

[54] **LIGHTWEIGHT CHAIN SAW WITH
ENGINE RESTARTING SYSTEM AND
METHOD AND APPARATUS FOR
RESTARTING A WARM INTERNAL
COMBUSTION ENGINE**

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3,763,842.

[52] **U.S. Cl.** **123/179 S, 123/179 P**
[51] **Int. Cl.** **F02h 5/02, F02h 3/02**
[58] **Field of Search** **123/179 S, 179 P**

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[57] **ABSTRACT**

A lightweight chain saw including a starting mechanism for starting the saw while the saw engine is cold and a restarting mechanism for restarting the saw while the saw engine is warm.

A method and apparatus for rewinding a starter spring characterized by a starter energy generating system which is continuously engaged with a starter spring and by a friction clutch which is continuously engaged with and operable to disable a reaction device in order to divert energy away from the starter spring.

Methods and apparatus for indicating the level of energy in an engine mechanism and for permitting selective adjustment of the level of starter energy stored in the mechanism.

8 Claims, 9 Drawing Figures

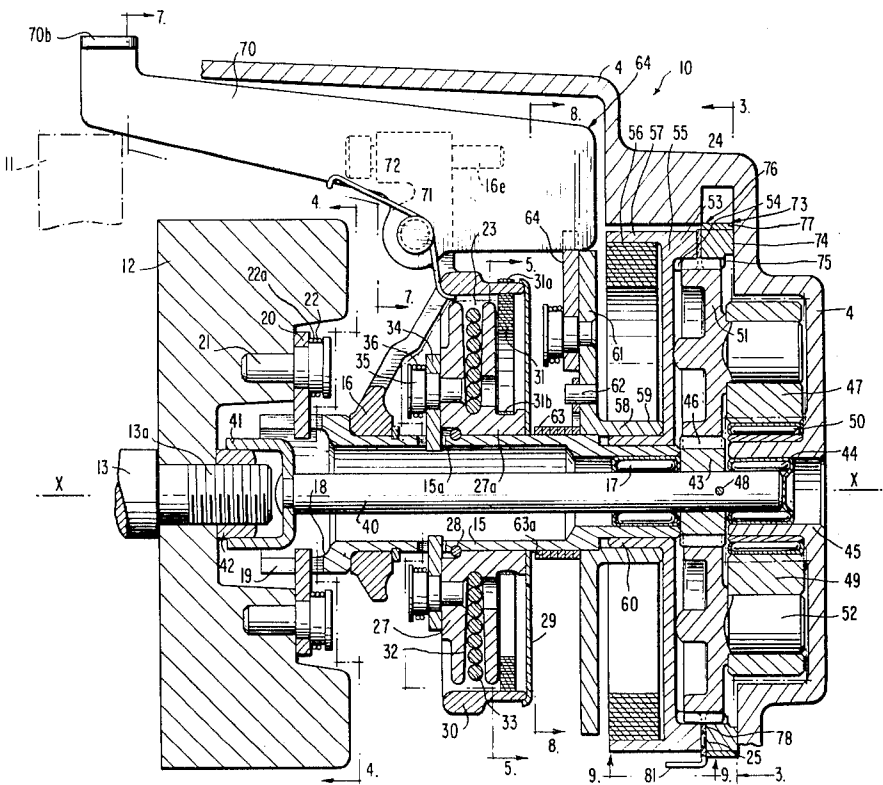


FIG. 1

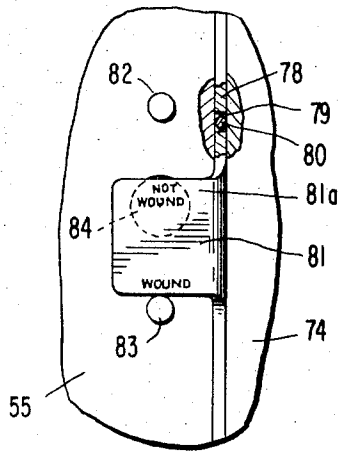
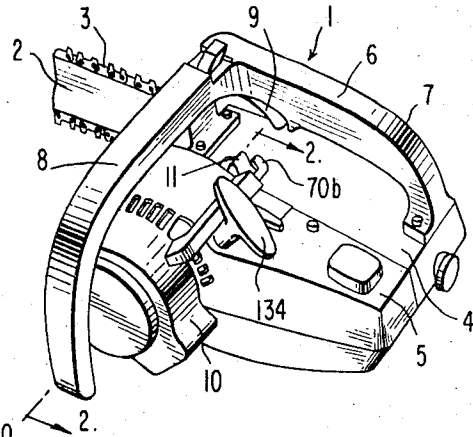


