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Pflüger et al.

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[54] **STARTER FOR INTERNAL COMBUSTION ENGINES**

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[51] **Int. Cl.** ... **F16d 7/02,** F16d 47/04, F02m 11/00

[58] **Field of Search** .... 74/6, 7 R, 7 A; 192/48.3, 192/48.92, 104 R, 42, 114 R; 64/30 R, 30 C

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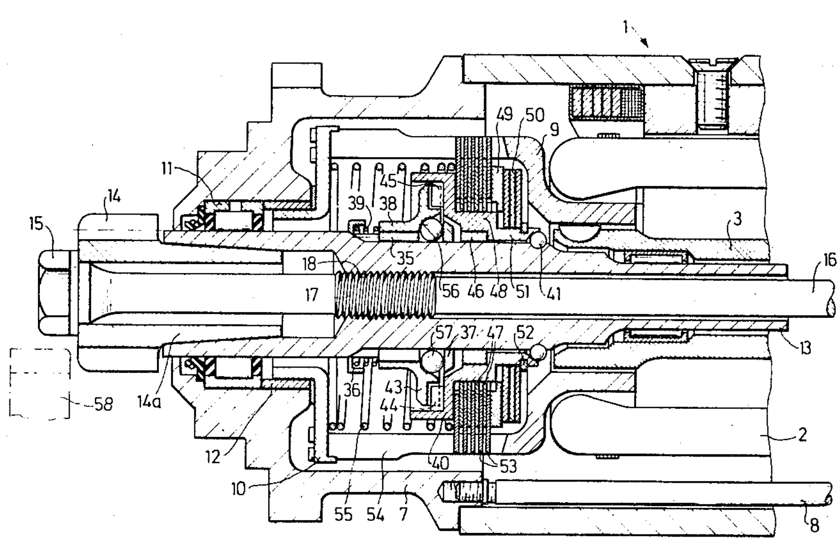
[57] **ABSTRACT**

A starter for internal combustion engines wherein the armature shaft of the starter motor rotates an axially movable transmission shaft by way of a friction clutch which is driven by the armature shaft and an overrunning claw clutch which is driven by the friction clutch and drives the transmission shaft. The transmission shaft carries a pinion which is movable into mesh with a gear of the engine by a solenoid-operated shifter assembly. The overrunning clutch is disengaged when the gear begins to drive the pinion, and such disengagement is assisted by one or more balls which are movable by centrifugal force radially of the transmission shaft to thereby move an axially reciprocable element of the overrunning clutch away from a second clutch element which is driven by the friction clutch.

