Jan. 30, 1951 C. P. PEPPER 2,540,009

SPRING CLUTCH MECHANISM AND ENGINE STARTER UNIT

Filed Oct. 29, 1947

Fig. 1

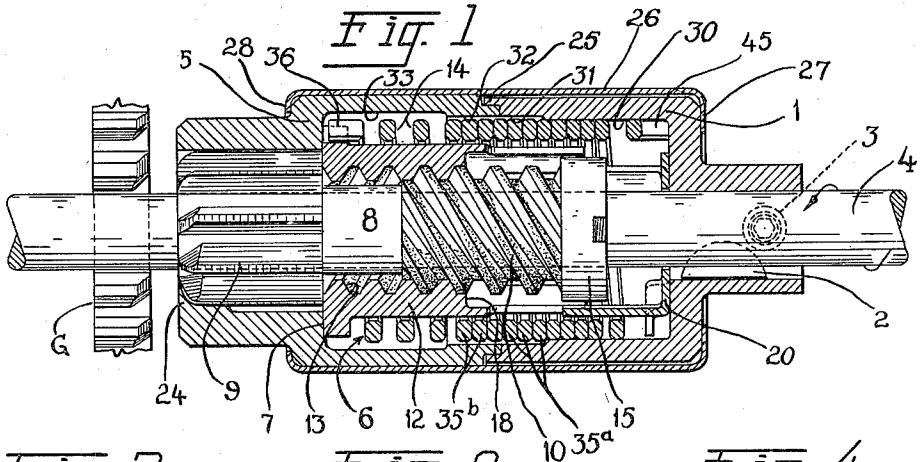


Fig. 3

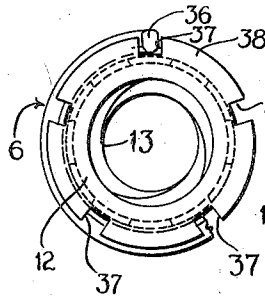


Fig. 2

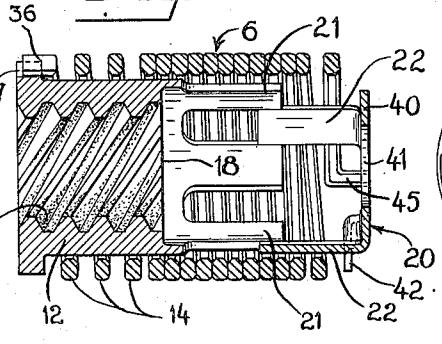


Fig. 4

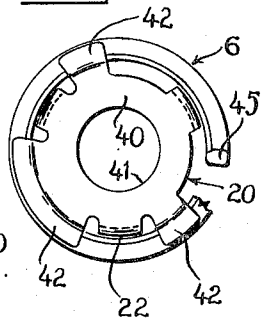


Fig. 5

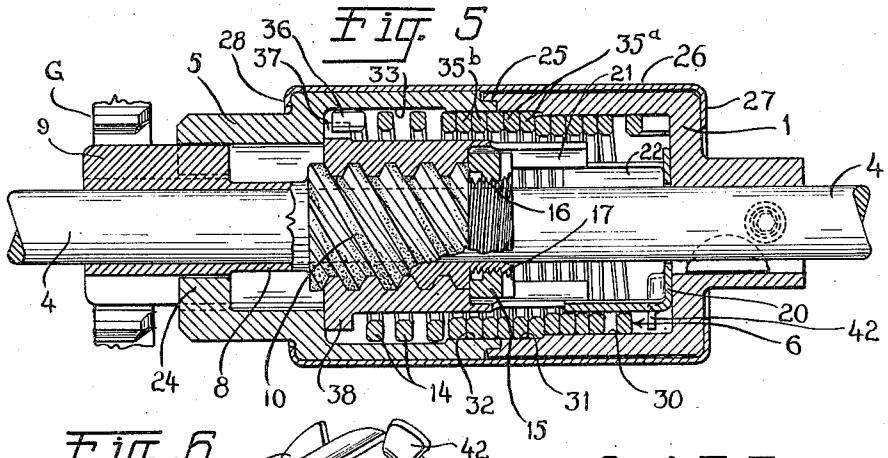
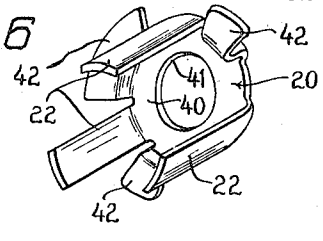


