

[54] CHAIN SAW STARTING SYSTEM

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Related U.S. Application Data

[63] Continuation of Ser. No. 92,643, Nov. 25, 1970, abandoned, and a continuation-in-part of Ser. No. 13,806, Feb. 24, 1970, abandoned, and a continuation-in-part of Ser. No. 739,798, June 25, 1968, Pat. No. 3,497,706, and a continuation-in-part of Ser. No. 543,583, April 19, 1966, Pat. No. 3,405,293.

[52] U.S. Cl. **30/382**, 123/182

[51] Int. Cl. **B27b 17/00**

[58] Field of Search 123/182; 30/123.4, 30/381, 382, 390, 394

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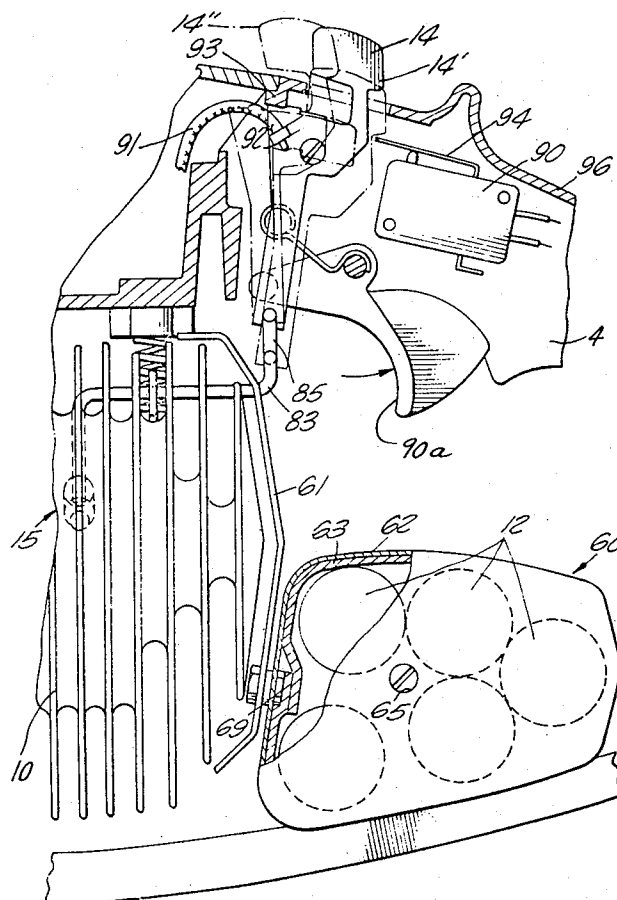
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[57]

ABSTRACT

Method and apparatus for effecting one hand controlled starting of a portable chain saw. By manipulating one hand, and while gripping a chain saw hand grip means, an engine is first concurrently conditioned for starting and caused to operate at a reduced engine compression. After the engine is started, and while continuing to grip the hand grip means, the starting condition is terminated and the compression of the engine is increased for normal operational purposes.

