July 29, 1969 W. FANT ET AL 3,458,019

STARTER ENGAGING MECHANISM

Filed Feb. 6, 1968 2 Sheets-Sheet 1

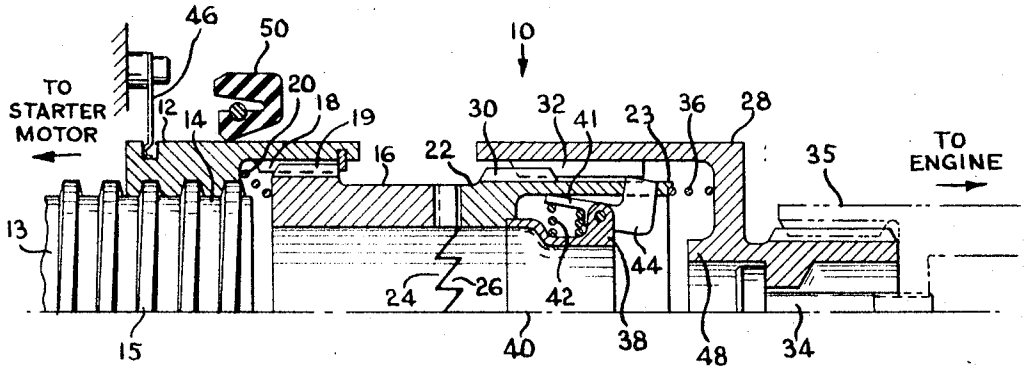

FIG. 1

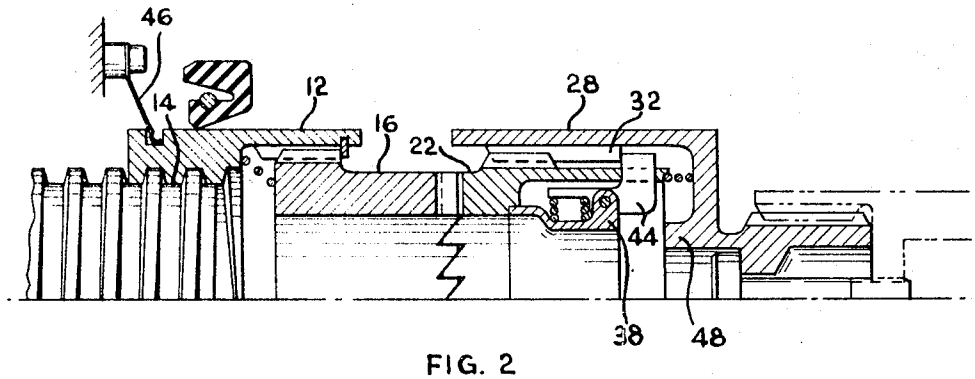

FIG. 2

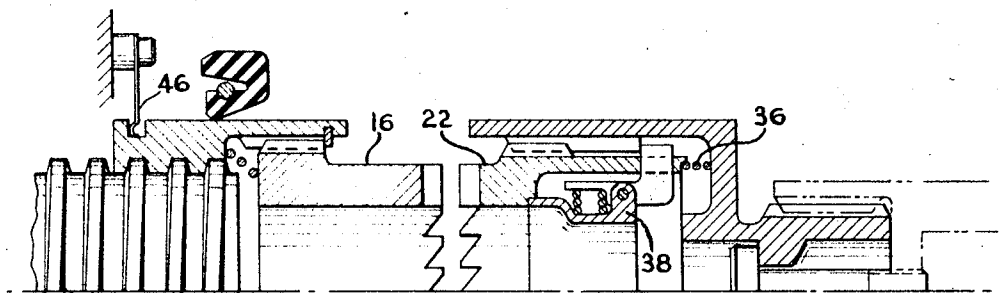

FIG. 3

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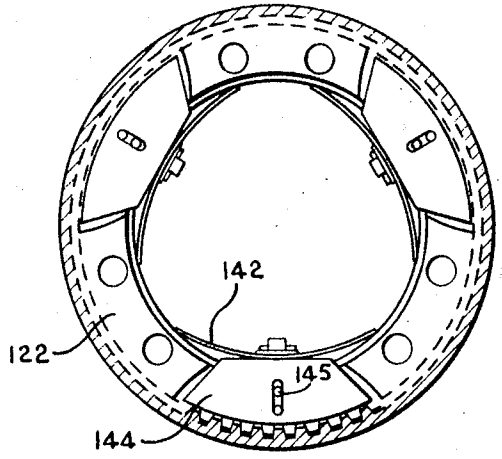