20 Claims, 2 Drawing Figures



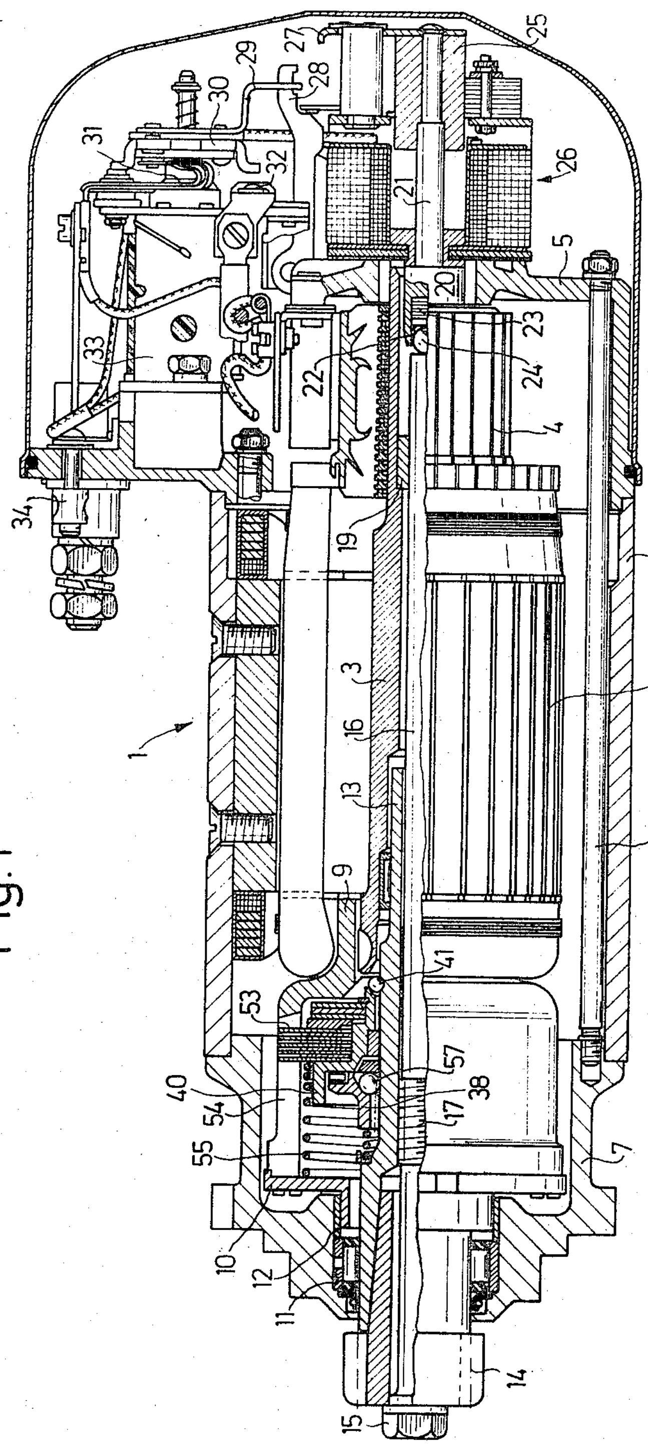

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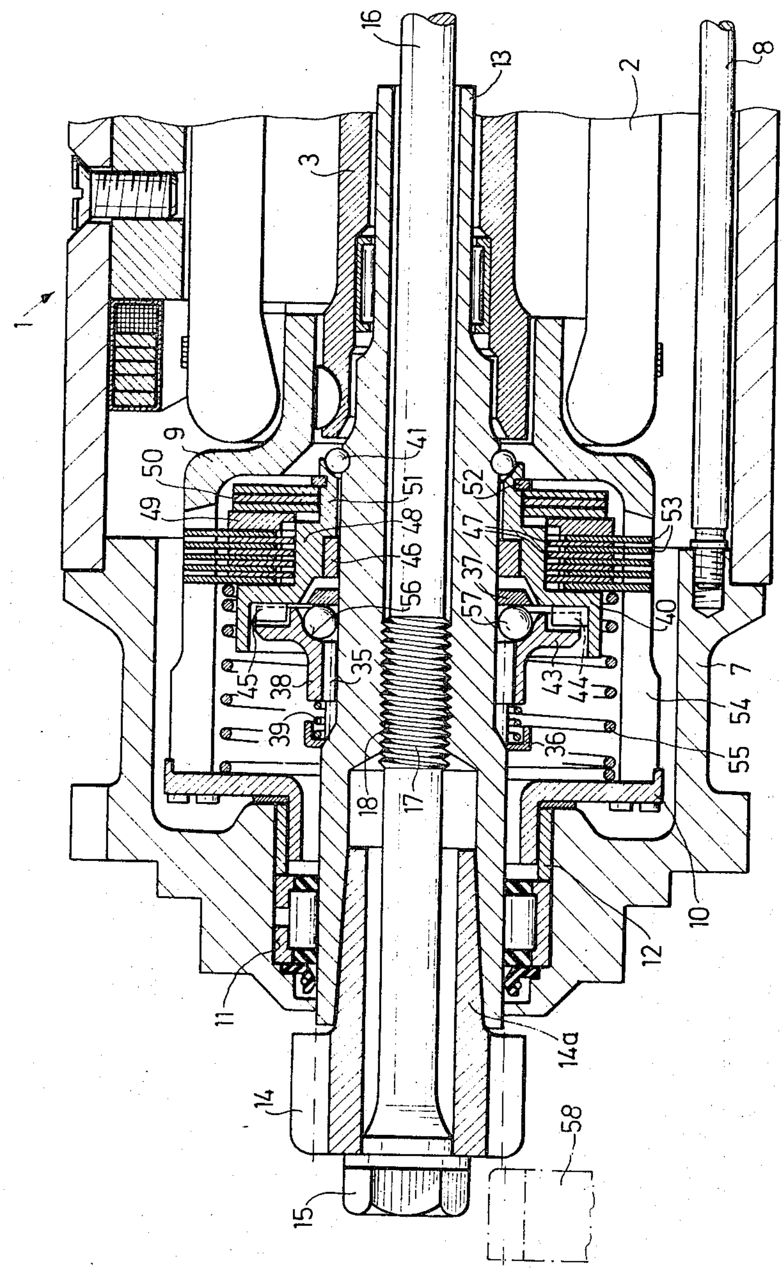
Fig. 1

