AUTOMATIC STARTER FOR SMALL ENGINES

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Fig. 1.

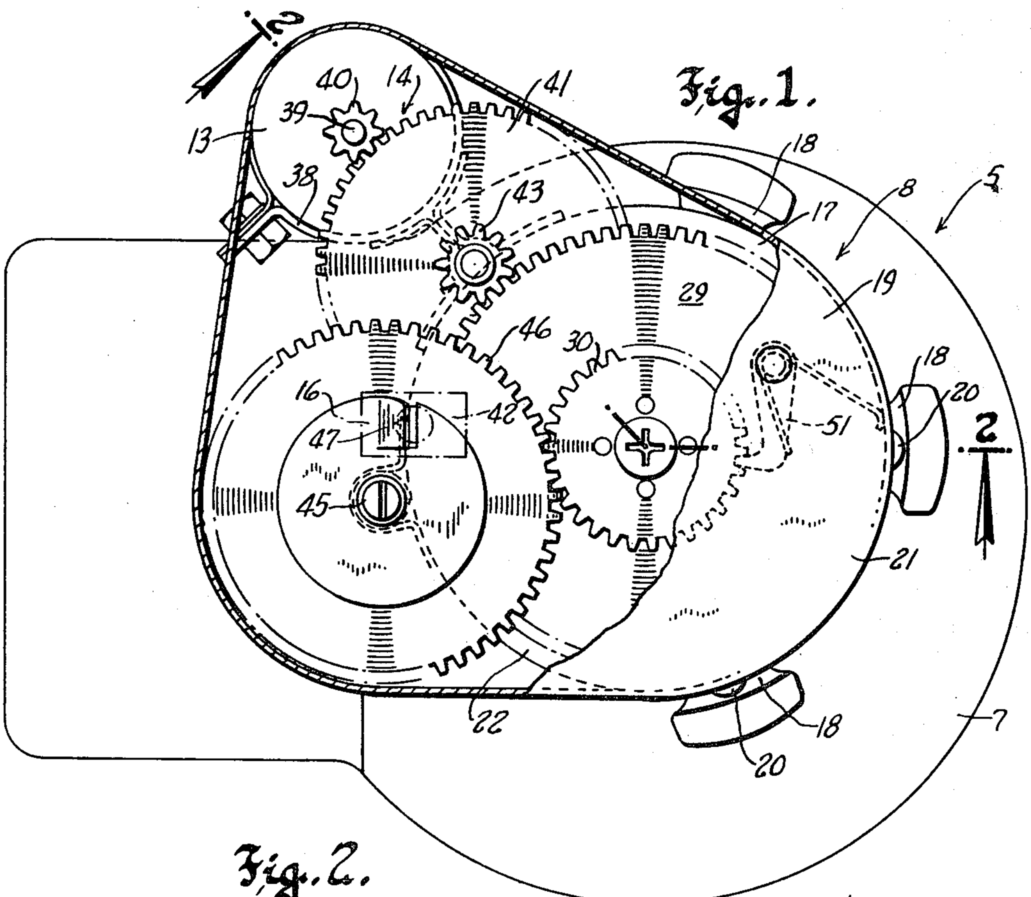
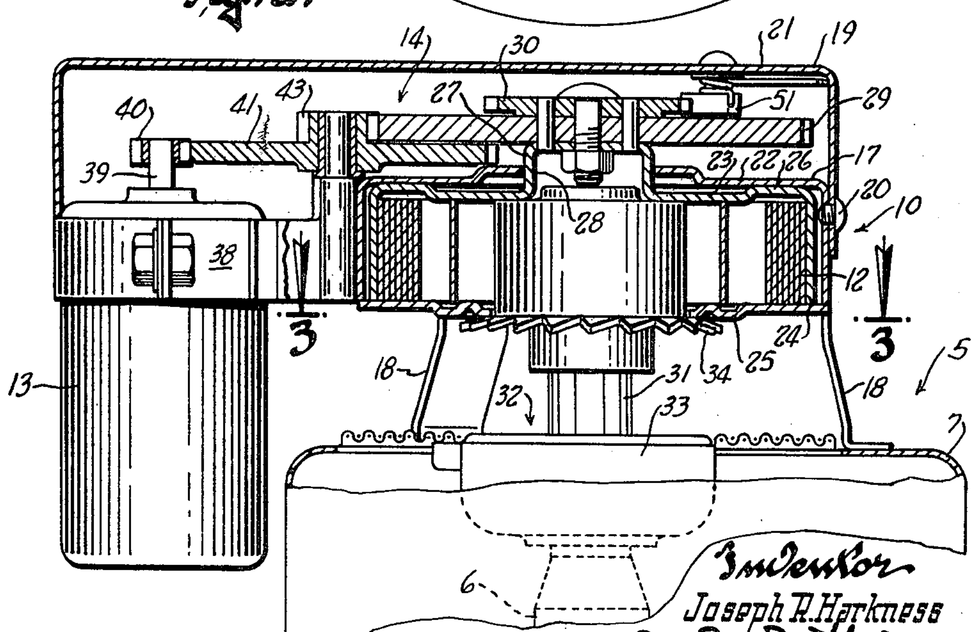


Fig. 2.



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AUTOMATIC STARTER FOR SMALL ENGINES

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Fig. 3.