FIG. 9

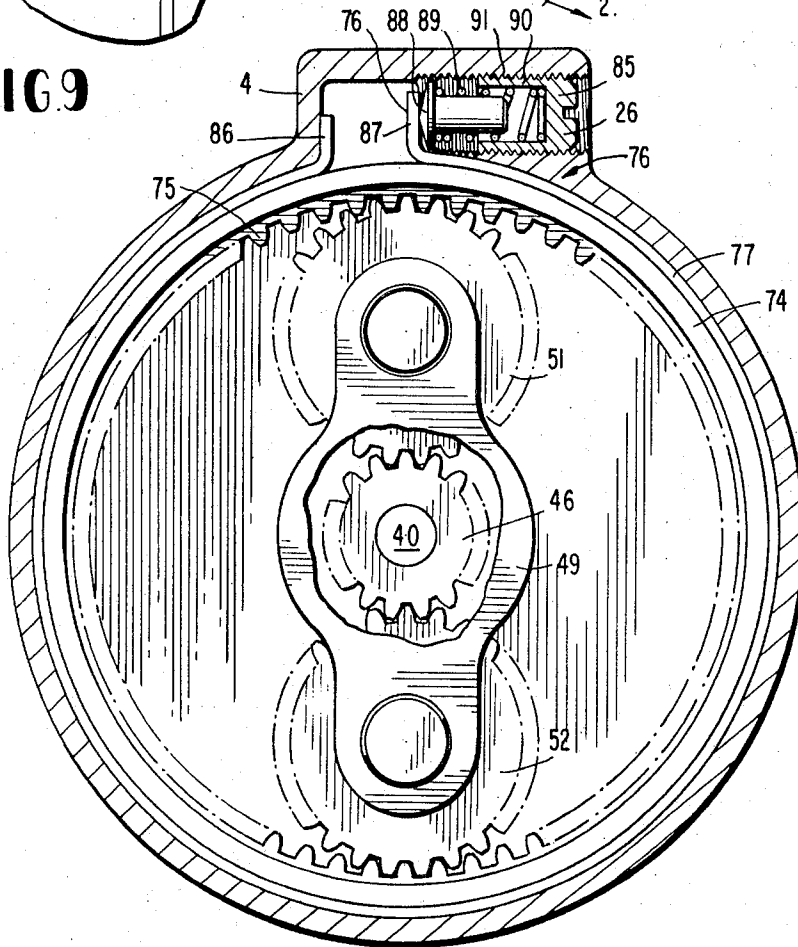


FIG. 3

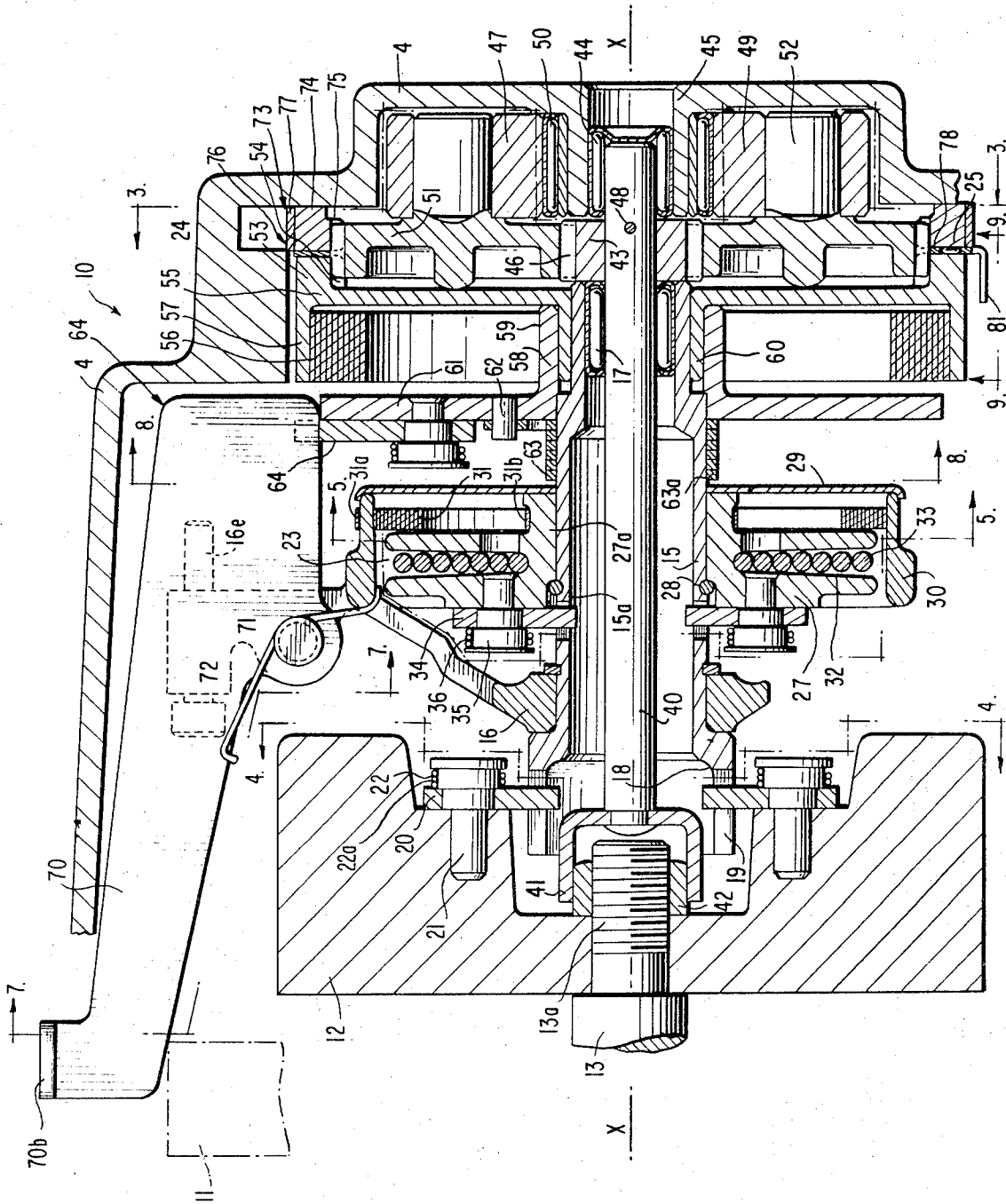


FIG. 2

FIG. 4

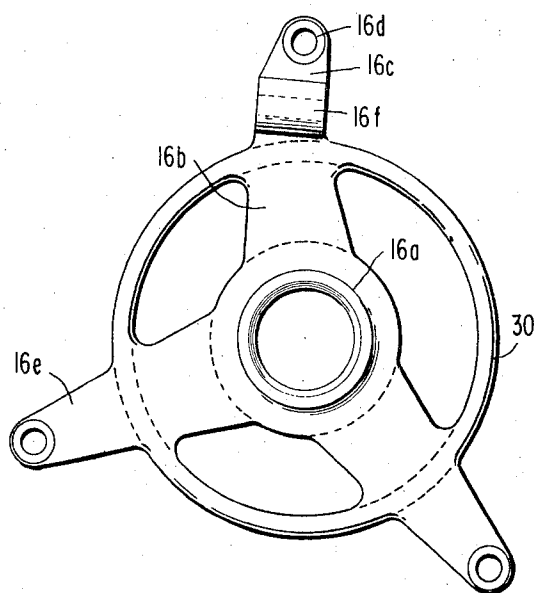
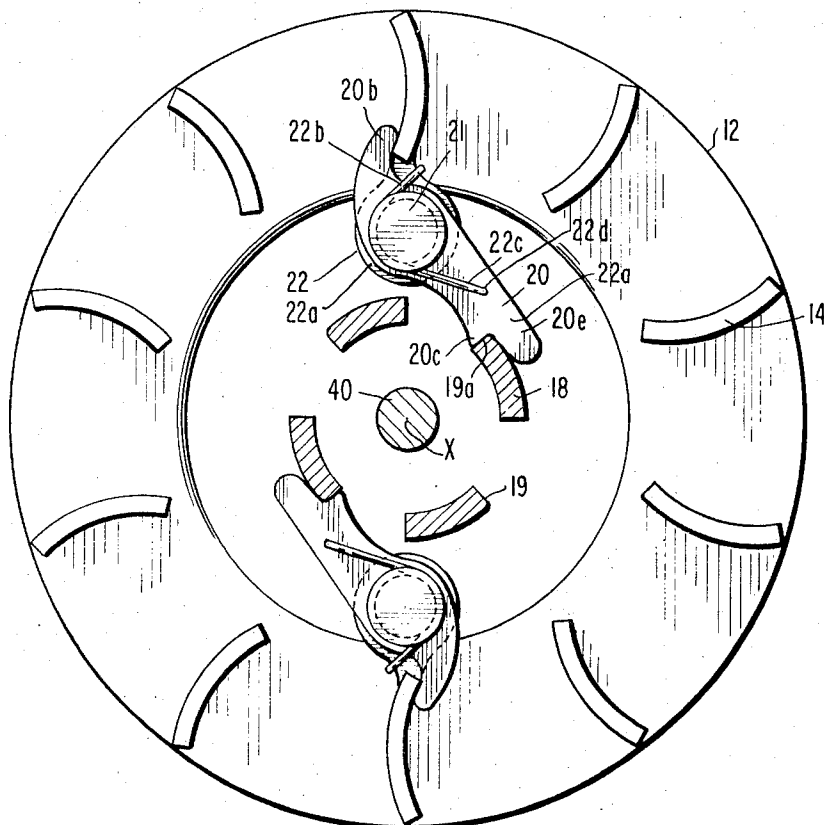