Fig. 2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STARTER FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

The present invention relates to improvements in starters for internal combustion engines, and more particularly to improvements in starters wherein a pinion is shiftable axially into and out of mesh with a gear of the engine and receives torque from the armature of an electric motor.

It is already known to provide a starter with an overrunning clutch which is installed between the armature and the pinion and comprises sawtooth-shaped claws capable of transmitting torque to the pinion during starting of the engine. Once the engine begins to run, i.e., when the pinion is driven by the gear at a speed exceeding the speed of the armature, the clutch becomes disengaged so that the pinion cannot transmit torque to the armature. A drawback of such starters is that the claws of the clutch remain in frictional engagement with each other while the speed of the pinion changes within a wide range including the speed at which the RPM of the pinion begins to exceed the RPM of the armature. This creates considerable noise and causes extensive wear upon the claws. Attempts to reduce the interval of relative movement between the driving and driven elements of the overrunning clutch include the provision of a locking device which couples the pinion with one clutch element as soon as the speed of the pinion exceeds the speed of the armature whereby the locking device prevents the claws of the thus coupled clutch element from engaging the claws of the other coupling element until after the pinion has been decelerated to a relatively low RPM.

It was also proposed to place a cupped torque transmitting member between the armature and the driving element of the overrunning clutch and to install a cushioning or damping device between the bottom wall of the torque transmitting member and the driving clutch element. The cushioning device undergoes elastic deformation during starting of the engine and bears against the bottom wall of the torque transmitting member; its purpose is to reduce the shocks during movement of the pinion into mesh with the gear of the internal combustion engine as well as to reduce the likelihood of excessive rise in torque during starting. It was found that the cushioning action is unsatisfactory, especially when the starter includes a strong electric motor, mainly because the lead of the threads which cause the pinion to move into mesh with the gear is insufficient.

It is further known to provide the starter with an overrunning friction clutch, especially a friction clutch with two sets of interdigitated disks. Such clutches furnish a certain damping or cushioning action; however, the inertia of disks and other characteristics of such clutches render them unsuited for use in starters for recent types of internal combustion engines.

SUMMARY OF THE INVENTION

An object of the invention is to provide a starter for internal combustion engines with a novel and improved unit for transmitting torque from the armature of the starter motor to the pinion which is shiftable into mesh with a torque receiving gear of the engine.

Another object of the invention is to provide the starter with a torque transmitting unit which is capable of disengaging the pinion from the armature as soon as the pinion begins to receive torque from the engine, which protects the armature against excessive stresses during starting, and which is quieter than heretofore known torque transmitting units.

A further object of the invention is to provide a torque transmitting unit which is more versatile than but just as compact as heretofore known units, and which can be used in starters having manually or solenoid-operated shifter means for the pinion.

An additional object of the invention is to provide novel and improved shifter means for the pinion of a starter for internal combustion engines.

An ancillary object of the invention is to provide a novel and improved overrunning clutch for use in starters for internal combustion engines and to provide the overrunning clutch with novel means for separating its elements in immediate response to firing of the engine.

A further object of the invention is to provide the starter with novel and improved means for transmitting torque from the armature of the starter motor to the overrunning clutch.