Fig. 6



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SPRING CLUTCH MECHANISM AND ENGINE STARTER UNIT

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Application October 29, 1947, Serial No. 782,905

13 Claims. (Cl. 74—7)

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The invention relates to an improvement in spring clutches and to an automatic engaging and retracting type starter unit for internal combustion engines, thus indicating the general object.

An object of this invention is the provision of a spring clutch mechanism embodying driving and driven drum elements, a clutch spring cooperating therewith having a portion thereof normally engaged with one of said drums and a second portion normally disengaged from the second of said drums, and a load transmitting element co-rotative with one of said drums and having an energizing connection with one end of the spring whereby imposition of a certain torque thereon will cause the spring to become in tight frictional contact with both of said drums.

A further object is to provide in a mechanism as described above, means whereby upon imposition of a large, i. e. overload, torque, a torque-limiting, de-energizing operation of the spring is caused to take place, relieving the frictional contact between the spring and one or both of said drums.

The starter mechanism unit disclosed hereby is of the automatic engaging and disengaging type wherein energization of a starter motor causes a pinion on the starter unit to be moved from its normal idle position axially into mesh with a starter gear of the engine, whereupon the gear is rotated until the engine starts; and the starting of the engine then causes the pinion to be moved out of engagement with the gear to or toward the initial idle position. The automatic operations result from abrupt start or change of speed of rotation through inertia of the pinion or parts co-rotatively connected therewith in cooperation with a helical pinion-actuating means which, in the illustrated form, is a steeply pitched screw thread couple. The torque-limiting clutch mechanism outlined above is used in the present starter unit, to limit the starting torque which can be imposed on the pinion and gear teeth during attempted starting and to perform other desirable functions referred to below.

Specific objects hereof include provision of an improved engine starter mechanism, including a spring clutch, wherein if the usual starter pinion and ring gear teeth collide end-to-end during the starting operation, a portion of the clutch spring yields in a manner to enable cessation of meshing movement of the pinion while continuing its rotation until the pinion and gear teeth can go into mesh; an improved arrangement in which a portion of the clutch spring acts independently of its associated clutch drum to produce initial inertia-operation of the pinion toward its engine starting position and subsequently acts as a torque sensitive element of the mechanism for torque limiting purposes; a starter mechanism wherein a portion of the clutch spring and associated friction means operates to prevent creeping or jarring of the starter pinion out of its initial or idle position during normal operation of the engine; an improved arrangement wherein a portion of the clutch spring acts to absorb shock when the engine begins to operate under its own power and throws the pinion out of mesh with the engine starter gear and permits it to overrun after disengagement, and a simple readily-adjustable torque limiting mechanism for a starter unit of the type shown to protect the unit and the starter gear teeth against high impact load and/or in the event the engine refuses to start or backfires during the starting operation.

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Other objects and features of the invention will become apparent from the following description of the preferred form shown in the drawing, wherein:

Fig. 1 is a longitudinal sectional view of the starter unit with the starter pinion in retracted, idle position. Fig. 2 is a similar view showing the clutch spring and torque limiting mechanism assembly. Figs. 3 and 4 are respective end views of the assembly shown in Fig. 2. Fig. 5 is an assembly view similar to Fig. 1 but with the starter pinion in driving position with respect to the engine ring gear. Fig. 6 is an isometric perspective view of a clutch spring de-energizer sleeve of the clutch mechanism.