FIG. 6

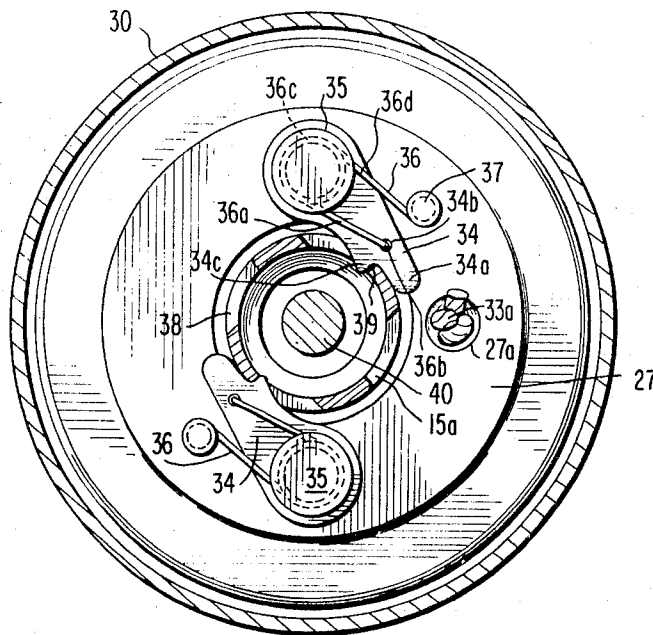


FIG. 5

FIG. 7

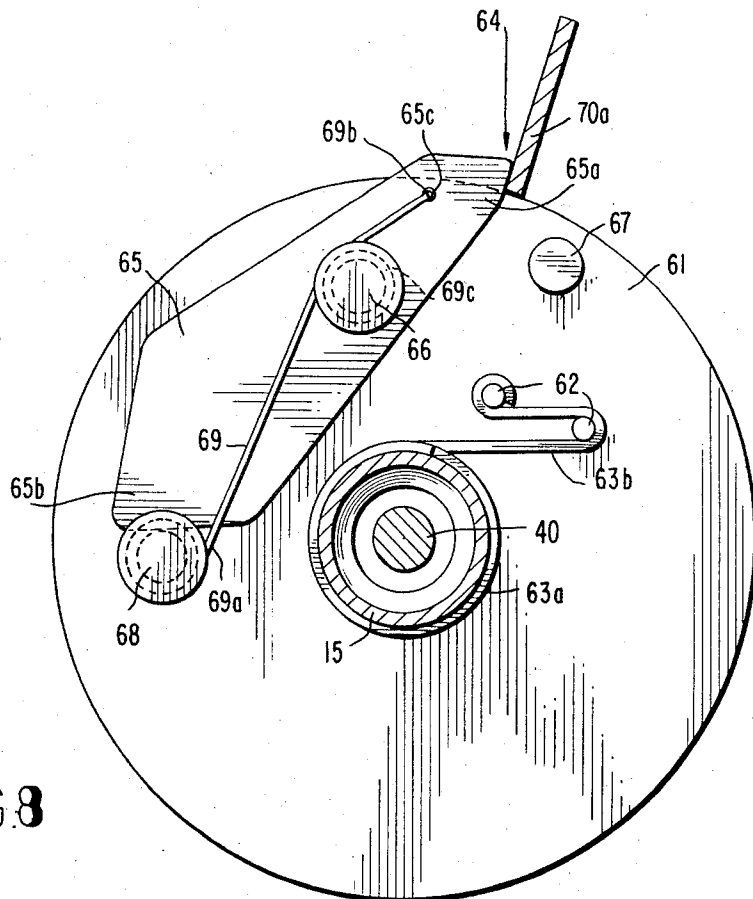
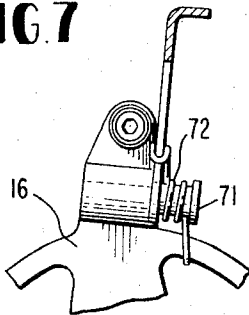


FIG. 8

LIGHTWEIGHT CHAIN SAW WITH ENGINE RESTARTING SYSTEM AND METHOD AND APPARATUS FOR RESTARTING A WARM INTERNAL COMBUSTION ENGINE

This is a division of application Ser. No. 140,371, 5
filed May 5, 1971, now Pat. No. 3,763,842 issued Oct.
9, 1973.

GENERAL BACKGROUND, OBJECTS AND SUMMARY OF INVENTION

In the last few years the chain saw art has reflected an increasing consumer interest in the use of portable structures which may be utilized by homeowners and which may be manipulated with increased ease and efficiency.

Two factors, among others, have contributed to the commercial success of lightweight chain saws.

Modern technology and innovative techniques have enabled the design production of extremely compact chain saws, where engine and drive systems have been simplified and significantly reduced in weight.

In recent years, considerable attention has been paid to the provision of restart mechanism where electrical restarting energy is automatically stored in a starting mechanism while a chain saw is being operated so as to enable an operator to effect restarting of the chain saw.

Such electrical restarting mechanisms, while particularly advantageous, have added such weight and size to portable chain saws so as to significantly limit their utility where extremely lightweight chain saws are involved.

Such extremely lightweight chain saws have encountered increased consumer acceptance, particularly where ordinary homeowners are concerned.

Thus, this invention is concerned with a unique concept which enables a restarting mechanism to be effectively employed in extremely lightweight chain saws, without significantly increasing the bulk or weight of such chain saws.

The invention is also concerned with a unique restarting control mechanism which prevents overstressing of an engine restarting spring and which eliminates the necessity for disengaging an engine from a restarting spring winding means when winding has been completed. The net result of the invention is to improve and extend the utility of portable chain saws and increase operator safety.

All this is achieved without the necessity of drastically redesigning engine and/or drive structures and cutter chain mechanisms incorporated in lightweight, portable chain saws.

Thus, a principal object of the invention is to provide a lightweight chain saw including a restarting mechanism which is light in weight, which does not create significant bulk or size, yet which is extremely reliable in operation.

Another principal object of the invention is to provide a starting system for an internal combustion engine, particularly of the type used in portable chain saws, where a recoil starter is employed to effect the starting of a cold chain saw engine while a small re-starter mechanism is employed to effect the restarting of a warm chain saw engine.

In this connection it is a related object of the invention to provide a method and apparatus for restarting internal combustion engines, particularly of the type used in chain saws, where the amount of energy re-

quired to be stored for engine starting purposes is minimized.

Yet another object of the invention is to provide methods and apparatus, as heretofore noted, which eliminate the necessity for engaging and disengaging components in a starter spring rewinding system in order to prevent overstressing of the starter spring.

A further object of the invention is to provide methods and apparatus, of the type heretofore noted, by means of which an operator may selectively adjust the level of energy stored in a starting system for the purpose of effecting restarting of an engine.

It is also an object of the invention to provide such methods and apparatus which enable an operator to determine whether or not sufficient energy is stored in a starting mechanism for the purpose of effecting engine restarting.

In accomplishing certain of the foregoing objectives, a method of restarting an internal combustion engine, particularly of the type used in chain saws, is envisioned.

In the practice of this method, the internal combustion engine is started while the engine is cold and below a normal operating temperature. Thereafter an amount of energy is stored sufficient to restart the engine. This amount of energy is sufficient to restart the engine when it is warm and at the normal operating temperature. However, the amount of energy is relatively small, and generally not sufficient to start the engine when it is cold and substantially below a normal operating temperature.

This minimized amount of stored energy is later used to restart the engine when it is warm and at a normal operating temperature.

Another independently significant method aspect of the invention is directed to a technique for restarting an engine, particularly an engine of the type used in chain saws.

In this second method aspect of the invention, a generating means is provided which is continuously operable to mechanically generate engine restarting means. The energy generated by this generating means is stored in energy storing means until an amount of energy has been accumulated which is sufficient to start the engine when the engine is warm and at a normal operating temperature, but which is insufficient to start the engine when it is cold.

After this amount of energy has been stored in the energy storing means, additional energy emanating from the generating means (i.e., mechanical means for generating engine restarting energy) is diverted through energy diverting means away from the storage means while continuing to operate the generating means. This operation of the energy diverting means is initiated in response to slippage of an energy transmitting reaction means, as permitted by slip clutch means.

This slip clutch means is maintained in continuous frictional but yieldable engagement with the reaction means. Additionally, the energy generating means is maintained in continuous engagement with each of the energy storage means and the reaction means so as to effect an automatic diversion of energy from the storage means, through the reaction means and slip clutch means, without requiring engagement or disengagement of moving parts.

A third, independently significant, aspect of the invention, which is particularly significant in the context

of a portable chain saw, entails indicating and adjusting systems relating to the energy storage means.

In this third aspect of the invention, a means is provided for indicating that the storage means has not received an amount of energy from the generating means sufficient to restart a warm engine. Additional indicating means provide an operator with an indication that the storage means has received an amount of energy sufficient to effect engine starting.

In this third aspect of the invention a slip clutch means is maintained continuously operable to enable an operator to selectively adjust the level of restarting energy accumulated or stored in the system.

Other aspects of the invention relate to various combinations of apparatus means which uniquely coact so as to perform the foregoing methods. These apparatus elements are so integrated as to produce overall improvements in operating characteristics of starter systems and particularly chain saw starter systems. These improvements go beyond the functions attributed to individual elements in that they coact to enable starter systems and chain saws to be significantly reduced in weight and improved in restarting characteristics so as to yield unusually lightweight, safe, and easy to restart devices.

A uniquely significant apparatus aspect of the invention relates to a combination of first and second gear means, with one of the gear means being coupled with a restarter spring winding arrangement and the other gear means being associated with an energy diverting mechanism. A slip clutch means incorporated with the latter gear means automatically serves to effect a diversion of energy from the restarter spring to an energy diverting mechanism without requiring any coupling or decoupling action of drive train components.

In describing the invention, reference will be made to a preferred embodiment. However, it will be recognized that this embodiment is presented by way of example and is not restrictive in relation to the overall scope of the invention.

In describing the preferred embodiment, reference will be made to drawings appended hereto.

