of the inner clutch member, thereby avoiding any hindrance to overrunning as has been the case with an overrunning clutch in which the roller camming surfaces are provided by the inner clutch member. In this way the centrifugal force which is present at the time the engine starts, instead of being a hindrance as in the case of the clutch heretofore used with electrical engine starters, will be a positive assistance in the overrunning action of the clutch.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings where a preferred embodiment of the present invention is clearly shown.

In the drawings:

Fig. 1 is a longitudinal, sectional view of an engine starter comprising an electric motor and

an engine starter drive embodying the present invention, the drive being shown in side elevation.

Fig. 2 is in part a side view and in part a longitudinal sectional view of a starter drive embodying the present invention.

Fig. 3 is a view looking in the direction of arrow 3 of Fig. 2.

Fig. 4 is a view looking in the direction of the arrow 4 of Fig. 2.

Fig. 5 is a fragmentary cross section taken on the line 5-5 of Fig. 2 and is drawn to a larger scale than Fig. 2.

Fig. 6 is a fragmentary cross sectional view of a clutch of the conventional type heretofore employed in engine starter drives.

Referring to Fig. 1, numeral 10 designates a series wound electric motor of the conventional type used for starting an internal combustion engine such as used on automotive vehicles. The motor 10 comprises a field frame 11 supporting and housing field windings 12 which are connected in series. One end of the field circuit is connected with a terminal 13 insulatingly supported by the field frame 11. The other end of the field circuit is connected with an insulated brush 14 bearing on a commutator 15 with which the windings of the armature 16 are connected. The commutator 15 and the armature 16 are mounted upon an armature shaft 20, rotatably supported by bearing frames 17 and 18 secured to the field frame 11 through bolts 19. A commutator brush, not shown, bears against the commutator 15 and has a connection with the ground, thus making a ground return to a storage battery or other suitable source of current.

The non-grounded terminal of the storage battery, or other current source, is connected with terminal 81 of switch 80, which is mounted upon the field frame 11 of the motor. The stationary contacts of the switch 80 are provided by the head 82 of the bolt 81 and the head 83 of the terminal bolt 13. The movable contact of the switch is indicated at 84 and is insulatingly mounted on a plunger 85 which is normally maintained in contact open position by a spring 86. The plunger 85 is operated by a lever 87 connected with a pedal, not shown, within convenient reach of the driver. Lever 87 is pivotally supported upon a shaft or stud 88 carried by the frame 18 of the motor. A coil spring 89 yieldingly retains the lever 87 in the position shown in Fig. 1. The lower portion of the lever 87 is bifurcated so as to provide arms 90, each carrying a study or pin 91. The pins 91 are in alignment and held diametrically on opposite sides of the axis of the shaft 20. These pins 91 cooperate with the engine starter drive now to be described.

The shaft 20 has splines 21 with which a sleeve 22 is slidably connected. Sleeve 22 has a bearing 23 journaled on the smooth portion of the shaft 20. A disc 24 and a clutch ring 26 are welded to the sleeve 22. The clutch ring 26 provided with notches 27 each receiving a roller 28. The notch 27 is defined by approximately radial side surfaces 29 and 30 and an intermediate roller camming surface 31 which is eccentric with respect to the axis A of the clutch, the center of curvature of the surface 31 being at B in Fig. 5. The rollers 28 provide driving engagement between the ring 26 and a ring 32 which is welded to the hub of a pinion 33 which meshes with the fly wheel gear 100 of the engine to be started.

The pinion 33 has bearings 34 journaled on the shaft 20. The camming surfaces 31 need not be arcs of circles, but any surfaces which would cause the rollers to be cammed or wedged against the surface 32a of the driven member 32.

The two parts of the clutch are maintained in assembled relation by a shell 35 having an annular part 36 provided with a central opening which will clear the pinion 33 and also a portion of the ring 32 which has a diameter slightly less than the diameter of the roller engaging surface 32a to provide a shoulder 37. A washer 38, which is located between the part 36 of shell 35 and the ring 26, has a central hole which also clears the pinion and a part of ring 32. Washer 38 bears against shoulder 37. The shell 35 has a portion 39 which is formed against a knurled beveled portion 39 of ring 26.

Since the center of curvature of the roller camming surface 31 is located at B, whereas the center of curvature of the outer cylindrical surface 32a of the ring 32 is located at A in Fig. 5, it is apparent that the space between the roller camming surface 31 and the outer surface 32a of the ring 32 is greatest near the surface 30 of the ring 26 and is least nearest the surface 29 of ring 26. This difference is indicated by the overlap of surface 32a by a circle 28b tangent to surfaces 29 and 31 of ring 26, said circle 28b being the same in diameter as circle 28 representing a roller. Therefore, the driving of the ring 32 by the ring 26 is effected owing to the fact that the rollers 28 are wedged between converging surfaces 31 and 32a. Each roller 28 is urged into its normal driving relation between surface 31 and 32a (as shown in full lines) by a plunger 40 slidable within a pocket 41 provided by the ring 26 and urged toward the roller by a spring 42 received within the hollow bore in plunger 40 and confined between the head of the plunger 40 and the shell 35.