The principal parts of the starter mechanism shown comprise: a driving clutch drum member 1 adapted to be secured conventionally as by a key 2 and cross pin 3 to a suitable starter motor drive shaft 4; a driven clutch drum member 5 coaxial with the driving drum; a clutch spring 6 in bridging relation to the drums; a starter pinion sleeve 8 slidable along the drive shaft and having a pinion 9 thereon at one end and a steeply pitched screw thread formation 10 at the other end, and an actuator nut member 12 in the form of a sleeve having internal screw threads 13 mating the thread formation 10.

The nut 12 is normally held in axially fixed position within the drum assembly by an openly wound coil portion 14 of the clutch spring which portion holds smooth faces of the nut and drum 5 together as at 7. Additionally the pinion sleeve 8 has a stop shoulder enlargement 15 secured thereto conventionally as by screw threads 16

and key stakings 17, the shoulder being freely movable from the position thereof shown in Fig. 1 to the pinion-stopping position of Fig. 5 wherein the shoulder 15 abuts a circular face 18 formed inside the actuator nut and defining the inner ends of the actuator nut threads 13.

At the inner end of the pinion-actuator nut 12 and within the clutch drum 1 is a clutch-spring-deenergizer sleeve 20 which is splined to the actuator nut 12 by interfitting oppositely extending finger portions 21 and 22 of the nut and sleeve respectively, for enabling the nut 12 to move from its normal illustrated position against the axial stress of the open wound spring coils 14 in event of mismating of the pinion teeth 9 with teeth of the cooperating ring gear G of the engine flywheel. The splined connection 21, 22 forms a spring de-energizing connection between the actuator nut and the end portion of the spring contained in the driving drum as will be more fully explained.

The driven drum 5 is in continuously splined relation to the pinion 9 by reason of internal spline teeth 24 of the drum 5, engaging the pinion teeth so that the pinion is turned with sufficient force for engine starting whenever the clutch is rendered operative.

The clutch drums 1 and 5 are maintained in light-abutment, free-running contact, at a stepped shoulder connection 25 of the drums, by a housing shell tube 26 which also assists, particularly in cooperation with the stepped shoulder 25, to retain a supply of lubricant within the clutch drum assembly. Inturned end flanges 27 and 28 of the housing shell (flange 28 turned in during final assembly) abut associated end faces of respective drums 1 and 5 in sufficiently light contact so as not to interfere with free relative rotation of the drums. The shell may be peripherally tight on one of the drums (e. g. 5) and loose on the other.

The drums 1 and 5 while shown of the internal or "pocket" type in reference to the clutch spring could, so far as operation is concerned, be of the "stud" type, i. e. arranged to be gripped and released by internal coil surfaces of the clutch spring.

The peripheral spring-engaging surface portion 30 of the driving drum 1 is tight on the associated coils of the spring 6 and the engine-starting direction of rotation of the drum 1 (see arrow on shaft 4) is such as to tend to expand the spring still more tightly in the drum. That direction of rotation requires a left hand wound spring in the particular assembly shown. Slightly enlarged diameter inner surface portions 31 and 32 of the clutch drums 1 and 5 respectively (adjacent the joint 25) are normally in slightly radially spaced or non-gripping relationship to associated spring coils 35a and 35b. A further enlarged inner surface portion 33 of the driven drum 5 surrounds the openly wound coils 14 of the spring. The clutching or load carrying coils 35 of the spring are principally those shown as closely wound. The openly wound coils 14 serve as a direct torque transmitting connection between the driving drum 1 (through the load carrying coils 35 co-rotative therewith) and the actuator nut 10 by reason of a forwardly projecting toe 36 of the spring being seated with slight circumferential clearance in one of several notches 37 of the forward flange portion 38 of the actuator nut.

