

[54] **AUTOMATIC SYSTEM FOR SPRING STARTING AN INTERNAL COMBUSTION ENGINE**

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[22] Filed: **Nov. 27, 1970**

[21] Appl. No.: **93,236**

[52] U.S. Cl. .... **123/185 C**, 123/179 S

[51] Int. Cl. .... **F02n 5/02**

[58] Field of Search ..... 123/179 S, 179 SE, 185 BB, 123/185 C, 185 CA, 179, 185; 185/38, 39, 40

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[57] **ABSTRACT**

A system is provided for spring starting an internal combustion engine including a convolute spring disposed about the crankshaft axis of the engine. The spring drives the crankshaft through a one-way clutch operatively connected with one end thereof. The spring is fastened to a spring casing at the other end thereof. A spring rewind drive train drivingly connects the crankshaft with the spring casing and is operable to wind the spring when the crankshaft is being rotated by the engine after starting. The spring may also be either hand wound or wound by an electric or hydraulic motor or other motive power. A unique linkage mechanism is provided for automatically controlling the winding and releasing sequences of the starter spring in response to the manipulation of a control by a human operator. The linkage mechanism is designed to rotate, expand or contract to perform the necessary functions in response to single movements of the control rod.

**18 Claims, 12 Drawing Figures**

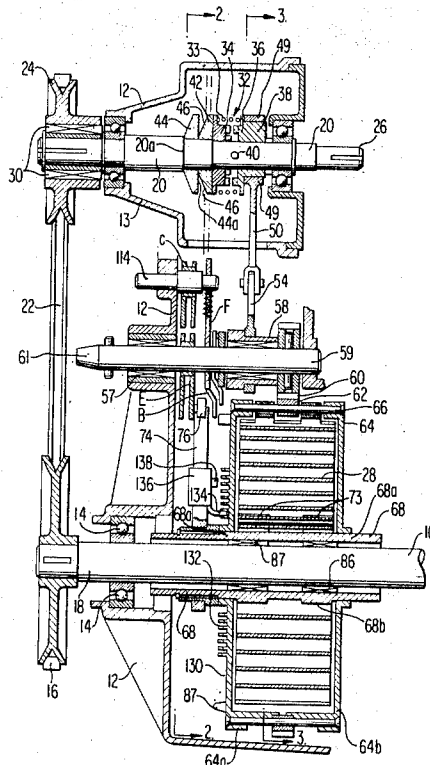


FIG 1

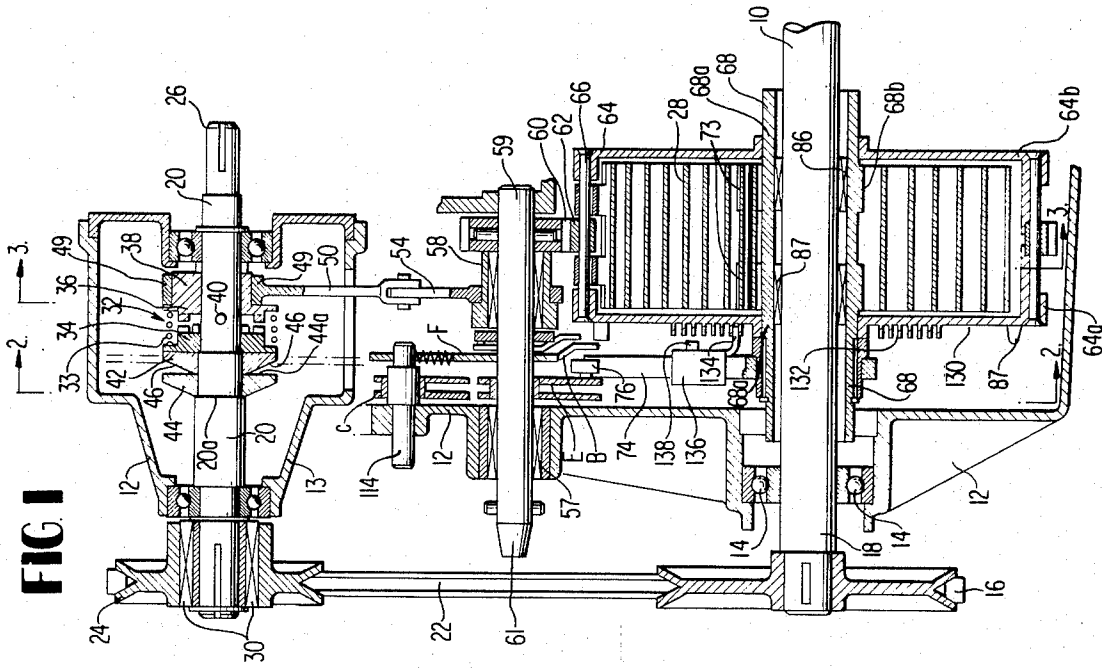


FIG 3

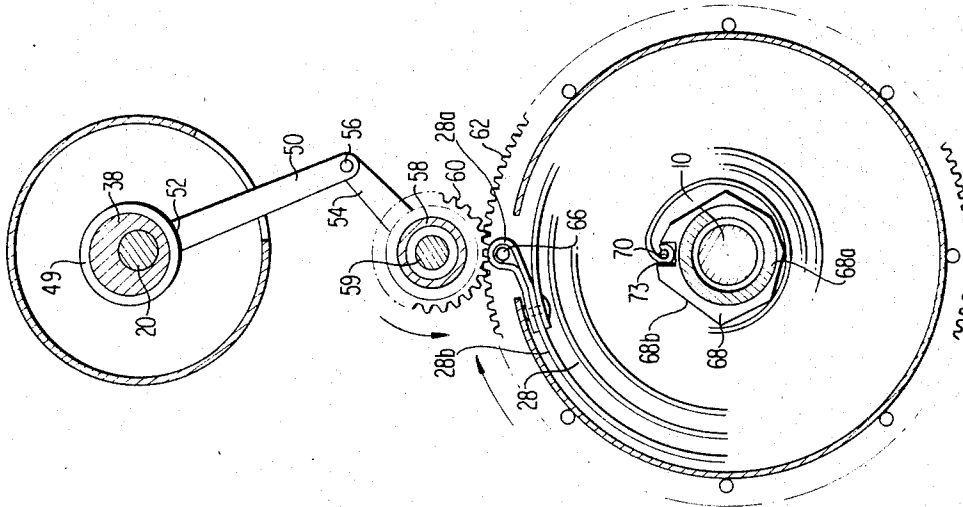
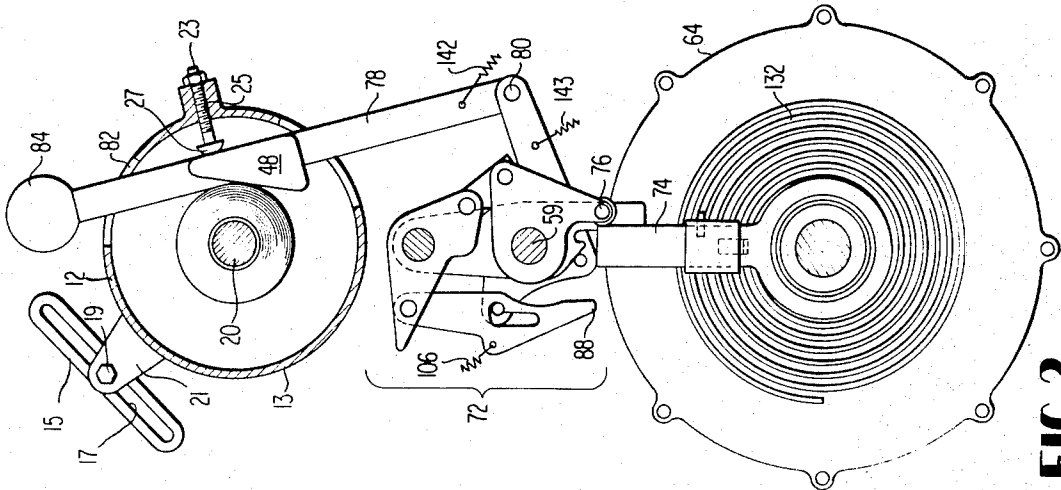


