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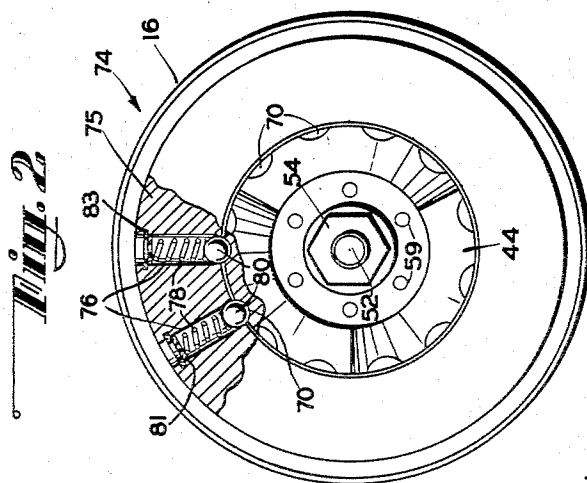
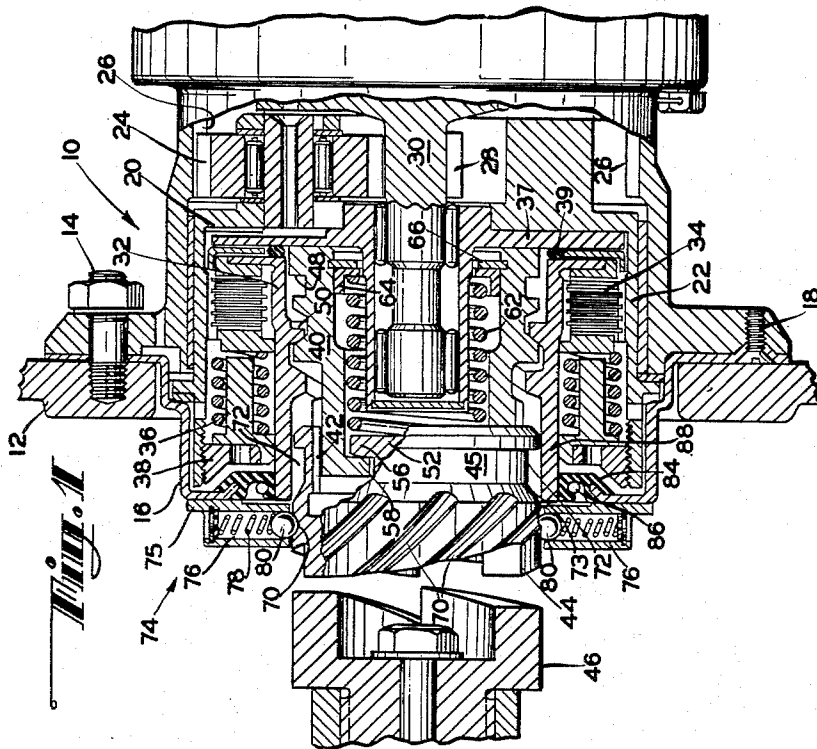
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2,566,445