The starter drive shown in Figs. 1 and 2 is moved along the shaft 20 by a collar 50 which is supported upon the sleeve 22 and which is provided with flanges 51 and 52 defining an annular groove 53 which receives the diametrically opposite studs or pins 91 carried by the arms 90 of the bifurcated shifting lever 87. The collar 50 moves the starter drive sleeve 22 through a compression spring 54 which is maintained in a state of initial compression between the disc 24 and the collar 50. The collar 50 is retained on the sleeve 22 by a wire split ring 56 which is snapped into a groove 57 provided by the sleeve 22.

In case the end faces of the starter pinion 33 should collide with the end faces of the gear teeth 100 (see Fig. 1) of the fly wheel of the engine to be started before actual meshing thereof, the car driver can continue to press the pedal which controls the shifting lever 87 and thereby move the collar 50 without moving the sleeve 22. Thus, the closing of the switch 80 which controls the electric starting motor 10 may take place before the starter pinion 33 is actually meshed with the engine fly wheel gear 100. The motor 10 will then rotate the pinion 33 into meshing registration with the engine fly wheel gear 100; and, when such meshing registration has been effected, the spring 54, which has been compressed beyond its initial state of compression, will be released quickly to snap the pinion 33 to mesh with the engine fly wheel gear 100.

The motor shaft 20 is rotated in a clockwise

direction as viewed in Fig. 5 and as looking in the direction of arrow 3 of Fig. 2. The driving ring 26 tends to move ahead of the driven ring 32 thereby causing the rollers 28 to be wedged between the surfaces 31 of the ring 26 and the surface 32a of the ring 32. In this way, the torque of the starting motor 10 is transmitted from the shaft 20 to the pinion 33. When the engine becomes self operative, the ring 32 is driven at a rate faster than the ring 26 is driven by the starting motor 10. This causes each roller to move into the position indicated by the dot-dash line circle 28a in Fig. 5, in opposition to the spring-pressed plunger 40. Each roller is then urged against a stop surface 30 provided by the driving member 26. In this way, the rollers 28 each move into a position to free the ring 26 from driving connection with the ring 32 which then is being driven by the engine at a high rate of speed.

When the engine becomes self operative, the electric motor 10 tends to speed up, since it is relieved of its load and is a series electric motor. The free speed of the electric motor may be as much as 7000 R. P. M. Therefore, the tendency is for the rollers 28 to move outwardly due to centrifugal force developed by the electric motor. This tendency occurs concurrently with the tendency of the rollers 28 to move toward the stop surfaces 30 of the pockets 27 due to the fact that ring 32 is overrunning the ring 26. Thus, the tendency is to crowd each roller between a stop surface 30 and camming surface 31, which surfaces are provided by the same member, namely the member 26. Thus the centrifugal force which is present at the time the engine becomes self operative is effective to tend to move each roller 28 away from driving engagement with any member of the clutch except the one which provides the camming surface 31 and the stop surface 30.

This construction and arrangement has not been used heretofore in the overrunning clutches heretofore provided on electric motor operated engine starters. Fig. 6 shows the old or conventional form of overrunning clutch heretofore used with electric motor operated engine starter drives. A driving member 60 which is driven by the electric starting motor is provided with roller notches 61 each defined by a roller camming surface 63 between end surfaces 62 and 64. Surface 63 is cylindrical and has a center of curvature at the point B, which is out of alignment of the point A, the center curvature of surface 65 of the clutch driven member 66. Each notch 61 receives a roller 67 urged by a spring-pressed plunger 68 into driving position between surfaces 65 and 63. It is apparent that the space between the surfaces 65 and 63 is widest adjacent the surface 64 of the pocket and narrowest adjacent the surface 62. The extent of convergence of the surfaces 63 and 65 is substantially the same as the extent of convergence of the surfaces 31 and 32a of the improved clutch. To show this, circle 67b of same size as circle 67 (which is of same size as circle 28 in Fig. 5) has been drawn tangent to surfaces 62 and 63. Note that circle 67b overlaps surface 65 to the extent that circle 28b overlaps surface 32a in Fig. 4.

In the conventional clutch, as shown in Fig. 6, the driving member 60 rotates in a clockwise direction thereby causing the wedging action to take place between surfaces 63 and 65, thereby driving the clutch driven member 66. When the engine becomes self operative, the driven mem-

ber 66 is driven in a clockwise direction at a rate faster than the clutch driving member 60 can be driven by the starting motor. Therefore, the releasing movement of each roller 67 from the position shown by the full line circle 67 into the position shown by the dot-dash line circle 67a in opposition to the spring pressed plunger 68 tends to relieve engagement between the clutch members 60 and 66. The starting motor, being relieved of its load and being a series motor, quickly speeds up thereby applying centrifugal forces to each roller 67 such as to cause it to move outwardly against the inner cylindrical surface 65 of the clutch driving member 66, while being urged into engagement with the stop surface 64 provided by the driven member 60.