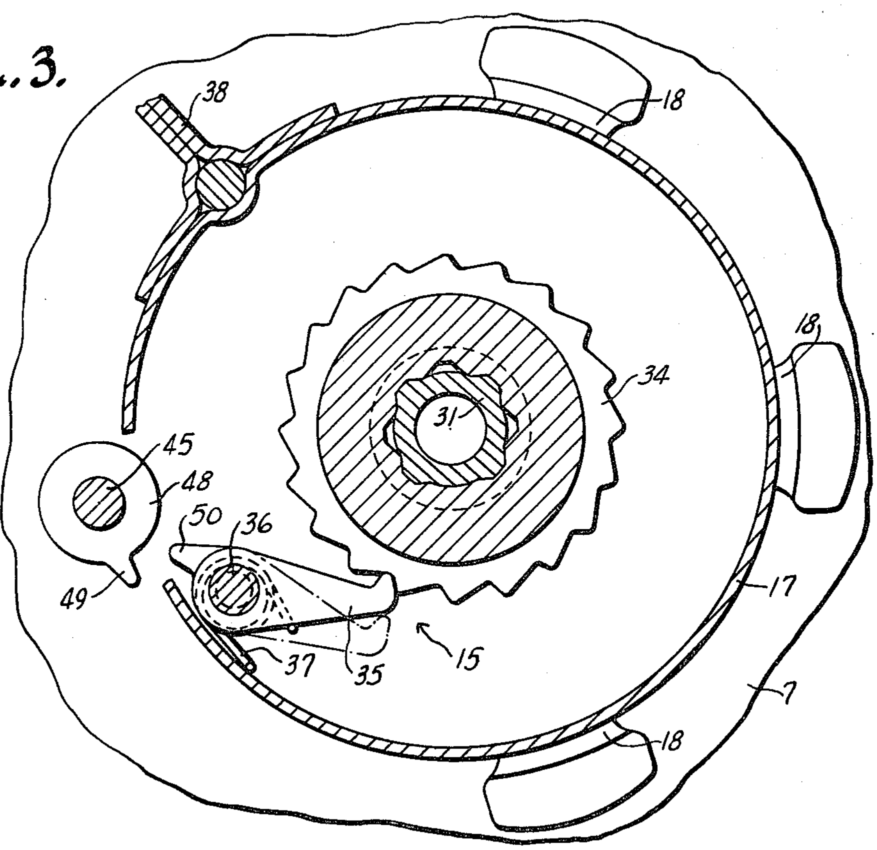

Fig. 4.

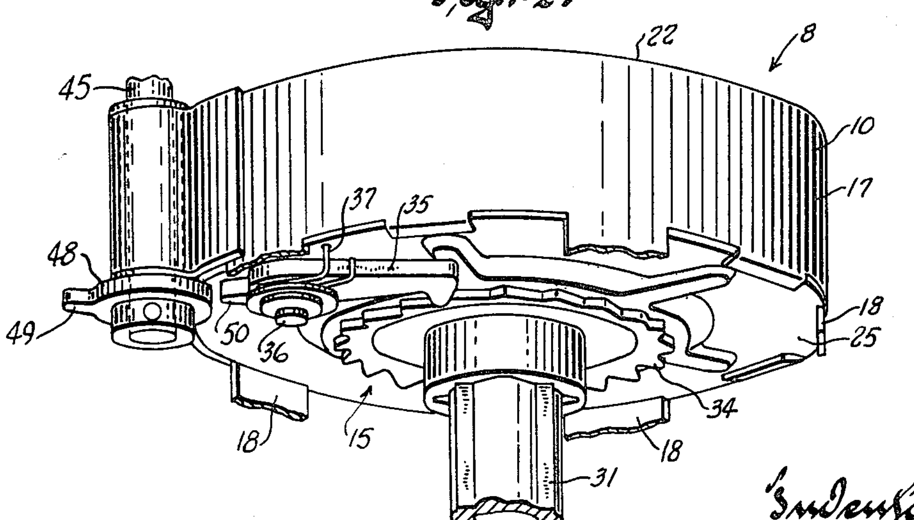

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Fig. 5.

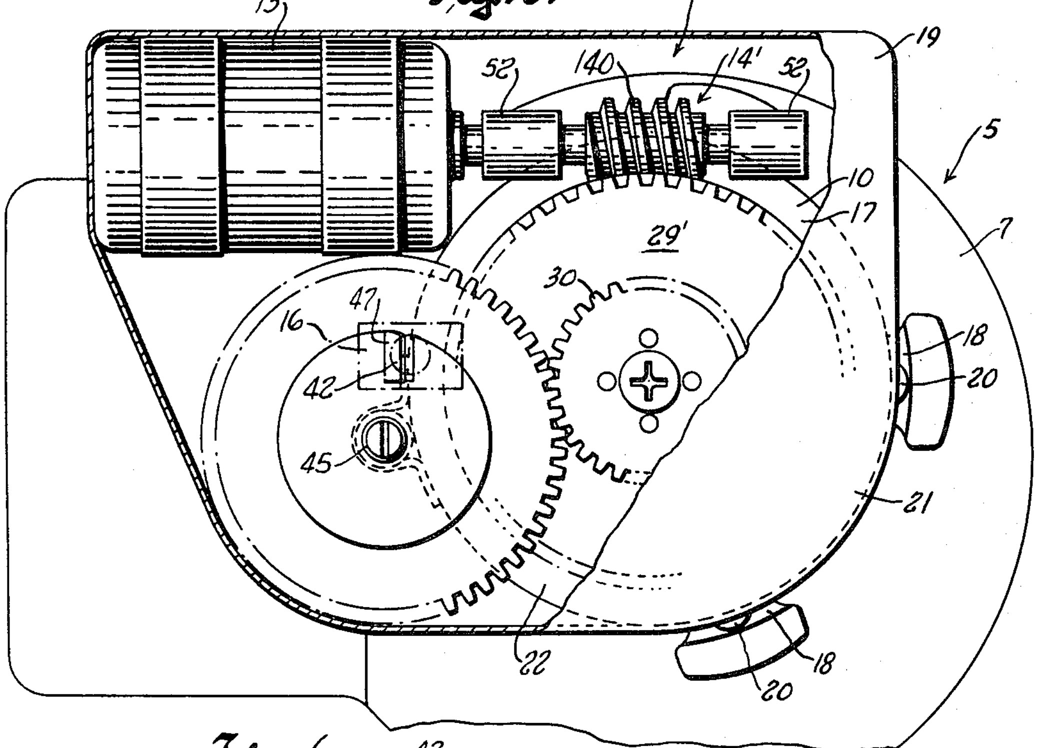

Fig. 6.