The invention is embodied in a starter for an internal combustion engine of the type having a torque receiving gear. The starter comprises an electric motor having a rotary armature shaft, a second shaft which is coaxial with, movable axially of and preferably journalled in the armature shaft, a pinion which is secured to the second shaft, shifter means which is actuatable (e.g., by a solenoid) to move the second shaft axially and to thus place the pinion into mesh with the gear of the internal combustion engine, and a torque transmitting unit which is interposed between the two shafts.

In accordance with a feature of the invention, the torque transmitting unit comprises a friction clutch which protects the armature shaft against excessive stressing and an overrunning claw clutch which becomes disengaged when the gear of the internal combustion engine begins to drive the pinion. One of the clutches (preferably the friction clutch) is driven by the armature shaft and the other clutch is driven by the one clutch and transmits torque to the second shaft.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved starter itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an axial sectional view of a starter which embodies the invention; and

FIG. 2 is an enlarged detail view of the left-hand portion of the structure shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The starter of FIGS. 1 and 2 comprises an electric motor 1 having an armature 2 mounted on a hollow armature shaft 3. The shaft 3 further carries a commutator 4 and one of its ends is journalled in a commutator end head 5. The latter is adjacent to one end of a housing 6. The other end of the housing 6 is adjacent to a transmission casing 7. The parts 5, 6, 7 are connected to each other by elongated through bolts 8.

That end portion of the hollow armature shaft 3 which is adjacent to the casing 7 is connected with a cupped torque-transmitting member 9 the open side of which faces away from the armature 2 and is closed by a cover or lid 10. The lid 10 constitutes a radially extending flange of a rotary guide sleeve 12 which is received in a bore 11 of the casing 7.

The hollow armature shaft 3 further serves as a bearing for one (inner) end portion of a hollow transmission shaft 13. The shaft 13 has an intermediate portion which is rotatable in the bore 11 of the casing 7 and an outer end portion which extends from the casing 7 and carries a pinion 14 adapted to mesh with a complementary torque receiving gear 58 (see FIG. 2) of the internal combustion engine. The pinion 14 is adjacent to an enlarged portion or head 15 of a shifter rod 16 which extends through the hub 14*a* of the pinion 14, through the shafts 3, 13, and into the interior of the end head 5. The hub 14*a* is conical and extends into a complementary socket provided therefor in the outer end portion of the transmission shaft 13.

The shifter rod 16 has an externally threaded portion 17 which meshes with an internally threaded portion 18 of the transmission shaft 13. Thus, the parts 13, 16 are movable axially as a unit to move the pinion 14 into and out of mesh with the gear 58. The right-hand end portion of the armature shaft 3 (as viewed in FIG. 1) contains a friction bearing or sleeve bearing 19 for the shifter rod 16 and further receives an enlarged end portion 20 of a shift plunger 21. The end portion 20 has a blind bore 22 for one or more damping and cushioning elements 23 and for a portion of a spherical motion transmitting element 24. The purpose of the elements 23, 24 is to urge the exposed portion of the element 24 against the adjacent end face of the shifter rod 16.

The shift plunger 21 is connected with the axially movable armature 25 of an electromagnet 26 which must be energized in order to cause the pinion 14 to move axially into mesh with the gear 58 by way of the parts 25, 20–21, 23, 24, 16 and 13. The shift plunger 21 is further connected with a projection or bracket 27 which moves in a direction to the left, as viewed in FIG. 1, when the electromagnet 26 is energized to move the pinion 14 into mesh with the gear 58 whereby the bracket 27 moves a locking pawl 28 from an operative position in which the pawl 28 engages and blocks the movements of a lever 29. The lever 29 is rigid with a contact carrier 30 forming part of a master switch. When the electromagnet 26 is deenergized so that the pawl 28 engages and holds the lever 29, the carrier 30 causes a contact spring 31 to maintain the main contact 32 of a relay 33 in open position. A terminal 34 of the relay 33 is connected with a starter button (not shown) in a manner well known from the art of solenoid shift starters.