DIRECT CRANKING ENGINE STARTER

Filed April 30, 1947

2 Sheets-Sheet 1



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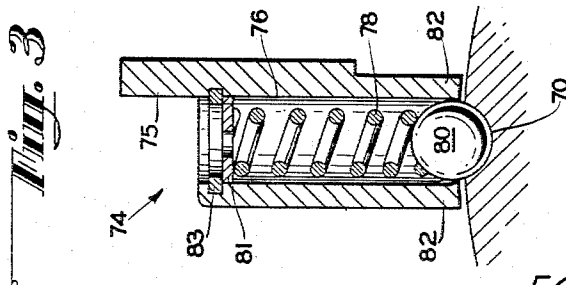
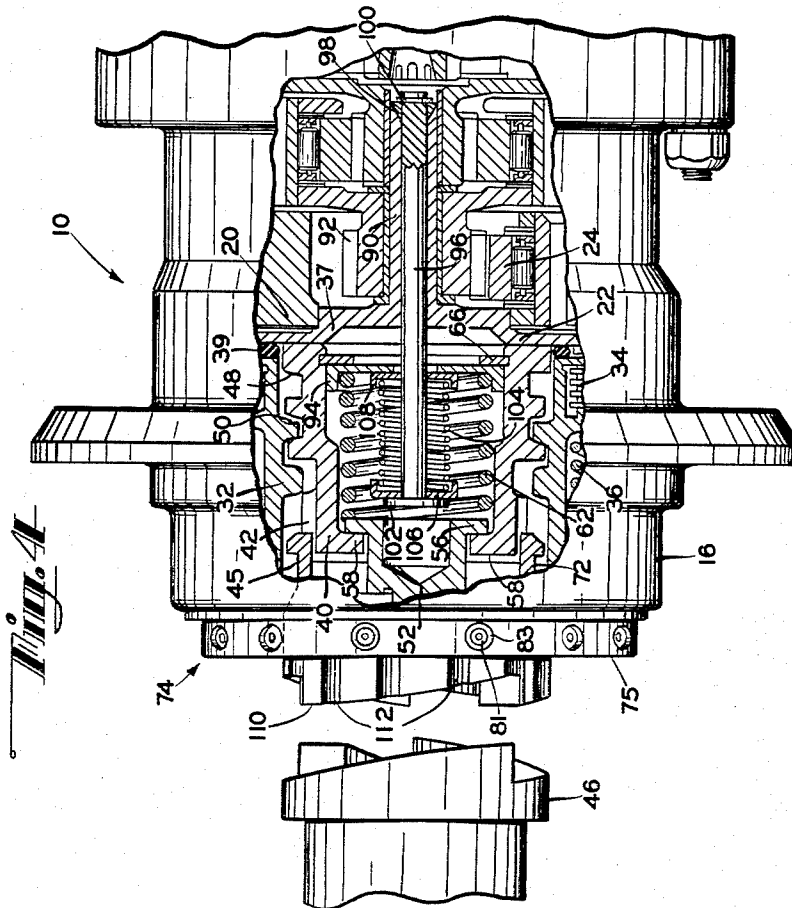
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DIRECT CRANKING ENGINE STARTER

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UNITED STATES PATENT OFFICE

2,566,445

DIRECT CRANKING ENGINE STARTER

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The invention hereof relates to direct-cranking engine starters and the like, and particularly to means for holding a starter jaw against rotation for effecting axial movement thereof into engagement with an engine jaw element, and for releasing the starter jaw upon such engagement for rotation to start the engine.

With a prior direct cranking starter of a certain type, it is usual to reduce the speed of a motor shaft to that of the engine starting speed of the starter jaw through a gear train, an axially stationary rotatable barrel, a torque-limiting friction disc pack in the barrel having discs splined to the barrel and to an axially stationary hollow nut, respectively, which nut is surrounded by the pack. A screw shaft, in the nut, has long lead screw thread connection to the nut and is splined to the starter jaw for axial movement relative thereto. Spring means is provided between the screw shaft and the starter jaw, through the intermediary of which spring means, when the starter jaw is held against rotation, the shaft moves the starter jaw into engagement with the engine jaw, whereupon a shoulder in the nut engages a shoulder on the screw shaft for locking the shaft to the nut for rotation therewith to rotate the jaws to start the engine.

The means for holding the starter jaw against rotation for axial movement as aforesaid, has heretofore been of the friction type, generally as of a split phosphor bronze ring contracted against the jaw and held against rotation. Other rings and means of various types have also been employed, which operate on the friction principle.

Such starters, especially in aircraft practice, are particularly subject to the ingress of fluid such as oil, and mixtures of oil and gasoline or other substances, from the engine and, irrespective of effective sealing means, vapors from the hot engine oil enter the starter housing and condense between the threads of the nut and the screw shaft.

During cold weather, especially after the craft has been grounded for some time, the oil in the starter congeals, so that the friction holding means aforesaid is incapable of exerting enough force to break the seal of the congealed oil, with the results that the starter jaw merely rotates, and does not advance axially to engage the engine jaw.

An object of the present invention is to overcome the above mentioned and other disadvantages by novel effective means.

Another object is to provide means, which in

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contradistinction to former means which holds the starter jaw merely by friction, positively holds the starter jaw for movement into engagement with the engine jaw, upon which engagement the positive holding is released for rotation of the jaws to start the engine.