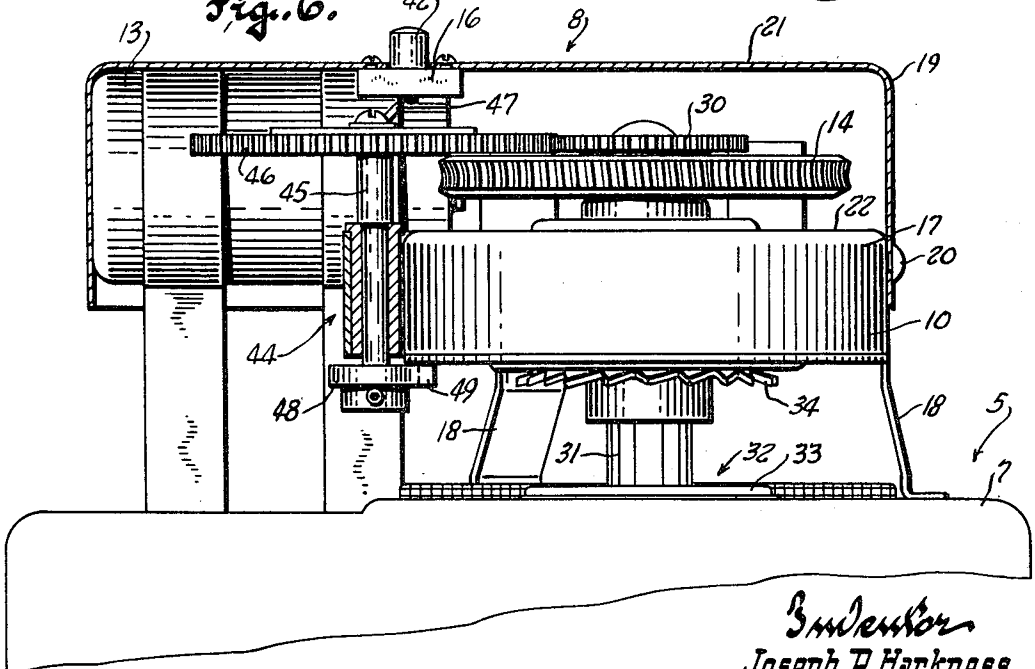

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Fig. 7.

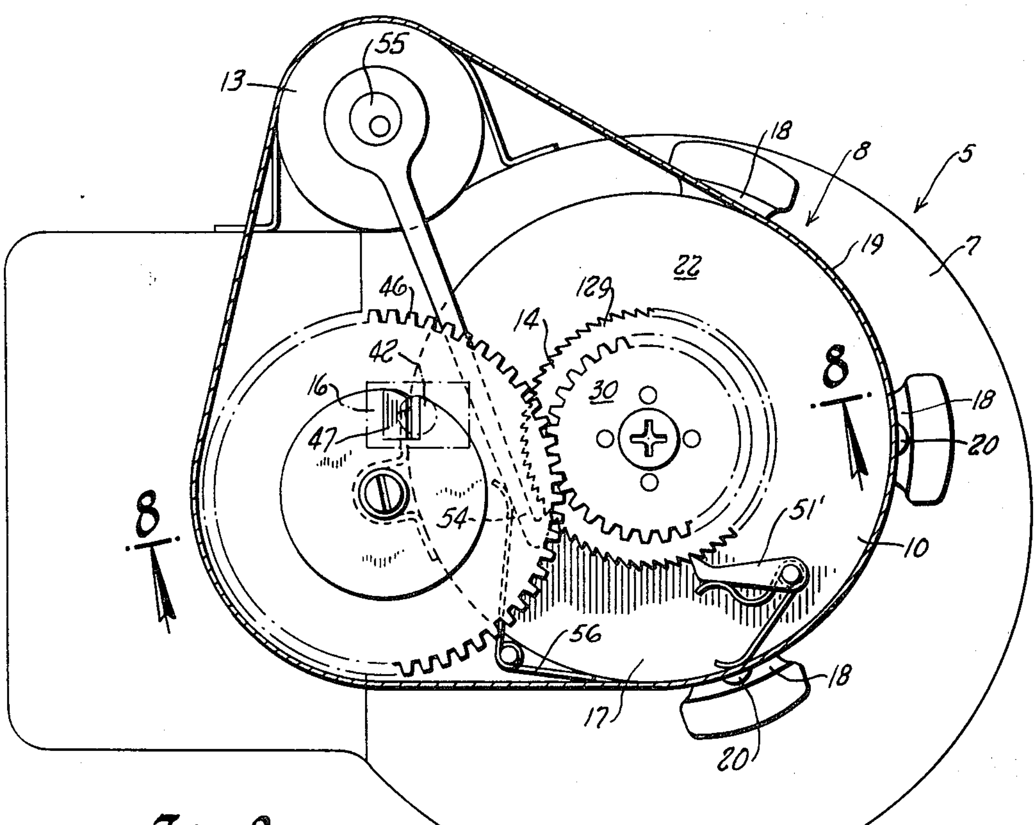
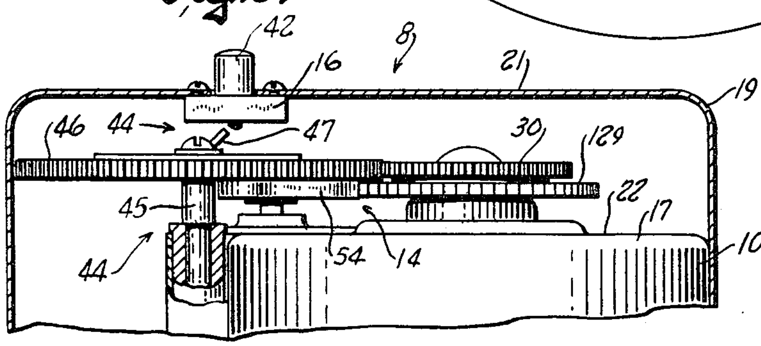