FIG 2



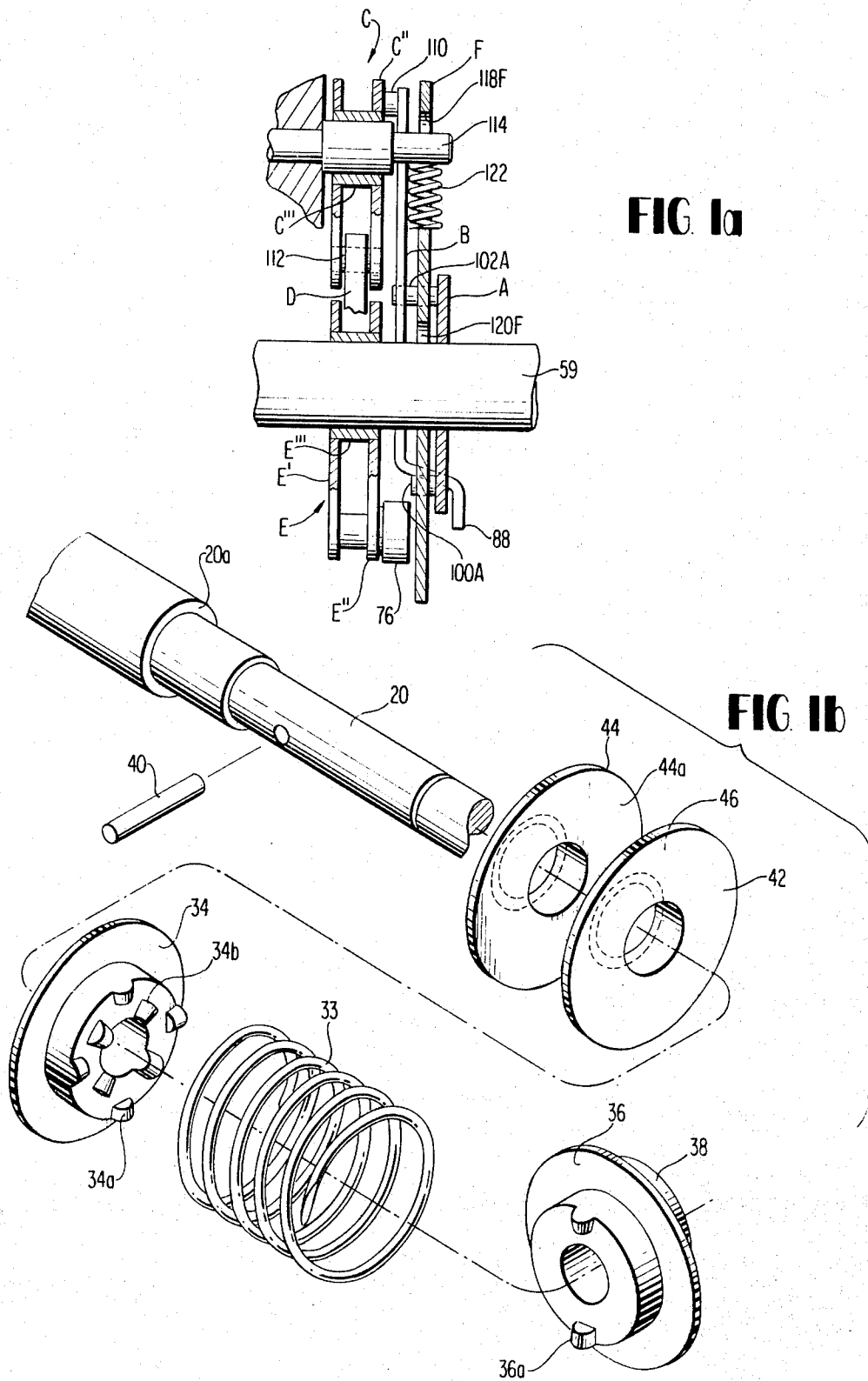
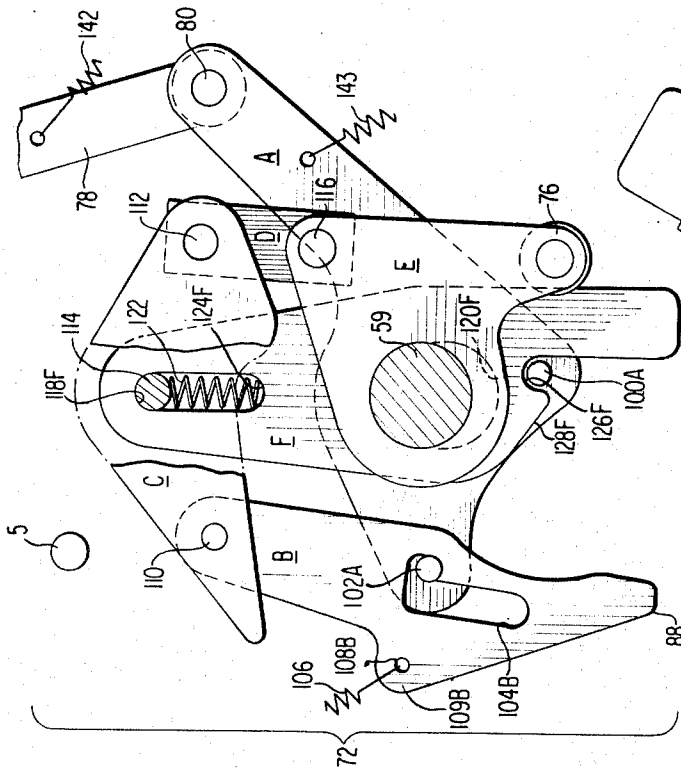
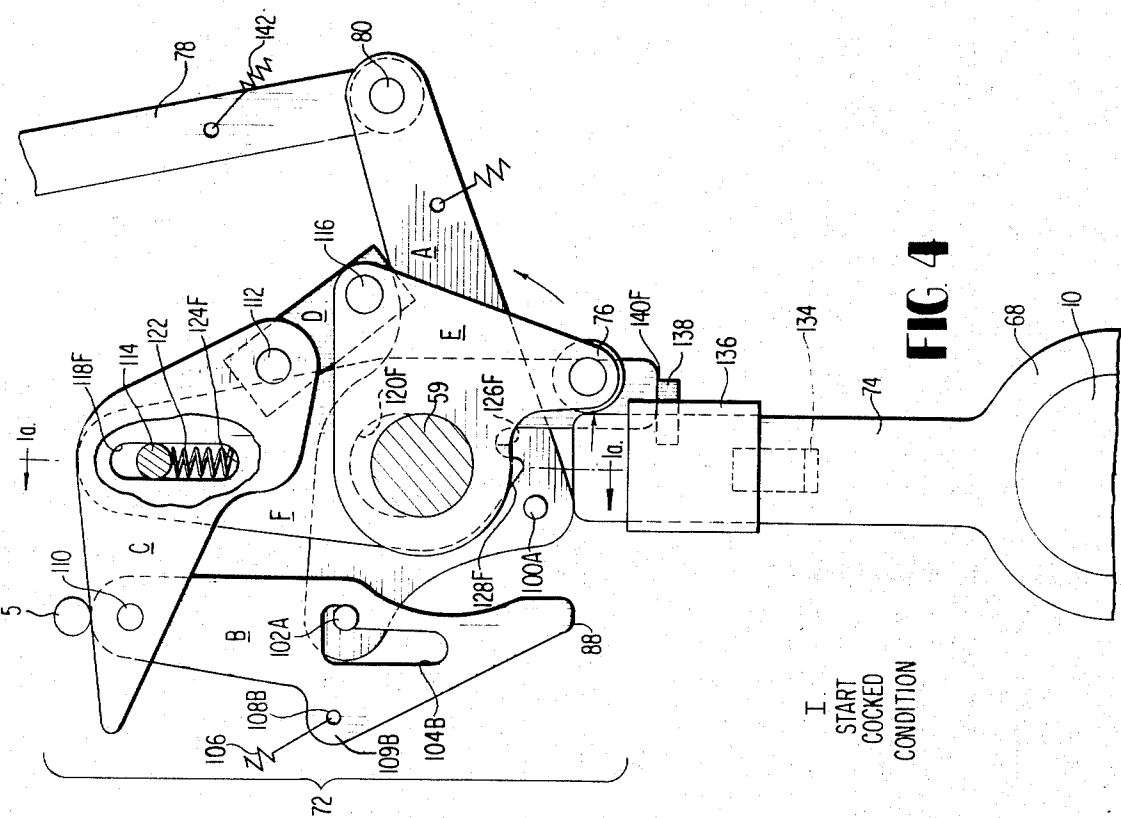


FIG. 1a

FIG. 1b



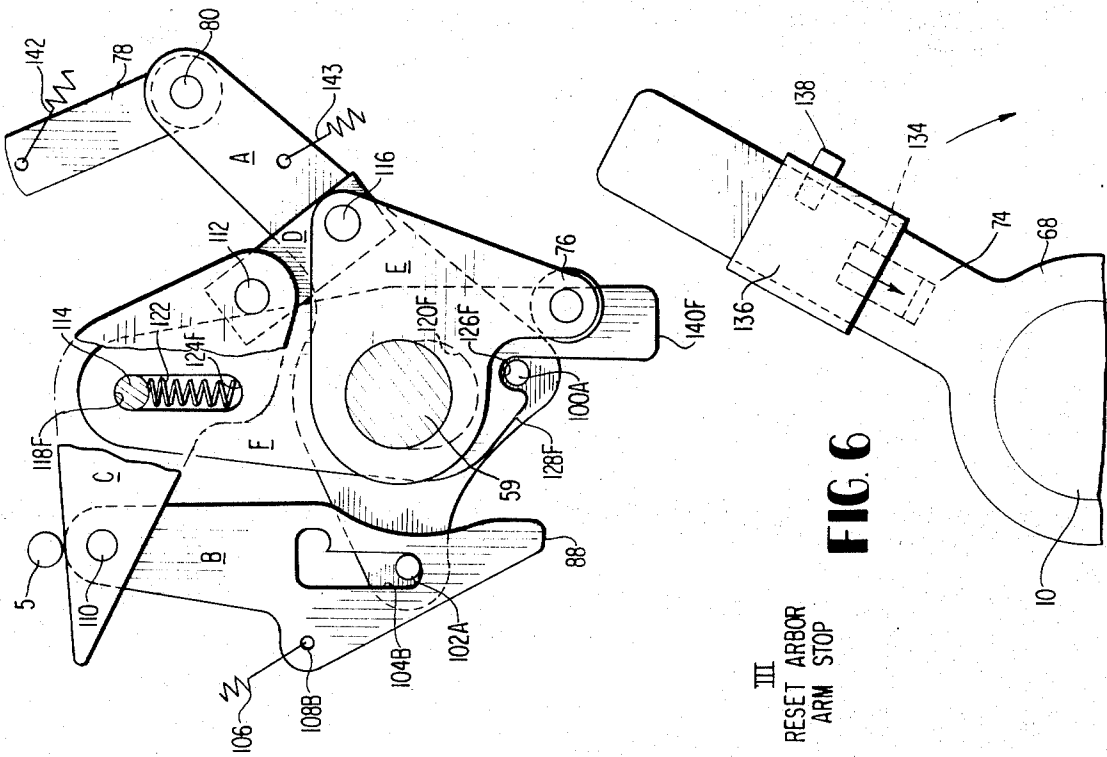
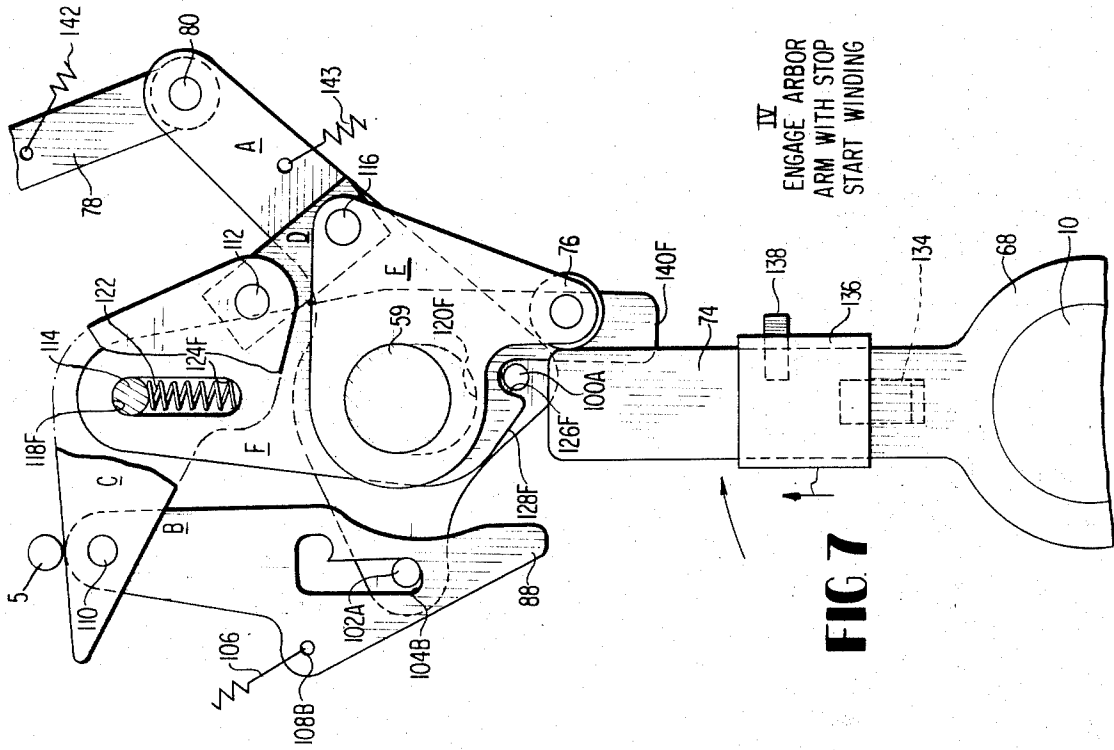
I.  
START  
COCKED  
CONDITION