The transmission shaft 13 comprises a portion 35 (see FIG. 2) which is located in the torque transmitting member 9 and has an annulus of axially parallel external teeth. The left-hand end of the toothed portion 35 is adjacent to a cupped retainer 36 for a helical spring 39. The retainer 36 surrounds and is secured to the transmission shaft 13. If desired, the axially parallel teeth of the shaft portion 35 can be replaced by helical teeth or threads; however, the structure shown in FIG. 2 is preferred at this time because it is simpler and therefore cheaper to make than the cutting of helical threads or teeth.

The right-hand end of the toothed shaft portion 35 is adjacent to ring-shaped guide member 37 which surrounds the shaft 13 and confines an annulus of weights or balls 57 in discrete sockets 56 of a sleeve-like inner clutch element 38. The latter has internal teeth which mate with and are movable axially of the teeth on the shaft portion 35. The aforementioned spring 39 reacts against the retainer 36 and bears against the left-hand end face of the clutch element 38. The clutch element 38 forms part of an overrunning claw clutch which further includes an outer sleeve-like clutch element 40. It will be noted that the spring 39 urges the clutch element 38 toward the clutch element 40. The latter comprises a cylindrical hub 51 which abuts against the rolling elements of a combined radial and thrust bearing 41 on the transmission shaft 13. The bearing 41 compels the clutch element 40 to move axially with the shaft 13 when the shifter rod 16 is moved to place the pinion 14 into mesh with the gear 58. The clutch element 38 comprises a radially outwardly extending portion or flange 43 having an annulus of sawtooth-shaped teeth or claws 44 normally engaging with similarly configurated complementary teeth or claws 45 of the clutch element 40. A portion of the hub 51 of the clutch element 40 is rotatable on a sleeve bearing or friction bearing 46 which surrounds the shaft 13 in a region between the bearing 41 and the guide 37. The retainer 36 constitutes a stop which limits the extent of axial movement of the clutch element 38 away from the clutch element 40. The extent to which the clutch element 38 can move away from the retainer or stop 36 is limited by the bearing 41 which holds the clutch element 40 against axial movement away from the pinion 14. It will be noted that the clutch element 38 is mounted on the shaft 13 between the hub 51 of the clutch element 40 and the pinion 14.

The outer clutch element 40 further serves as a holder or support for the inner disks 47 of a friction clutch. The innermost portions of the disks 47 are provided with teeth which mesh with the teeth of an intermediate portion 48 of the clutch element 40 so that the disks 47 can be moved axially of but cannot rotate relative to the clutch element 40. The intermediate portion 48 is further surrounded by a pressure transmitting ring 49 which is biased toward the nearest disk 47 by a package 50 of prestressed dished springs surrounding the hub 51 of the clutch element 40. The rightmost spring of the package 50 abuts against a split ring 52 extending into an external groove of the hub 51.

The friction clutch further comprises a second set of disks 53 which alternate with the disks 47 and are nonrotatably but axially movably mounted in the torque transmitting member 9. To this end, a cylindrical portion of the member 9 comprises axially parallel slots 54 for outwardly extending projections of the disks 53. A strong helical spring 55 reacts against the lid 10 and bears against the leftmost disk 53, as viewed in FIG. 2. The rightmost disk 53 is located between the ring 49 and the rightmost disk 47. The purpose of the spring 55 is to assist the package 50 in urging the disks 53 against the neighboring disks 47 of the friction clutch as well as to disengage the pinion 14 from the gear 58 subsequent to firing of the engine.

The aforementioned balls **57** in the sockets **56** can move radially outwardly in response to increasing centrifugal force to thereby shift the clutch element **38** away from the guide member **37** and to thus stress the spring **39.** The extent to which the clutch element **38** can move away from the guide member **37** suffices to move the claws **44** out of engagement with the claws **45.**

The right-hand end portion of the clutch element **38** constitutes a second guide member for the balls **57.** This second guide member moves away from the guide member **37** when the RPM of the pinion **14** reaches a predetermined value to thus move the clutch element **38** away from the clutch element **40.** The just described centrifugal disengaging means **37, 56, 57** for the clutch elements **38, 40** is practically noiseless because its parts are not influenced by the angular movement of shaft **13** relative to the armature shaft **3** or vice versa. The centrifugal disengaging means further reduces the likelihood of excessive wear upon or other damage to the claws **44, 45** because of disengagement of claws **44** from the claws **45** is completed rapidly and to the extent which is necessary to preferably insure the absence of any and all contact between the clutch elements **38, 40** when the pinion **14** is driven by the gear **58.** Still further, and as mentioned above, the wear upon the weights or balls **57** is negligible because these balls move radially of but orbit about the axis of the shaft **13** at the same speed as the guide means (**38, 37**) therefor.