FIG. 5

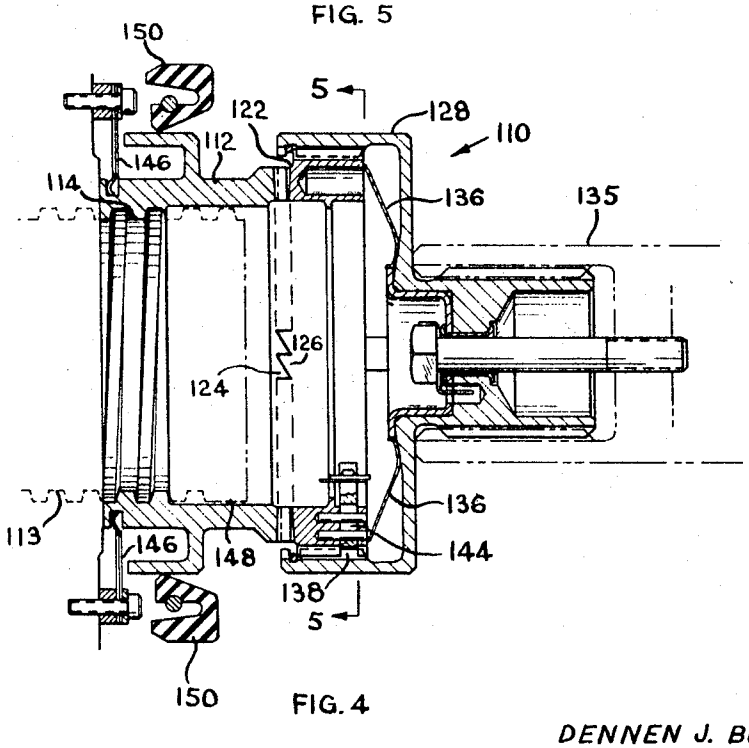

FIG. 4

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STARTER ENGAGING MECHANISM

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U.S. Cl. 192—42 5 Claims

ABSTRACT OF THE DISCLOSURE

A starter engaging mechanism wherein the driving and driven jaws are engaged at rest. The driving jaw advances upon a helical spline under screw-jack action, retarding the driven jaw which has been extended under spring pressure. When the driven engine starts, centrifugal weights lock the driven jaw in its retarded position and the driving jaw retracts under spring bias when the starter is turned off. The driven jaw will remain in the retarded position until engine speed drops sufficiently below locking speed to allow the centrifugal weights to unlock. At this time, it will again be extended into engagement with the driving jaw.

Brief summary of invention

In starting an engine, the start speed is usually well below the normal operating speed so that it becomes desirable to separate the starting motor from the main engine once the main engine has started. This is necessary to reduce power losses from the main engine, prevent the starter motor from wearing due to extended periods of rotation at speeds above that for which the starter motor was designed and to reduce the wear due to ratcheting on the driving and driven jaws of those starter mechanisms equipped with overrunning clutches.

Since the spaced-apart relationship of the starter jaws is necessary when the starter motor is turned off after the main engine has been started, one logical approach was to maintain the spaced-apart relationship at all times when the starter motor is turned off, and to then use the energy developed during the first few moments of engine start to advance the driving jaw of the starter mechanism into engagement with the driven jaw.

Prior art starter engaging mechanisms which have employed the sequence of disengaged, advanced into engagement, engaged during start up, and disengaged, have suffered from any one of a series of problems and difficulties. These have ranged from impositive advance, torque losses and bounce experienced by inertia and friction advance to high cost and complexity of design in the pneumatic advance systems.

