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STARTER GEARING FOR INTERNAL COMBUSTION ENGINES

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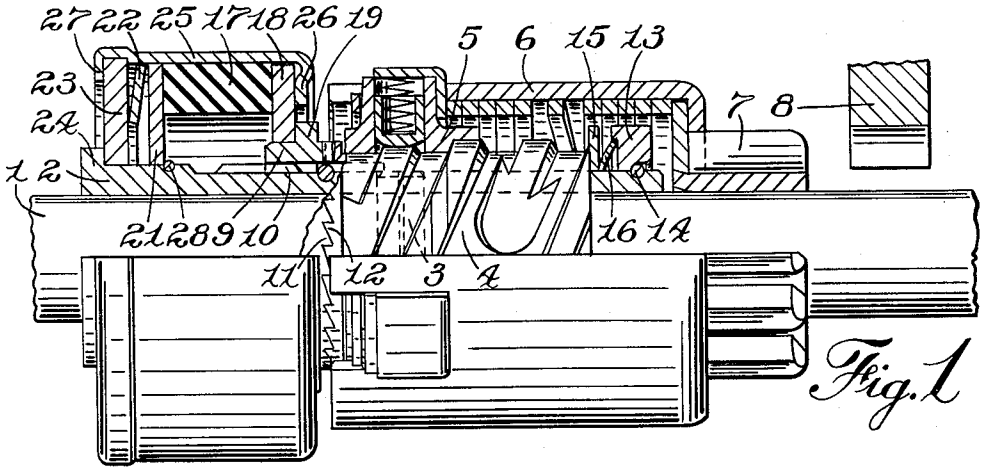


Fig. 1

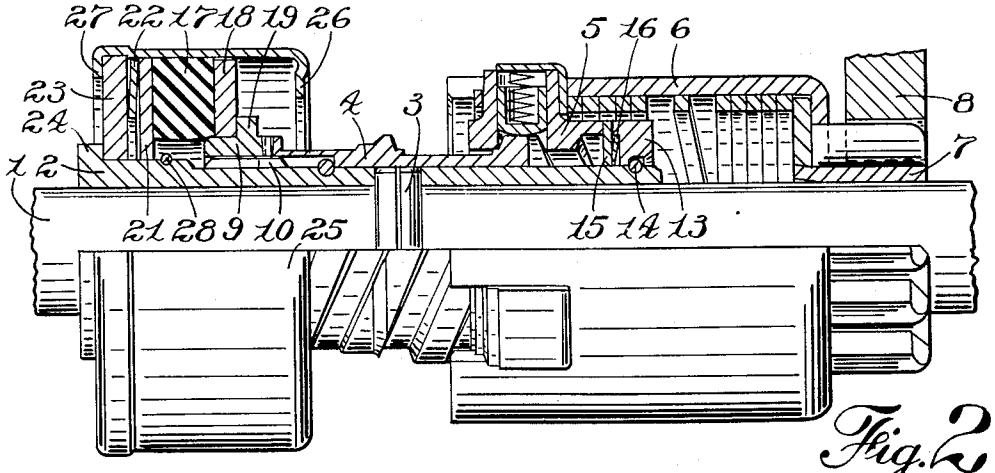


Fig. 2

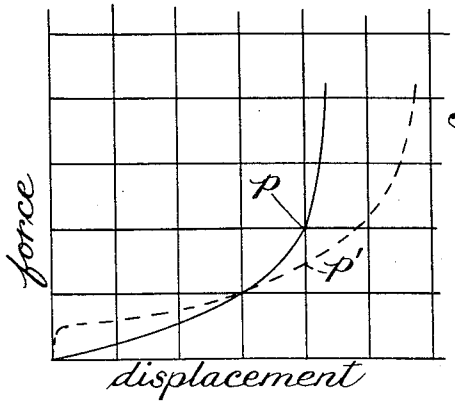


Fig. 3

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6 Claims. (Cl. 74—7)

The present invention relates to starter gearing for internal combustion engines and more particularly to a drive of the automatic engaging and disengaging type.