II.  
RELEASE  
START ENGINE

FIG 4

FIG 5





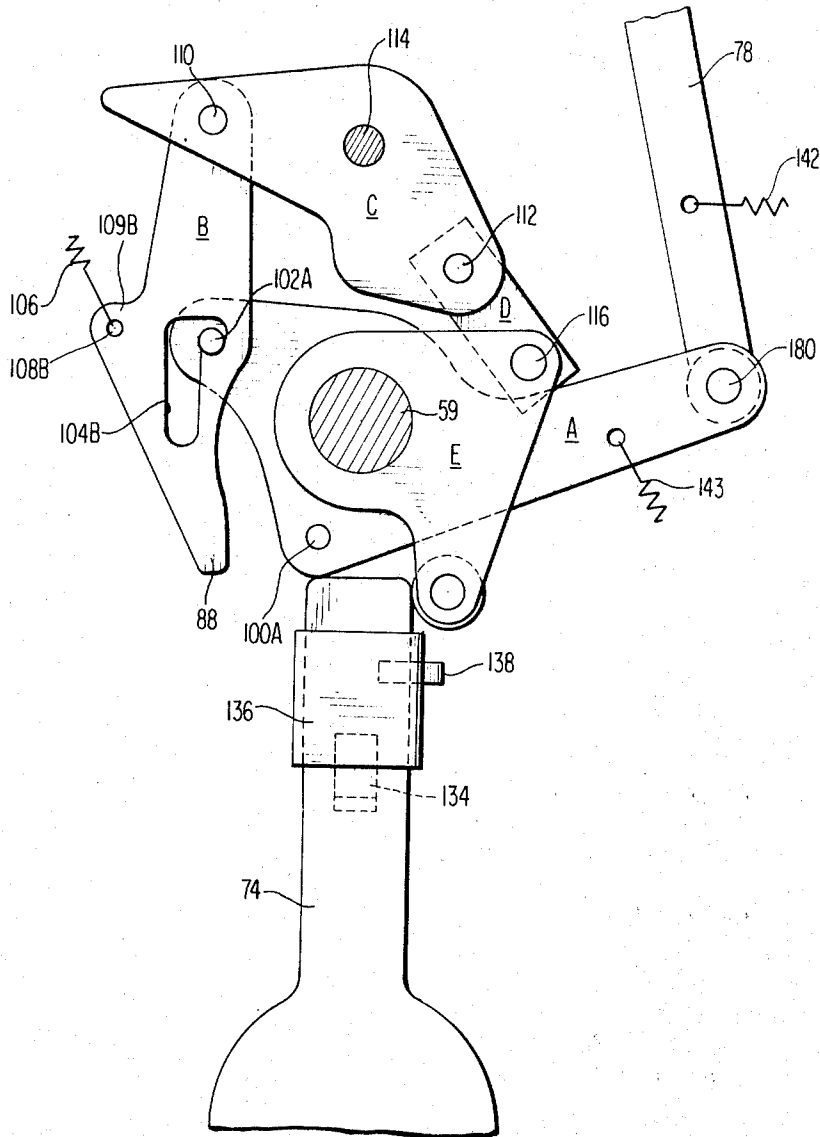


FIG. 10

## AUTOMATIC SYSTEM FOR SPRING STARTING AN INTERNAL COMBUSTION ENGINE

### BACKGROUND OF THE INVENTION

The invention relates to starter systems for internal combustion engines and, more particularly, to systems for controlling spring starting of compression ignition engines.

The diesel engine is currently used in a wide spectrum of applications for driving devices such as cement mixers, pumps, generators and vehicles such as boats. It has long been recognized that starting a cold diesel engine is generally a difficult matter. Many procedures and devices have been developed for facilitating cold engine starting such as the use of already compressed air, the introduction of heated air, and the injection of various fluid materials. All of these approaches for facilitating the cold starting of diesel engines require a significant amount of additional auxiliary apparatus and are generally expensive to incorporate within a conventional engine or present logistics supply problems. The reliability of such engine starting facilitating methods and devices has been less than desirable in many applications such as in the field or in cold remote areas and, of course, reliability is of primary importance in these aforementioned applications.

The direct manual starting of a diesel engine is a difficult matter for a full-grown man and should hardly be attempted by a woman or a child. Therefore, a distinct disadvantage exists in diesel engines which must be hand cranked even when such diesel engines are provided with the above-mentioned starter facilitating features. If the diesel engine should be turned over too slowly during the starting process, there is a tendency for the compressed gases to leak through various spaces in the piston chambers and the cold walls of the chamber have a longer time during which to act upon and cool the compressed gases so as to impede ignition and starting. Another disadvantage in turning a crankshaft of an engine over too slowly during the starting of the engine is that the fuel injection system will not spray a satisfactory mist into the chamber for combustion. This disadvantage similarly impedes proper ignition and starting of the engine.

Therefore, it can be generally said that reliable and fast ignition of a compression ignited internal combustion engine requires that the engine be turned over very rapidly during the starting period. Also, it would be advantageous if a system could be provided which would permit a woman or a child to provide the energy for rotating the crankshaft for proper starting. This last advantage is of particular significance in relation to the application of diesel engines to small boats or as auxiliary engines on large boats or electric generators for emergency power.

In the context of these basic objectives, the invention is concerned with their attainment, along with the elimination of cumbersome and unreliable control mechanisms heretofore often encountered in the art.

It would be particularly desirable for this basic goal to be accomplished in the context of a control mechanism which is compact, reliable, relatively inexpensive, and capable of performing a series of control functions essential to a starting and spring rewinding operation.

Most significantly, the state of the art indicates a need for a compact, reliable starter control mechanism, operable with minimum manipulation, confined to a small space, and easily incorporated on an engine frame or housing.

### OBJECTS AND SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide an automatic system for high speed cranking of internal combustion engines during starting, which system precludes many of the problems encountered in currently used apparatus.

It is another object of the present invention to provide an automatic system for spring starting an internal combustion engine which is more reliable than existing spring starting systems.

It is still another object of the present invention to provide an automatic system for spring starting an internal combustion engine which is particularly adapted to cold starting diesel engines.

It is yet another object of the present invention to provide an automatic system for spring starting an internal combustion engine which system insures that the engine will be turned over very rapidly during the starting period.

It is a further object of the present invention to provide an automatic system for spring starting an internal combustion engine which system may be operated by a woman or a small boy with the same results of reliability and quick ignition as if the system were operated by a full-grown man.

It is still a further object of the present invention to provide a system for spring starting an internal combustion engine which system is particularly adaptable to existing conventional internal combustion engine equipment.

It is yet a further object of the present invention to provide a system for spring starting an internal combustion engine which system is relatively uncomplicated and lends itself to ease of manufacture and installation.

It is yet still a further object of the present invention to provide a system for spring starting an internal combustion engine which system automatically rewinds the starter spring while precluding the overwinding thereof.

It is yet still another object of the present invention to provide a system for spring starting an internal combustion engine which system minimizes the problems of gas leakage from within the piston cylinders, the loss of compressed charge heat to the cold walls of a cylinder, and the lack of fuel pressure for properly spraying fuel through a fuel injection system due to a slowly rotating crankcase.

At least some of the objects are carried out by the provision of an automatic system for spring starting an internal combustion engine wherein a starter spring is disposed in driving relationship with a crankshaft of the engine. A rewind drive train connects the crankshaft with the spring and is operable to wind the spring when the crankshaft is rotated by the internal combustion engine. A unique mechanical linkage control mechanism is provided for releasing the spring to start the engine and for controlling the rewinding of the spring after the engine has been started. The mechanism rotates, ex-

pands and contracts in a synergistic manner to perform the necessary sequential control functions in response to single movements of a control rod.

### BRIEF DESCRIPTION OF THE DRAWINGS

While the specification concludes with claims which particularly point out and distinctly claim the subject matter of the present invention, a preferred embodiment is described in the following detailed description which may best be understood when read in connection with the accompanying drawings in which:

FIG. 1 is a partial sectional view of an overall spring starting system according to the present invention shown in elevation;

FIG. 1a provides an enlarged, partially sectioned, elevational, view of a control linkage mechanism incorporated in the FIG. 1 apparatus as viewed along section line 1a—1a of FIG. 4;

FIG. 1b provides an enlarged, perspective view of components of a clutch mechanism incorporated in the FIG. 1 apparatus, showing these components in an axially separated condition;

FIG. 2 is a sectional view of the apparatus shown in FIG. 1 taken along the line 2—2;

FIG. 3 is a sectional view of the apparatus shown in FIG. 1 taken along the line 3—3;

FIG. 4 shows a spring rewind and release control mechanism according to the present invention wherein the spring is in a cocked condition;

FIG. 5 shows the control mechanism of FIG. 4 upon initial release of the starter spring for starting the internal combustion engine;

FIG. 6 shows the control mechanism of FIG. 4 wherein an arbor arm stop is repositioned for stopping the rotation of one end of the spring so that the spring may be rewound when an arbor arm drivingly connected with the spring rotates into engagement with the stop;

FIG. 7 shows the mechanism of FIG. 4 wherein the arbor arm is in engagement with the arbor arm stop to hold one end of the spring stationary to commence a rewinding process;

FIG. 8 shows the control mechanism according to FIG. 4 wherein a rewinding clutch lock pin is disengaged;

FIG. 9 shows the control mechanism of FIG. 4 wherein the rewind clutch has been disengaged and the starter spring is once again cocked for another engine start; and

FIG. 10 is a front view of the spring rewind and release control mechanism shown in FIGS. 4 through 9 with a central, non-rotatable plate removed to provide a clearer view of the rotatable members.

### GENERAL DESCRIPTION OF OVERALL SPRING STARTER SYSTEM

Referring now to the drawings in which like numerals are used to indicate like parts throughout the various views thereof, FIGS. 1, 2 and 3 show an overall spring starter system for an internal combustion engine which spring starter system incorporates the automatic rewind feature of the present invention.