Another object is to provide starter jaw positive holding means, as aforesaid, which will operate at least as well as a friction holding means at its best, over all corresponding temperature ranges, but which will do so over a longer life range, and enable the starter to function at temperatures greatly below the lowest temperature at which it is operable with friction means.

Another object is to provide holding means, as indicated, which prevents unintentional forward movement of the starter jaw from retracted position.

Another object, in a modification of the invention, is to assist the retracting movement of the jaw.

Another object is to provide a device of the above-indicated character which is simple and durable in construction, economical to manufacture, and effective in its operation.

These and other objects and features of the invention are pointed out in the following description in terms of the embodiment thereof which is shown in the accompanying drawing. It is to be understood, however, that the drawing is for the purpose of illustration only, and is not designed as a definition of the limits of the invention, reference being had to the appended claims for this purpose.

In the drawing:

Figure 1 is a side view, partially in section and partially in elevation of a portion of a direct-cranking engine starter embodying the invention in one form, together with portions of an engine with which the invention is adapted to cooperate;

Figure 2 is an end elevation of a portion of the starter structure, as viewed from the left of Figure 1, the engine portions having been removed;

Figure 3 is an enlarged view of portions seen at the upper left center of Figure 1; and

Figure 4 is a view similar to Figure 1, of a starter of different form to which the invention is adapted, and which assists the return of the jaw from extended position to retracted position.

Referring to Figure 1, which shows only a portion of a direct-cranking aircraft engine starter sufficient for an understanding of the invention,

the structure comprises a starter housing 10 secured to an engine crank casing 12, as by studs 14.

An end housing portion or baffle plate 16 is secured, as by the studs 14, between the housing 10 and the casing 12, and to the housing 10, as by screws 18.

An end wall 20, of a barrel 22, which is axially fixed but rotatable in the housing 10, supports planet gears 24 operating between an orbital gear 26, fixed to the housing 10, and a sun gear 28 on a shaft 30, which sun gear may be driven in a usual manner, by a motor through further speed reducing means.

A hollow nut 32 is connected to the barrel 22 therein by a torque-limiting friction disc pack 34 having discs splined to the nut 32 and the barrel 22, respectively, and axially biased together by springs 36 held in adjusted relation to the discs, as by a ring nut 38 screw-threaded in the opposite end of the barrel 22. The pack 34 is backed against the action of the springs 36 by an annular imperforate plate-like member 37, which is sealed relative to the nut 32, as by an O-ring 39.

A screw shaft 40, has long-lead thread connection to the nut 32, therein, and a spline connection 42 to a starter clutch jaw member 44, which has a shank portion 45 and is adapted to engage a cooperating engine clutch jaw element 46. A shoulder 48 on the screw shaft 40 is adapted to engage a shoulder 50 in the nut 32.

A meshing rod or member 52 extending through a central web portion of the jaw member 44, to which it is secured, as by a fixed nut 54, has a flange 56 behind a flange 58 of the screw shaft 40. The web in this instance, is provided with vent holes 59 to prevent a dash pot effect on the axial movement of the jaw member 44.

A spring 62, in the shaft 40 and through the intermediary of which the shaft acts when it pushes the jaw 44 for engagement with the jaw 46, is disposed between the rod 52 and a spring backing ring 64, which is held in place, as by a split locking ring 66 in a groove of the shaft 40.

That portion of the structure above set forth with which the invention is more closely associated comprises a plurality of grooves 70, which although they may be of various forms and direction, such as extending parallel to the axis of the jaw member 44, in this case are spiral, twelve in number, of round section and certain depth extending along the shank 45 spaced relative to each other about the outer periphery of the shank and of reverse hand pitch corresponding to the lead of the thread connection between the nut 32 and the screw shaft 40. The shank 45 also forms an annular depression 72, of greater depth than the grooves 70, intersecting the latter at the inner ends thereof, to the right, as viewed in Figure 1. The left-hand side 73 of the depression 72 is sloped to gradually lead forwardly into the grooves 70, and onto the shank between the grooves, for reasons which will further appear.