DRAWINGS

A preferred embodiment, presented herein by way of example, is shown in appended drawings wherein:

FIG. 1 comprises a fragmentary, perspective view of a lightweight chain saw in which the starting concept of the present invention is embodied;

FIGS. 2 provide a fragmentary transverse sectional view of a recoil starting mechanism and a restarting mechanism incorporated in the FIG. 1 chain saw, as viewed along section line 2—2 of FIG. 1;

FIG. 3 provides an enlarged, transverse sectional view of the FIG. 2 assembly, as viewed along section line 3—3 of FIG. 2, and illustrating in end elevation a slip clutch mechanism which provides an adjustable energy diverting function;

FIG. 4 provides an enlarged transverse sectional view of the FIG. 2 assembly, as viewed along section line 4—4 of FIG. 2, and illustrating a centrifugally responsive coupling between a starting shaft and a chain saw engine flywheel assembly;

FIG. 5 provides a transverse sectional view of the FIG. 2 assembly, illustrating a ratchet-type, recoil mechanism incorporated in the starter portion of the FIG. 2 assembly;

FIG. 6 provides an end elevational view of spider mechanism incorporated in the FIG. 2 assembly, which spider mechanism serves to provide partial support for a starting and restarting shaft and also provides pivotal support for a restarter actuating, lever mechanism;

FIG. 7 provides a fragmentary and end elevational view of the FIG. 2 assembly, as viewed along direction 7—7 of FIG. 2, and illustrating the method of pivotal mounting of a restarter controlling or actuating lever;

FIG. 8 provides a transverse sectional view of the FIG. 2 assembly, as viewed along section line 8—8 of FIG. 2, and illustrating certain structural and operational relationships between the actuating lever of FIG. 7 and a restarter spring tripping lever and torque transmitting clutch mechanism; and

FIG. 9 provides an exterior view of the FIG. 2 assembly, as viewed generally along view direction 9—9, and illustrating components of an indicating mechanism which serves to visually reflect the level of energy accumulated in the restarter mechanism.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

In describing a preferred embodiment, reference will be made to the presently known, most advantageous and significant application of the warm engine restarting concept presented herein.

This application entails the incorporation of a warm engine restarting mechanism in a lightweight chain saw, which may weigh on the order of 5 or 6 pounds, or less

OVERALL STRUCTURE

Major components of the chain saw restarter concept of the present invention are illustrated in FIG. 1.

As shown in FIG. 1, a chain saw 1 in which the present invention is incorporated comprises a guide bar 2 supporting an articulated, cutter chain 3.

The guide bar 2 extends from a housing 4. This housing 4 contains an internal combustion engine, normally a small, two-cycle engine. A suitable drive system contained within housing 4 drivingly connects this engine with the cutter chain 3, possibly through a centrifugal clutch-type torque transmitting mechanism.

Housing 4 also contains a fuel tank 5, a carburetor assembly, and possibly other chain saw accessories such as oiling mechanisms, etc.

The chain saw 1 is supported by a handle assembly 6 which includes a longitudinally extending portion 7 and a transversely extending stabilizing portion 8.

A throttle trigger 9 may be pivotally mounted on handle portion 7. This throttle trigger serves to permit the operator to use the hand grasping handle portion 7 to control chain saw operating speeds.

Saw 1 also includes a starter and restarter assembly 10 and a control switch 11.

The starter assembly 10 includes independently operable components designed to effect cold engine starting and warm engine starting.

Switch 11 is movable longitudinally of housing 4 and serves, in one position; to terminate engine operation by interrupting the ignition circuit of the engine. Switch 11 may be operated by a hand of an operator engaged with either handle portion 7 or handle portion 8.

With the major components of chain saw 1 having been identified, it now becomes appropriate to consider details of the heart of this invention, namely the starter and restarter mechanism.

PRINCIPAL COMPONENTS OF STARTER ASSEMBLY

Principal components of starter assembly 10 are illustrated in FIGS. 1, 2 and 3.

These principal components include a chain saw engine flywheel 12. Flywheel 12, as shown in FIG. 2, is mounted on an engine drive shaft 13. As shown in FIG. 4, flywheel 12 may also provide a plurality of engine cooling fan blades 14.

An engine starting and restarting shaft 15 is journaled in housing 4 and may be rotatably supported by a spider frame 16 and a roller bearing assembly 17.

Starter shaft 15 is well known in structure and, as shown in FIGS. 2 and 4, includes a cylindrical terminus 18 provided with a series of circumferentially spaced and longitudinally extending slots 19.

Flywheel 12 may be provided with a plurality of, and as illustrated two, dogs or pawls 20. Each such dog or pawl 20 is pivotally supported on flywheel 12 by a pivot pin 21. A conventional coil-type torque spring 22, associated with each pivot pin 21 and lug 20, biases an eccentrically weighted end 20a of each pawl generally radially inwardly toward the central axis of rotation X of the starter assembly and engine shaft 13.

As shown in FIGS. 2 and 4, each such spring 22 includes a helical coil portion 22a encircling its associated pivot pin 21. One end 22b of each such spring abuttingly engages an abutment portion of flywheel 12. Another end portion 22c is secured in a pawl aperture 20d and serves to bias the lug end 20e toward axis X.

Each pawl may have an end 20b which abuttingly engages a fan vane 14 to limit the inward movement of pawl end 20e to the position shown in FIG. 4.

With this arrangement, pawl extremity, abutment portions 20c are biased into abutable engagement with edges 19a of slots 19 as shown in FIG. 4.

With pawls 20 disposed in relation to starter shaft 15 as shown in FIG. 4, engine starting or restarting torque generated by the starter assembly 10 will be transmitted from shaft 15, through the lugs 20, to the flywheel 12, and then from the flywheel 12 to the engine shaft 13 so as to effect engine starting.

Once engine starting has been effected, the flywheel 12 will attain a sufficient operating speed so as to cause the eccentrically weighted pawl ends 20a to move radially outwardly in response to centrifugal force, so as to automatically disengage the running engine from the starting and restarting shaft 15.

At this point it becomes appropriate to note that counterclockwise engine starting torque (viewing the apparatus in FIG. 2 from its right end) may be imparted to shaft 15 by either of two starter mechanisms incorporated in starting assembly 10.

The first of these starter mechanisms, which will be used to effect starting of the chain saw engine when the engine is cold, comprises a now well-known recoil starter assembly or mechanism 23.

Once the engine has attained a normal operating temperature and has been stopped temporarily, as often occurs when using a chain saw, restarting may be effected by a restarter mechanism 24.

At this juncture it is important to note that the term "normal operating temperature" is used in a broad sense to include the wide range of temperatures of a chain saw engine which are encountered during the period of time that a chain saw is in use. As the term "nor-

mal operating temperature" is here used, it encompasses operating temperatures while the engine is running and the somewhat reduced temperatures which result when operation of the chain saw is interrupted for a brief period of time during normal cutting operations. Such interruption occurs, for example, when an operator needs to change either his position or the position of the saw.

The function of recoil starting mechanism 23 is to initiate the operation of the chain saw engine when an operator first commences the use of the saw and the engine is cold, i.e. at an ambient temperature substantially below a normal operating temperature. After the saw has once been started, the operator may initiate restarting of the saw, when he has momentarily interrupted cutting operations, by operation of the restart mechanism 24.

An indicating means 25, shown generally in FIGS. 2 and 9, enables an operator to determine the degree of operability of the restarter mechanism 24.

Depending upon operating conditions, component wear, ambient temperatures, etc., it may be appropriate for an operator to adjust the level of energy stored by the restart mechanism 24 for the purpose of effecting engine restarting. This adjustment of the level of stored energy to be used for engine restarting may be effected by operator manipulation of an energy level accumulation determining means 26, shown generally in FIG. 3.

With principal components of the starter and restarter system having been described, it now becomes appropriate to consider detailed aspects of the starter assembly 23, the restarter assembly 24, the indicator assembly 25, and the energy accumulation determining means 26.

STARTER ASSEMBLY

Details of starter assembly 23 are shown in FIGS. 1, 2, 4 and 5.

Recoil starter assembly 23 includes a sheave-type wheel 27 which is journaled on starter shaft 15.