Fig. 8.



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AUTOMATIC STARTER FOR SMALL ENGINES

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Fig. 9.

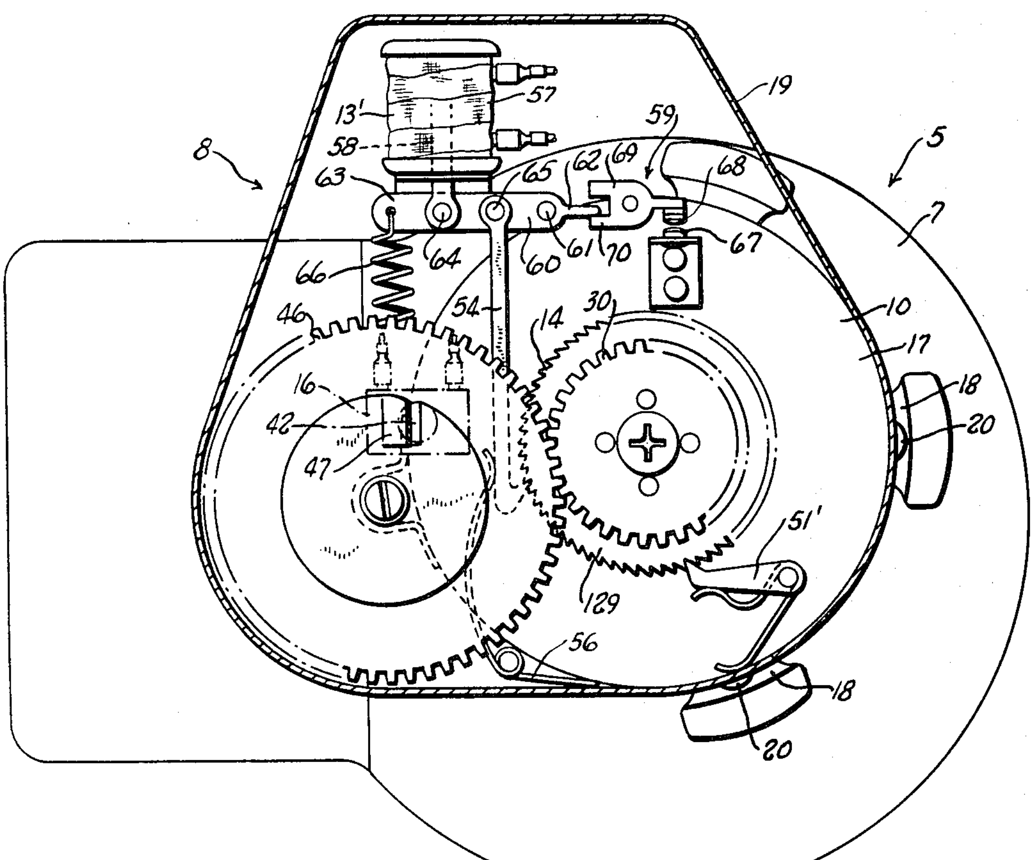
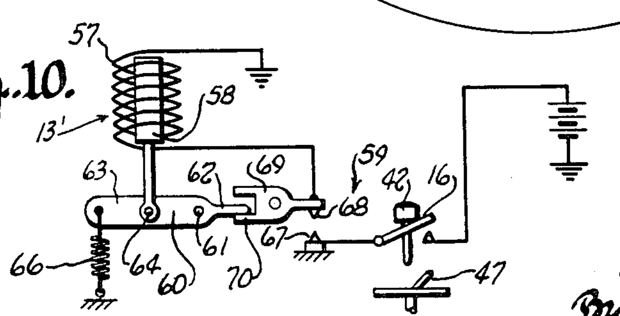


Fig. 10.



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United States Patent Office

3,395,687

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3,395,687

AUTOMATIC STARTER FOR SMALL ENGINES

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Filed Mar. 20, 1967, Ser. No. 624,337
5 Claims. (Cl. 123—179)

ABSTRACT OF THE DISCLOSURE

The spring of a spring motor starter is wound by a small, low powered electric motor (rotating or reciprocating), driving through a high ratio transmission. A cyclically moving actuator, driven by the electric motor in synchronism with spring winding, automatically opens the motor energizing circuit when the spring is wound and concurrently releases the engine crankshaft for spring propelled cranking.