The free speed attained by the electric motor may be as much as 7000 R. P. M. The rollers 67 will therefore be subjected to a relatively high centrifugal force and will exert considerable pressure against the internal cylindrical surface 65 of the driven member 66 of the clutch. The driven member 66 then drags the rollers 67 with it so that they are urged against their respective stop surfaces 64 provided by the driving member 60 with the result that the driving member 60 is dragged along with the driven member 66. In other words, the conventional clutch shown in Fig. 6 which was intended to overrun becomes, at high speed, a friction clutch by which a torque is transmitted from member 66, normally the driven member, to the member 60, normally the driving member. I have observed that, even though the driving member 60 having the roller stop surfaces 64 integral therewith is hardened, that these stop surfaces 64 are actually worn by the roller 67, each surface 64 having a groove of substantial depth due to the failure of the clutch to overrun and the tendency of the clutch to operate as a friction clutch in the manner referred to.

Referring now to Fig. 5 which shows in a corresponding manner the operation of the improved clutch, it will be observed that the centrifugal force present when the engine becomes self operative causes the clutch rollers to be wedged in between converging stop surfaces 30 and roller camming of the same clutch member. Therefore, centrifugal force cannot operate at the time the engine becomes self operative to cause the rollers to be wedged between the clutch driving and driven members; and, instead of being an actual hindrance as in the case of the conventional form of clutch shown in Fig. 6, centrifugal force affords a positive assistance to the overrunning of a clutch constructed in accordance with Fig. 5. This has been made possible by so constructing the outer member of the clutch to provide the roller camming surfaces and roller stop surfaces instead of so shaping the inner member of the clutch as to provide these surfaces as shown in Fig. 5.

The present invention provides a clutch in which the pinion 33 is attached to relatively small overrunning driven members, the ring 32. The assembly of pinion 33 and ring 32 has relatively low inertia. This is an important advantage due to the high rotational speeds obtained during overrunning, as the result of the engine driving the pinion through a gear reduction of 15 to 1 or 16 to 1, such reduction being required to obtain the best cranking efficiency. When the engine becomes self operative and attains a speed of 1000 R. P. M. before the pinion is demeshed from the fly wheel gear, the pinion

would be driven at 15,000 to 16,000 R. P. M. so that it is very advantageous to have a low inertia pinion assembly. The material of this assembly is all relatively close to the shaft 20 so that eccentricity of the parts which would produce a tendency to wobble would be relatively low. The clearance between the shaft 20 and the bearings 34 of the pinion assembly is necessarily generous to permit easy shifting of the pinion along the shaft 20, hence wobbling would be permitted. By constructing the pinion assembly so that its mass is small and so located relatively close to the shaft, the tendency to wobble at high speeds is materially reduced.

The roller stop surfaces 30 are illustrated as being integral with the clutch ring 26. However, these roller stop surfaces could be provided by a roller spacing cage which would be articulated with the clutch ring 26 through a spring device which would urge the cage in a direction to push the rollers into the normal driving relation to the rings 26 and 32. Such roller stop surfaces would obviously be engaged by the rollers, during the overrunning of the clutch, for the same reasons that the surfaces 30 shown in Fig. 5 are engaged by the rollers 28.

While the embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. Starting apparatus for internal combustion engines comprising, in combination, an electric motor, a pinion movable into mesh with a gear of the engine to be started, means for moving the pinion and controlling the motor, and a one-way over-running clutch for connecting the motor with the pinion to crank the engine and for permitting the pinion to overrun the motor when the engine becomes self-operative, said clutch having driving and driven members concentrically mounted for rotation one within the other, the outer member being the driving member connected with the motor and the inner member being the driven member connected with the pinion, the inner or driven member providing a cylindrical surface, the outer or driving member pro-

viding roller camming surfaces cooperating with the cylindrical surface of the inner member to provide roller receiving recesses, roller stop surfaces associated with the outer member and each located near the widest part of a roller receiving recess, and clutch rollers one in each recess and cooperating with the camming surfaces of the outer member and cylindrical surface of the inner member to provide a driving connection between said clutch members, each roller being subjected to a force which urges it toward a roller stop due to the tendency of the engine to rotate the pinion at a rate greater than it can be driven by the electric motor, each roller being subjected to a centrifugal force applied as the result of the rotation of the driving member by the electric motor at a relatively high speed when the load on the motor is reduced by the starting of the engine, said centrifugal force urging each roller toward the roller camming surface of the outer member, whereby each roller tends to move out of engagement with the cylindrical surface of the inner or driven clutch member to permit free overrunning of the clutch when the engine becomes self operative.

2. Starting apparatus for internal combustion engines comprising, in combination, a series-wound electric motor, a pinion movable into mesh with the flywheel gear of an engine to be started, and an overrunning clutch having an outside clutch cam member connected with the electric motor, an inside cylindrical member connected with the pinion, and intermediate rollers adapted to become wedged between cam surfaces of the outside clutch cam member and the cylindrical surface of the inside clutch member to drive the pinion when cranking the engine, and adapted in conjunction with the outside cam member to be released from driving relation when the engine becomes self operative, centrifugal force produced by the electric motor when running free of engine cranking load acting upon the rollers through the coaction of the rapidly rotating cam member upon the rollers, thereby causing the pressure of the rollers upon the cylindrical member to be substantially reduced.

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