Aug. 22, 1961 J. J. SABATINI 2,996,924

STARTER GEARING FOR INTERNAL COMBUSTION ENGINES

Filed Nov. 13, 1959 2 Sheets-Sheet 1

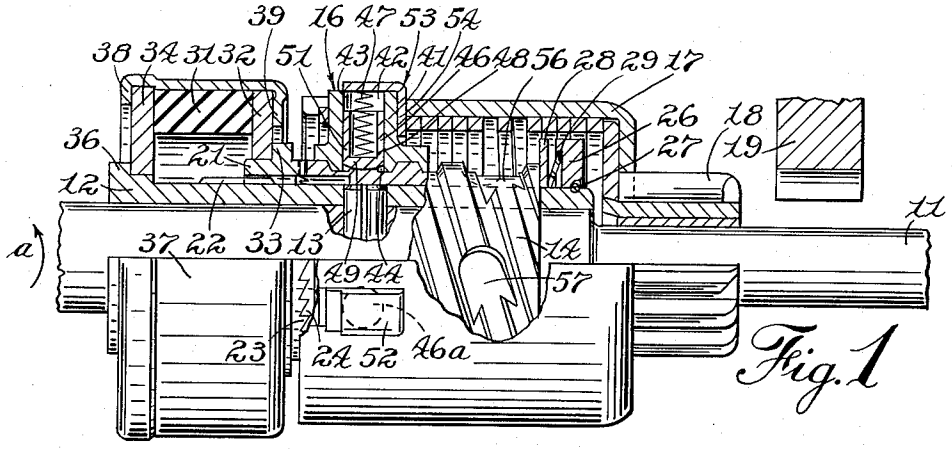


Fig. 1

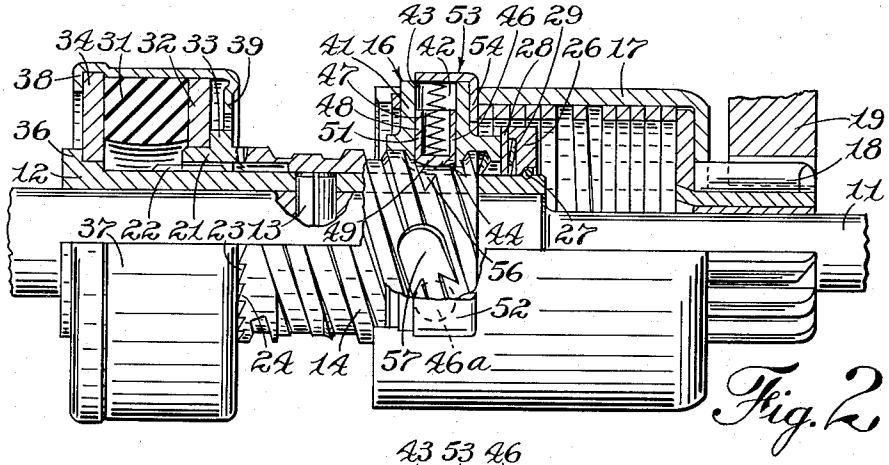


Fig. 2

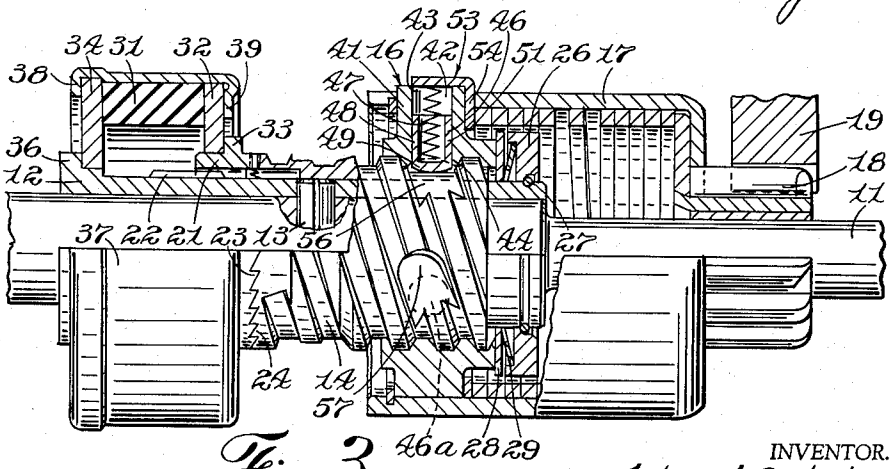


Fig. 3

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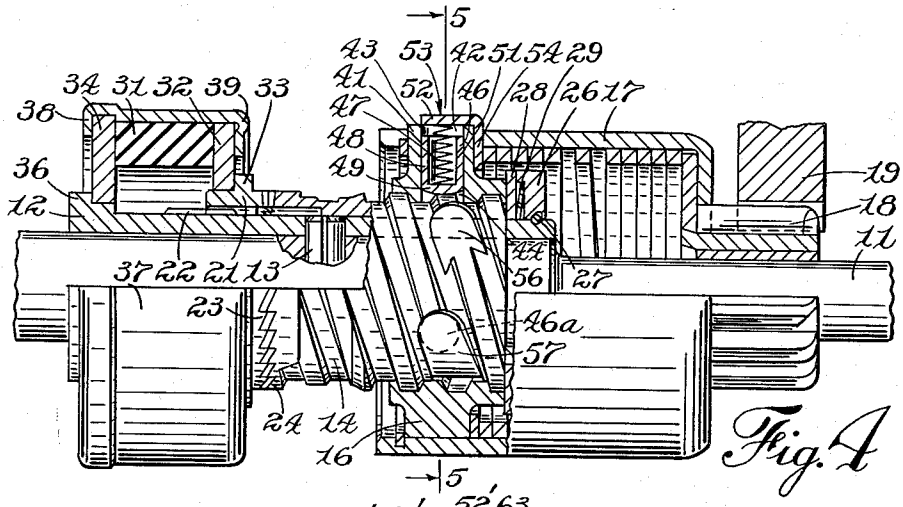


Fig. 4

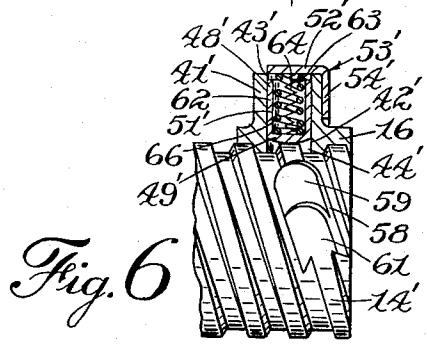


Fig. 6

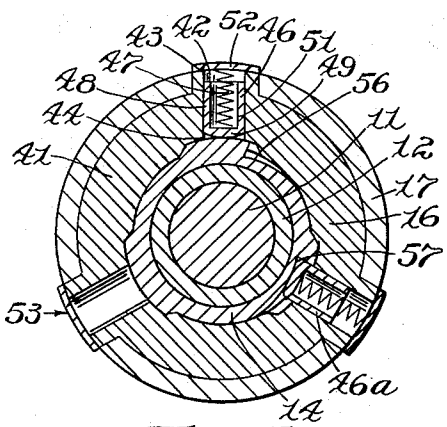


Fig. 5

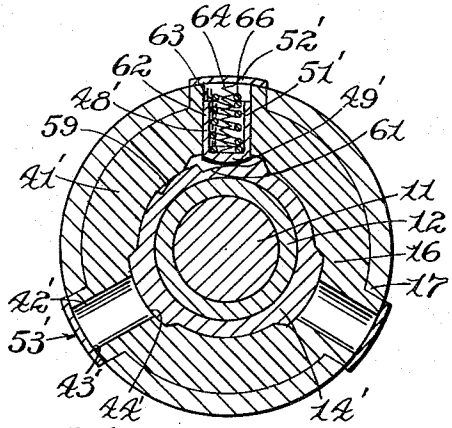


Fig. 7

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STARTER GEARING FOR INTERNAL COMBUSTION ENGINES

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11 Claims. (Cl. 74—7)

The present invention relates to starter gearing for internal combustion engines and more particularly to the type of gearing which is automatically meshed and demeshed. More specifically the invention relates to a type of starter gearing in which sequentially centrifugally actuated latch means are incorporated for sequentially opposing and limiting the operation of an overrunning clutch and preventing the demesh of the gearing until the engine is reliably self-operative.

In the development of drives of this particular character the problem of pumping has become quite serious. When the engine is rotated to a point just beyond its peak compression, or if an engine misfire occurs, there is an inherent tendency for the engine to momentarily drive a portion of the starter gearing at a faster rotational rate than that of the starting motor armature. This temporary assumption of the propelling duties by the engine momentarily releases the starting motor from any load thereby allowing its armature to accelerate and incidentally causing separations between the teeth of the overrunning clutch members and between the screw shaft and the abutment member.