The mounting of the disks **47** on the intermediate portion **48** of the clutch element **40,** combined with the mounting of disks **53** in the torque transmitting member **9,** contributes to a substantial reduction of the overall length of the torque transmitting unit including the friction clutch (disks **47, 53**) and overrunning claw clutch (elements **38, 40**). Moreover, such mounting of the disks **47, 53** results in a reduction of the number of parts.

The operation:

In order to operate the starter, the driver of the vehicle depresses or otherwise moves the aforementioned starter button which is connected to the terminal **34** of the relay **33.** The relay **33** is energized and energizes the electromagnet **26** in a manner well known from the art. During the initial stage of operation, the armature **2** of the motor **1** rotates slowly because the main winding of the motor receives a small current. The electromagnet **26** causes its armature **25** to move the shift plunger **21** in a direction to the left, as viewed in FIG. **1,** whereby the pinion **14** moves into mesh with the gear **58** of the internal combustion engine by way of the elements **23, 24,** shifter rod **16,** mating threads **17, 18** and transmission shaft **13.** The spring **55** in the torque transmitting member **9** is compressed during shifting of the pinion **14** into mesh with the gear **58** because the clutch element **40** moves with the transmission shaft **13** in response to leftward movement of the shifter rod **16.** The leftward movement of the clutch element **40** in a direction toward the lid **10** is shared by the clutch element **38,** disks **47, 53** of the friction clutch, rings **49, 52** and package **50.** The left-hand end face of the outer clutch element **40** reaches and abuts against the lid **10** before the pinion **14** is moved into full mesh with the gear **58.** When the pinion **14** moves into full mesh with the gear **58,** the bracket **27** on the shift plunger **21** disengages the pawl **28** from the lever **29** immediately prior to completion of the leftward movement of the armature **25.** The lever **29** then allows the carrier **30** to abruptly close the main contact **32** so that the main winding of the motor **1** receives maximum current. The motor **1** then furnishes a maximum torque which is transmitted to the pinion **14** via shaft **3,** torque transmitting member **9,** disks **53, 47** of the friction clutch, the overrunning claw clutch **40, 38** and the transmission shaft **13.** The pinion **14** cranks the engine by way of the gear **58.**

As mentioned above, the disks **53** and **47** are biased against each other by the prestressed dished springs of the package **50** which reacts against the clutch element **40.** If the disks **47** offer an excessive resistance to rotation with the disks **53,** the friction clutch becomes inoperative and allows the torque transmitting member **9** and armature shaft **3** to rotate relative to the clutch element **40.** It will be noted that the friction clutch can become engaged or disengaged without necessitating any axial movements of the disks **47** relative to the disks **53** or vice versa. Moreover, the disks of the friction clutch are not influenced by inertia and the likelihood of their breakage is minimal, mainly because they need not be shifted axially relative to each other in order to initiate or terminate the transmission of torque from the torque transmitting member **9** to the clutch element **40.**