Referring now to FIG. 1, an engine crankshaft 10 or its extension is rotatably mounted within an engine housing 12 by means of bearings 14. A pulley 16 is

mounted at the end 18 of the crankshaft 10 furthestmost from the engine (not shown).

The engine crankshaft 10 may be disposed in driving relationship with a motor-generator shaft 20 by means of a drive belt 22 operatively mounted between the pulley 16 of the engine crankshaft 10 and a pulley 24 which is mounted on the fan and generator shaft 20 and disposed generally above the pulley 16. A generator/motor (not shown) may be drivingly connected with the end 26 of the shaft 20. The generator/motor may be used as a generator to supply electrical power to the engine and auxiliary equipment or may be used as a motor to drive the shaft 20 for rewinding a starter spring 28 in a manner which will be described in detail later in the specification.

In order that the fan and generator shaft 20 not be able to transmit torque back to shaft 10 when shaft 20 is being rotated by an auxiliary motor, a one-way clutch 30 is incorporated within the hub of the pulley 24 to insure that, in this case, the shaft 20 is driven only in the clockwise direction viewing FIG. 1 from the left end. The clutch 30 may be of the type indicated as a drawn cup roller clutch in a publication KC 10M 7/67 of the Torrington Company of Torrington, Conn., United States of America.

As can be seen, the generator and fan shaft 20 is continuously driven clockwise when the engine is driving the crankshaft 10 in the clockwise direction as viewed from left to right. While shaft 20 has been here referred to as a generator and fan shaft, it obviously need not necessarily be associated with these components. Instead, shaft 20 may comprise a rotatable member conveniently mounted within the apparatus.

A clutch mechanism 32 is provided in the apparatus to selectively control the starter spring winding operation.

Clutch mechanism 32, as shown in FIGS. 1 and 1b, includes a pair of disc-like clutch members 34 and 36 which are journaled on shaft 20 for free rotation thereabout. Member 34 is slidable along shaft 20 while member 36 is constrained against such slidable movement by its interconnection with a crank arm 50, subsequently described. Members 34 and 36 are biased to a separated condition, shown in FIGS. 1 and 1b, by a coil spring 33 interposed axially between these members.

Members 34 and 36 comprise mutually engageable, toothed clutch members. Member 34 is provided with an outer annular row of circumferentially spaced, clutching teeth 34a. Teeth 34a, as shown in FIG. 1b, may be provided with rounded peripheral portions to provide smooth meshing interengagement, with the "rounding" extending generally as shown in FIG. 1b. Clutch member 34 also includes an inner row of circumferentially spaced, rounded clutch teeth 34b, these teeth again being rounded as shown in FIG. 1b to facilitate clutch meshing.

Disc member 36 is provided with a row of circumferentially spaced, clutching teeth 36a. Teeth 36a are rounded as shown in FIG. 1b and are adapted to meshingly interengage with teeth 34a in response to movement of member 34a to the right, viewing the apparatus elements as shown in FIG. 1.

Shaft 20 is provided with a transversely extending pin member 40 which is fixedly connected therewith and

projects laterally from opposite sides of the shaft 20. Pin 40 serves to clutchingly interconnect shaft 20 and plate 34 when the plate 34 is moved to the right as shown in FIG. 1. This rightward movement of member 34 will cause the pin 40 to meshingly interengage the inner tooth row 34b so as to interclutch or interengage the shaft 20 and member 34. It is contemplated that the interengagement of the pin 40 and member 34 may occur slightly prior to or simultaneously with the intermeshing or interengagement of the teeth components 34a and 36a.

The clutch mechanism 32 additionally includes cam means provided by disc members 42 and 44 as shown in FIG. 1. To facilitate interchangeability of components, members 42 and 44 may be identically configured and each may be freely journalled on the shaft 20.

Leftward movement of disc 44 is prevented by shaft shoulder 20a. Leftward movement of disc 42 is limited by its engagement with the right side of disc 44. However, disc 42 is movable to the right. As shown in FIG. 1, disc 42 ordinarily is disposed in abutting but disconnected engagement with the left side of member 34. Rightward movement of disc 42 will force the clutch component 34 into meshing engagement with the elements 40 and 36, as heretofore described, so as to clutchingly interengage the shaft 20 and member 36. Member 36 is rotatable with, and connected with, an eccentric member or means 38.

The eccentric means 38, of a generally disc-like format, is preferably integrated with, but axially displaced from, the component 36, and is journalled on shaft 20. With this arrangement, rotation of the interconnected members 36 and 38 with the shaft 20 will provide an eccentric motivating force on the cylindrical periphery of the member 38, which cylindrical periphery is eccentrically located with respect to the axis of the shaft 20.

As shown in FIG. 1, the left side of disc member 42 is provided with a frustoconical cam surface 46, diverging outwardly from shaft 20 and away from member 44. The left side 44a of disc member 44 may extend perpendicularly to the axis of shaft 20.

When a cam-like member 48, carried by an arm 78, (see FIG. 2) is forced within the wedge-shaped space defined by the surfaces 42 and 46, the toothed plate 34 of the clutch 32 is moved longitudinally of the fan and generator shaft 20 to the right and into driving engagement with the toothed plate 36 and pin 40, with plate 36, in essence, comprising a portion of the rotatable, eccentric member 38. When the clutch 32 is thusly engaged, the freely rotatable eccentric member 38 is driven clockwise with the shaft 20.

As can be seen from FIG. 3, the cam member 38 is mounted eccentrically on the shaft 20 and is provided with an annular ring-like member 49 journalled on the outer periphery thereof. A crank arm link member 50 may be rigidly secured to the annular ring 49 at end 52 of the arm 50 to extend radially outwardly therefrom. The arm link 50 is, also, connected with a second arm linkage member 54 by means of a pivot pin 56. The arm linkage member 54, in turn, may be operatively connected with an outer race of a ratchet action mechanism 58 which is designed to "clutch" only when arm 54 rotates in the counterclockwise direction, as

shown in FIG. 3. The assembly 58 may comprise, for example, a one-way clutch of the Torrington type previously noted, or other types.

A one-way clutch assembly 58 is mounted on a shaft 59 which may have an extension for manually rewinding. Shaft 59 may be journalled in the starter frame, generally as shown in FIG. 1. Arm 54 is fixedly secured to the outer race of the clutch assembly 58, while the inner race of this assembly is fixedly secured to shaft 59.

A pinion gear with peripheral teeth 60 is coupled to shaft 59, as shown in FIG. 1. Teeth 60 engage external teeth 62 formed as a gear rim on a spring casing 64. The casing 64 is drivingly connected with the starter spring 28 by a pin 66.

A second one-way clutch arrangement 57, possibly of the Torrington type, may be provided on the shaft 59 to clutch in the opposite direction of the arrangement 58, i.e., clockwise when viewing FIG. 1 from the left. This permits the incremental but controlled one-way rotation of the shaft 59 when the clutch 58 is cranked by arm 54. Clutch 57 prevents clockwise or "backward" movement of shaft 59 as would be induced by the wound spring 28, and thus functions as a "holding" clutch.

The portion 13 of the overall housing 12 may be made adjustable so that the position of the shaft 20 may be arranged to put the pulley belt 22 in proper tension. A bracket 15 may be secured to some outer stationary engine housing (not shown) and formed with a longitudinal slot 17. A fastening means 19 may adjustably connect an arm 21 of the housing portion 13 with the bracket 15. A threaded adjustment member 23 may be mounted within the housing portion 13 by internal threading 25 formed therein. The adjustment member 23 may be provided with a head portion 27 for defining the proper position of wedge 48, resulting from the biasing action of spring 142 urging arm 78 (which carries wedge 48) toward head portion 27. Of course, the position of the head portion 27 is determined by the degree of threaded engagement of the member 23 within the threading 25.

Housing 13 may be pivotally supported on the starter frame for pivotal movement about an axis generally diametrically opposite fastener 19.

#### WINDING THE STARTER SPRING

In operation, the wedge-shaped cam member 48 shown in FIG. 2 is forced within the wedge-shaped space defined by the surfaces 46 and 42 of the overall dog clutch 32 mounted on the fan and generator shaft 20. The shaft 20 is continuously driven by the crankshaft 10 through the belt 22. The wedging action of the cam member between the two surfaces 42 and 46 forces the toothed plate 34 to the right and into driving engagement with the toothed plate 36 comprising a portion of the freely slipping member 38. The member 38 is then driven to rotate with the shaft 20. Since the member 38 is mounted eccentrically about the fan and generator shaft 20, the outer annular ring 49, which is held against rotation by the arm link member 50, is caused to oscillate in a direction aligned along the longitudinal extension of the arm link 50. This motion of the arm link 50 back and forth along its longitudinal extension causes the second arm link member 54 to crank

the assembly 58 so that the teeth 60 are incrementally rotated counterclockwise and drive the external teeth 62 on the spring casing 64 in a clockwise direction.

One looped end 70 of the main spring 28 is releasably secured to an arbor member 68 and another looped end 28a is secured to the spring casing 64 by a pin 66. The looped end 70 of the spring 28 is inserted in a radially facing notch 73 of the arbor 68. The looped end 70 is not held within the notch 73 by any clamping device. The outer spiral 28b of spring 28 is "pinned" or riveted adjacent looped end 28a so as to define a closed outer spring periphery, or self-defined casing. The casing 64 is mounted to rotate freely on axle portions 68a of the arbor 68. Thus, as the outer spring casing 64 is forced to rotate clockwise while the arbor 68 is restrained from rotation through arm 74 and stop system 72 (to be subsequently described), the spring 28 is wound.

The self cased nature of the outer periphery of spring 28, and the "drop-in" mounting of spring end 70 in notch 73 greatly facilitate assembly and servicing of the winding spring portion of the starter. As shown in FIG. 1, spring 28 is housed between casing halves 64a and 64b. These halves engage opposite sides of ring gear 62, as shown in FIG. 1.

In order to assemble these components, spring 28 may be positioned about mandrel 68, with end 70 disposed in notch 73. As shown in FIG. 3, the central portion 68b of mandrel 68 is polygonally shaped in a spiral-like form, enlarging in a clockwise direction, so as to define a spiral winding core.

By axially assembling components 64a, 64b and 62 about the assembled arbor and spring, the spring is enclosed. Insertion and securing of spring pin 66 through apertures of housing halves 64a and 64b, ring gear 62, and looped spring end 28a, and insertion and securing of other casing fasteners completes the assembly of the spring unit. All this is accomplished with ease due largely to the self cased nature of spring 28 and the "drop-in" securing of its inner end.