It has been found that if the reduction of the backlash and lost motion associated with the described separations can be eliminated or held to the absolute mechanical minimum, there will be a considerable reduction of the peak-torque requirement placed on the starting motor upon its resumption of the driving duties.

Reduction of the described separations has also been found to have the added effect of all but eliminating the noise of impact, which noise is a highly undesirable thumping or knocking associated with the taking up of the backlash and lost motion. Elimination of the separations causes the engine, when temporarily assuming the propelling duties, to drive the starting motor armature as well as the entire starter drive assembly. This temporary driving of the starting motor by the engine generally does not exceed the free-running armature speed and consequently it is not detrimental to the starting motor, or if it should exceed the free-running speed of the starting motor it is of such a short duration as not to be harmful.

The use of sequentially operating centrifugal latch means provided in the control nut member and screw shaft have been found to attain the desired objects. The screw shaft is provided with notch means which are engaged by detent means in the control nut at various positions in the axial travel of the control nut. The initial detent-notch engagement effectively locks up the overrunning clutch and additionally eliminates or lessens the axial separation between the screw shaft and abutment member. This initial detent-notch engagement is maintained until the engine drives the pinion at a first predetermined speed somewhat under the free-running armature speed whereupon the detent is urged radially outwardly due to centrifugal force thus allowing the control nut to axially traverse the screw shaft in a direction tending to demesh the pinion. The second sequence of detent-notch engagement then becomes operative and again effectively limits the axial travel of the control nut. The second detent-notch engagement is so positioned as to allow the normal operation of the overrunning clutch permitting the pinion and associated parts to overrun the starting motor armature. When a true engine start has been effected and the pinion rotated at a second predetermined speed centrifugal force will again cause the detent to disengage from the notch thereby allowing the control nut to axially traverse the screw shaft causing the starter gearing to completely demesh.

It is an object of the present invention to provide a novel engine starter drive of the automatically meshing and demeshing type which is efficient and reliable in operation and simple and relatively economical in construction.

It is a primary object to provide sequentially operating means for effectively and automatically controlling the demeshing functions of starter gearing.

It is an object to provide centrifugal latch means which will maintain the starter gearing overruning clutch members inoperative during a predetermined starting interval.

It is another object to provide centrifugal latch means which will maintain the starter gearing in mesh with a gear of an engine to be started but allow an overrunning clutch member to function within a predetermined range of overrunning speeds.

It is still another object to provide centrifugal latch means which will release as soon as the engine and the drive pinion have attained a predetermined rotational speed which speed indicates a true engine start and allows the demesh of the starter gearing.

It is a further object to provide latch means which substantially eliminate all but the initial impact noise associated with starter drive engagement.

It is a still further object to provide means whereby the peak-torque requirements placed on the starter motor armature when its kinetic energy is transferred to the engine flywheel after a false or abortive engine start are considerably reduced.

Further objects and advantages will be apparent from the following description taken in connection with the accompanying drawing which illustrates two complete examples of the physical embodiments of the invention constructed according to the best mode so far devised for the practical application of the principles thereof, and in which:

FIG. 1 is a longitudinal sectional view, partly broken away, of a preferred embodiment of the invention showing the parts in a normal or idle position;

FIG. 2 is a view similar to FIG 1 showing the parts in a cranking position;

FIG. 3 is a view similar to FIG. 1, showing the position of the parts when the engine has momentarily assumed propelling duties due to a misfire;

FIG. 4 is a view similar to FIG. 1 showing the parts in an overrunning position;

FIG. 5 is a section taken substantially on the plane of line 5—5 of FIG. 4;

FIG. 6 is a fragmentary longitudinal sectional view illustrating a second embodiment of the invention; and

FIG. 7 is a sectional view of the embodiment illustrated in FIG. 6 showing the detent means engaging the deepest notch of the stepped recess.

In FIG. 1 there is illustrated a power shaft **11** on which a hollow sleeve **12** is rigidly mounted by any suitable manner as by means of a cross-pin **13**. A hollow screw shaft **14** is slidably journalled on the sleeve **12** and has threaded thereon a control nut **16** which is connected by a barrel member **17** to a pinion **18** slidably journalled on the power shaft **11** for movement into and out of mesh with an engine gear **19**.