Sheave 27 is secured in position on shaft 15 by a snap ring 28 engaging the left end of sheave 27, as shown in FIG. 2. The right end of sheave 27, shown in FIG. 2, may be secured by an annular housing wall 29 which encircles shaft 15 and is fixedly carried by a cylindrical housing portion 30 of the spider assembly 16.

A conventional, spiral wound, recoil spring 31 is disposed radially between shaft 15 and cylindrical housing wall 30. One end 31a of spring 31 is secured to housing wall 30, while the other end 31b is secured to a generally cylindrical sheave base wall 27a.

At this point it is appropriate to refer to FIG. 6 to note that spider mechanism 16 comprises a hub 16a within which shaft 15 is journaled. A series of arms 16b radiate generally outwardly of hub 16a in an inclined fashion, as shown in FIG. 2, so as to provide support for the cylindrical wall means 30.

Radial tab portions 16c of the spider 16 provides collars or eye portions 16d which receive mounting pins 16e, one of which is schematically shown in FIG. 2. These mounting pins are threadably secured to internal boss portions of the housing means 4 so as to effectively anchor the spider assembly 16 to the housing means 4.

As is shown in FIG. 6, one radiating tab 16c includes a transversely extending aperture 16f. This aperture re-

ceives a pivot pin 71 associated with an actuating lever 70, to be subsequently described.

Sheave 27 also includes a radially extending and outwardly opening cavity 32 which receives a conventional, spirally-wound, pull cord 33. Pull cord 33 has, at its outer end, a conventional pull handle 134, as shown in FIG. 1.

As shown in FIG. 5, the innermost extremity 33a of pull cord 33 may be secured by a knotted end passing through a sheave aperture 27a.

Pull cord 33 is wound on sheave 27 such that a pull on handle 34, which induces counterclockwise rotation of sheave 27 (viewing the apparatus from the right end of FIG. 2) and unwinding of the pull cord, will concurrently cause stressing or spiral winding of the spring 31 so as to generate a sheave restoring and pull cord re-winding force.

As shown in FIGS. 2 and 5, a plurality of (as shown, two) dogs or pawls 34 may be pivotally carried by pivot pins 35 projecting from the left end of sheave 27 as shown in FIG. 3.

Outer extremities 34a of pawls 34 are biased generally radially inwardly by spring assemblies 36, generally shown in FIGS. 2 and 5.

Each such spring assembly includes a leg portion 36a having a bent extremity 36b engaging an aperture 34b of a pawl 34. A helical coil portion 36c of each spring 36 is mounted on the pivot pin 35, while another leg portion 36d of the spring is disposed in abutting or otherwise secured engagement with an abutment pin 37. The stressing of each spring 36 is such as to produce a tendency to separate its leg portions 36d and 36a, and thereby cause its associated pawl end 34a to move away from its associated abutment pin 37 which is fixedly mounted on the sheave 27.

The biasing arrangement, associated with each pawl 34, causes a pawl abutment portion 34c to be biased into ratcheting engagement with a ratchet portion 15a of shaft 15. This ratcheting portion comprises a series of circumferentially spaced, starter shaft openings 38, as shown generally in FIG. 5.

The abutment portions 34c of the pawls 34, shown in FIG. 5, are operable, when sheave 27 rotates clockwise relative to shaft 15 as shown in FIG. 5 (counterclockwise viewing the right end of FIG. 2), to engage abutment edges 39 on the edges of shaft slots 38 and thereby induce clockwise movement of the starter shaft 15. Such clockwise movement of the sheave 27 and starter shaft 15, as shown in FIG. 5, will be effected in response to pulling on the handle 134 and will serve to induce engine starting.

After the cord 33 has been extended, the stress of the spring 31 will automatically induce retracting or re-winding of the cord 33, with the ratcheting engagement between pawls 34 and slots 38 permitting a ratcheting recoil phenomena due to the general configuration of these components as shown in FIG. 5.

As will be appreciated, during the outward pulling of the handle 134, the flywheel pawls 20 will be disposed in driven engagement with the shaft end 18 so as to permit engine starting in response to rotation of the sheave 27. However, once engine starting has been effected, the centrifugally induced outward movement of the pawls 20 will disengage the engine from the starting shaft 15 so that the shaft 15 will remain stationary during normal engine operation.

The ability of shaft 15 to "ratchet" in a clockwise direction (as shown in FIG. 5) relative to sheave pawls 34 will ensure that any engine induced rotation of shaft 15 will not damage mechanism 23.

The structure and operation heretofore described relate to the manner in which an operator would effect starting of a cold chain saw engine.

It now becomes appropriate to consider the structure and technique involved in restarting a warm chain saw engine. Such restarting would be periodically implemented during normal chain saw operation when it became necessary for an operator to momentarily or temporarily interrupt cutting operations. Such interruptions may occur, for example, due to safety reasons, when it becomes necessary for an operator to move to a new cutting position or temporarily interrupt cutting for any other reason.

RESTARTER MECHANISM AND ITS MODE OF OPERATION

Structural and operational details of restarter mechanism 24 will be described with reference to components of this mechanism shown in FIGS. 2, 3, 7 and 8.

In describing the restarter mechanism and its mode of operation, it will be made apparent that particularly significant aspects of the invention reside in:

1. The concept of a chain saw starting system wherein only a limited amount of energy is required to be stored for restarting purposes, which amount of energy is sufficient to restart a warm engine but not sufficient to start a cold engine, and
2. An overwind prevention system associated with a restarter spring which is characterized by continuous coupling between components such that engagement and disengagement problems are avoided.

With these general criteria having been identified, it now becomes appropriate to pursue details of the restarter mechanism 24.

Restarter mechanism 24 includes a spring winding shaft 40, shown for example in FIG. 2.

Shaft 40 carries at its left end, as shown in FIG. 2, a polygonally cross-sectioned socket 41. Socket 41 is matingly engaged, in torque transmitting engagement, with a threaded polygonal nut 42 which is secured on a threaded end 13a of engine shaft 13.

Nut 42 serves to secure flywheel 12 on shaft 13.

With this arrangement, when the chain saw engine is operating and the shaft 13 is rotating, the shaft 40 serves as a part of a generating means 43 which is continuously operable to generate restarting energy.

Before pursuing additional details of the generating means 43, it is appropriate here to note that shaft 40 is supported at its left end by nut 42 and supported at its rightmost end by a roller bearing assembly 44. Roller bearing assembly 44, in turn, is supported in a cavity 45 of housing 4.

Generating means 43, in addition to including the shaft 40, comprises a pinion or drive gear 46 and a planetary gear assembly 47.

As shown in FIGS. 2 and 3, pinion gear 46 is fixedly connected to shaft 40 by a transverse pin 48.

Planetary gear assembly 47 comprises a radially extending arm or body 49 which is journaled on a housing carried, roller bearing assembly 50 for rotation about axis X.

Arm 49, at its radial ends, rotatably supports planetary gears 51 and 52. Each of the planetary gears 51 and 52 is disposed in driven engagement with pinion gear 46.

Each of the gear portions 51 and 52 of the planetary gear assembly 47 is disposed in continuous meshing engagement with an energy storage means 53. This energy storage means 53 comprises a radially inwardly facing ring gear 54 disposed in meshing engagement with planetary gears 51 and 52.

Ring gear 54 is carried by a generally cylindrical restarter spring housing or case 55 which is journaled on the exterior of shaft 15.

A spiral-wound, restarting spring 56 is radially interposed between a cylindrical extremity 57 of housing 55 and shaft 15.

The outermost end of the spring 56 is secured to rotatable spring housing portion 57. The radially inner end of spring 56 is secured to a spring arbor 58. Spring arbor 58 is thus interposed radially between the spring 56 and the shaft 15.

As shown in FIG. 2, arbor 58 may comprise a cylindrical body portion 59 which is journaled on a cylindrical body or base portion 60 of housing 55 and to which the inner end of spring 56 is attached.

Arbor 58 may also comprise a generally radially extending wall portion 61 which serves to confine the left side of the spring 56, the right side of spring 56 being confined by spring case 55.

As will now be appreciated, with arbor 58 and its wall 61 immobilized relative to housing 4, rotation of the spring casing 55 will produce stress or winding of the spring 56.