2 Claims, 11 Drawing Figures



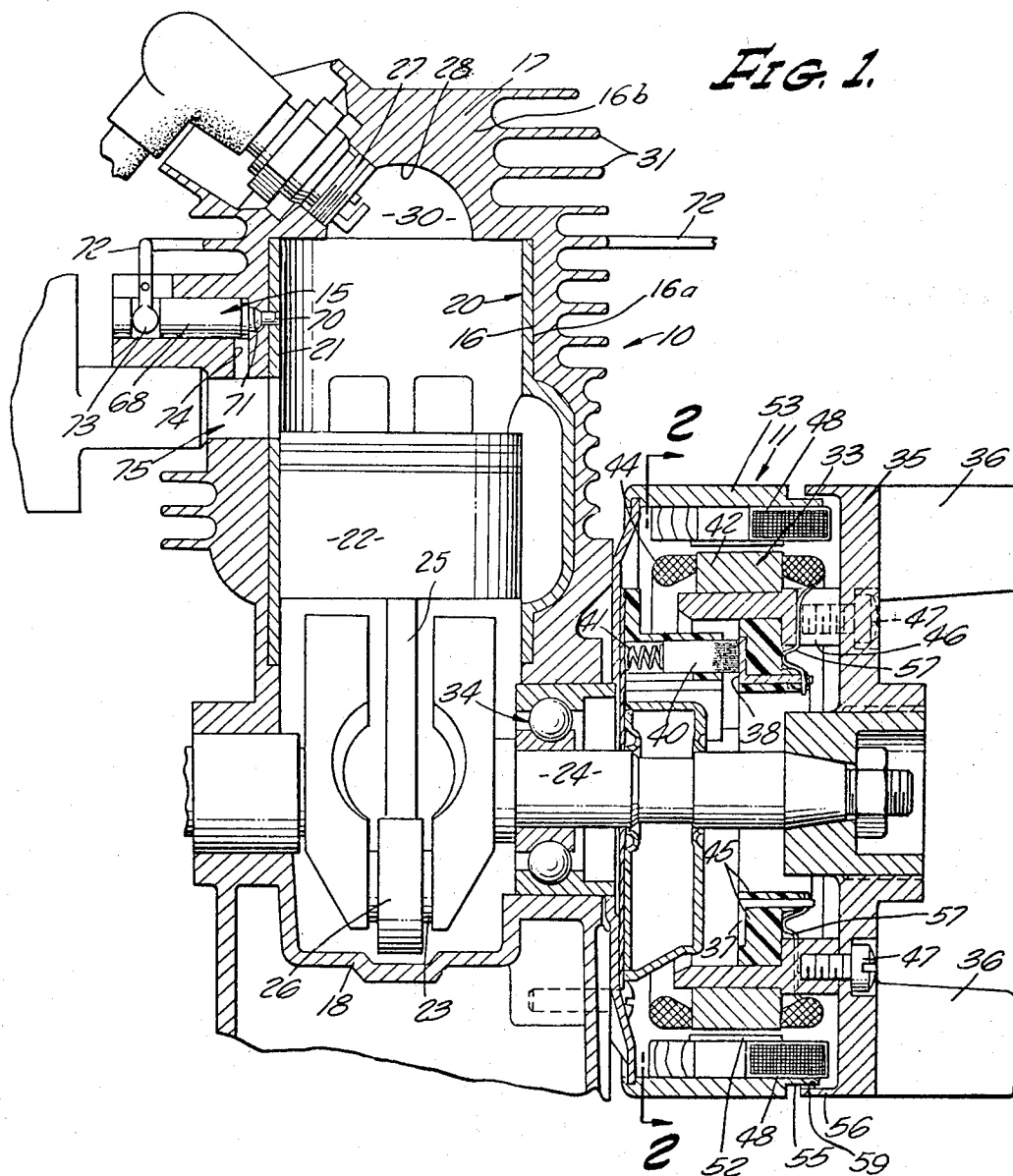


FIG. 1.

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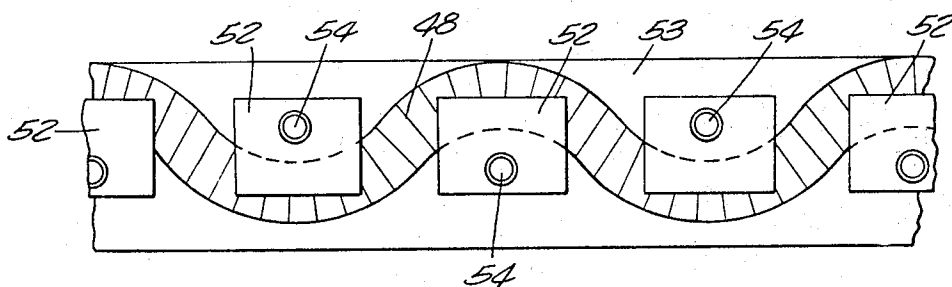
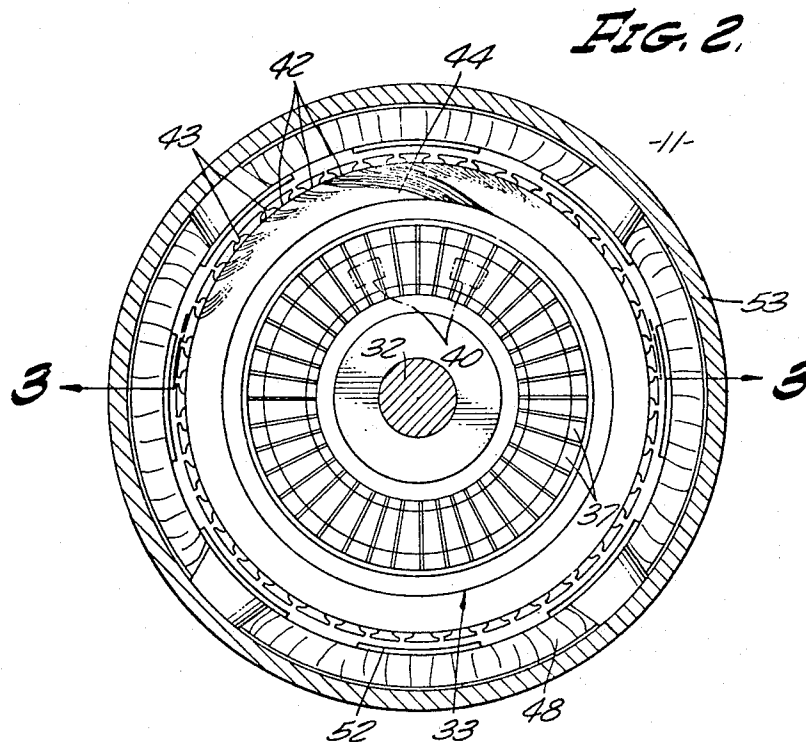
BY Burns, Doane, Swecker & Mathis