This invention relates to starting apparatus for small internal combustion engines such as are used on power lawn mowers, snow blowers, garden tractors and similar equipment; and the invention has more particular reference to a fully automatic electric starter for such an engine that incorporates a very small, low powered electric motor.

The small engines with which this invention is concerned have provided a very versatile and dependable power source for various implements and machines that make it possible and convenient for a person to perform many tasks that are beyond the normal limits of human strength and endurance. As such engines have been sold in increasing numbers, implements powered by them are being used to an ever greater extent by men whose occupations do not accustom them to great exertion, by women, and even by older children. As a result, there is an insistent demand for an automatic starter for such engines, so that the tasks performed with them can be accomplished with a minimum of muscular effort.

Although the price of such engines has become so low (thanks to volume production economies) that purchasers are willing and able to pay some premium for the benefits of automatic starting, it goes without saying that low cost is still an extremely important desideratum in any automatic starter mechanism.

However, low cost is not the only consideration. The machines powered by engines of the type here under consideration are of such nature as to make sturdiness, simplicity and compactness essential features in any starter. In particular, an electric starter should preferably be powered by a small, compact and lightweight motor and should be adapted for energization from a very small battery. These requirements are incompatible with the heretofore conventional starter mechanisms, wherein an electric starting motor was arranged for directly driving the engine crankshaft during starting. To crank the engine fast enough to start it, such a mechanism had to have a relatively heavy and powerful motor, energized from a substantially large battery.

The general object of this invention is to provide a fully automatic starter for internal combustion engines of the character described, powered by an electric motor so small and so low powered as to be normally incapable of turning over an engine at the required speed for starting if coupled to its crankshaft in the heretofore conventional direct driving relationship.

It follows that it is also an object of this invention to provide an automatic starter for engines of the character described that can be powered from a small, low-voltage battery of low ampere-hour rating.

A further object of this invention is to provide an engine starter that is fully automatic, so that an operator need only press a button to effect engine starting while the mechanism automatically effects de-energization of the starting motor at the proper time.

It is also an object of this invention to provide a fully automatic starter mechanism of the character described which incorporates readily available heretofore conventional starting mechanism already present on many engines, and which thus lends itself well both to retrofitting and to production with existing facilities.

With the above and other objects in view which will appear as the description proceeds, this invention resides in the novel construction, combination and arrangement of parts substantially as hereinafter described and more particularly defined by the appended claims, it being understood that such changes in the precise embodiment of the herein disclosed invention may be made as come within the scope of the claims.

The accompanying drawings illustrate several complete examples of physical embodiments of the invention, constructed according to the best modes so far devised for the practical application of the principles thereof, and in which:

FIGURE 1 is a view in top elevation, with portions cut away, of a vertical crankshaft engine equipped with a starter mechanism embodying the principles of this invention.

FIGURE 2 is a sectional view taken on the plane of the line 2—2 in FIGURE 1;

FIGURE 3 is a sectional view taken on the plane of the line 3—3 in FIGURE 2;

FIGURE 4 is a fragmentary perspective view looking obliquely upwardly at a portion of the starter mechanism shown in FIGURES 1 through 3;

FIGURE 5 is a view generally similar to FIGURE 1 but illustrating a modified embodiment of the invention;

FIGURE 6 is a view in side elevation, with portions broken away, of the embodiment of the invention shown in FIGURE 5;

FIGURE 7 is a view generally similar to FIGURE 1 but showing another modified embodiment of the invention;

FIGURE 8 is a fragmentary view in side elevation, with portions broken away, of the embodiment of the invention illustrated in FIGURE 7;

FIGURE 9 is a view generally similar to FIGURE 1 but showing still another modified embodiment of the invention; and

FIGURE 10 is a wiring diagram of the electrical circuit for the starting mechanism illustrated in FIGURE 9.

Referring now to the accompanying drawings, the numeral **5** designates generally a single cylinder internal combustion engine of the type commonly used on power lawn mowers, having a vertical crankshaft **6** projecting upwardly above a shroud or housing **7** that embraces the body (not shown) of the engine to guide the flow of cooling air over its crankcase and cylinder portions. The starting mechanism of this invention, designated generally by **8**, is mounted on the shroud, over the upper end portion of the crankshaft **6**.

The starting mechanism **8** comprises a spring motor **10**, which can be very similar in construction to the spring motor starters disclosed in Coughlin et al. Patent No. 2,999,489, Svendsen Patents Nos. 3,040,853 and 3,165,100, and Harkness Patent No. 3,270,732, except that it needs no manual crank for winding up its spiral spring **12**. Instead, energy is stored in the spring **12** by means of a small, low-power electric motor **13**, operating through a suitable driving transmission **14** which provides a high mechanical advantage for the electric motor whereby its high-speed, low-torque output is translated into low-speed, high-torque winding of the spring.

In addition to the spring powered starting motor **10** and the electric winding motor **13**, the starting mechanism **8** comprises a switch **16** connected in an energizing circuit for the electric motor and automatic holding and release means, designated generally by 15 (see FIGURES 3 and 4), by which the engine crankshaft is prevented from rotating in response to the energy stored in the spring until the spring has been wound to a predetermined extent. As more fully explained hereinafter, the switch **16** is manually closed to initiate engine starting but is automatically opened when the spring is fully wound, such opening of the switch occurring substantially concurrently with release of the crankshaft for spring propelled rotation.