The clutch spring is preferably ground to cylindrical form from end to end, being rendered operative to engage the enlarged diameter drum surfaces 31 and 32 by radial expansion of the radially adjacent load carrying coils 35a and 35b when the open coiled portion is torsionally stressed, by load reactance, as will be presently explained, in the proper direction to expand the spring. Such torsional stressing of the open wound coils is limited to less than would be required to make those coils contact with the drum surface 33 by the fact that as soon as the load carrying coils 35a and 35b are expanded against the surfaces 31 and 32 the load reactance forces which caused the spring to become expanded are shunted out of action by the operation of the clutch spring when the latter connects the clutch drums together for co-rotation at surfaces 31 and 32. The clutch spring is maintained by stress in the spring in spaced relation to the actuator nut 12 so as not to interfere frictionally with axial movement of the actuator nut when and if the pinion and gear teeth collide end-to-end.

The spring de-energizer sleeve 20, the preferred form of which is clearly shown in Fig. 6, has a disc-like end wall 40 centrally apertured at 41 so that the sleeve may be held centrally of the clutch assembly by the drive shaft 4 extending through the aperture. The wall 40 has a plurality of radially extending, circumferentially spaced ears 42 in the same transverse plane for circumferential abutment selectively with a de-energizer toe 45 at the rear end of the spring. The toe 45 normally is out of contact with circumferentially adjacent ears 42 but, for torque limiting, one of the ears is enabled to make de-energizing contact with the toe 45 when the torque attempted to be deliverd to the starter pinion by the starter motor is sufficiently high to endanger parts of starter mechanism. Capacity adjustment for torque limiting will be explained below.

Operation

The starter motor drive shaft 4 in the particular assembly shown rotates, for engine starting, in the direction of the arrow shown on the right hand end of the drive shaft, Fig. 1. Such rotation through the tight connection between the clutch spring and drum 1 causes rotation of the openly wound coils 14 in the direction in which the spring is wound (left hand, in the present instance), causing the actuator nut 12 to be suddenly rotated through the intermediary of the spring toe 36 and one of the notches 37 in the actuator nut flange. Since the steeply pitched threaded connection at 13 is right hand, the pinion 9 is thereby suddenly moved forwardly toward and into engagement with the ring gear G of the engine. The openly wound coils could not, without expanding into contact with the surface 33 of the drum 5, turn the engine fly-wheel through its gear G. The openly wound coils expand slightly due to the resistance to turning on part of gear G and in so doing progressively energize the load carrying spring coils 35b and 35a respectively into clutching contact with the drum surfaces 32 and 31. Thereafter, see Fig. 5, starting torque to the pinion 9 is principally carried through the clutch drum 5 and its splined connection 24 thereof with the pinion.

Assuming the engine has started, the pinion sleeve will, by reason of the steep pitched threaded connection 13, be moved to its initial position, Fig. 1, until the rear end of the pinion abuts the forward face of the flange 38 of the actuator nut. If the impact force is great

enough, the nut will move rearwardly under the resistance of the openly wound coils 14 reacting against the flange 38 of the nut. Subsequent recoil of the spring will reposition the nut 12 as illustrated in Fig. 1. Thereafter the axial prestress of the openly wound coils 14 against the flange 38 maintains friction pressure contact at 7 sufficient to prevent free relative rotation between the nut and drum, thereby preventing creeping or jarring of the pinion sleeve out of the normal or idle position. The friction and pressure are insufficient to interfere with inertia actuation of the pinion into and out of starting position. Friction between the actuator nut and the drum 5 operates as just described because the pinion is splined to the drum 5. The pinion sleeve cannot, by imposition of a relatively small turning force thereon turn the drum 5 relative to the actuator nut as would be necessary in order for the pinion sleeve screw threads to unscrew from the nut toward the ring gear G.