Means for transmitting rotation from the sleeve **12** to the screw shaft **14** is provided comprising a driving clutch member **21** splined on said sleeve as indicated at **22**, and having teeth **23** cooperating with similar teeth **24** on the end of the screw shaft. An abutment ring **26**, retained on the end of the sleeve **12** by a lock ring **27** serves to

define the meshed position of the pinion **18** by limiting the travel of the control nut **16**, a thrust washer **28** being preferably interposed between the screw shaft and the abutment ring. A light spring **29** locked between the abutment ring **26** and the thrust washer **28** serves to normally hold the overrunning clutch teeth **23**, **24** in engagement.

Cushioning means is provided for resisting axial movement of the screw shaft **14** and the clutch member **21** responsive to the screw-jack action of said screw shaft and control nut **16** after the meshing movement of the control nut is arrested by the abutment ring **26**. The cushioning means is in the form of a hollow cylinder **31** of elastically deformable material such as rubber locked between a thrust washer **32** seated on the driving clutch member **21** against a shoulder **33** and an annular pressure plate **34** seated on the end of the sleeve **12** against a flange **36**.

The cushioning element **31** is held in the assembled position under initial compression by a sleeve member **37** surrounding the cushioning element and having terminal flanges **38** and **39** limiting axial expansion thereof. The sleeve **37** also prevents outward radial expansion of the cushioning element **31** whereby axial compression thereof deforms it radially inward as is illustrated in FIG. 2.

Latch means on the control nut and screw shaft sequentially and centrifugally operate to progressively control the degree of demesh of the pinion as well as to oppose and limit the operation of the overrunning clutch members.

The control nut **16** is formed with an integral flange **41** having cylindrical passages **42** providing radial openings **43** and **44**. Detent means **46** and **46***a* are mounted in the passages **42** for radial movement therein while engaging portions of the screw shaft **14**. A calibrated spring **47** normally yieldably holds the detent means in engagement with the screw shaft.

The detent means comprise, in addition to the spring **47**, a substantially cup-shaped housing **48** consisting of a bottom face **49** and an integral cylindrical side wall **51** with the spring **47** being seated within the cup-shaped housing **48** and extending radially outward to compressively abut an integral projection **52** of a sleeve member **53**. The sleeve member additionally consists of a flat annular body **54** secured by any convenient method to one side of the control nut flange **41**.

Notch means are formed on the periphery of the screw shaft in position to receive the detent means **46** and **46***a* as the pinion and its associated parts approach the meshed position. The detent-notch engagement sequentially prevents the complete demeshing of the pinion until the rotation of the pinion and associated parts exceeds predetermined speeds and additionally opposes and limits the operation of the overrunning clutch. These notch means comprise peripheral axially spaced recesses **56** and **57** best illustrated in FIGURES 3 and 4.

In operation starting with the parts in the position illustrated in FIG. 1, rotation of the power shaft **11** in the direction of the arrow (*a*) causes the clutch member **21** and the screw shaft **14** to rotate and thereby threadedly traverse the control nut **16** partially by reason of its inertia until it directly engages the thrust washer **28** and indirectly engages the abutment ring **26**, thus defining the meshed position of the pinion **18** as shown in FIG 2. The screw-jack action of the screw shaft and control nut then thrust the clutch member **21** backwards, compressing the cushioning element **31**, illustrated in FIG. 2, to provide a yieldable driving connection for the initial cranking operation.

During the cranking operation premature demeshing of the pinion responsive to sporadic explosions or false starts of the engine is prevented by the sequential engagement of the detent means **46** and **46***a* with the notch means **56** and **57** of the screw shaft. The sporadic explosions or misfires of the engine tend to cause the pinion and associated parts to overrun the power shaft **11** and cause an axial separation to occur between the teeth **23** and **24** of the clutch members. This separation of the clutch parts just after the cranking operation has been initiated tends to produce a highly undesirable knocking or thumping sound. To eliminate this undesirable condition the detent means **46** will engage the notch **56** of the screw shaft as illustrated in FIG. 3 and in so doing will oppose longitudinal movement of the screw shaft away from the clutch member, causing the clutch teeth **23**, **24** to be locked and the overrunning clutch function to be completely eliminated. This locking up of the clutch causes the pinion to momentarily drive the power shaft. The free running speed of the power shaft in most modern installations is approximately 5,000 to 9,000 r.p.m. and it has been found that this initial driving of the power shaft by the pinion due to clutch lock-up will occur at speeds considerably under 5,000 r.p.m. and not be harmful to the starting motor. The detent means **46** will move out of the notch **56** at a first predetermined speed, generally, about 2,000 r.p.m. a speed normally greater than that generated by abortive starts but considerably under a true starting speed, so as to permit the control nut to thread itself back on the screw shaft **14** towards the idle position. However, the second detent means **46***a* then engages the notch **57** of the screw shaft thereby permitting the pinion and screw shaft to overrun the driving clutch member but maintaining the starter drive in a position to again assume cranking duties in the event of a false start. Sufficient longitudinal movement of the screw shaft which permits the teeth **24** of the screw shaft **14** to disengage the teeth **23** of the clutch member **21** is provided for by the compression of the spring **29**. This engagement of the detent **46***a* with the notch **57** allows the pinion and associated parts to overrun at speeds in excess of the free-running speed of the power shaft **11**. When the engine becomes reliably self-operative and rotates the pinion **18** and the control nut **16** above a second predetermined speed the detent means **46***a* by centrifugal force moves out of the notch **57** to permit the control nut to thread itself back on the screw shaft **14** toward the position illustrated in FIG.1.