Means 74, on the baffle plate 16, comprises a member 75 having a number of tubular pocket elements 76, twelve in this instance, spaced from each other about the shank 45 in correspondence to the spacing of the grooves 70, and containing springs 78, and balls 80 biased by the springs 78 toward the shank 45. As better seen in Figure 3, inner ends 82, of the pockets 76, in this instance, are constructed to extend radially inwardly of the pockets, as by peening, to a position just below the equators of the balls 80 for limiting the balls, laterally or radially of the shank 45, to

position in the depression 72 and the grooves 70. This position, in this instance, is such that the balls 80 forcibly engage the bottoms of the grooves 70, but are slightly spaced from or do not exert appreciable force on the bottom of the depression 72. When the means 74 is assembled, separate from the jaw member 44, or when the jaw is not in operative position, the balls 80 will be retained by the ends 82 in the pockets 76. Each spring 78 is backed at its outer end by a perforated washer 81 held by a lock ring 83 in a groove of the member 74.

A sealing ring 84, of neoprene or the like, is secured to the baffle plate 16, as by vulcanizing, and having a flexible annularly grooved portion containing a garter spring 86 biasing the ring 84 against an extension 88 of the nut 32.

In operation, with the starter parts in the position assumed thereby when the jaw member 44 is in its retracted position shown, the balls 80 are normally in the grooves 70 forwardly of the depression 72.

Since these grooves form flanges or shoulders at opposite sides of the balls peripherally of the shank, when the nut 32 is rotated under power, the positive holding of the shank by each ball against the aforesaid flange or shoulder at one side of the corresponding groove 70, under the force of the spring 78, ensures the certain rotation of the jaw 44 irrespective of several factors which prevent its rotation when it is held by friction or a friction ring only.

Certain of these factors, under any temperature condition, are early wear caused by friction, and insufficient friction caused by excessive oil on the friction surfaces, and, under low temperature conditions, the congealing of oil between the nut 32 and the screw shaft 40.

With the positive holding means of the invention above set forth, as the jaw 44 advances to the left, as shown, toward engagement with the engine jaw 46, and away from the balls 80, the latter approach the depression 72. The time of entry of the balls into this depression may vary slightly with the degree of axial overlap of the jaws of the member 44 relative to the jaws of the element 46, but should be such that, when the jaws fully mesh, the balls are clearly in the depression and removed from the grooves 70. With the balls in the depression 72, all resistance to turning of the member 44 by the balls is removed.

When the engine starts and the circuit of the starting motor is broken, the jaw 44 is cammed by the jaw 46 back to its initial or retracted position shown, during which the balls 80 may ride up the side 73 of the depression 72 onto the shank 45 forwardly of the depression irrespective of the positions of the grooves 70 or the spaces between the grooves. If the balls land on the jaw 44 between the grooves, the next slight rotation of the jaw, either as part of its retracting or advancing movement, will cause the balls to seek the positions in the grooves 70 shown, ready for the next starting operation.

Also, by reason of the positive holding of the jaw 44 by the balls 80 and the springs 78, the jaw is prevented from accidental forward movement under vibration or from other cause.

In Figure 4, in which corresponding reference characters are designated by corresponding reference numerals, and in which the construction and operation are generally the same, instead of having the shaft 30 extending into the barrel 22, the barrel is provided with a hollow trunnion or

extension shaft 90, on which a sun gear 92, corresponding to the gear 28, is rotatably journaled, and other parts of the gear train to the right are modified accordingly.

In this instance, the locking ring 66 holds a backing ring 94, corresponding to the backing ring 64, but having a smaller central opening by which it relatively closely and axially movably surrounds a rod 96. The latter is held, axially near the right-hand end of the trunnion 90 and within the trunnion, as by a cone head 98, fitting a depression in the end of the trunnion, and a lock ring 100, fitting a groove in the rod 96. The left-hand end of the rod 96 is provided with a head 102.

A spring 104, surrounding the rod 96 in the screw shaft 40, is held and centered by cupped washers 106 and 108 backed by the head 102 and the ring 94, respectively, and facing each other along the spring and the rod. Also, a starter jaw 110 is, in this instance, provided with straight grooves 112 for cooperation with the balls 80.