ATTORNEYS

Patented Nov. 27, 1973

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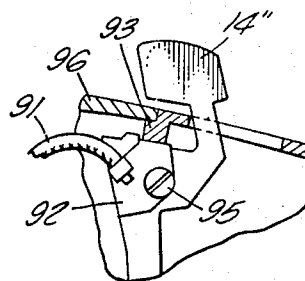
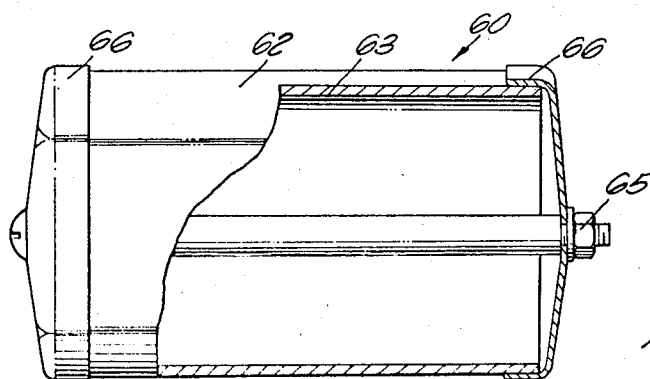
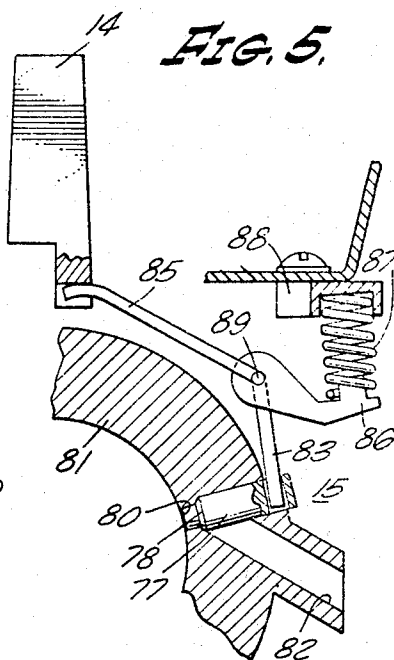