On the other hand, those systems which have started with the driving and driven jaws in contact, such as shown in U.S. Patent 3,319,755, issued to J. J. Digby, have required large rotational diameters and/or massive separating means to achieve and maintain the jaw separating function. This system has the obvious drawbacks of extreme size of weights and radius of rotation and associated costs of manufacture, and in some applications, these drawbacks are prohibitive. It is, therefore, an object of this invention to provide a starter engaging mechanism having an initial position with the starter jaws in contact but in which separation is achieved wthout the use of massive separating weights, but rather, by employing those forces already present and available in the starter engaging mechanisms which start with the torque transmitting jaws in a spaced-apart relationship.

It is an object of this invention to provide a starter-engaging mechanism in which the driving and driven jaws maintain a spaced-apart relationship during engine running and are, therefore, not subject to to excessive wear and damage. It is also an object of this invention to provide a starter-engaging mechanism wherein the limitations imposed by the present methods of advancing the driving jaw into engagement with the driven jaw are overcome.

It is a further object of this invention to provide a starter wherein the starter jaws are engaged at all times except when the engine has been started and is running.

Other and further objects and advantages of this invention will be apparent to those skilled in the art from the description and claims which follow and from the appended drawings.

Brief description of drawings

FIGURE 1 shows, in partial section, one embodiment of the starter-engaging mechanism of this invention in the at-rest position, that is, with both starter motor and engine at rest.

FIGURE 2 shows, in partial section, the starter-engaging mechanism in the start position.

FIGURE 3 shows, in partial section, the starter-engaging mechanism in the separated position with the starter motor at rest and the engine running.

FIGURE 4 shows a second embodiment of the starter-engaging mechanism according to this invention.

FIGURE 5 shows a cross section, along line 5—5, of the mechanism shown in FIGURE 4.

Detailed description

Referring now to the drawings and, in particular, FIGURE 1, the numeral **10** indicates a starter-engaging mechanism, according to the teachings of the present invention, for coupling a starter motor to an engine to be started in which both starter and engine are initially at rest. A driving jaw carrier **12**, having helical splines **14**, is connected to the output shaft **13** of a starter motor, not shown, having helical splines **15**, in the usual fashion. A driving jaw **16** is coupled to the carrier **12** by axially-extending straight splines **18** and **19** and is urged away from the starter motor by spring **20** acting between the jaw **16** and an internal shoulder of the driving jaw carrier **12**. This spring is ordinarily functional only to facilitate overrun, but is also provided as a driving jaw cushion in the event re-start is necessary at a time when the engine already has some rotational velocity and the starter jaws are separated. In both cases, its function is well-known and need not be further discussed. The driving jaw **16** is connected to the driven jaw **22** by axially-extending, circumferentially-spaced overrunning teeth **24** on the driving jaw **16** and mating teeth **26** on the driven jaw **22**. These teeth permit the driving jaw **16** to transmit torque to the driven jaw **22**, but inhibit the transmission of torque in the reverse direction by causing the jaws to separate due to the ramp surface of the teeth.

Driven jaw **22** is coupled to the driven jaw carrier **28** by axially-extending straight splines **30** on the jaw **22** and splines **32** on the carrier **28**. As an alternative, any axially-straight coupling means, like one or more key ways or roller or ball splines, could be used. The carrier **28** is, in turn, connected by bolt **34**, or any other suitable means, to the input shaft **35** of an engine to be started, not shown. The driven jaw **22** is urged away from the engine shaft by a spring **26** acting between the rear portion **23** of the jaw **22** and the rear interior wall of the carrier **28**. Abutment stop **48** is also shown at the rear interior wall of the carrier **28**.

The centrifugal-locking device, indicated generally by **38**, is pivotally connected to a ring element **40**, rigidly contained within the driven jaw **22**, and is shown in the radially-inward position. Bias spring **42** acts between the ring element **40** and the arm **41** of the centrifugal-locking device **38** to bias the locking device toward the unlocked

position. The end of the centrifugal-locking device **38**, opposite the arm **41**, is the weight member **44**.