In the development of drives of this character to meet the increasingly exacting demands for higher gear ratios and reduction in size and cost, the problem of utilization of the deceleration torque of the starting motor and associated parts at the initiation of the cranking operation without overloading the drive has become increasingly serious. The recent adoption of 12 volt starting systems with their starting motors having very high rates of acceleration has rendered this problem still more acute.

The peak deceleration torque in any particular installation will, of course, vary directly with the peak rate of deceleration of the rotating parts, so that it is customary to incorporate in the drive some form of cushioning means to prolong the time of deceleration of the motor armature and consequently reduce the peak torque as its kinetic energy is being transferred to the engine fly wheel.

The use of a block or ring of rubber for such a cushioning means as shown for instance in the patent to Digby 2,752,794, issued July 3, 1956, has decided advantages in the way of softness and quietness of operation, economy and satisfactory life, but in view of the space limitations commonly imposed it has been found difficult to achieve the desired reduction in peak torque without incurring some disadvantageous features such as poor meshing characteristics. In other words, if the cushion is made soft enough to secure easy and quiet meshing, the initial transmission of cranking torque is weak, thus allowing the motor armature to build up kinetic energy until the cushion is compressed substantially solid when there is very little yield, and the consequent peak torque is undesirably high. This problem was recognized as early as the patent to Rushmore 1,387,559, issued August 16, 1921, but the use of a spring having a tapered cross-section as there proposed would be expensive and impracticable. The use of a cushioning member having elements of different stiffness to improve meshing characteristics is disclosed in the patent to Jones 2,306,539, issued December 29, 1942, but such devices do not solve the particular problem here concerned, namely, the flattening out of the torque-displacement curve under the imposed space limitations.

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

It is another object to provide such a device in which the cushioning element is so constituted as to have a comparatively flat displacement-pressure curve throughout its normal operative range.

It is another object to provide such a device incorporating a composite cushioning element, the parts of which co-operate to provide a comparatively constant increase in resistance to compression as the element is loaded.

Further objects and advantages will be apparent from the following description taken in connection with the accompanying drawing in which:

Fig. 1 is a side elevation, partly broken away and in section of a preferred embodiment of the invention showing the parts in normal or idle position;

Fig. 2 is a view similar to Fig. 1 showing the parts in heavily loaded condition as during the initiation of the cranking operation, and

Fig. 3 is a graphical representation of the torque-displacement relation of a cushioning element for a drive constructed according to the present invention as compared to a conventional compression spring drive.

In Fig. 1 there is illustrated a power shaft 1 on which a hollow sleeve 2 is rigidly mounted in any suitable manner as by means of a cross-pin 3. A hollow screw shaft 4 is slidably journalled on the sleeve 2 and has threaded thereon a control nut 5 which is rigidly connected by a barrel member 6 to a pinion 7 slidably journalled on the power shaft 1 for movement into and out of mesh with an engine gear 8.

Means for transmitting rotation from the sleeve 2 to the screw shaft 4 is provided comprising a driving clutch member 9 splined on said sleeve as indicated at 10, and having teeth 11 cooperating with similar teeth 12 on the end of the screw shaft. An abutment ring 13, retained on the end of the sleeve 2 by a lock ring 14 serves to define the meshing position of the pinion 7 by limiting the travel of the control nut 5, a thrust washer 15 being preferably interposed. A light spring 16 located between the abutment ring 13 and thrust washer 15 serves to normally hold the teeth 11, 12 in engagement.

Cushioning means is provided for resisting axial movement of the screw shaft 4 and clutch member 9 responsive to the screw-jack action of said screw shaft and control nut 5 after the meshing movement of the control nut is arrested by the abutment ring 13. As herein illustrated this cushioning means comprises two elements having dissimilar characteristics and functioning substantially in sequence. The first element is in the form of a hollow cylinder 17 of elastically deformable material such as rubber located between a thrust washer 18 seated on the driving clutch member 9 against a shoulder 19, and a second thrust washer 21 slidably mounted on the sleeve 2. The second element is in the form of a dished spring washer 22 located between the thrust washer 21 and an annular pressure plate 23 seated on the end of the sleeve 2 against a flange 24.

This spring may be so constituted as to have a substantially flat compression-displacement curve, so that as it is compressed, its resistance to compression does not increase substantially and may even decrease slightly, as is common with this type of spring.