The spring motor **10** is enclosed in a housing **17** that rests on downwardly projecting legs **18** secured at their lower ends to the upper portion of the shroud **7**. As viewed from above, the spring motor housing **17** is substantially circular, and the legs **18** hold it in substantially concentric relation to the crankshaft **6**, spaced above the upper end thereof. A cover **19**, which can be detachably secured to the spring motor housing as by means of sheet metal screws **20**, overlies and encloses the electric motor **13** and the transmission means **14** that drivingly connects the electric motor with the spring motor, the top wall **21** of the cover being spaced above the top wall **22** of the spring motor housing.

The spring motor comprises an inverted cup-shaped spring carrier **23** inside of which the spring **12** is spirally coiled and to the side wall **24** of which the outer end of the spring is connected. An annular plate **25** on the bottom of the spring carrier cooperates with the top wall **26** thereof to confine the spring against edgewise displacement. A concentric pilot or hub portion **27** formed on the top wall of the spring carrier projects upwardly through a concentric hole **28** in the top wall **22** of the spring motor housing to provide a journal for the spring carrier; and a pair of coaxial gears **29** and **30** are anchored to the top of the hub portion. The gear **29**, which is larger than the gear **30**, is an element of the transmission **14** through which the spring carrier is rotatably driven by the electric motor **13** to effect winding of the spring.

The inner end of the spring **12** is connected with the driving element **31** of an overriding clutch which is designated generally by **32** and which can be of the type disclosed in the above mentioned Svendsen Patent No. 3,040,853. The driven element **33** of the overriding clutch is directly coupled to the upper end of the crankshaft **6**. When the clutch is engaged, the energy stored in the spring is of course transmitted through the clutch directly to the crankshaft, to effect rotation of the latter; and when the engine starts, the clutch decouples automatically.

The automatic holding and release means **15** comprises a ratchet **34** which is coaxially secured to the driving element **31** of the overriding clutch, beneath the bottom wall of the spring carrier, and a pawl **35** that cooperates with the ratchet. The pawl **35** is swingably mounted on a pivot pin **36** that is fixed on the housing **17** with its axis parallel to that of the crankshaft, and the pawl is biased into engagement with the ratchet **34** by means of a suitable torsion spring **37** that reacts against a part of the housing **17**. It will be apparent that when the pawl **35** is engaged with the ratchet **34**, the driving member of the overriding clutch is confined against rotation, to allow the spring to be wound in consequence of rotation of the spring carrier.

In the embodiment of the invention illustrated in FIGURES 1 and 2, the electric motor **13** is of the conventional rotating armature type. It is mounted on a bracket **38** which projects laterally from the spring motor housing and which holds the electric motor spaced to one side of the spring motor with its shaft **39** parallel to the axis of the crankshaft. A pinion **40** on the upper end of the motor shaft **39** meshes with a larger intermediate gear **41** that is coaxially anchored to an idler pinion **43**, and the latter meshes with the large driven gear **29** on the hub of the spring carrier. The electric motor thus drives the spring carrier **23** through substantially high ratio speed reduction gearing.

With a small motor rated at about 9 volts and having a no-load speed of about 4,500 r.p.m. and a torque of about 90 oz.-in. at stall, and with a gear transmission ratio of about 50:1, about 7 seconds is required to wind five turns on a spring motor adequate for starting a 3 or 4 horsepower engine. An electric motor of this size and rating is very small and light so that its presence on an engine is not likely to create installation problems, and its power requirements are such that it can be energized by a very small rechargeable battery. Such a motor could not reasonably be expected to be adequate for starting if it were directly coupled to the crankshaft of an engine, yet by using it to wind a spring in the arrangement contemplated by this invention, the mechanical energy that it produces during its seven seconds (approximately) of operation can be stored to be released very rapidly when the spring is permitted to unwind. The seven second delay between initiation of the starting cycle and completion of spring winding is not long enough to be objectionable, especially when measured against the advantages gained from the herein disclosed arrangement.

The switch **16** that controls energization of the motor is preferably mounted on the top wall of the cover **19** for the starter mechanism near the pivot axis of the pawl **35**. The switch is preferably of the overcenter or toggle type. It is shown with a pushbutton **42** that projects from its top when the switch is open and from its bottom when the switch is closed. Hence manual downward actuation of the pushbutton **42** energizes the motor.

When the spring has been wound a predetermined number of turns (five turns would ordinarily be adequate to provide dependable starting), the pushbutton is automatically actuated to its raised switch open position by means of an actuator **44** which is cyclically driven by the electric motor and which also effects disengagement of the pawl **35** from the ratchet **34** substantially simultaneously with de-energization of the motor.

As shown, the actuator **44** comprises an upright shaft **45** rotatably mounted at one side of the spring motor **17**, a gear **46** on the shaft, just below its upper end, meshing with the smaller gear **30** on the spring carrier hub, a switch actuating cam or eccentric **47** on the top of the shaft, and a pawl releasing cam **48** on the bottom of the shaft. By means of the gear **46** on the actuator, the actuator is drivingly connected with the electric motor through the transmission **14**. Gears **46** and **30** have about a 5:1 ratio so that the actuator shaft makes one revolution when the spring is wound about five turns.

The pawl actuating cam **48** has a finger-like radially projecting lobe **49** that is adapted to engage a similar lobe **50** on the pawl **35** at each revolution of the cam, to thereby swing the pawl out of engagement with the ratchet **34** when the spring has been wound to the desired extent, thus releasing the driving element of the overriding clutch to allow the crankshaft **6** to be turned by the spring.

The cam or eccentric **47** that cooperates with the switch **16** comprises a finger-like lobe that engages the downwardly projecting end of the pushbutton **42** of the switch to raise the same and thus open the switch at about the same time that the pawl actuating cam **48** is swinging the pawl **35** out of engagement with ratchet **34**. The switch of course remains in its open (pushbutton up) condition until the pushbutton is manually depressed for the purposes of a subsequent engine start.