If the pinion teeth and those of the ring gear G are not aligned when the pinion is inertia-actuated into contact with the ring gear teeth, the openly wound coils 14 are axially compressed momentarily while relative rotation of the pinion sleeve and actuator nut 12 continues to take place. Winding up of the openly wound spring coils during the lost motion also absorbs shock and cushions the blow between the pinion and ring gear. When the pinion and gear teeth then come into alignment by further rotation of the pinion sleeve the axially stressed coils 14 expand to cause the teeth to mesh.

When the engine gear G returns the starter pinion to initial position, rotation of the starter motor shaft at excessively high speed such as might damage the starter motor is prevented by the inherent overrunning operation of the clutch. That operation is due to de-energization of the clutch spring from its forward end through operation of the openly wound coils 14 in contracting the load carrying coils 35b then 35a out of forcible driving contact with the respective drums. Continued contraction of the spring away from the surface 30 of the drum 1 causes the spring to overrun in the driving drum.

Upon imposition of torque in the normal starting direction of such magnitude as could damage the starter unit or the ring gear teeth, the few load carrying spring coils 35b which are in engagement with the driven drum surface 32 are designed to slip at a value well below the danger point. Thereupon, assuming the pinion 9 is in active position, the drum 1 through the tight connection with the spring coils 35 therewith causes relative angular movement between said drum and the actuator nut 12 in a direction to expand the openly wound spring coils 14 through the spring and actuator nut toe-and-notch connection 36, 37. The relative angular movement (see Fig. 4), as determined by the amount of overload torque and the torque capacity of the free spring coils 14, acting in parallel with the low torque capacity clutching coils 35b as combined torque-sensitive means, causes the de-energizer sleeve to be turned (through its splined connection with the actuator nut 12) until the radial ear or flange of the de-energizer sleeve 20 which is in trailing relation to the spring toe 45 in the direction of winding of the spring (Figs. 2 and 4) comes into contact with said toe. Such contact causes progressive contraction of the spring coils 35 away from the surface 30 of the driving drum until the spring coil assembly (coils 35) slips in the driving drum. Upon reduction of torque below overload a reverse relative rotation between the actuator nut and de-energizer sleeve takes place by re-expansion of the openly wound coils 14, enabling the spring coils 35 to re-expand into clutching relation to the driving drum.

To adjust the torque limiting capacity of the unit at some point between the torque capacity necessary for engine starting and such value as might damage a part of the mechanism, the de-energizing sleeve 20 is positioned with one of its spring de-energizing ears 42 in predetermined position with relation to the spring toe 45, so that predetermined angular relative movement of the actuator nut and the driving drum can take place before de-energization of the spring coils commences to occur by reason of contact between said ear and the toe 45 of the spring. Through different angular spacing between the radial toe receiving notches 37 in the flange 38 of the actuator sleeve, as related to the angular spacing of the radial ears of the de-energizing sleeve, small increment or vernier adjustment is possible. Such adjustment may be secured by providing, for instance, six equally spaced spline fingers on the actuator nut and de-energizer sleeve respectively, and a smaller or larger number (i. e. five or seven) of notches in the actuator nut flange 38 for restraining the toe at the opposite end of the spring. Through selective positioning of the de-energizing sleeve with reference to the actuator nut as related to the position of the spring toe 36 within the radial notches thereof, torque limits may be adjusted as required. The torque limiting mechanism hereof is an improvement on or adaptation of the prior disclosures of William Carleton Starkey in one or more of the following Starkey applications: Serial No. 508,601, filed November 1, 1943, now Patent No. 2,459,972; Serial No. 614,496, filed September 5, 1945; Serial No. 760,670, filed July 12, 1947.

I claim:

1. A torque limiting spring clutch mechanism comprising two clutch drums and a clutch spring bridging the drums and normally in tight frictional contact with one only of the drums, a load transmitting element co-rotative with one of the drums and having an energizing connection with one end of the spring operative upon imposition of a certain torque on the load element to cause the spring to become in tight frictional contact with both of the drums, said load transmitting element having a de-energizing connection with the opposite end of the spring operative upon imposition of a greater torque on said element to limit the torque transmissible through the mechanism.