The composite cushioning element is held in assembled position under initial compression by means of a barrel member 25 surrounding the parts of the yielding connection and having terminal flanges 26, 27, limiting axial expansion thereof. The barrel 25 also prevents radial expansion of the rubber element 17, whereby axial compression thereof deforms it radially inward as shown in Fig. 2.

It is well known that a hollow rubber cylinder has characteristically substantially more resistance to inward movement than to outward expansion in response to lateral compression. The prevention of radial expansion of the cylinder 17 by the barrel 25 thus permits the use of a softer and livelier type of material to secure the desired resistance to compression than would otherwise be required, with consequent improved meshing characteristics of the drive.

The spring washer 22 is held under initial compression by a lock ring 28, which limits the movement of the

thrust washer 21. The initial resistance to further compression of the spring washer 22 is designed to be slightly less than that corresponding to the peak torque which the drive is designed to transmit.

In operation, starting with the parts in the positions illustrated in Fig. 1, acceleration of power shaft 1 by the starting motor, not illustrated, causes rotation of the clutch member 9 to be transmitted to the screw shaft 4 whereby the control nut 5 traverses the pinion 7 into mesh with the engine gear 8 until stopped by the abutment ring 13. The screw shaft 4 then moves backward by screw-jack action, causing compression of the rubber cushioning element 17 with consequent building up of torque tending to rotate the pinion 7.

Fig. 3 illustrates graphically the comparison in operation of a conventional cushioned type drive, with a drive having a precompressed type of composite cushioning member incorporating an element having a low or negative coefficient of compression-displacement relationship. The solid line shows the characteristic behavior of the usual cushioned drive in which the torque initially builds up quite slowly, and then more steeply till at the neighborhood of the point P, there is a rather sharp "knee" in the curve beyond which the drive becomes practically solid. When this point of substantial solidity of the cushioning element is reached by reason of a large amount of kinetic energy to be dissipated, as in case of a spinning mesh, the peak torque may severely overload the drive.

The dotted line shows a characteristic curve of the present type of drive using a somewhat pre-compressed exteriorly confined rubber element, with a spring washer which is arranged to yield at about the pressure indicated by the point P'.

It will be noted that substantial torque is transmitted at the initiation of the cranking engagement, thus preventing the motor from rotating freely and storing up a substantial amount of kinetic energy. From that point the curve is comparatively flat till it approaches the point P' where the curve would normally become very steep. At this point, however, the spring washer yields and lengthens out the curve so that the peak torque in the operative range is reduced to a safe maximum.

While certain specific structure has been shown and described in detail, it will be understood that changes may be made in the precise 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 thereon, a screw shaft slidably journalled on said sleeve, a pinion slidably journalled on the power shaft for movement into and out of mesh with a gear of an engine to be started, means for actuating the pinion from the screw shaft including a control nut threaded on the screw shaft and a barrel member connecting the control nut to the pinion, an abutment member on the sleeve limiting axial movement of the screw shaft and control nut in the meshing direction, and means for actuating the screw shaft from said sleeve including a driving clutch member splined to the sleeve having an overrunning clutch connection to the screw shaft, and a composite yielding means resisting axial movement of the driving clutch member in the demeshing direction, said yielding means comprising an elastic element having a variable coefficient of resistance to pressure with a rapid increase in such ratio as the torque approaches its normal upper limit, and a second elastic element having a comparatively constant coefficient throughout and substantially beyond the normal upper limit of cranking torque.

2. An engine starter drive as set forth in claim 1 in which the first mentioned elastic element is in the form of a cylinder of elastically deformable material.

3. An engine starter drive as set forth in claim 2 including further means for preventing radial expansion of the cylinder of elastically deformable material.

4. An engine starter drive as set forth in claim 1 in which the last mentioned elastic element is in the form of a dished spring washer.

5. An engine starter drive as set forth in claim 1, including means for holding the composite yielding means under initial axial compression.

6. An engine starter drive as set forth in claim 1 including means for holding the second elastic element under compression slightly less than that corresponding to the safe peak torque of the drive.

References Cited in the file of this patent

UNITED STATES PATENTS

2,304,241	Buxton	Dec. 8, 1942
2,815,669	Mendenhall	Dec. 10, 1957