A unique linkage mechanism, indicated generally as 72 in FIG. 2, is provided for automatically controlling the winding and releasing operations of the starter spring 28 in a synergistic manner. This mechanism 72 will be described in detail later in the specification and especially in connection with FIGS. 4-9.

#### STARTING THE ENGINE WITH THE WOUND STARTER SPRING

Referring back to FIG. 1, the arbor member 68 may be rotatably mounted on the engine crankshaft 10 by means of one-way or overrunning clutch means which may comprise two one-way clutches 86 and 87, or possibly such clutch or more, again possibly but not necessarily of the Torrington type. These identically mounted units 86 and 87 "clutch" when arbor 68 rotates in a clockwise direction relative to shaft 10, viewing the components in FIG. 1 from the left. Clockwise rotation of shaft 10 relative to arbor 68, which occurs during engine running, will place units 86 and 87 in their "declutched" condition.

The end of the arbor member 68 away from the engine may be provided with a radially extending arbor arm 74. When the spring 28 is in the wound condition, the spring casing 64 is held against rotation by means of

the ratchet-like assembly 57 acting through shaft 59 and the exterior teeth 62 formed as a ring gear on the spring casing 64.

The sleeve-like arbor 68 which rotates independently of the spring casing 64 and which is biased for rotation in the clockwise direction by the wound starter spring 28 is held against such clockwise rotation during winding by the engagement of the arbor arm 74 with an arbor stop lug or roller 76. This roller 76 comprises a portion of the overall automatic control mechanism 72.

A manually operated engine starting rod 78 (see FIG. 2) is connected with the automatic control mechanism 72 by means of a pivot pin 80 extending through a portion of the mechanism 72 and through the rod at a first end thereof. A second end of the rod projects through an aperture 82 formed in a portion of the overall housing 12 and terminates in a ball-like handle 84 which may be disposed to be readily accessible to an engine operator. It should be noted that the cam-like member 48 for engaging the dog clutch 32 is also mounted on the rod 78.

When the rod 78 is moved upwardly, the arbor arm stop 76 moves out of engagement with the arbor arm 74 in a manner to be discussed with respect to FIGS. 4-10. When the arbor arm is thus released, the arbor is free to rotate clockwise under the high torque bias of the starter spring 28 and is operable to drive the engine crankshaft 10 in the clockwise direction through the one-way clutches 86 and 87 until the spring 28 has been unwound and the engine started. The casing 64 is held stationary during the portion of this period prior to engine starting operation of the one-way clutch 57. The spring and engine are designed so that the engine should start within the time the spring 28 is unwinding. Due to the operation of the overrunning clutches 86 and 87, the crankshaft 10 cannot directly drive the surrounding arbor 68 or the spring 28 connected therewith when the engine starts.

In the preferred embodiment, the mechanism 72 is designed so that the arbor arm 74 is permitted at least a full 6 turns for driving the crankshaft through 6 rotations before the arbor arm stop 76 is repositioned for stopping further rotation of the arbor and for commencing a rewind operation. The arrangement for controlling the desired number of turns will be discussed in the next section of the specification.

If the engine should not start during the predetermined number of rotations of the engine crankshaft 10, two alternative methods for rewinding the spring for starting the engine are provided. A hand crank (not shown) may be connected with end 61 of manual winding shaft 59 upon which the ratchet means 57-58 is mounted. The shaft 59 may then be hand rotated by an operator to wind the starter spring through the assembly 58 and another attempt at restarting may be made. It should be noted that the spring 28 will drive the crankshaft 10 with the same speed and torque whether a full grown man forcefully and rapidly hand winds the spring or a child winds the spring over a longer period of time.

Alternatively, a motor/generator (not shown) connected with the end 26 of the fan and generator shaft 20 may be powered by a battery (also not shown) to rotate the shaft 20.

Whether the spring 28 is to be wound manually, automatically or electrically, the rod 78 will be in a raised and locked condition. In any winding mode, when the rod 78 drops, the operator knows the spring 28 has been properly wound.

#### DETAILED DESCRIPTION OF THE AUTOMATIC CONTROL MECHANISM FOR WINDING AND RELEASING THE STARTER SPRING

Referring now to FIGS. 4-10, the control mechanism indicated in FIG. 2 generally as 72 is shown in detail.

In FIG. 4, the rod 78 is shown in the down position so that the wedge-shaped member 48 (FIG. 2) is not in actuating relationship with the rewind dog clutch 32 (see FIG. 1). The arbor arm stop 76 is in operational engagement with the arbor arm 74 to prevent the rotation thereof by the spring bias of the wound starter spring 28.

FIG. 5 shows the mechanism 72 with the starter rod 78 disposed in the upper, "engine starting" position wherein the spring winding dog clutch 32 (see FIG. 1) is engaged and the arbor arm stop 76 is moved away from engagement with the arbor arm 74 to permit the clockwise rotation thereof. As earlier mentioned, the starter rod 78 is operable to release the arbor arm 74, rigidly fixed to the arbor 68, and to engage the winding dog clutch 32 upon the upward movement thereof. Therefore, the arbor 68 and the arbor arm 74, acting through clutches 86 and 87, turn the crankshaft 10 upon the release thereof by the arbor arm stop 76.

The gear and pulley ratios of the drive train for winding the spring by rotating the spring casing 64 are chosen so that the arbor arm 74 will rotate a full 6 turns before a lug 87 formed on the casing 64 rotates to engage a trip finger 88 projecting from the automatic control mechanism 72 which engagement with the trip finger 88 is operable to reset the arbor arm stop through a sequence which will be explained later in the specification. Once the arbor arm stop is reset, with the clutch 38 locked in engagement, as shown in FIG. 7, the spring 28 is again subjected to a rewinding operation.

The automatic sequencing of linkage means 72 through the phases shown in FIGS. 5-9 will now be considered, preceded by a detailed discussion of the components of this linkage means.

#### STRUCTURE AND ARRANGEMENT OF MEMBERS COMPRISING THE AUTOMATIC CONTROL MECHANISM

FIG. 10 shows the mechanism 72 without a central, non-rotatable plate member F and may be referred to, along with FIGS. 4-9, for facilitating an understanding of the operation of the rotatable members.

Referring to FIG. 4, the automatic control mechanism 72 is shown to comprise a plurality of linkage members connected with the engine starting control rod 78 by means of the pin 80. The group of the links comprising the overall mechanism 72 is generally arranged about the ratchet and hand wind shaft 59 and each member may be spaced axially of the shaft in any desired relationship according to the configuration of the engine to be started. For the purpose of facilitating an understanding of the synergistic interaction of the various members comprising the mechanism 72, the

mechanism will be described as though the various members lie in axially contiguous planes of movement.

In order to further facilitate an understanding of the interaction of the various members, each member will be identified by a capital letter and each portion of each member identified by a numeral will be displayed in combination with a capital letter associated with the member forming that identified portion.

Link A is mounted for rotation about the shaft 59 and is connected with the control rod 78 by means of the pin 80 passing through both the control rod and the link. The link A is provided with a laterally and normally projecting clutch-lock pin 100A (FIG. 9) disposed adjacent a lower portion thereof and with a slot engaging pin 102A projecting normally from an upper portion and on a side thereof opposite the side connected with the control rod 78.

A second link B is provided and is formed with a J-slot 104B. The slot pin 102A slidingly engages within the J-slot 104B so that, when the pin 102A is positioned within the slot 104B as shown in FIG. 4, an upward movement of the control rod 78 by an operator is operative to pivot the link A counterclockwise about the shaft 59 and to move the plate link B downwardly against the combined upward and sidewise force of the bias of a spring 106 which may be attached to the engine casing (not shown) at one end and to the link B at the other end thereof by means of a connector pin 108B. The portion of the link B adjacent the pin 108B may be formed to extend outwardly as an arm 109B to provide a larger moment arm through which the bias of spring 106 operates. The lowermost portion of the link B comprises the rewind trip finger 88 which is engaged by the lug 87 of the casing 64 to reset the arbor stop 76 after at least 6 turns of the crankshaft 10.

The position of the link A and of the spring biased link B, when the rod 78 is in the upper, or engine starting, position, is shown in FIG. 5.

One end of a third link C is connected with the link B at an upper end of link B by a pin 110 which passes only through the links B and C. The other end of the link C is connected with a fourth link member D by means of a pin 112. The pin 112 passes only through the links C and D. The link C is pivotable about a shaft 114 which is secured to the overall engine housing 12 as shown in FIG. 1. It can be seen that the link C is so disposed that an upward pull on the rod 78 pivots the link A to move the link B downwardly and to rock the link C counterclockwise about the second shaft 114.

FIG. 5 shows the link C in a position rotated slightly counterclockwise in response to an upward displacement of the rod 78. The link D is, in turn, moved upwardly in response to the counterclockwise rocking motion of the link C and is connected at a second end thereof with a fifth link E by a pivot pin 116. The arbor arm stop lug or roller 76 is mounted on a lower portion of the link E. The pin 116 connects only links D and E.

#### MOUNTING OF LINKS

As shown in FIGS. 1 and 1a, links C and E may be bifurcated in nature. Thus, link C may include axially spaced link plates C' and C'' which are connected by a hub C''' which is journaled on pin 114. Similarly, link E may include axially spaced link plates E' and E'' which are connected by a hub E''' which is journaled on shaft 59.

As is also shown in FIG. 1, links B and A are displaced from vertically aligned links C and E, progressively from left to right. Link F may be coplanar with link B. Link D, which connects links C and E, may be mounted in the axial gaps between the link plates of these links.

#### COMMENCEMENT OF STARTING

It can now be seen that an upward displacement of the rod 78 rotates the link A counterclockwise so as to move the link B downwardly. The downward displacement of the link B, then, rocks the link C counterclockwise about the fixed shaft 114 secured to the engine housing 12. The counterclockwise rocking of the link C moves the linkage D upwardly which, in turn, rotates the link E counterclockwise about the fixed shaft 59 so as to move the arbor arm stop 76 away from engagement with the arbor arm 74. This sequence of linkage movement results in the links A, B, C, D, and E taking the position illustrated in FIG. 5 of the drawings and in the release of the arbor arm 74 and arbor 68 which is spring biased to rotate clockwise by means of the wound starter spring 28. The arbor 68, in turn, is operable to rotate the crankshaft 10 therewith through the one-way clutch 86 shown in FIG. 1.