2. A torque limiting spring clutch mechanism comprising two clutch drums and a clutch spring bridging the drums and normally in tight frictional contact with one only of the drums, a load transmitting element co-rotative with one of the drums and having a lost motion energizing connection with the spring operative upon taking up of the lost motion and imposition of a certain torque on the load element to cause the spring to become in tight frictional contact with both of the drums, said load transmitting element having a de-energizing connection with the spring operative upon imposition of a greater torque on said element to limit the torque transmissible through the mechanism.

3. A torque limiting spring clutch mechanism comprising aligned driving and driven clutch drums, a clutch spring having a coil portion normally frictionally and releasably engaged with the driving drum and a free coil portion normally frictionally disengaged from the driven drum but engageable therewith, a load element co-rotatively connected with the driven drum, a clutch energizing connection between the load element and the free coil portion operative upon imposition of a certain torque on the load element to cause the normally free coil portion clutchingly to engage the driven drum for driving of the load element, and a clutch de-energizing connection between the load element and the normally engaged coil portion operative upon imposition of greater torque on the load element to render the clutch mechanism ineffective to turn the load element.

4. A torque limiting spring clutch mechanism comprising aligned driving and driven clutch drums, a clutch spring having a coil portion normally frictionally and releasably engaged with the driving drum and a coil portion normally in non-driving relation to the driven drum, a load element co-rotatively connected with the driven drum, a clutch energizing lost-motion connection between the load element and the second mentioned coil portion operative upon imposition of a certain torque on the load element following taking up of the lost motion to cause the normally non-driving coil portion of the spring to drive the driven drum and thereby the load element, and a clutch de-energizing connection between the load element and the normally engaged coil portion operative upon imposition of greater torque on the load element to render the clutch mechanism ineffective to turn the load element.

5. An automatic engine starter unit comprising a driving clutch drum adapted to be secured to a starter motor drive shaft, a screw threaded starter pinion sleeve slidable along the drive shaft for movement of the pinion into and out of mesh with a gear of the engine, a screw threaded pinion actuator sleeve mating with the thread of the pinion sleeve, a driven clutch drum slidably keyed to the pinion sleeve in alignment with the driving drum, means to prevent axial separation of said drums, a clutch spring bridging said drums, having one end co-rotatively associated with the driving drum and its opposite end positively connected with the actuator sleeve for inertia movement of the pinion into engine starting position upon initial rotation of the driving drum by the drive shaft, said clutch spring being energized from its positively connected end into clutching relationship with the driven drum for imparting starting torque to the pinion consequent upon meshing engagement of the pinion with such engine gear.

6. The mechanism according to claim 5, wherein the clutch spring has an open wound coil portion operatively in abutment axially of the spring with the actuator sleeve to hold the latter normally in axial abutment with the driven drum, and wherein the actuator sleeve is axially movable against the initial stress of the open wound coil portion to permit retraction of the pinion sleeve unitarily with the actuator sleeve in event of mismating of pinion and engine gear teeth during the engine-starting operation.

7. The mechanism according to claim 5, wherein the clutch spring has an open wound coil portion axially prestressed against the actuator sleeve in a manner to hold axially opposing faces of the

actuator sleeve and driven drum in frictional abutment normally resisting relative turning of the pinion sleeve and actuator sleeve through the intermediary of the driven drum but with insufficient force to prevent inertia-actuation of the pinion sleeve during the engine-starting operation of the mechanism.

8. The mechanism according to claim 5, wherein the clutch spring has a coil portion normally in prestressed friction clutching relationship to the driving drum serving as the sole torque transmitting connection between the spring and driving drum, and a torsionally flexible coil portion of the spring is circumferentially anchored to the actuator sleeve, the latter sleeve having a clutch de-energizing connection with said prestressed clutching coil portion operative to limit the driving force transmissible to the pinion through the driven drum by causing slippage between the driving drum and the clutch spring in event overload torque causes relative rotation between the driving drum and the actuator sleeve.