When the engine including the gear **58** is fired, the gear **58** accelerates the pinion **14** so that it rotates at a speed exceeding that of the armature shaft **3,** disks **47, 53** of the friction clutch and the element **40** of the claw clutch. This causes the pinion **14** to rotate the clutch element **38** by way of the toothed portion **35** of the shaft **13** whereby the inclined flanks of the claws **44** slide relative to the inclined flanks of the claws **45** and the clutch element **38** moves axially of and away from the clutch element **40** to thereby stress the spring **39.** It will be recalled that the claws **44, 45** resemble saw teeth so that they rotate as a unit when the claws **45** drive the clutch element **38** by way of the claws **44** but that the clutch element **38** can rotate relative to the clutch element **40** when the speed of the clutch element **38** exceeds that of the clutch element **40** while the two clutch elements rotate in the same direction. Thus, the overrunning clutch including the elements **38, 40** enables the pinion **14** to rotate at a speed exceeding the speed of the armature shaft **3.** The centrifugal force furnished by the balls or weights **57** in the sockets **56** assists the axial movement of clutch element **38** against the opposition of the spring **39.** The action of balls **57** upon the clutch element **38** increases with increasing RPM of the pinion **14** so that the claws **44** become rapidly disengaged from the claws **45** and the pinion **14** is thereupon free to rotate at a high RPM (determined by the gear **58** of the running internal combustion engine) independently of the RPM of the armature shaft **3.** The ring-shaped guide member **37** confines the balls **57** in the respective sockets **56** and thus reduces the wear and frictional losses. It will be recalled that the guide member **37** is fixed to and thus rotates with the transmission shaft **13.** Since the speed of the pinion **14** and clutch element **38** equals the speed of the shaft **13,** the balls **57** are confined by parts **38, 37** which rotate at the same speed. Such arrangement reduces the friction to a minimum because the balls **57** merely move radially but do not perform any other movements relative to the adjacent guide members.

An important advantage of the torque transmitting unit including the improved friction clutch and the improved overrunning clutch is that it is capable of reacting without any appreciable delay, i.e., in immediate response to rotation of the pinion **14** at a speed exceeding that of the armature shaft **3.** Moreover, and since the overrunning clutch **38, 40** can be disengaged practically instantaneously due to the provision of balls or weights **57**, the pinion **14** is not likely to accelerate the armature shaft **3**, even to a very small extent, when the engine is fired and the gear **58** begins to drive the transmission shaft **13.** Any acceleration of the armature shaft **3** by the pinion **14** is highly undesirable. It was found that the speed of the armature shaft **3** does not increase beyond the speed which is determined by the motor **1** even if the pinion **14** remains in mesh with the gear **58** for a long interval of time after the engine is fired.

When the operator releases the aforementioned starter button, the relay **33** is deenergized and deenergizes the electromagnet **26.** The motor **1** is disconnected from the source of electrical energy but the armature shaft **3** continues to rotate for a while due to inertia. The spring **55** shifts the armature **25** of the electromagnet **26** back to the position shown in FIG. **1** (by way of the clutch element **40**, bearing **41**, transmission shaft **13**, threads **17, 18**, shifter rod **16**, elements **24, 23** and shift plunger **21**). The pinion **14** becomes disengaged from the gear **58** of the internal combustion engine while the claws **44, 45** remain disengaged from each other. Since the parts of the centrifugal disengaging means (**56, 57, 37**) cannot rotate relative to each other, the disengagement of the pinion **14** from the gear **58** is practically unopposed. Consequently, the pressure upon the flanks of teeth on the pinion **14** is relatively small and the disengagement of this pinion from the gear **58** can be completed within a very short interval of time. The balls **57** return to the illustrated inner end positions in response to a substantial reduction of RPM. The balls **57** then reenter the respective sockets **56** and the spring **39** is free to expand in order to return the claws **44** into mesh with the claws **45.** In the course of such engagement of claws **44** with the claws **45**, the clutch element **38** moves axially of the shaft **13** because its internal teeth mate with the external teeth of the shaft portion **35.**

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of our contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. In a starter for an internal combustion of the type having a torque receiving gear, a combination comprising an electric motor having a rotary armature shaft; a second shaft coaxial with and movable axially of said armature shaft; a pinion secured to said second shaft; shifter means actuatable to move said second shaft axially and to thereby place said pinion into mesh with said gear; and a torque transmitting unit interposed between said shafts and including a friction clutch and an overrunning clutch, said friction clutch being driven by said armature shaft and said overrunning clutch being driven by said friction clutch and arranged to rotate said second shaft, said overrunning clutch comprising a first clutch element movable lengthwise of and arranged to rotate with said second shaft and a second clutch element rotatable on said second shaft and receiving torque from said friction clutch, said clutch elements having mating claws which transmit torque from said second clutch element to said first clutch element when said second clutch element receives torque from said friction clutch and said pinion drives said gear.