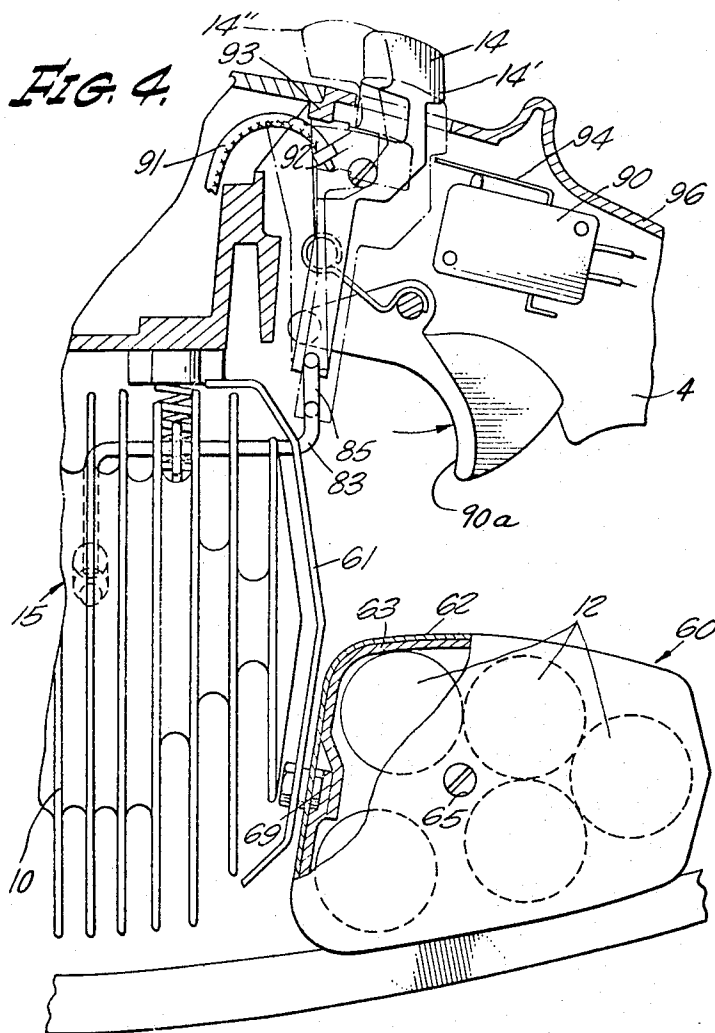
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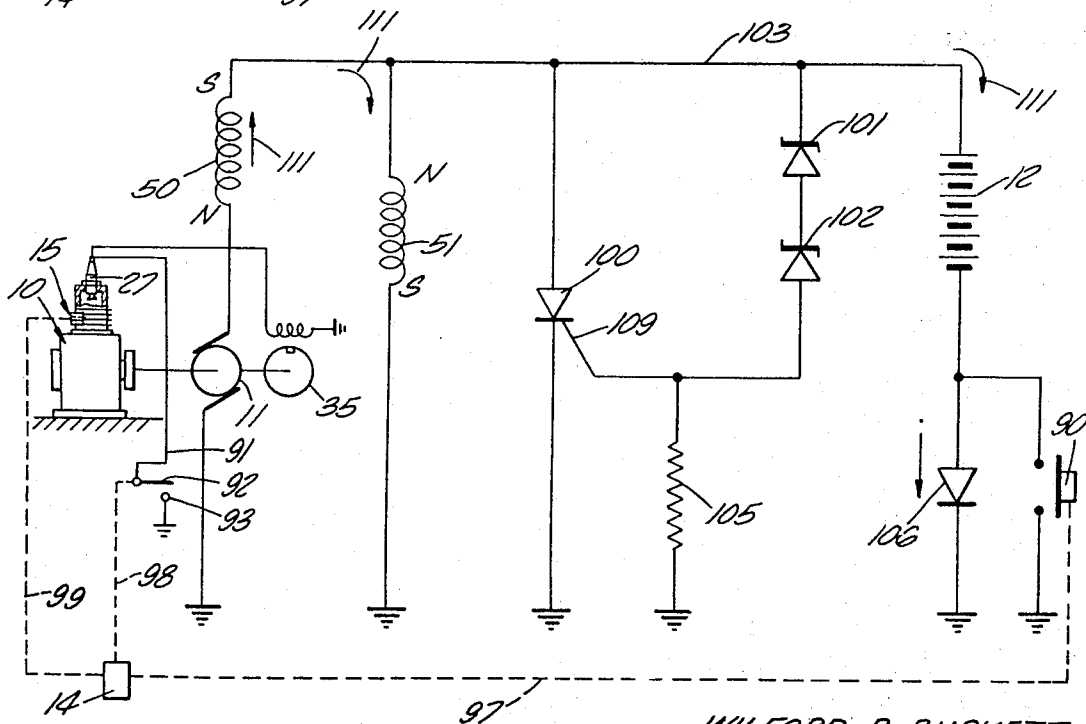
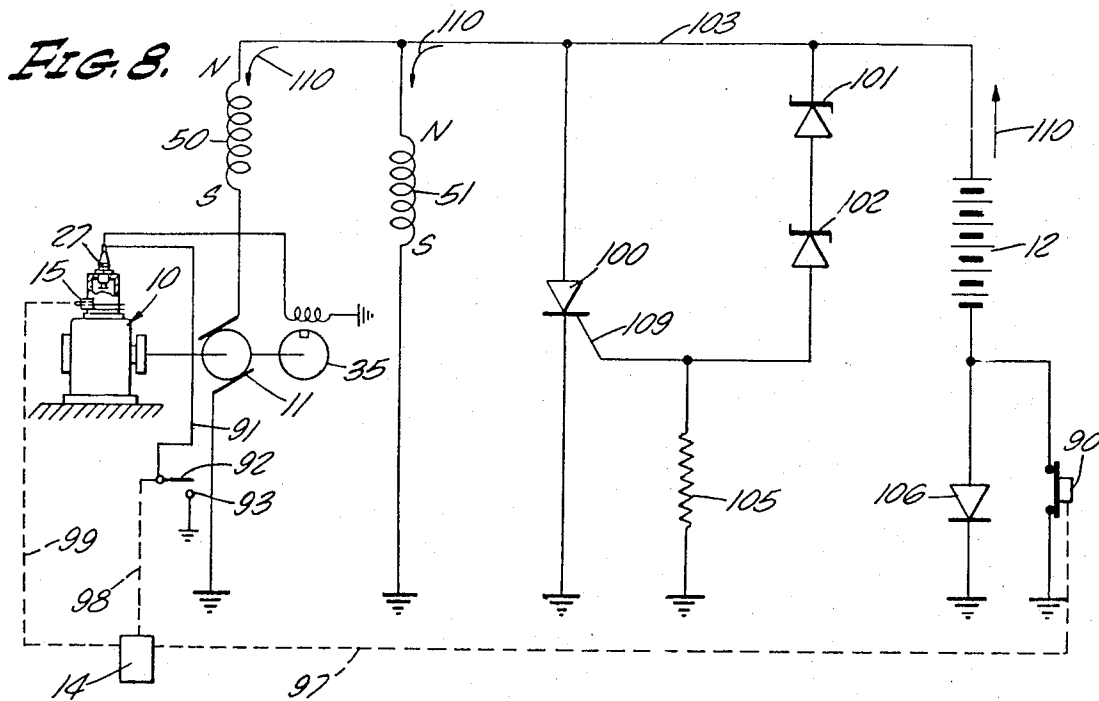