FIGURE 2 shows the starter-engaging mechanism, in partial section, in the operating condition with the engine to be started running and the starter motor not yet turned off. For clarity, only those component parts being here discussed are numbered. The driving jaw carrier **12** and the driving jaw **16** have advanced (i.e. moved rightward in the drawing) because of the screw-jack action of the helical splines **14** and **15** and the jaws **16** and **22** are still engaged. Because the driven jaw carrier **28** is axially stationary, the driven jaw **22** has been forced back into its recessed position and has abutted stop **48**, thereby terminating the axial travel. Since the engine has started and is accelerating toward its normal operating speed, the centrifugal-locking device **38** has operated and weight **44** has pivoted, due to centrifugal force, into the locked-out position behind the splines **32** on the driven jaw carrier **28**. The driving jaw carrier **12** has advanced against the spring bias of spring **46** which is attached to a stationary portion of the frame of the starter motor or the like.

FIGURE 3 shows the starter jaws **16** and **22** in the spaced-apart relationship necessary for the engine to run. The locking device **38** is preventing the driven jaw **22** from executing axial movement away from the engine which the spring **36** is urging the jaw **22** to execute. The starter motor has been turned off and the spring **46** has withdrawn the driving jaw **16** from engagement with the driven jaw **22**. The running clearance which has been established between the starter jaws is, of course, equal to the amount of rightward travel of the driven jaw **22**.

Referring now to FIGURE 4, a second embodiment of this invention is shown in section wherein the component parts having the same functional purpose as those shown in FIGURES 1, 2 and 3 have the same numbers but are in the 100 series. The starter engaging mechanism, shown generally by **110**, has a one-piece driving jaw element **112** having helical splines **114** on one end, adapted to engage mating splines on a shaft **113**, shown by broken lines, of a starter motor, not shown, and circumferential dentil teeth **124** on the other end. Spring **146** places a bias on the driving jaw element **112**, tending to hold it in its extreme leftward position. The dentil teeth **124**, on the driving jaw element **112**, engage mating teeth **126** on the driven jaw **122**. The driven jaw **122** is slidably retained by driven jaw carrier **128** so that there can be limited relative axial motion between the driven jaw **122** and driven jaw carrier **128**, but not relative rotation therebetween. The driven jaw **122** may be retained by the driven jaw carrier **128** by means of axial splines, as shown here, or by one or more keyways or by roller or ball splines. The driven jaw carrier **128** is connected to the input shaft **135** of an engine, not shown, by any suitable means. Springs **136** serve to bias the driven jaw towards its extreme axially-leftward position. Centrifugal-locking device **138**, comprised of a series of weight members **144** interconnected by leaf springs, shown in FIGURE 5 as number **142**, is shown with the springs urging the weight members **144** toward their radially-inward position. Seal **150** serves as a lubricant seal and also provides a small friction force to assist, in the conventional manner, in starter jaw advance in the event that a restart is desired and necessary, while the starter jaws are in a spaced-apart condition; i.e. after the engine has been started and the starter motor brought to rest.

In this configuration, the springs **146** are attached to the shaft **113** and rotate with the shaft but remain axially stationary. It should also be noted that the stop **148** is located on the end of shaft **113** and is a discontinuity in the threaded portion of the shaft **113**. By placing the stop **148** on the end of the shaft **113**, axial thrust loading of the shaft **135** of the engine to be started is kept to a minimum.

Referring now to FIGURE 5, the weight members **144** are shown slidingly retained on the rear of the driven jaw **122** by dual pins **145** which allow slight radial movement. Leaf springs **142** are shown which urge the weight members radially inward.

Operation

Using the starter-engaging mechanism depicted in FIGURES 1, 2 and 3 and starting with the starter motor and engine at rest, as in FIGURE 1, the starter motor is initially turned on. As the output shaft of the starter motor begins to rotate, the driving jaw carrier **12** and driving jaw **16** attempt to rotate along with the output shaft. However, the contact between the driving and driven jaws imposes the torque load of the engine upon the driving jaw carrier **12** and retards its rotation. The output shaft of the motor is now rotating relative to the driving jaw carrier **12** and because of the helical spline connection between the starter motor output shaft and driving jaw carrier, the driving jaw carrier axially advances on the shaft. The torque load of the engine provides very positive advance without reliance on friction, inertia or other impositive advance techniques.