2. A combination as defined in claim **1**, wherein said friction clutch is driven by said armature shaft and said overrunning clutch is disengaged when the speed of said pinion exceeds the speed of said armature shaft in response to firing of the engine.

3. A combination as defined in claim **2**, wherein said friction clutch is disengaged in response to a predetermined resistance which said second shaft offers to rotation with said armature shaft.

4. A combination as defined in claim **1**, wherein said second shaft has axially parallel external teeth and said first clutch element of said overrunning clutch has axially parallel internal teeth meshing with said external teeth.

5. A combination as defined in claim **1**, further comprising a combined radial and thrust bearing interposed between said second shaft and said second clutch element and arranged to move said second clutch element axially in response to actuation of said shifter means.

6. A combination as defined in claim **1**, wherein said first clutch element is located between said pinion and said second clutch element and is movable away from said second clutch element by said claws when the speed of said pinion exceeds the speed of said armature shaft, said overrunning clutch further comprising stop means provided on said second shaft and arranged to limit the extent of movement of said first clutch element away from said second clutch element.

7. A combination as defined in claim **6**, wherein said overrunning clutch further comprises resilient means for biasing said first clutch element away from said stop means and thrust bearing means for holding said second clutch element against axial movement away from said stop means.

8. A combination as defined in claim **1**, further comprising centrifugal disengaging means provided on said second shaft and arranged to move said first clutch element away from said second clutch element in response to acceleration of said second shaft to a predetermined speed exceeding the speed of said armature shaft.

9. A combination as defined in claim **8**, wherein said centrifugal disengaging means comprises a pair of guide means rotatable with said second shaft and at least one weight interposed between said guide means and arranged to move radially outwardly in response to said acceleration of said second shaft to thereby move said first clutch element away from said second clutch element by way of one of said guide means.

10. A combination as defined in claim **9**, wherein said one guide means is rigid with said first clutch element.

11. A combination as defined in claim **10**, wherein said one guide means has a socket which receives said weight while said second shaft receives torque from said armature shaft and from which said weight moves radially outwardly in response to said acceleration of said second shaft.

12. A combination as defined in claim 11, wherein said weight is a ball.

13. A combination as defined in claim 1, wherein said friction clutch comprises at least one first disk rotatable with said armature shaft and at least one second disk frictionally engaging said first disk and rotatable with said second clutch element.

14. A combination as defined in claim 13, wherein said friction clutch further comprises resilient means reacting against said second clutch element and arranged to bias said disks against each other.

15. A combination as defined in claim 1, further comprising a friction bearing interposed between said second clutch element and said second shaft and a thrust bearing interposed between said second shaft and said second clutch element and arranged to move said second clutch element axially with said second shaft in response to actuation of said shifter means.

16. A combination as defined in claim 1, wherein said torque transmitting unit further comprises a torque transmitting member rigid with said armature shaft, said friction clutch comprising at least one first disk axially movably mounted in said torque transmitting member, at least one second disk axially movably mounted in said second clutch element, and means for biasing said disks against each other.

17. A combination as defined in claim 16, wherein said torque transmitting member is a cup having a cylindrical portion provided with at least one axially parallel slot and said first disk is received in said cylindrical portion and comprises a projection extending into said slot.

18. A combination as defined in claim 17, further comprising a casing surrounding said torque transmitting unit, and a lid rotatably mounted in said casing, said torque transmitting member having an open end which is closed by said lid.

19. A combination as defined in claim 1, wherein said shafts are hollow and said second shaft is rotatably journalled in said armature shaft, said shifter means comprising an elongated rod extending into said second shaft, said rod and said second shaft respectively having mating external and internal threads.

20. A combination as defined in claim 19, wherein said second shaft comprises an end portion extending beyond said armature shaft and said pinion comprises a hub extending into said end portion of said second shaft.

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