9. The mechanism according to claim 5, wherein the clutch spring has a coil portion normally in prestressed friction clutching relationship to the driving drum serving as the sole torque transmitting connection between the spring and driving drum, and a torsionally flexible coil portion of the spring is circumferentially anchored to the actuator sleeve, the latter sleeve having an adjustable clutch de-energizing connection with said prestressed clutching coil portion operative to selectively limit the driving force transmissible to the pinion through the driven drum by causing slippage between the driving drum and the clutch spring in event overload torque causes relative rotation between the driving drum and the actuator sleeve.

10. In a spring clutch mechanism, a clutch drum, a rotary member coaxial with the drum, a clutch spring having clutching coils frictionally engaging the drum, said spring having at least one non-clutching but torque-sensitive coil selectively and detachably connectable to the rotary member at one of a number of circumferentially spaced points around the member, a clutch de-energizing member arranged to be moved into torque-limiting abutment relation to one of the clutching coils of the spring during relative angular movement between the drum and rotary member, and a detachable spline connection between the de-energizing member and the rotary member arranged to enable a different number of angular adjustments to be effected between the de-energizing member and said one of the clutching coils from that enabled by the aforesaid selective connection.

11. An engine starter clutch unit comprising aligned driving and driven clutch drums, the former adapted for connection with a starter motor drive shaft, a starter pinion sleeve splined to the driven drum and having a screw thread portion, a drive nut mating said portion for inertia actuation of the sleeve and mounted for limited axial movement relative to both drums, a clutch spring frictionally engaged with the driving drum for co-rotation therewith and engageable with the driven drum, said spring having an open wound nonclutching torque-sensitive coil portion normally holding the drive nut at one end of the limit of its movement while permitting the nut and sleeve to move bodily against the axial stress of the open wound coil portion, and a rotatively mounted spring de-energizer sleeve axially fixed in operative association with the driving-

drum-engaged portion of the spring, the de-energizer sleeve having a splined connection with the nut for spring de-energizing operation by the nut, the nut being co-rotatively connected with a terminal part of the open-wound torque-sensitive portion of the spring and becoming active to cause spring de-energization consequent upon a predetermined angular relative movement of the driving drum and the nut.

12. An engine starter clutch unit comprising aligned driving and driven clutch drums, the former adapted for connection with a starter motor drive shaft; a starter pinion sleeve splined to the driven drum and having a screw thread portion, a drive nut mating said thread portion for inertia actuation of the sleeve and mounted for limited axial movement relative to both drums, a clutch spring frictionally engaged with the driving drum for co-rotation therewith and engageable with the driven drum, said spring having an open wound non-clutching torque sensitive coil portion normally holding the drive nut at one end of the limit of its movement while permitting the nut and sleeve to move bodily against the axial stress of the open wound coil portion, and a rotatively mounted spring de-energizer sleeve in operative association with the driving-drum-engaged portion of the spring, the de-energizer sleeve having a circumferentially adjustable splined connection with the nut for adjusted spring de-energizing operation thereby, a terminal part of the open-wound torque-sensitive portion of the spring being arranged for connection selectively with the nut at a plurality of points around the nut different from the number of angular adjustments enabled by the spline connection, said mechanism becoming active to cause spring de-energization consequent upon imposition of overload torque to the driven drum.

13. A spring clutch mechanism comprising two clutch drums, a helical clutch spring bridging the drums and with load-carrying coils normally in right frictional but overrunning contact with one of the drums and other load carrying coils out of contact with the other drum, a load transmitting element co-rotative with one of the drums and having an energizing connection with one end of the spring operative upon imposition of a certain torque on said load transmitting element to cause said other load carrying coils of the spring to become in tight frictional contact with said other drum, the spring having a non-clutching torque-shock-absorbing portion between the normally non-contacting load carrying coils and said energizing connection.

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