The lobe **49** on the pawl actuating cam **48** is arranged to hold the pawl **35** out of engagement with the ratchet **34** through a small period of dwell, so that even though the electric motor coasts to some extent after the switch **16** is opened, the pawl will not re-engage the ratchet to interfere with rotation of the driving element of the clutch. Preferably the switch **16** is actuated to its open position very slightly after the pawl **35** is disengaged from the ratchet **34**. The pawl **35** is of course re-engaged with its ratchet **34** shortly after the motor **13** is energized for a subsequent winding cycle.

It will be apparent that the starter mechanism of this invention can readily incorporate the expedient disclosed in the above mentioned Svendsen Patent No. 3,165,100, or that of Harkness Patent No. 3,270,732, whereby the pawl would be positively prevented from engaging the ratchet so long as the engine is running.

The spring **12** will of course exert upon the spring carrier **23** a torque equal and opposite to that which it applies to the crankshaft **6**, and when the electric motor is de-energized such torque will tend to turn it in the reverse of its running direction. However, because of the high ratio of the gearing that comprises the transmission **14** connecting the electric motor with the spring carrier, the inertia of even a light motor armature should satisfactorily resist such rotation. In cases where the electric motor does not sufficiently resist torque, as where the gear ratio is low or the armature of the motor is very light, a pawl **51** can be arranged for cooperation with the gear **30** to hold it against rotation in the spring unwinding direction but permit its rotation in the winding direction.

The embodiment of the invention illustrated in FIGURES 5 and 6 avoids the possibility of reverse rotation of the electric motor during cranking of the engine, without the need for an expedient like the pawl last described and also has some advantage in compactness. In the FIGURES 5 and 6 embodiment the transmission **14'** which provides the driving connection between the electric motor **13** and the spring carrier **23** comprises a worm **140** coaxially connected with the shaft **39** of the electric motor and having direct meshing engagement with the larger gear **29'** on the spring carrier hub. If the gear **29'** has about 50 teeth, the same electric motor to spring carrier drive ratio will be provided as in the FIGURES 1–2 embodiment, without the need for intermediate gearing like the gear **41** and pinion **43**, and the worm arrangement will of course prevent torque from being imposed upon the motor shaft as the spring unwinds. Obviously the worm **140** should be journaled in bearings **52** that accommodate the end thrust imposed upon the worm by spring reaction.

In other respects the embodiment of the invention illustrated in FIGURES 5 and 6 can be identical with that illustrated in FIGURES 1 and 2.

In the embodiment of the invention illustrated in FIGURES 7 and 8 a rotating electric motor **13**, which can be similar to the motors of the FIGURES 1–2 and 5–6 embodiments, is again employed to effect winding of the spring mechanism, but in this case the rotation of the motor shaft **39** is translated into endwise reciprocation of a winding pawl **54** that drivingly cooperates with a ratchet **129** coaxially secured to the hub or pilot **27** of the spring carrier **23**. It will be apparent that the ratchet **129** is the functional equivalent of the gear **29** of the FIGURES 1–2 embodiment of the invention and the gear **29'** of the FIGURES 5–6 embodiment.

At its captive end the winding pawl **54** is journaled on a circular eccentric **55** which is fixed on the shaft of the motor **13** and which imparts reciprocating motion to the pawl. The pawl **54** is biased laterally toward engagement with the ratchet **129** by means of a suitable leaf spring **56**, reacting against the side wall of the cover **17**.

As the pawl **54** is moved lengthwise in the direction toward the motor shaft **13**, it effects incremental advance of the ratchet **129** in the spring winding direction by a circumferential distance equal to the pitch of a ratchet tooth. As the pawl is moved in its return stroke, a holding pawl **51'** engages the ratchet to prevent retrograde rotation of the spring carrier. Inasmuch as the ratchet **129** can have about fifty teeth, the pawl and ratchet spring winding transmission of FIGURES 7 and 8 can provide the same drive ratio between the motor **13** and the spring carrier **23** as the reduction gear transmission of FIGURES 1 and 2.

The actuator **44** in the FIGURES 7 and 8 embodiment of the invention can be identical with the actuators **44** of the previously described embodiments, being similarly driven by a gear **46** on its shaft that meshes with a gear **30** fixed on the spring carrier pilot **27** coaxially with the ratchet **129**.

The embodiment of the invention illustrated in FIGURE 9 is generally similar to that of FIGURES 7 and 8, except that a reciprocating electric motor **13'** replaces the rotating armature motors of the previously described embodiments.

The reciprocating motor **13'**, which drives a ratchet **129** on the spring carrier **23** through a pawl **54**, comprises a solenoid **57** having a hollow core in which a magnetically permeable plunger **58** is reciprocable, a breaker mechanism **59** which controls energization of the solenoid **57**, and a lever **60** to which the plunger **58** and pawl **54** are connected and which actuates the breaker mechanism **59**.

The lever **60**, which extends generally transversely to the plunger **58** and pawl **54**, is fulcrumed about a pivot pin **61** that is fixed to the spring motor housing **17** with its axis parallel to that of the spring carrier **23** and spaced therefrom. The fulcrum of the lever **60** is intermediate its ends, but nearer one end than the other so as to define a shorter arm **62** and a longer arm **63** of the lever. The plunger **58** has a pivotal connection **64** to the longer arm **63** of the lever, at a substantial distance from its fulcrum **61**, and the pawl **54** has a pivotal connection **65** with the lever that is intermediate its fulcrum and the plunger connection **64**. A tension spring **66** is connected to the free end of the longer arm **63** of the lever and reacts against a fixed part of the structure to bias the lever in the direction to carry the plunger **58** axially out of the solenoid and to move the pawl **54** in its return stroke.