FIG. 9.

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FIG. 10

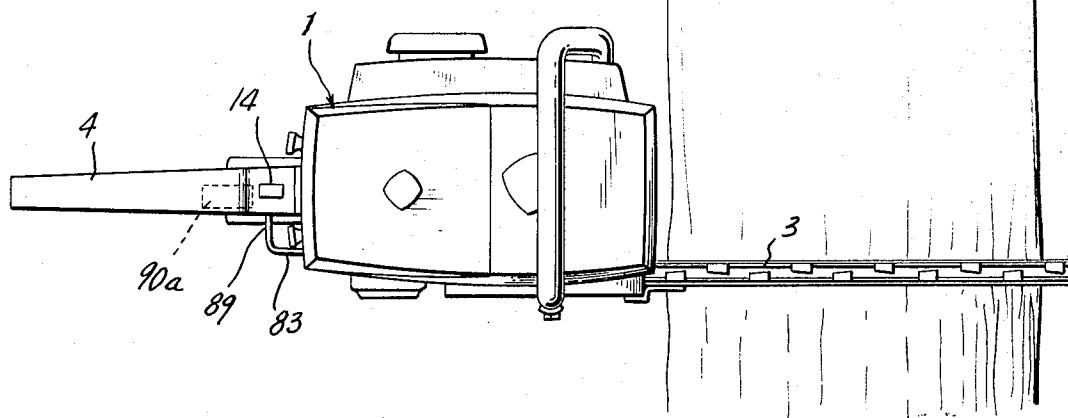
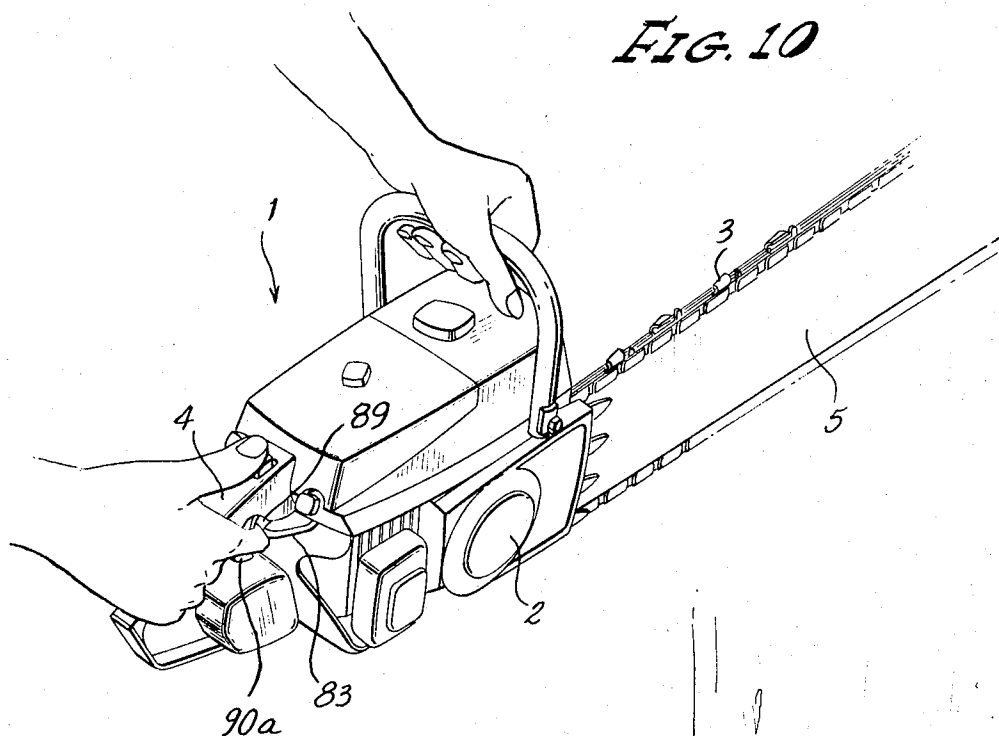