Conversely, with the spring 56 stressed or wound and the case 55 immobilized, releasing of the arbor 58 and its wall 61 for rotation about shaft 15 will serve to transmit spring energy, for engine restarting purposes, from arbor 58 to the shaft 15.

These modes of operation of the spring case 55 and arbor 58 will now be considered.

Arbor wall 61 includes spring mounting pin means 62. A helical spring-type clutch 63, as shown in FIGS. 2 and 8, includes a helical body portion 63a constrictably secured about the periphery of starter shaft 15 and frictionally but yieldably engaged therewith.

A free end 63b of clutch spring 63 is secured to the pin means 62 as shown generally in FIG. 8.

Body portion 63a of the coil spring is arranged such that clockwise rotation of spring body portion 63a and arbor 58 about the stationary shaft 15 (viewing the apparatus as shown in FIG. 8) will induce automatic tightening or constriction of the coil spring clutch portion 63a about the shaft 15 and thereby transmit clockwise engine starting torque to the shaft 15. The automatic, overriding nature of the coil spring clutch portion 63a will ensure that transient clockwise rotation of the shaft 15 as shown in FIG. 8, which may occur at the outset of engine starting and which will occur when recoil starter means 23 is actuated, will not damage the one-way coil spring clutch mechanism 63a.

The selective securing of arbor 58, or the releasing of the arbor for rotational movement relative to shaft 15 for the purpose of imparting stored spring energy thereto, is controlled by lever means 64.

This lever means 64 comprises a first lever 65 which is pivotally secured to wall 61 by a pivot mounting pin 66. As shown in FIG. 8, first lever 65 may pivot clock-

wise until its end 65a engages an abutment pin 67. Counterclockwise rotation of lever 65 in FIG. 8 is limited by engagement of lever end 65b with another abutment 68 carried by wall means 61.

Biasing spring 69, coiled in part about pin 66, biases a lever 65 to undergo counterclockwise movement, viewing the apparatus as shown in FIG. 8. This biasing is effected by securing one end 69a of the spring 69 against pin 68, while another extremity 69b, passing from a helical portion 69c secured to pin 66, engages a mounting aperture 65c of the lever 65.

Spring means 69 thus will serve to bias lever 65 in a generally counterclockwise direction, as shown in FIG. 8, so as to cause the tip 65a to be biased into the condition where it projects radially beyond the cylindrical periphery of wall means 61. This biasing will tend to dispose the lever extremity 65a at a position where it is abuttingly engageable with a second lever 70 now to be described.

A second lever 70 included in lever means 64 is pivotally mounted on a pivot shaft 71, which shaft 71 is secured by the spider assembly 16. As shown generally in FIGS. 2 and 7, a biasing spring 72 serves to bias lever 70 so as to tend to cause this lever to undergo clockwise rotation about pin 71, viewing the apparatus as shown in FIG. 2.

The biasing of lever 70 causes lever end 70a to be biased into the path of the radially projecting extremity 65a of the first lever 65. If desired, the rest position of lever 70 may be determined by abutting engagement of lever 70a with the radial periphery of cylindrical wall means 61.

Thus, when rewinding of spring 56 is commenced, and when lever 70 is disposed as shown in FIG. 2, with its end 70a in the circumferential travel path of lever extremity 65a, winding of spring 56 will cause arbor 58 to tend to bring the lever end 65a into abutting engagement with the lever end 70a. When this abutting engagement occurs, further rotation or movement of arbor 58 will be prevented. Thus, continued winding of case 55 with arbor 58 immobilized will produce winding or stressing of the spirally wound coil spring 56.

Because of the yieldably secured nature of the lever 65, rotational movement of the arbor 58 during restarting will not damage the lever 70 in the event that the lever end 70a should be disposed in the path of the projecting lever end 65a. Centrifugal force acting on eccentrically weighted end 65b of lever 65 will cause lever 65 to pivot clockwise, as shown in FIG. 8, to move lever end 65a generally inwardly toward axis X and out of the path of lever 70.

As will thus be appreciated, with spring 56 wound, an operator may press down on a lever extremity 70b, projecting above housing means so as to remove lever end 70a from abutting engagement with lever means 65. This will permit the arbor 58 to rotate in a counterclockwise direction about shaft 15 (viewing the apparatus from the right end of FIG. 2), with the frictional interaction between helical clutch spring portion 63a and shaft 15 producing a constriction of spring portion 63a so as to interclutch spring 56 in torque transmitting engagement with shaft 15.

The stop button 11 may be arranged relative to lever 70 so as to prevent restarting initiating or depressing movement of lever end 70b when the button 11 is in an engine running position. It would only be when button 11 was slid longitudinally of housing 4 to an engine

starting position, so as to move out of the abutting engagement relation shown in FIG. 2, that lever end 70b would be able to be depressed or moved counterclockwise about pivot pin 71 so as to effect starting operation of the energy storage means 53.

Having described the manner in which energy storage means 53 functions and serves to selectively store restarting energy derived from generating means 43 and release this energy for transmission to starting shaft 15, it now becomes appropriate to consider a unique aspect of the invention which prevents overwinding or overstressing of spring 56 without involving any engagement or disengagement of components.

This operation is achieved by energy diverting means 73 acting in cooperation with generating means 43.

As shown generally in FIG. 2, diverting means 73 comprises a reaction means 74 including an internal ring gear 75 and also includes slip clutch means 76.

Reaction gear means 74 is coaxially arranged relative to spring case means 55 and its ring gear 75, like gear means 54, is disposed in meshing engagement with the planetary gears 51 and 53. A spring means, not shown, may yieldably bias reaction means 74 to the left, as the apparatus is shown in FIG. 2.

Ring gear portion 75 has a number of gear teeth somewhat different from the number of gear teeth on gear means 54. In one embodiment, for example, it is contemplated that gear means 75 may have 92 teeth, while gear means 54 have 90 teeth. This arrangement provides a reduction drive system somewhat similar to that described in the U.S. Pat. No. 3,453,906.

The mode of operation of this reduction drive arrangement is such that with reaction means 74 immobilized relative to housing 4, the tracking or meshing engagement of the planetary gears 51 and 52 with the ring gears 54 and 75 will cause a relatively slow winding operation of the spring case 54.

So long as reaction gear means 74 is stabilized or immobilized relative to housing means 4, this reaction means 74 will function to transmit energy from shaft 15, through the gear means 46 and 47, to the winding gear means 54. This winding energy is then transmitted from gear means 54, through the spring case 55, to the restart spring 56.

The slip clutch means 76, which serves to immobilize means 74 during winding of spring 56, may comprise a circumferentially constrictable metallic clutch band 77 disposed in circumferentially embracing engagement with the cylindrical periphery of gear means 74, is disposed in continuous, frictional but yieldable engagement with the cylindrical periphery of this reaction gear means 74. Similarly, the generating means 43, including the planetary gear means 47, is disposed in continuous engagement with each of the energy storage means 53 and the reaction means 74.

Thus, once an amount of energy has been accumulated in spring 56 sufficient to restart a warm engine disposed at a normal operating temperature, but insufficient to overstress the spring 56 or start a cold engine, the band 77 of slip clutch means 76 will enable the reaction means 74 to rotate about axis X relative to housing means 4, and thereby dissipate energy and terminate the spring winding operation.

This phenomena results by selectively adjusting the friction clutch means 76 so that it will immobilize the reaction gear means 74 until a reaction is transmitted from case 55 and gear means 54, back through plane-

tary gear means 51 and 52, to gear means 74, which reaction corresponds to the accumulation in spring 56 of the amount of energy appropriate to effect restarting of a warm engine. Once this reaction phenomena occurs, the friction clutch 76 will permit slippage or rotary movement of the gear means 74. As a result, the case 55 will remain stationary so that the winding of spring 56 will be terminated, and the continued operation of the planetary gear means will merely induce rotation of the reaction gear means 74 relative to the friction clutch means 75. As a result, overwinding of the spring 56 will be prevented.

Significantly, this overwinding prevention is achieved without requiring any coupling or uncoupling of components of restarter 24.