The breaker mechanism **59** comprises a fixed contact **67** and a cooperating movable contact **68** carried on one arm of a short, medially pivoted lever **69**. The other arm **70** of the lever **69** is bifurcated, and the shorter arm **62** of the lever **60** is disposed between the bifurcations to provide a lost motion connection between the two levers.

As illustrated in FIGURE 10, the fixed contact **67** of the breaker mechanism is connected in series with a current source through the switch **16**. The movable breaker contact **68** is connected with the solenoid. When the switch **16** is closed and the breaker mechanism is in the position to maintain its contacts **67** and **68** engaged, the solenoid **57** is energized to attract the plunger **58** and thus propel the pawl **54** through a winding stroke. As the pawl reaches the end of its winding stroke the lost motion connection between the levers **60** and **69** is effective to swing the lever **69** to its position in which the contacts **67** and **68** are separated, breaking the energizing circuit to the solenoid and permitting the spring **66** to propel the pawl **54** in its return stroke. As the pawl **54** nears the end of its return stroke, the lost motion connection between levers **60** and **69** again becomes effective, this time, however, swinging the lever **69** to its position in which the breaker mechanism contacts are engaged, initiating another cycle of reciprocation of the winding pawl **54**.

As in the FIGURES 7 and 8 embodiment of the invention, a holding pawl **51'** cooperates with the ratchet **129** to prevent retrograde rotation of the spring carrier.

The mechanism for actuating the switch **16** and for releasing the driven clutch element when spring winding is terminated can be the same in the FIGURE 9 embodiment of the invention as in those previously described.

From the foregoing description taken with the accompanying drawings it will be apparent that this invention provides a compact, inexpensive and dependable fully automatic starting mechanism for small internal combustion engines, capable of being powered by a very small, low powered electric motor.

What is claimed as my invention is:

1. Mechanism for starting a small internal combustion engine comprising:

(A) a coiled spring;
(B) a rotatable winding element connected with one end of the spring for winding the same;
(C) a rotatable output element connected with the other end of the spring and drivingly connectable with the crankshaft of an engine to be started;
(D) a latching element movable between a locking position in which it restrains the output element against rotation and a releasing position freeing the output element for rotation;
(E) an electric motor drivingly connected with the winding element for winding the spring;
(F) an actuator driven by the electric motor and cyclically movable in a predetermined relationship to rotation of the winding element so that the actuator attains a predetermined position whenever the winding element has been driven through a predetermined number of turns;
(G) cooperating means on the latching element and the actuator for effecting motion of the latching element to its releasing position in consequence of motion of the actuator to its said predetermined position; and
(H) switch means connected with the motor and actuable by the actuator to effect de-energization of the motor in consequence of motion of the actuator to its said predetermined position.

2. Mechanism for starting a small internal combustion engine comprising the combination of:

(A) an energy storage motor of the type comprising:
  (1) a coiled spring which is adapted to be wound up,
  (2) a rotatable output element connected with the spring to be driven thereby and drivingly connectable with the crankshaft of an engine to be started, and
  (3) holding means movable to an operative position preventing rotation of the output element and to a releasing position permitting rotation of the output element;
(B) an electric motor so connected with the spring as to be operative to wind the same;
(C) release means operatively associated with said holding means for moving the latter to its releasing position in consequence of the spring being wound to a predetermined extent;
(D) switch means connected with the motor for controlling energization of the same; and
(E) actuator means synchronized with the release means and operatively associated with the switch means to effect de-energization of the motor concurrently with movement of the holding means to its inoperative position.

3. The mechanism of claim 1, further characterized by:

the electric motor being of the rotating type and having a geared connection with the winding element.

4. The mechanism of claim 1 wherein the winding element comprises a ratchet, further characterized by:

(A) the electric motor comprising
  (1) a solenoid,
  (2) an armature reciprocable between defined limits of motion, said armature being biased in one direction of its motion and adapted to be magnetically moved in the opposite direction in consequence of energization of the solenoid, and
  (3) circuit breaker means connected with the armature for actuation thereby and electrically connected with the solenoid, said circuit breaker means providing for energization of the solenoid as it nears the limit of its motion in the first mentioned direction and for de-energization of the solenoid as it nears the limit of its motion in said other direction; and
(B) the connection between the electric motor and the winding element comprising a pawl connected with said armature to be reciprocated thereby and engageable with the ratchet to effect incremental rotation thereof in consequence of reciprocation of the armature.

5. Means for utilizing a substantially small and low powered electric motor to effect starting of an internal combustion engine, comprising:

(A) a spring motor having
  (1) a coiled spring,
  (2) a rotatable winding element by which the spring can be wound, and
  (3) a rotatable output element by which the spring is drivingly connectable with the crankshaft of an engine to be started;
(B) means so connecting the electric motor with the winding element that a substantially large number of cycles of electric motor operation is required to effect one turn of the winding element;
(C) releasable holding means for restraining rotation the output element while the spring is being wound;
(D) switch means connected with the electric motor for controlling energization thereof;
(E) an actuator cyclically driven by the electric motor;
(F) means operatively associated with the actuator and with the holding means for releasing the output element when the actuator reaches a predetermined point in its cycle; and
(G) means operatively associated with the actuator and with the switch means for effecting de-energization of the electric motor substantially concurrently with release of the output element.

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WENDELL E. BURNS, *Primary Examiner.*