As soon as the driven jaw **22** reaches the stop **48** on the driven jaw carrier **28**, it ceases its axial travel, causing the driving jaw to cease its axial advance and to begin to rotate with the output shaft, causing the engine to begin to rotate. At this point, the driven jaw has been recessed to its extreme rightward position as shown in FIGURE 2, but the locking device has not yet operated due to the bias spring **42**. At some point after the enine has caught and begun to accelerate, the locking device rotates due to the centrifugal force operating on the weight member **44** in opposition to the spring **42**. As shown in FIGURE 2, the weight member will then have moved radially outward into a position directly behind the axial splines **32** of the driven jaw carrier **28**. Since the engine will now be rotating at a higher rotational velocity than the starter motor, overrun will occur, and spring **20** will allow the driving jaw to move axially leftward to provide overrun tooth clearance as the teeth **24** and **26** cam apart.

As soon as the starter motor is turned off, the spring **46** will draw the driving jaw axially leftward. Depending on requirements and spring strength, spring **46** may be a light anti-drift spring or it may provide the major retraction force to retract the driving jaw carrier when the starter motor is switched off. With the screw-jack forec removed by the overrunning of the starter jaws, the only forces acting on the carrier are the slight inertia of its own mass, the spring force, and the frictional force of seal **50**. These forces will result in a resultant force causing the axially leftward motion of the carrier. If a false start should occur or should the engine cease running for some reason, the starter motor may be turned back on, and the frictional force provided by the seal along the inertia of the jaw and jaw carrier will serve to advance the carrier and jaw in order to engage the starter jaws and initiate a restart. As the engine decelerates, the locking device will disengage at some speed below the lockup speed due to the friction force between the weight member and splines, and the return spring will urge the driven jaw forward. By selecting springs **36** and **42** of proper spring constants, the locking device disengagement speed can be as low as may be desirable to reduce jaw ratcheting after engine shut-off.

Two clearly defined start conditions exist, first with the jaws in contact and second with the jaws separated. In the first condition, engine speed is either zero or very close to zero, and there are no impact loads. In the second, the engine is running at some speed above the locking device disengagement speed, and a restart is being initiated. In this situation, impact loads will be encountered, but the relative rotation between the jaws will be low, thereby minimizing impact loads to the point that they are completely tolerable.

If restart is not necessary, the situation shown in FIGURE 3 will prevail, and the driven jaw and its carrier will rotate at engine speed without making contact with the driving jaw which has come to rest at its axially-leftward position. Seal **50** will then be necessary only as a lubricant seal.

We claim:

1. A starter engaging mechanism for coupling a starter motor having an output shaft to an engine to be started having an input shaft comprising:

driving jaw means coupled to said output shaft by a first connection means for rotation therewith;

driven jaw means in normally-abutting contact and in axial alignment with said driving jaw means;

said first connection means operative upon initial rotation of said output shaft to cause said driving jaw means to advance from a first position to a second position while forcing said driven jaw means from a first position to a second position;

a driven jaw carrier fixedly connected to said input shaft and coupled to said driven jaw means by a second connection means; and

locking means connected to one of said driven jaw means and said driven jaw carrier, and operative upon rotation to lock said driven jaw means in its second position.

2. The starter engaging mechanism as claimed in claim **1** wherein:

said first connection means comprise a pair of mated helical threads operative upon mutual relative rotation of said output shaft and said driving jaw means to cause axial translation of said driving jaw means with respect to said output shaft.

3. The starter engaging mechanism as claimed in claim **1** including further:

first resilient means operative to bias said driven jaw means into said first position; and

second resilient means operative to bias said locking means in the unlocked position.

4. The starter engaging mechanism as claimed in claim **2** wherein:

said second connection means is a telescopic connection operative to allow one of said driven jaw means and said driven jaw carrier to receive internally the other of said driven jaw means and said driven jaw carrier when said driven jaw means are forced into its second position; and

said locking means comprise one or more centrifugal weight members radially movably attached to the inner of said driven jaw means and said driven jaw carrier.

5. The starter engaging mechanism as claimed in claim **2** wherein:

said second connection means is operative to allow relative axial motion but prevents relative rotational motion.

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74—6; 192—46, 103, 114