SUMMARY OF MODE OF OPERATION OF RESTARTING MECHANISM 24

Restarting of the warm engine of chain saw 1, after cutting has been temporarily interrupted, is effected in response to the following sequence:

1. During initial engine operation, the mechanical energy generating means 43 (comprising shaft 40, drive gear 46 and planetary gear means 47) imparts spring winding movement to spring case 55. During this winding action, lever means 65 and 70 maintain restarter spring arbor 58 stationary relative to restarter shaft 15.
2. When an amount of energy sufficient to restart a warm engine, but insufficient to start a cold engine, has been stored in spring 56, a reaction is transmitted from gear means 54, through planetary gear means 47, to reaction gear 75. This reaction induces slippage of reaction means 74 relative to friction clutch 76. As a result of this slippage between clutch means 76 and reaction means 74, spring winding case 55 is immobilized so as to terminate the winding of spring 56.
3. After the winding of spring 56 has been terminated, generating means 43 will continue to operate and will remain in engagement with winding case 55 as well as the energy diverting means 73 (comprising reaction means 74 and friction clutch 76). However, at this stage, energy will be diverted or dissipated through the slipping or rotation of reaction means 74 relative to the friction clutch 76.
4. When the restarting of the engine is to be effected, the operator will depress lever end 70b so as to free arbor 58 for rotation. Rotation of arbor 58 will cause the helical spring clutch 63 to clutchingly engage shaft 15 and transmit restarting torque from spring 56 to the pawls 20 of flywheel 12. Torque transmitted to these lugs will be transmitted through the pin means 21 and flywheel body, to the engaging shaft 13 so as to effect engine starting. Once engine starting is effected, the flywheel pawls 20 will centrifugally disengage from shaft 15.
5. Once the engine is restarted, the generator means 43 will again induce the rewinding of spring 56 for the purpose of effecting a subsequent restarting operation. It is contemplated that such rewinding may be completed within a short time, possibly on the order of 15 seconds or so.

With the overall structure and mode of operation of the restarter mechanism 24 having been described, it is now appropriate to consider structural details of the in-

dicating means 25 and the energy level accumulation determining means 26.

STRUCTURE AND MODE OF OPERATION OF INDICATING MEANS

The indicating means 25 may comprise an annular disc 78 interposed axially between the radially extending rims of gear means 75 and 54.

As shown in FIG. 9, disc means 78 may include one or more generally radially extending apertures 79 which house roller means 80 functioning as a friction clutch. Friction clutch roller means 80 is disposed in frictional but yieldable engagement with each of the rims of gear means 54 and 75. This engagement may be maintained by spring means, previously noted, urging reaction means 74 toward spring case 55.

Disc 78 includes a longitudinally extending peripheral tab 81 which is located circumferentially between abutment means 82 and 83 carried by housing means 4. Housing means 4 may also include an indicating window means 84, the location of which is schematically shown by dotted lines in FIG. 9.

With this arrangement, when reaction gear means 75 is held immobile by friction clutch 76, winding movement of the rim of gear means 54 will act on friction clutch means 70 so as to cause the disc 78 to move with the gear means 54 and position an indicia (or colored portion, green for example) 81a of tab means 81, reflecting a "not wound" condition of spring means 56, in alignment with indicator aperture 84. This alignment will occur as a result of the engagement of the lower end of tab 81, shown in FIG. 9, with the housing-carried stop 83.

When winding has terminated such that case 55 and gear means 54 are immobilized and reaction gear means 75 has begun to move, the friction clutch means 79 will cause the disc means 78 to move with the gear means 75 and dispose the tab 81 in the position shown in FIG. 9. In this position, an indicia portion (or colored portion, red for example) 81a of the tab reflecting a "wound" condition of spring 56, will be disposed in alignment with the window 84. This alignment will be maintained by virtue of engagement of the upper end of the tab 81 in FIG. 9 with the housing-carried stop 82.

At this point, it will be recognized that the reduction gear arrangement involving gear means 54 and 74 will be such as to cause these gear means, when they undergo movement, to move in mutually opposite directions relative to axis X and housing means 4.

Thus, an operator may immediately determine the condition of spring means 56 by monitoring housing aperture 84 to determine whether or not sufficient energy has been accumulated in the restarter mechanism 24 for the restarting of a warm engine.

ENERGY LEVEL ACCUMULATION DETERMINING MEANS

FIG. 3 illustrates components of an energy level accumulation determining means 85 associated with the friction clutch means 76.

Mechanism 85 includes a portion of housing means 4 which serves to secure one extremity 86 of the clutch band 77. The other end 87 of the clutch band 77 is disposed in selectively adjustable engagement with a plunger 88. Plunger 88 is yieldably and telescopically supported in a housing recess by a coil spring 89. Coil

spring 89, in turn, is supported by a threadably adjustable plug 90 mounted in this recess 91.

Threaded manipulation of plug 90, relative to a housing recess 91, will serve to adjust the degree of circumferential contraction of the band 77 and thus selectively adjust the reaction force which must be exerted on reaction gear means 74 so as to permit movement thereof. The inclusion of spring 89 will ensure that the adjusting mechanism 26 will not be operated so as to permanently immobilize the gear means 74. In other words, the spring 89 will provide an upper limit for the level of reaction force which will permit movement of the gear means 74 and thus establish an upper limit on the level of winding of the spring 56.

Having described structural details of all of the components of the starting and restarting mechanism of this invention in a most advantageous chain saw environment, it is useful at this juncture to review certain of the more significant advantages, as well as the overall scope of the invention.

SUMMARY OF ADVANTAGES AND SCOPE OF INVENTION

A principal advantage of the invention resides in the use of a restarting mechanism which enables restarting of a warm engine with minimal amounts of accumulated energy. This significantly reduces the weight and bulk of starting mechanisms. As a result, the ease and safety with which a chain saw, including this restarting mechanism, may be manipulated are significantly enhanced.

By way of example, where a spring 56 having approximately 20 turns might be required to start a cold chain saw engine, a spring 56 having only about five or six turns would suffice to start a warm chain saw engine.

In thus reducing the bulk and weight of chain saws, the ability of an operator to restart a chain saw with one hand, with the chain saw disposed in a not altogether stabilized position, is facilitated. Operator safety will be enhanced by the ability of an operator to grip the saw handle means with both hands while using one or more digits to manipulate button means 11 and starter lever means 70b.

Unobviousness of this warm engine restarter concept, with its attendant conservation of space, weight, and level of stored energy, is reflected by prior patents such as Kopp U.S. Pat. No. 2,987,057. Kopp discloses an engine-wound, starting mechanism utilized in conjunction with an auxiliary recoil starter. However, Kopp makes no mention of the warm engine restart concept of the present invention, and appears to contemplate the engine-wound starter as a principal starting device. The disclosure by Kopp of two starting systems, but his failure to disclose the warm engine starting concept of the present invention, is indicative of the failure of the prior art to suggest or make obvious the present invention.

In totally eliminating the necessity for engaging and disengaging components in order to prevent overwinding of the restarter spring, the reliability of the restarter mechanism has been significantly enhanced. In addition, the danger of rattling and component breakage and excessive wear is significantly reduced. This advantage is particularly significant in the context of a chain saw where normal operation is prone to generate vibration.

Here, again, the Kopp U.S. pat. No. 2,987,057 evidences unobviousness of this continuous engagement concept.

Where the present invention contemplates continuous engagement between components of the restarter system, Kopp specifically contemplates the utilization of disengaging and reengaging mechanisms.

The indicating mechanism contributes to efficiency and reliability of the restarting operation in enabling an operator to determine, before attempting a restart, whether or not sufficient energy has been accumulated. In knowing whether or not sufficient restarting energy has been accumulated, an operator can determine whether or not the restarter or recoil starter mechanism should be employed for engine starting purposes.

The energy accumulation adjusting means enables an operator to make appropriate adjustments as may be necessary due to wear of friction clutch components, manufacturing variations, and changes in ambient temperature.

While the invention has been described in the context of a preferred chain saw embodiment, those familiar with chain saw and engine starter art and familiar with this disclosure may well recognize additions, deletions, substitutions or other modifications and design variations which would fall within the scope of the invention as set forth in the appended claims.