#### LOCKING THE SPRING WINDING CLUTCH IN DRIVING ENGAGEMENT

A locking plate F is provided in the overall mechanism 72 and is supported by the two shafts 59 and 114 which are fixedly secured to the overall engine housing 12. The plate F is provided with a vertically extending longitudinal slot 118F formed at an upper end thereof and disposed about the upper fixed shaft 114. A lower, wider longitudinal slot 120F is disposed about the shaft 59 mounted within the engine housing 12. The plate F is not connected with any other link but is operable to slide vertically along the shafts 114 and 59. A compression spring 122 is disposed within the slot 118F between the shaft 114 and a lower portion 124F of the upper longitudinal slot 118F. The spring 122 is operable to bias the plate F downwardly.

When the operator control rod 78 is displaced upwardly, as in the aforementioned discussion with respect to the release of the arbor arm 74, and as shown in FIG. 5, the clutch lock pin 100A is moved counterclockwise about the shaft 59 and is moved into locking engagement with a clutch lock pin slot 126F formed adjacent a lower portion of the plate F. When the clutch lock pin 100A first engages the plate F, the pin 100A slides along a cam-like surface 128F of the non-rotatable plate F until it slips into the slot 126F under the downward biasing force of the spring 122 acting between the shaft 114 and the lower surface 124F of the slot 118F. With the rewind clutch lock pin 100A lockingly engaged within the slot 126F, the entire linkage system is frozen against rotation and the clutch actuating cam 48 on the operator's starting rod 78 is held in the upward position so as to lock the spring winding clutch 32 (FIG. 1) in driving engagement. At this point, of course, the engine not being started, the engine driven shaft 20 is stationary.

With the linkage mechanism locked in the position shown in FIG. 5, the released spring 28 will serve to impart several full turns to the arbor 68. (In the preferred embodiment 6 turns is believed to be a sufficient

number of turns to effect engine starting. However, it will be understood that the number of engine turns imparted by the spring will vary from engine to engine, depending upon starting requirements.)

#### STARTING AND RECONDITIONING FOR SPRING REWINDING

The released arbor arm 74 will allow spring 28 to impart several revolutions to arbor 68. During these revolutions, the arbor 68, acting through one-way clutches 87, will "turn-over" the engine connected shaft 10 and start the engine. After the engine has started, the shaft 20 connected with the started engine will commence to rotate and impart incremental rotation to spring case 64 via clutch 32, crank means 50-54 and gear 60, as controlled by clutch means 56 and 58. During this rotation, lug 87 will be rotated clockwise (viewing the linkage displayed in FIG. 6) about shaft 10 and will engage the left side of trip finger 88. When the lug 87 so engages the finger 88, disposed in the link position shown in FIG. 5, the generally horizontal portion of the J-slot 104B is displaced to the right as shown in FIG. 5, so as to position pin 102A in the generally vertically extending portion of the slot and the link B may thus move upwardly to the FIG. 6 position under the influence of the bias of the spring 106. The link A remains stationary due to the clutch lock pin 100A being engaged within the clutch lock pin slot 126F. The upward movement of the link B counterrotates the link C clockwise about the fixed shaft 114, back into engagement with stop pin 5, so as to move the link D clockwise which, in turn, moves the link E clockwise about the shaft 59. As shown in FIG. 6, this repositions the arbor arm stop 76 for engagement with the arbor arm 74.

With the stop 76 positioned as shown in FIG. 6, this stop component of the linkage mechanism is operable to engage the arm 74 as shown in FIG. 7, so as to prevent further clockwise rotation, viewing the apparatus as shown in FIG. 6. With arm 74 and arbor 68 thus immobilized, continued incremental rotation of case 64 will commence rewinding of spring means 28 about the arbor 68.

The spring of the linkage mechanism has now been traced to the point where the engine has been started and the arm 74 reengaged with stop 76 so as to recondition the mechanism for rewinding action.

In describing the spring rewinding action, reference will now be made to a slide arrangement which is mounted on the arm 74 and which is operable to control the duration of the spring rewinding operation.

#### SPRING REWINDING

Spring rewinding commences with the elements disposed as shown in FIG. 7 and terminates with the linkage mechanism disposed as shown in FIG. 9. FIG. 8 displays the linkage mechanism at the point in time where it is to be "tripped" and manipulated to the FIG. 9 position where winding has terminated and the components have been restored to their FIG. 4 condition.

Spring rewinding results, as above noted, from incremental rotation of case 64 about the constrained or immobilized arbor 68. Winding terminates through action of a groove actuated cam means, the overall operation of which will now be described.

As can be seen from FIGS. 1 and 2, one radially extending surface 130 of the spring casing 64 is provided with a spiral groove pattern 132. A cam finger 134 is mounted on a slider member 136 which is slidingly mounted on the arbor arm 74 to move freely along the longitudinal extension thereof. A link engaging finger 138 is also formed on the slider member 136 and is positioned to engage a lower edge surface 140F on the non-rotatable plate F when the arbor arm 74 is engaged with the arbor arm stop 76 and the slider member 136, slidingly mounted on the arbor arm 74, is in an uppermost position.

Upon the upward displacement of the rod 78 by an operator, when starting the engine, the arbor arm commences the rotation induced by spring 28. The spring casing 64 is held stationary by means of the assembly 57 shown in FIG. 1. As the cam finger 134 travels along the spiral groove 132 of the fixed spring casing 64, the slider member 136 is caused to move radially inwardly toward shaft means 10 until the spring is unwound.

By the time the spring induced turns of the arbor 68 have been effected, the slide mechanism 136 will have moved toward the radius of the shaft 10 and be disposed in a lower position on arm 74, generally as shown in FIG. 6.

At this time the engine should be started and the spring casing 64 should be rotating clockwise relative to the arbor 68 so that after lug 87 has tripped plate B, thereby returning plate E to engage arm 74, the cam finger 134 retraces the spiral path outwardly and moves the slidable member 136 back to the uppermost position. In this latter position, the link engaging finger 138 engages the surface 140F of the non-rotatable plate F, as shown in FIG. 8, and the clutch lock pin 100A is freed from within the clutch lock pin slot 126F so that the members of the overall mechanism 72 are no longer frozen against rotation and the rod 78 is free to move back downwardly. At this point, the pin 102A moves upwardly along the vertical extension of the slot 104B and comes to rest within the horizontal extension thereof as shown in FIG. 9.

The spring 28 has been wound during the time the slidable member moved back up into the uppermost position and the unlocking of the clutch lock pin 100A from within the clutch lock pin slot 126F has permitted the operator's control rod 78 to move downwardly. The downward displacement of the control rod under the bias of spring 142 removes the wedge-shaped member 48 (shown in FIG. 2) from operable engagement within the space defined by the surfaces 42 and 46 of the overall dog clutch 32. An additional spring 143 may be added to augment this operation.

The clutch 32, which may be biased into the non-engagement position by the spring 33, is thereby disengaged so that while the shaft 20 is rotated by the engine crankshaft 10 through the belt 22, the rotation of the shaft 20 is not transmitted to the ratchet mechanism 58. Since the arbor is held against clockwise rotation by the arbor stop 76 of the control mechanism 72, and since the one-way clutch 86 prevents the direct driving of the arbor 68 by the crankshaft 10 when the crankshaft drives in the clockwise direction, the arbor 68 is similarly fixed against rotation but is spring biased in the clockwise direction by the wound spring 28, for restarting the engine.

#### INTERACTING, ROTATIONAL, COUNTERROTATIONAL, EXPANDABLE, CONTRACTIBLE, TOGGLE, AND LOCKING CHARACTERISTICS OF LINKAGE MECHANISM

The linkage mechanism 72, comprising links A, B, C, D, E, and F, operates through a variety of uniquely interacting motions to provide overall control over the entire winding operation.

FIG. 4 may be defined as a rest or "cocked" position of the linkage 72, with the interconnected linkages B, C, D, and E being pivotally supported on the shafts 114 and 59. These interconnected linkages may be considered contracted because of the shortened nature of the link B, resulting from the disposition of the pin 102A in the transverse portion of the J-slot 104B.

In the FIG. 4 condition, the linkage 72 maintains the starting mechanism in a cocked condition.

In FIG. 5 the linkage elements B, C, D, and E have been rotated generally counterclockwise about the supporting pivot mounts 114 and 59 (in response to counterclockwise rotation of the manipulating link A) so as to condition the engine for starting. "Rotating" as here utilized is defined in a broad sense to encompass the rotational movement permitted by the two shafts 114 and 59.

In FIG. 6 the tripping of the link finger 88 of link B has, in effect, enabled the link B to expand so as to in general expand the periphery defined by lines interconnecting the pivot points joining the links A, B, C, D, and E (link B having been lengthened by the pin 102A moving into the long leg of the J-slot 104B).

This expansion of the linkage mechanism has served to condition the linkage means to place the starting mechanism in condition for rewinding. This expansion of linkage B has also served to counterrotate the linkage elements B, C, D, and E about the shafts 114 and 59, respectively, so as to reposition the stop 76 at the location where arm 74 may be stopped and rewinding effected.

Throughout the linkage arrangements shown in FIGS. 5, 6 and 7, the locking link F has served to maintain the manipulating linkage A in the position which holds the winding clutch 32 in its engaged condition, with the interengagement of the pin 100A and the notch 126F preventing movement of the arm 78.

When the linkage 72 is conditioned, as shown in FIG. 9, in response to the actuation of the slide carried trip finger 140F, the locking link F is manipulated so as to free the manipulating link A. Link A, in being freed, enables the arm 78 to move downwardly and thus disengage the winding clutch. This movement of manipulating link A moves pin 102A back into the transverse portion of J-slot 104F so as to again in effect shorten the length of link B between links A and C. This contracting of the previously counterrotated linkage mechanism, resulting from the "shortening" of link B, which occurs in response to the full winding of the spring 28, restores the linkage mechanism 72 to the FIG. 4, starting, or cocked condition.

With the linkage components disposed as shown in FIG. 6 as well as in FIGS. 4, 7, 8, and 9, link means D performs a significant toggle function. In this arrangement, the pivot axis of connections 112 and 116 are on a line extending through the center of shaft 114. With this arrangement, the energy stored in the starter spring means 28 will be exerted through the arm 74 and stop

76 and act on the linkage assembly so as to transmit force through the toggle link D, which force is directed toward the fixed mounting shaft 114. This toggle arrangement will effectively constrain the force of the winding spring and minimize the extent to which the linkage assembly must absorb the force of the wound spring.

The toggle arrangement will also minimize the force necessary to be exerted on the operating handle 78 when the handle is to be moved to and held in the "cocked" position shown in FIG. 4.

#### SUMMARY OF THE STARTER SPRING WIND DRIVE TRAIN

The engine crankshaft 10 rotates the pulley 16 which, in turn, rotates the pulley 24 by means of the drive belt 22. The pulley 24 continuously rotates the shaft 20 while the engine is running. When the control rod 78 is disposed in the upper or rewind and start position, the member 48 attached thereto actuates the spring rewind clutch 32. With the clutch plates 34 and 36 engaged, the drum 38, which is eccentrically mounted on the shaft 20, causes the oscillation of the crank arm 54 via the link arm 50. The link arm 50 is rigidly attached to the ring member 49 and "cranked" by rotating eccentric 38.