In FIG. 6 of the drawing there is illustrated latch means comprising a second embodiment of the invention and showing a screw shaft **14'** having formed therein a step-shaped peripheral recess **58** providing different depth notches **59**, **61**. The control nut flange **41'** is also provided with a passage **42'** and an enclosing sleeve member **53'**. Detent means **62** is slidably journalled in the passage **42'** and comprises a cup-shaped housing **48'** having a bottom base **49'** and a substantially cylindrical side wall **51'**. Composite yielding means **63** are housed within the cup-shaped housing **48'** and consists of a first spring **64** centrally disposed within the housing **48'**, and a second spring **66** also disposed within the housing **48'** and encompassing the first spring **64**.

When the detent means **62** engages notch **61**, as illustrated in FIG. 7, the overrunning clutch will be maintained inoperative. In this position it will be noted that the spring **66** while radially projecting above the cylindrical side walls **51'** does not abut the sleeve projection **52'** whereas the spring **64** compressively engages this projection. When the first predetermined rotational speed is reached centrifugal force will urge the detent means **62** outward and compress the spring **64** allowing the detent means to withdraw from the notch **61**. The radial movement of the detent will then be limited by the additional compressive abutment of spring **66** causing the detent **62** to engage the shallower depth notch **59**. The engagement of the detent in notch **59** allows the overrunning clutch to become operative but limits the demeshing action of the pinion and its associated parts. At a second predetermined rotational speed, indicative of a true start, the composite force of springs **64**, **66** will be

overcome by centrifugal force and the detent 62 will be withdrawn from the step-recess 58 so as to permit the control nut to thread itself back on the screw shaft 14' towards an idle position comparable to that illustrated in FIG. 1.

Although two forms of the invention have been shown and described in detail it will be understood that changes may be made in the form and arrangement of the parts without departing from the spirit of the invention.

I claim:

1. In an engine starter drive a power shaft, a sleeve fixedly mounted on said shaft, a screw shaft slidably journalled on said sleeve, a pinion slidably journalled on said shaft for movement into and out of mesh with a gear of an engine to be started, a control nut threaded on the screw shaft, means connecting the control nut and pinion for axially and rotatably actuating the pinion, an abutment member on said sleeve limiting axial movement in the meshing direction of said screw shaft and said control nut, means for actuating said screw shaft from said sleeve including a driving clutch member splined on said sleeve having an overrunning clutch connection with said screw shaft, yielding means resisting axial movement in the demeshing direction of said driving clutch member, latch means in the control nut and in the screw shaft operatively engaged during pinion mesh sequentially cooperating to progressively control the overrunning clutch connection and the degree of demesh of said pinion.

2. An engine starter drive as set forth in claim 1 in which the latch means includes notch means formed in the screw shaft, and sequentially operating yielding detent means supported in the control nut, said detent means engaging said screw shaft notch means during pinion mesh whereby the longitudinal movement of said screw shaft away from said clutch member is sequentially opposed and limited, said detent means being centrifugally releasable at predetermined rotational speeds.

3. An engine starter drive as set forth in claim 1 in which said latch means comprise: peripherally spaced recesses formed in the screw shaft, yielding detent means mounted in the control nut adapted to provide the sequential engagement with said recesses when the pinion is in its meshed position.

4. An engine starter drive as set forth in claim 3 in which the control nut comprises an integral radial flange housing a plurality of slidably axially aligned detent means, said detent means each being centrifugally releasable at various predetermined rotational speeds.