What is claimed is:

1. A method of storing energy in an engine starting mechanism, said method comprising:
 - providing a continuously operable generating means to generate engine restarting energy;
 - storing an amount of energy generated by said generating means in energy storing means;
 - providing energy diverting means including energy transmitting reaction means engaged with said energy storage means and operable, while stationary relative to said energy storage means, to transmit energy from said generating means to said energy storage means, and
 - slip clutch means yieldably and frictionally engaging said reaction means;
 - after said amount of energy has been stored, diverting energy from said generating means through energy diverting means, away from said storage means while continuing to operate said engine and said generating means;
 - initiating energy diverting operation of said energy diverting means in response to an accumulation of said amount of energy by said energy storage means, with said accumulation being operable to prevent said reaction means from transmitting energy from said generating means to said storage means by causing said reaction means to movably yield relative to said slip clutch means;
 - maintaining said slip clutch means in continuous frictional, but yieldable, engagement with said reaction means; and
 - maintaining said generating means in continuous engagement with each of said energy storage means and said reaction means.
2. A method of operating an engine starting mechanism, said method comprising:
 - indicating than an energy storage means in a starting mechanism has not received an amount of energy from energy generating means sufficient to start an engine; by

rotating a disc means intercalated between a ring gear means and a reaction gear means to a first position under the influence of said ring gear means. indicating that said storage means has received said amount of energy and that energy is being diverted from said generating means to an energy diverting means; by

rotating the disc means intercalated between the ring gear means and the reaction gear means to a second position under the influence of said reaction gear means,

providing means operable to selectively adjust the level of said amount of energy stored by said energy storage means including,

selectively adjustable clutch band means operably embracing the outer periphery of said reaction gear means.

3. Apparatus for storing energy in an engine starting mechanism, said apparatus comprising:

continuously operable generating means operable to generate engine restarting energy;

energy storage means for storing an amount of energy generated by said generating means;

energy diverting means including

energy transmitting reaction means engaged with said energy storage means and operable, while stationary relative to said energy storage means, to transmit energy from said generating means to said energy storage means, and

slip clutch means yieldably and frictionally engaging said reaction means;

said energy diverting means being operable, after said amount of energy has been stored, to divert energy from said generating means away from said storage means while continuing to operate said engine and said generating means;

means for initiating energy diverting operation of said energy diverting means in response to an accumulation of said amount of energy by said energy storage means, with said accumulation being operable to prevent said reaction means from transmitting energy from said generating means to said storage means by causing said reaction means to movably yield relative to said slip clutch means;

means maintaining said slip clutch means in continuous frictional, but yieldable, engagement with said reaction means; and

means maintaining said generating means in continuous engagement with each of said energy storage means and said reaction means.

4. Apparatus for operating an engine starting mechanism, said apparatus comprising:

continuously operable generating means operable to generate restarting energy;

ring gear means connected to said generating means; energy storing means for storing an amount of energy generated by said generating means;

ring gear means connected to said energy storage means;

means for indicating that said energy storage means in a starting mechanism has not received an amount of energy from said energy generating means sufficient to start an engine and indicating that said storage means has received said amount of energy and that energy is being diverted from said generating means to an energy diverting means,

said means for indicating including disc means intercalated between said reaction gear means and said ring gear means and being movable to a first position under the influence of said ring gear means when said energy storage means is received energy and to a second position under the influence of said reaction gear means when energy is being diverted to said energy diverting means; and

means operable to selectively adjust the level of said amount of energy stored by said energy storing means,

a selectively adjustable clutch band operably engaged about the periphery of said reaction gear means.

5. A starting apparatus for an internal combustion engine, said starting apparatus comprising:

spring means operable, when stressed and released, to start an internal combustion engine;

first ring gear means including a first number of gear teeth;

second ring gear means including a second number of gear teeth different from said first number;

drive gear means drivingly engaged with each of said first and second ring gear means and operable, in response to operation of said engine, to induce rotation of a movable one of said first and second ring gear means;

said first ring gear means being connected with said spring means and operable to impart spring stressing energy thereto;

releasable friction clutch means;

said second ring gear means being clutchingly engaged with said releasable friction clutch means, said second ring gear means being operable, when held stationary by said friction clutch means, to function as a force reacting means and cause said drive gear means to induce rotation of said first ring gear means, and

said second ring gear means, when permitted to undergo movement by said releasable friction clutch means, being operable to prevent said drive gear means from imparting rotational movement to said first ring gear means for the purpose of stressing said spring means;

said releasable friction means being operable to permit rotation of said second ring gear means so as to cause said second ring means to prevent rotation of said first ring gear means in response to a degree of stressing of said spring means;

release means selectively operable to release stress energy accumulated in said spring means and effect starting of said engine; and

securing means selectively operable to secure said spring means during stressing thereof and prevent transmission of stress energy from said spring means to said engine.

6. An apparatus as described in claim 5 further including:

energy level accumulation determining means operably associated with said clutch means and selectively operable to cause said clutch means to release said second ring gear means in response to different levels of energy accumulated in said spring means.

7. A starting apparatus for an internal combustion engine, said starting apparatus comprising:

spring means operable, when stressed and released, to start an internal combustion engine;

first gear means including a first number of gear teeth;

second gear means including a second number of gear teeth different from said first number;

drive gear means drivingly engaged with each of said first and second gear means and operable, in response to operation of said engine, to induce rotation to a movable one of said first and second gear means;

said first gear means being connected with said spring means and operable to impart spring stressing energy thereto;

releasable friction clutch means;

said second gear means being clutchingly engaged with said releasable friction clutch means, said second gear means being operable, when held stationary by said friction clutch means, to function as a force reacting means and cause said drive gear means to induce rotation of said first gear means, and

said second gear means, when permitted to undergo movement by said releasable friction clutch means, being operable to prevent said drive gear means from imparting rotational movement of said first gear means for the purpose of stressing said spring means;

said releasable friction means being operable to permit rotation of said second gear means so as to cause said second gear means to prevent rotation of said first gear means in response to a degree of stressing of said spring means;

release means selectively operable to release stress energy accumulated in said spring means and effect starting of said engine;

securing means selectively operable to secure said spring means during stressing thereof and prevent transmission of stress energy from said spring means to said engine;

indicator means disposed in slip clutched engagement with each of said first and second gear means;

means operable to indicate movement of said indicator means in response to movement of said gear means to thereby indicate incomplete winding of said spring means;

means to indicate movement of said indicator means in response to movement of said second gear means to thereby indicate the conclusion of winding of said spring means;

energy level accumulation determining means operably associated with said clutch means and selectively operable to cause said clutch means to release said second gear means in response to different levels of energy accumulated in said spring means; and

recoil starter means operable, independent of said spring means, to effect starting of said engine.

8. A starting apparatus for an internal combustion engine, said starting apparatus comprising:

spring means operable, when stressed and released, to start an internal combustion engine;

first gear means including a first number of gear teeth;

second gear means including a second number of gear teeth different from said first number;

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drive gear means drivingly engaged with each of said first and second gear means and operable, in response to operation of said engine, to induce rotation of a movable one of said first and second gear means;
 said first gear means being connected with said spring means and operable to impart spring stressing energy thereto;
 releasable friction clutch means;
 said second gear means being clutchingly engaged with said releasable friction clutch means,
 said second gear means being operable, when held stationary by said friction clutch means, to function as a force reacting means and cause said drive gear means to induce rotation of said first gear means, and
 said second gear means, when permitted to undergo movement by said releasable friction clutch means,
 being operable to prevent said drive gear means from imparting rotational movement to said drive gear means for the purpose of stressing said spring means;

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said releasable friction means being operable to permit rotation of said second gear means so as to cause said second gear means to prevent rotation of said first gear means in response to a degree of stressing of said spring means;
 release means selectively operable to release stress energy accumulated in said spring means and effect starting of said engine;
 securing means selectively operable to secure said spring means during stressing thereof and prevent transmission of stress energy from said spring means to said engine;
 indicator means disposed in slip clutched engagement with each of said first and second gear means;
 means operable to indicate movement of said indicator means in response to movement of said gear means to thereby indicate incomplete winding of said spring means; and
 means to indicate movement of said indicator means in response to movement of said second gear means to thereby indicate the conclusion of winding of said spring means.

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