In operation, as in the case of Figure 1, the screw shaft 40 advances the jaw through the intermediary of the ring 94 and the spring 62, but, at the same time moves the washer 108 to compress the spring 104. Thus, although the spring 62 operates the same as above set forth, to yieldably engage the starter jaw to the engine jaw, the spring 104 is compressed, in the extended position of the starter jaw, to assist in the return of the starter jaw to retracted position.

Although only two embodiments of the invention have been illustrated and described, various changes in the form and relative arrangements of the parts, which will now appear to those skilled in the art, may be made without departing from the scope of the invention. Reference is, therefore, to be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. In an engine starter comprising a housing adapted for mounting on an engine casing and having a baffle-plate end portion for position in the casing, an axially stationary rotatably driven hollow nut in the housing having an internal shoulder, a screw shaft in said nut having long-lead thread connection to said nut and capable of axial movement relative to the nut in response to rotation thereof and including a shoulder adapted to engage said nut shoulder for rotation of the shaft with the nut after said axial movement, spring means, and means operative between said baffle-plate portion and said nut for sealing the housing against the ingress of fluid from the casing, the combination of a jaw member disposed partially in said housing including a cylindrical shank embodying a transverse outer jaw end and having an inner end length splined to said shaft adapting the shaft in its axial movement to move said jaw member through the intermediary of said spring means to engage said jaw member to an engine jaw element and to rotate the jaw member and jaw element to start the engine, said shank having a plurality of round-section spiral grooves therealong of certain depth equally spaced from each other about the outer periphery of the shank and of reverse hand pitch corresponding to the lead of said thread connection, the shank also forming an annular depression of greater depth intersecting the inner ends of said grooves and gradually leading forwardly into the grooves and onto the shank between the grooves, and means on said baffle-plate portion forming

a corresponding plurality of tubular pockets correspondingly spaced from each other about the shank, a spring in each of said pockets, and a ball in each of said pockets movably biased by the spring to position against the bottom of any of said grooves and limited in said biased movement beyond said position by the pocket, said balls moving into said depression after engagement of said jaw member with said engine jaw element so as to permit rotation of the jaw member and element to start the engine.

2. In an engine starter comprising an axially stationary rotatably driven nut, a screw shaft having long-lead thread connection to said nut and capable of axial movement relative to the nut in response to rotation thereof and of rotation with the nut after said axial movement, and spring means, the combination of a driving jaw member including a shank embodying an outer jaw end and having an inner end portion splined to said shaft adapting the shaft in its axial movement to axially move said member through the intermediary of said spring means to engage the member to an engine jaw element and to rotate the jaw member and element to start the engine, said shank having a plurality of grooves therealong of given depth equally spaced from each other about the periphery of the shank and a depression of greater depth about the shank intersecting the inner ends of said grooves and having a surface gradually leading forwardly into the grooves and onto the shank between the grooves, and non-rotative means providing a corresponding plurality of ball supports correspondingly spaced from each other about the shank, and a ball supported by each of said supports and held biased toward the shank for position in any one of said grooves to hold said jaw member against rotation for said axial movement aforesaid effecting engagement of the jaw member to the jaw element, said balls moving into said depression after said engagement to permit rotation of the jaw member and element to start the engine.

3. In an engine starter, having an axially stationary rotatable nut and a screw shaft capable of axial movement relative to the nut in response to rotation thereof and of rotation with the nut after said axial movement, the combination of means including a member operatively connected to said shaft for axial movement thereby to effect engagement of the member to an element of the engine to be started and for rotation by the shaft to rotate said element, said member having defined holding means extending therealong, and means cooperating with said holding means in overlapping relation thereto laterally of the axis of said member for positively restraining the latter against rotation to effect said axial movement for the member, a depression about said shaft, and said cooperating means movable out of said overlapping relation into said depression upon said engagement to permit rotation of said member and element to start the engine.

4. In an engine starter, having a member including a shank portion, the combination of means forming spiral groove means of given depth along said shank and depression means of greater depth around the shank intersecting the groove means leading axially therinto and onto the shank aside the groove means, and non-rotative ball means biased toward the shank for position in said groove to prevent rotation of said shank portion during disengagement of said member with an element of the engine to be

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started, and into said depression means to permit rotation of said shank portion upon engagement of said member with the element of the engine to be started.

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