5. An engine starter drive as set forth in claim 1 in which the latch means comprise: a plurality of separate peripheral recesses axially spaced on the screw shaft; yielding detent means mounted in the control nut adapted for sequential radial movement, said detents including spring means normally urging said detents into engagement with said screw shaft and into engagement with said recesses during pinion mesh whereby the detents sequentially oppose and limit the longitudinal movement of said shaft away from the clutch member while the pinion is in its meshed position.

6. An engine starter drive as set forth in claim 5 in which the yielding detents are sequentially centrifugally releasable.

7. An engine starter drive as set forth in claim 1 in which said latch means comprises: a stepped peripheral recess formed in the screw shaft, a yielding detent mounted in the control nut positioned therein to sequentially engage the steps of the recess when the pinion is in its meshed position.

8. An engine starter drive as set forth in claim 7 in which the control nut includes a flange member having radially opening passages formed therein, a sleeve member having a flat annular body adjacent one side of said flange and an integral projection angularly disposed relative to the annular body covering one of said passage openings, the yielding detent means being slidably mounted in said passages and comprising a cup-shaped body having a bottom face and a cylindrical side wall, the bottom face adapted to engage portions of the screw shaft through the other of said radial openings, composite yielding means contained within said cup-shaped housing yieldably resisting radial movement of the detent means, said yielding means comprising a first spring member centrally disposed within said cup-shaped housing and yieldingly abutting the bottom face and the sleeve member, a second spring member disposed within said cup-shaped housing and encompassing said first spring, said second spring having a substantially high coefficient of resistance to pressure and having an assembled radial height less than that of said first spring.

9. An engine starter drive as set forth in claim 8 in which said first spring assembled height exceeds that of said second spring by an amount substantially equal to the height of a step of said peripheral recess.

10. In an engine starter drive a power shaft, a sleeve fixedly mounted on said shaft, a screw shaft slidably journalled on said sleeve, a pinion slidably journalled on said shaft for movement into and out of mesh with a gear of an engine to be started, a control nut threaded on the screw shaft, means connecting the control nut and pinion for axially and rotatably actuating the pinion, an abutment member on said sleeve limiting axial movement in the meshing direction of said screw shaft and said control nut, means for actuating said screw shaft from said sleeve including a driving clutch member splined on said sleeve having an overrunning clutch connection with said screw shaft, yielding means resisting axial movement in the demeshing direction of said driving clutch member, said screw shaft having a pair of peripheral axially spaced notch means formed therein, said control nut having a pair of axially aligned yielding detents mounted therein, one of said detents positioned to enter one of said notch means when the pinion is moved into mesh with said gear thereby preventing the longitudinal movement of said screw shaft away from said clutch member and preventing the operation of the overrunning clutch connection, said one detent being centrifugally releasable at a first predetermined rotational speed whereby said control nut is allowed movement in a demeshing direction, said other detent being positioned to sequentially enter said other notch means thereby allowing the operation of said overrunning clutch connection but opposing further demeshing movement of said control nut, said other detent being centrifugally releasable at a second predetermined rotational speed thereby allowing the pinion to move out of mesh with said gear.

11. In an engine starter drive a power shaft, a sleeve fixedly mounted on said shaft, a screw shaft slidably journalled on said sleeve, a pinion slidably journalled on said shaft for movement into and out of mesh with a gear of an engine to be started, a control nut threaded on the screw shaft, means connecting the control nut and pinion for axially and rotatably actuating the pinion, an abutment member on said sleeve limiting axial movement in the meshing direction of said screw shaft and said control nut, means for actuating said screw shaft from said sleeve including a driving clutch member splined on said sleeve having an overrunning clutch connection with said screw shaft, yielding means resisting axial movement in the demeshing direction of said driving clutch member, said screw shaft having a stepped peripheral recess defining a plurality of varying depth notch means, said control nut having a detent mounted therein positioned to enter one of said notch means when the pinion is moved into mesh with said gear thereby preventing the longitudinal movement of the screw shaft away from said clutch member and preventing the operation of the overrunning clutch, composite yielding means within said detents for yieldably resisting radial movement of said detent, said yielding means comprising a first spring member having a predetermined coefficient of resistance to pressure and a second spring member

having a substantially higher coefficient; and in which said detent is centrifugally actuated at a first predetermined rotational speed to overcome said first spring member whereby said control nut is allowed movement in a demeshing direction, said detent subsequently engaging other of said notch means thereby allowing the operation of said overrunning clutch connection and opposing further demeshing movement of said control nut, said detent being centrifugally actuated at a second predetermined rotational speed to overcome said second spring member thereby allowing the pinion to move out of mesh with said gear.

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