Link 50 connects with arm 54 and imparts motion to crank arm 54 which in turn cranks the ratchet mechanism 58 which, in turn, slowly and incrementally rotates the spring casing 64 in the clockwise direction. The spring casing 64 thus rotates about the arbor 68 to wind the spring 28. Holding of the casing 64 between increments of spring winding is effected by clutch 57.

#### SUMMARY OF THE SEQUENTIAL OPERATION OF THE REWIND CONTROL MECHANISM

FIG. 4 shows the control mechanism 72 when the starter spring is fully wound and the operator's control starting rod 78 is in the nonstarting or downward position. The arbor arm 74 is engaged with the arbor arm stop 76 and the rewind clutch lock pin 100A is out of engagement with the rewind clutch lock pin slot 126F. This may be characterized as an initial condition for the mechanism 72, with a frame mounted stop pin 5 limiting clockwise movement of link C and assuring close alignment of pins 114, 112 and 116. Pin 5 may be adjustably positioned in the frame to facilitate alignment of linkage 72.

In FIG. 5, the operator's control rod 78 has been displaced upwardly to the uppermost position, and the arbor arm stop 76 has been moved out of engagement with the arbor arm 74 to release the arbor arm, which arm is spring biased to rotate clockwise by the starter spring 28. The condition of linkage 72 in FIG. 5 may be characterized as a rotated, contracted condition.

The upward movement of the rod 78 is also operable to move the rewind clutch lock pin 100A into locking engagement within slot 126F to "freeze" or lock the linkage system with the cam member 48 on the rod 78 disposed in position to actuate the starter spring rewind clutch 32 shown in FIG. 1. When the arbor arm 74 moves clockwise in respect to the spring casing 64, the slidable member 136 moves radially inwardly relative to shaft 10 as the cam finger 134 rides within the spiral groove 132 formed on the radial face 130 of the spring casing 64.

FIG. 6 illustrates the point in the operational sequence of mechanism 72 wherein the lug 87 formed on the radial face 130 of the casing 64 has engaged the finger 88 of link B and has disengaged the pin 102A from within the horizontal portion of the J-slot 104B. The link B is then permitted an upward movement under the bias of the spring 106, which upward movement causes the clockwise movement of link C into engagement with pin 5, which movement, in turn, causes the clockwise movement of links D and E. This movement produces what may be characterized as a counterrotated, expanded condition for the mechanism 72. The clockwise rotation of link E about the shaft 59 repositions the arbor arm stop 76 and further rotation of the arbor arm 74 is precluded as shown in FIG. 7, when arm 74 engages the left side of stop 76.

Referring to FIG. 7, the arbor arm 74 is in engagement with the arbor arm stop 76 and the winding of the starter spring 28 now commences. As the casing 64 rotates clockwise relative to the arbor 68 to wind the spring 28, the spiral groove 132 and cam finger 134 cooperate to move the slidable member 136 upwardly along the extension of the arbor arm 74. It should be remembered that the linkage mechanism is still frozen against rotation about shaft 59 by virtue of the rewind clutch lock pin 100A being locked within the slot 126F. During this time, and as shown in FIG. 7, the starter spring 28 is being wound and will continue to be wound until the spring rewind clutch 32 (FIG. 1) is disengaged through the sequences shown in FIGS. 8 and 9.

In FIG. 8, the cam finger 138 has engaged the lower portion 140F of the non-rotatable plate F and has released the rewind clutch lock pin 100A from engagement with the slot 126F. The link A is now free to rotate clockwise under the influence of bias spring 143 connected with link A and the starter frame or housing. Of course, the spring bias 142 also assists the rotation of the link A clockwise upon the disengagement of the pin 100A from within the slot 126F.

FIG. 9 shows the overall mechanism restored to the arrangement shown in FIG. 4 wherein the non-rotatable plate F is held in the upward position by the cam finger 138. The pin 102A has moved along the vertical portion of the J-slot 104B, as the link A rotated clockwise, and has come to rest within the horizontal extension of the slot 104B. The mechanism is thus counterrotated and peripherally contracted, i.e., restored to the FIG. 4 initial cocked position, and ready for another sequence as just described in connection with FIGS. 4-9.

#### SUMMARY OF SOME OF THE ADVANTAGES AND SCOPE OF THE INVENTION

It can thus be seen that an improved apparatus has been herein provided for automatically, spring starting internal combustion engines.

The basic mechanical nature of the apparatus insures a high degree of reliability in repeated operation. The rapidity with which the spring arrangement of the present invention may rotate the crankshaft of an internal combustion engine insures good starting characteristics even for the cold starting of diesel engines. Of course, the invention is not limited to use in diesel engines.

Due to the manual winding arrangement provided in one feature of the present invention, a woman or a

small boy could start an engine as effectively as a full-grown man.

Since the members of a mechanism, according to the present invention, are easily mounted on shafts which accordingly exist in conventional internal combustion engines, the invention is easily adapted to currently manufacture equipment. The circumferential and width-wise compactness, resulting from the synergistically interacting, rotation, contracting, counterrotating and expanding character of linkage 72 enhances this feature.

The operation of the present invention is automatic and, due to the positive control of the winding process, overwinding of the main starter spring is precluded.

Since the starter system of the present invention may turn a crankshaft over very rapidly, a gas charge is not given sufficient time during a compression or expansion stroke to lose heat to the cylinder walls of a cold engine. The high speed of crankshaft rotation also insures adequate fuel pump pressure to properly spray fuel into the combustion chamber and does not permit the cylinder gas time to leak through various imperfections in the structure of a compression ignition engine.

The utilization of rotational, counterrotational, expandable, and contractible toggle and locking components of the linkage mechanism enables a wide variety of control functions to be performed with particular reliability and in a confined space. The interacting nature of these manipulations enables a starting control mechanism, as herein described, to be readily incorporated in existing engine mechanisms without requiring significant increases in engine size. The toggle and locking aspects of the linkage mechanism yield position control with minimum structure.

Obviously, the linkage mechanism may be modified with respect to shape, size, numbers of links, mounting arrangements, etc. while maintaining significant advantages of the invention.

The linkage mechanism has been described as being mounted in part on the manual rewind shaft 59 and while the clutch 32 has been described as being mounted on a motor-generator and/or fan shaft 20. However, the shafts 20 and 59 as well as the shaft 114 should be viewed broadly as support shafts for the starting control mechanism, independent of whatever other function they might incidentally perform in relation to the engine or starting device. While such variations in arrangement are within the scope of the invention, the particularly described arrangement is believed to afford an especially compact and effective arrangement.

In describing the invention, reference has been made to specific embodiments and particular manufacturing components. However, these configurations and embodiments have been disclosed in many instances by way of example only. For example, Torrington one-way clutches have been described as they are well known. However, a variety of other one-way clutch or ratchet mechanisms could be employed in the practice of the invention. The winding spring has been illustrated as a unitized assembly with the spring housing being fabricated from a series of components. However, the single spring 28 might be replaced by two or more coaxially related springs and the housing could be effectively unitized.

Indeed, the overall apparatus is susceptible to changes in structure and function of this nature within the scope of the invention.

While what has been herein shown and described is a preferred embodiment of the present invention, it is of course understood that various changes and modifications may be made therein without departing from the invention. It is therefore intended to cover in the appended claims all such changes and modifications as may fall within the true spirit and scope of the invention.

What is claimed is:

1. An apparatus for automatically controlling a starter spring for an internal combustion engine having a crankshaft comprising:

arbor means rotatably mounted on said crankshaft and connected therewith by one-way clutch means;

said arbor means, crankshaft and one-way clutch means being arranged so that torque is transmitted only from said arbor means to said crankshaft;

spring casing means mounted to rotate freely on said arbor means;

a first end of the starter spring being connected with said arbor means and a second end of the starter spring being connected with said spring casing means;

a starter spring rewind drive train drivingly connecting the crankshaft with said spring casing means;

a combined starter spring release and rewind control means comprising

means for holding said arbor means against rotation when the crankshaft is winding said starter spring through said starter spring rewind drive train,

means for uncoupling said starter spring rewind drive train when said starter spring is generally fully wound,

means for releasing said arbor means to drive the crankshaft under the bias of said wound starter spring through said one-way clutch means for starting the engine, and

means for holding said spring case against rotation while driving the crankshaft for starting the engine.

2. An apparatus according to claim 1 wherein said starter spring rewind drive train comprises:

first and second auxiliary shafts;

first sheave means fixedly mounted on said crankshaft;

second sheave means fixedly mounted on said first auxiliary shaft;

driving web means operatively disposed about said first and second sheave means fixedly mounted, respectively, on said crankshaft and said first auxiliary shaft whereby said crankshaft is drivingly connected with said first auxiliary shaft;

eccentrically mounted drum means mounted on said first auxiliary shaft to rotate freely thereon;

starter spring rewind clutch means operable to rotate said drum means with said first auxiliary shaft;

ring means mounted on said drum means to rotate freely thereabout;

arm means extending radially from said ring means;

ratchet means mounted on said second auxiliary shaft and connected with said arm means of said ring means;

said ratchet means being operable to rotate said second auxiliary shaft in response to an oscillating movement of said arm means when said eccentrically mounted drum means is rotated within said ring means by said first auxiliary shaft;

gear mean mounted on said second auxiliary shaft and in driving relationship with ring gear means formed on an exterior portion of said spring casing; and

said ratchet means and said gear means on said second auxiliary shaft being operable to hold said spring casing against rotation in one direction and to wind said starter spring by rotating the spring casing in the other direction.

3. An apparatus according to claim 1 wherein said means for holding said arbor means against rotation when the crankshaft is winding said starter spring through said starter spring rewind drive train comprises:

a starter spring rewind and release control link mechanism;

an arbor arm formed on said arbor means and extending radially therefrom to a point adjacent said link mechanism; and

an arbor arm engaging projection extending from one link member of said link mechanism.

4. An apparatus according to claim 1 wherein said means for releasing said arbor means to drive the crankshaft under the bias of said wound starter spring through said one-way clutch means for starting the engine comprises:

control handle means accessible for manipulation by an operator;

means provided on said control handle means for actuating said starter spring rewind drive train upon movement of said control handle means to an engine starting position;

said control handle means being operatively connected with said starter spring release and rewind control mechanism;

an arbor arm extending radially from said arbor means;

an arbor arm stop carried by said starter spring rewind and release control mechanism;

said arbor arm stop being operable to hold said arbor arm and said arbor means against rotation caused by the spring bias of said starter spring; and

said starter spring release and rewind control means being operable to permit rotation of said arbor arm stop away from engagement with said arbor arm upon disposition of said control means in an engine starting position.

5. An apparatus according to claim 2 wherein said ratchet means for holding said spring casing against rotation comprises first and second, oppositely acting, one-way clutch means mounted on said second auxiliary shaft.

6. An apparatus according to claim 3 wherein:

said means for uncoupling said starter spring rewind drive train when said starter spring is generally fully wound comprises

a sliding cam member movably mounted on said arbor arm and operable in response to a predetermined number of turns of said spring casing means;

said sliding cam member engaging a portion of said starter spring release and rewind control means in response to said spring casing means rotating a predetermined number of turns while winding said starter spring; and

said starter spring release and rewind control means includes

a clutch in said starting spring rewind drive train, and

locking means for locking said clutch in an engaged position;

the engagement of said starter spring release and rewind control means by said sliding cam member on said arbor arm being operable to unlock said locking means and thereby uncoupled said starter spring rewind drive train.

7. A mechanism for controlling a starter spring for an internal combustion engine having a crankshaft comprising:

a control rod;

a first end of said control rod extending through an engine casing and being accessible to an engine operator;

a first auxiliary shaft mounted generally above said crankshaft;

a first link rotatably mounted on said first auxiliary shaft and formed with at least one transverse projection spaced radially from said auxiliary shaft;

a second end of said control rod being pivotally connected with said first link whereby said control rod is operable to rotate said first link about said auxiliary shaft in response to movement of said control rod;

a second link formed with a J-shaped slot;

said one projection on said first link being slidably engaged within said J-shaped slot;

said second link being spring biased generally outwardly from said first auxiliary shaft;

a second auxiliary shaft spaced from said first auxiliary shaft;

a third link rotatably mounted on said second auxiliary shaft and pivotally connected to said second link;

said third link being pivotally connected with a fourth link;

said fourth link being pivotally connected with a fifth link; and

said fifth link being rotatably mounted on said first auxiliary shaft and carrying an arbor arm stop spaced outwardly from said first auxiliary shaft;

movement of said control rod being operable to rotate said arbor arm stop away from engagement with a starter spring biased, arbor arm of a starter spring arbor; and

said arbor being operable to rotate said crankshaft to start said engine in response to the bias of the starter spring.

8. A mechanism according to claim 7:

wherein said starter spring is a convolute spring connected with said arbor at one end thereof and connected with a spring casing at another end thereof; said mechanism further including

spiral groove means formed on a face of said spring casing and disposed generally adjacent said arbor arm,

said spiral groove means generally encircling said crankshaft,

a slider member mounted to slide freely along said arbor arm, and

a cam follower formed on said slider member and engaged with said spiral groove means,

relative rotation between said spring casing and said arbor during winding and unwinding of said starter spring being operable to move said slider member along said arbor arm and cause stopping of a winding operation of said starter spring.

9. A mechanism according to claim 8 with the addition of:

non-rotatable, locking plate means mounted on said first and second auxiliary shafts;

said first and second auxiliary shafts extending through longitudinally extending slots formed in said locking plate means to give said locking plate means limited freedom of movement;

said locking plate means being spring biased to one position;

said slider member on said arbor arm being provided with a locking plate means engaging surface;

movement of said locking plate means engaging surface of said slide member being operable to uncouple a rewind drive train for winding said starter spring.

10. A mechanism according to claim 9:

wherein said rewind drive train for winding said starter spring includes

a disengageable clutch means which is engaged during a spring winding operation; and

wherein said clutch means includes

a clutch lock pin being formed on said first link and operable to engage a clutch lock pin slot formed in said locking plate means in response to movement of said control rod,

said movement of said control rod being operable to actuate said clutch means in said rewind drive train into engaged condition for winding said starter spring, and

wherein said clutch lock pin is operable to be disengaged from said clutch lock pin slot in response to winding of said starter spring.

11. An apparatus for controlling a starting mechanism, said apparatus comprising:

first, rotatable and counterrotatable linkage means operable to at least partially control one function of a starting mechanism;

pivot means rotatably supporting said first linkage means;

second, expansible and contractible linkage means operable to at least partially control another starting function;

said second linkage means including two pivotally interconnected link elements;

shiftable pivot means pivotally interconnecting said two elements of said second linkage means and operable to shift along at least one of said link elements;

means operable to shift said shiftable pivot means along at least said one of said link elements to ef-

fect expansion and contraction of said second linkage means; third, toggle linkage means connected with at least one of said first and second linkage means, and operable to direct force transmitted through at least a portion of said first and second linkage means to a portion of said pivot means;

fourth, locking linkage means operable to selectively secure at least a portion of said first and second linkage means in a selected position determining at least one of said starting functions;

starter spring means;

incremental winding means operable to rewind said starter spring means; and

clutch means operably controlled by at least one of said linkage means, and operable to start and stop said incremental winding means.

12. A spring winding mechanism comprising:

arbor means including

generally radially outwardly facing recess means;

winding spring means encircling said arbor means and having, a loop portion defining an inner terminus of said spring means, said loop portion being nestled in said recess means and substantially unrestrained by said arbor means with respect to movement directly out of said recess means, and interconnected outer spiral portions of said winding spring means,

means interconnecting said outer spiral portions of said winding spring means and defining with said interconnected outer spiral portions a fixed, nonexpansible, closed outer periphery for said winding spring means operable to constrain inner spiral portions thereof;

casing means connected with said closed spring periphery.

13. A mechanism as defined in claim 12 wherein said arbor means includes a plurality of generally planar sides extending about the axis of rotation of said arbor means in a generally spiral pattern.

14. An apparatus for controlling a starting mechanism including

starter spring means;

winding means operable to rewind said starter spring means; and

clutch means operable to start and stop said winding means;

the improvement characterized by:

first, rotatable and counterrotatable linkage means operable to at least partially control one function of a starting mechanism;

pivot means rotatably supporting said first linkage means;

second, expansible and contractible linkage means operable to at least partially control another function of said starting mechanism;

locking linkage means operable to selectively secure at least a portion of said first and second linkage means in a selected position determining at least one of said starting functions;

said second linkage means including two pivotally interconnected link elements;

shiftable pivot means pivotally interconnecting said two elements of said second linkage means and operable to shift along at least one of said link elements; and

means operable to shift said shiftable pivot means along at least said one of said link elements to effect expansion and contraction of said second linkage means.

15. An apparatus as described in claim 14 further including toggle linkage means connected with at least one of said first and second linkage means, and operable to direct force transmitted through at least a portion of said first and second linkage means to a portion of said pivot means while at least one of said functions is being performed.

16. An apparatus as described in claim 15 wherein: said first and second linkage means define a generally closed configuration; said apparatus includes means for rotating at least a portion of said linkage means on said pivot means from an initial position to release a wound starter spring means for starting an internal combustion engine; said apparatus includes means for expanding and counterrotating at least a portion of said linkage means to condition said linkage means for rewinding said spring; and said apparatus includes means for contracting at least a portion of said linkage means in response to said spring means being in a generally fully wound condition to restore said linkage means to said starting position.

17. An apparatus as described in claim 16 wherein: said apparatus includes: a control rod; a first end of said control rod extending though an engine casing and being accessible to an engine operator; a starter spring means arbor; an arbor arm carried by said arbor; and an arbor arm stop; said pivot means includes: a first auxiliary shaft mounted generally above a crankshaft of an engine to be started by said mechanism; a second auxiliary shaft spaced from said first auxiliary shaft; said second linkage means includes: a first link rotatably mounted on said first auxiliary shaft and formed with at least one transverse projection spaced radially from said auxiliary shaft; a second end of said control rod pivotally con-

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nected with said first link whereby said control rod is operable to rotate said first link about said auxiliary shaft in response to movement of said control rod;

a second link formed with a J-shaped slot; said one projection on said first link being slidingly engaged with said J-shaped slot; said second link being spring biased generally outwardly from said first auxiliary shaft; and said first linkage means includes: a third link rotatably mounted on said second auxiliary shaft and pivotally connected to said second link; a fourth link defining said toggle linkage means; said third link being pivotally connected with said fourth link; a fifth link; said fourth link being pivotally connected with said fifth link; and said fifth link being rotatably mounted on said first auxiliary shaft and carrying said arbor arm stop spaced outwardly from said first auxiliary shaft; movement of said control rod being operable to rotate said arbor arm stop away from engagement with said arbor arm of a starter spring arbor; and said arbor being operable to rotate said crankshaft to start said engine in response to the bias of the starter spring means.

18. An apparatus for controlling an automatic spring starter system for an internal combustion engine comprising: articulated and expansible linkage means defining a generally closed configuration; said linkage means being supported for pivotal movement on pivot means in a starting position; means for rotating at least a portion of said linkage means on said pivot means from an initial position to release a wound spring for starting said internal combustion engine; means for expanding and counterrotating at least a portion of said linkage means to condition said linkage means for rewinding said spring; and means for contracting at least a portion of said linkage means in response to said spring being in a generally fully wound condition to restore said linkage means to said starting position; said pivot means including a hand operated crankshaft for winding said spring.

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UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,692,010 Dated September 19, 1972

Inventor(s) James Linville Dooley and Clarence John Harasta

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

- Column 4, line 40, after "are" change "journalled" to -- journaled --.
- Column 5, line 13, after "as" omit "as".
- Column 5, line 16, after "freely" change "journalled" to -- journaled --.
- Column 5, line 33, after "is" change "journalled" to --journaled --.
- Column 5, line 58, after "49" change "journalled" to --journaled--.
- Column 6, line 50, after "the" omit "wedge-shape".
- Column 15, line 59, after "within" change "clot" to --slot--.
- Column 17, line 5, change "accordingly" (first word) to --ordinarily--.
- Column 17, line 7, change "manufacture" (first word) to --manufactured--.
- Column 19, line 9, change "mean" to --means--.
- Column 21, line 3, change "arboe" to --arbor--.
- Column 22, line 2, after "means;" (first occurrence) "third, toggle linkage means connected ..... to a portion of said pivot means;" should be a separate paragraph.
- Column 22, line 21, after "having, ", "a loop portion defining an inner ..... movement directly out of said recess means, and" should be a separate paragraph.
- Column 22, line 35, after "spring" add --outer--.
- Column 24, line 18, after "fourth" change "liik" to --link--.

Signed and sealed this 17th day of April 1973.

(SEAL)  
Attest:

EDWARD M. FLETCHER, JR.  
Attesting Officer

ROBERT GOTTSCHALK  
Commissioner of Patents