FIG. 11

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CHAIN SAW STARTING SYSTEM

This application is a continuation of Ser. No. 92,643 filed Nov. 25, 1970, Abandoned; and this application is a continuation in part of Ser. No. 13,806 filed Feb. 24, 1970, Abandoned; and is a continuation in part of Ser. No. 739,798 filed June 25, 1968 U.S. Pat. No. 3,497,706 and a continuation in part of Ser. No. 543,583 filed Apr. 19, 1966 U.S. Pat. No. 3,405,293.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention has particular utility in connection with small, lightweight, portable, chain saws which are driven by internal combustion engines of the single cylinder, two-cycle type such as chain saws.

Gasoline-engine-driven portable chain saws enjoy great popularity and are used on a large scale for cutting down trees or branches of trees and for bucking down trees. Due to the very nature of operation of such chain saws they are not used continuously and, hence, must be frequently restarted.

While chain saws are in widespread use and while safety standards are continuously employed and improved, the nature of cutting operations with chain saws inherently entails some degrees of risks. Minimization of these risks may be effected by ensuring that a chain saw is effectively stabilized during starting operations. However, such stabilization is impeded by vibrations and erratic engine conditions which may develop during the starting of chain saw engines.

This invention is directed toward a unique concept which enables an operator, with one hand, to concurrently stabilize and grip a chain saw condition an engine for starting, and reduce its compression so as to minimize starting induced vibration and erratic performance. All this is achieved while interlocking the starting and compression reduction operations.

SUMMARY OF THE INVENTION

It is accordingly an object of the present invention to provide a starter system particularly adapted for a lightweight, internal combustion engine which may be of the single-cylinder, two-cycle type.

In practicing the chain saw starting method of this invention, an operator grips a portion of hand grip means of the chain saw with one hand. While thus gripping the chain saw hand grip means, the operator manipulates movable means mounted on or adjacent the hand grip means to concurrently condition at least a portion of the chain saw engine for starting and reducing engine compression. While continuing to grip the hand grip means of the chain saw, and while the engine is starting, the reduced engine compression is maintained. After engine starting of the chain saw has been effected, and while the operator continues to grip the portion of the hand grip means with one hand, the operator causes the movable means on the hand grip to move to a release position and concurrently terminates the engine starting condition and restores engine compression to its normal operating level.

An especially significant apparatus aspect of the invention relates to a unitized starting control and hand grip assembly in a chain saw. This unitized assembly permits a chain saw engine to be concurrently conditioned for starting, while reducing engine compression and facilitating the overall starting operation, and stabilizing the saw. This apparatus combination is characterized by an engine condition starting control means, a throttle trigger means, a movable means, and a decompression valve actuating means, all of which are unitized in close proximity and in unique, mutually related configuration, on a chain saw hand grip means. With this arrangement, an operator, with one hand, may grip the chain saw hand grip means, and manipulate the movable means to a position operable to concurrently condition at least a portion of the engine condition starting control means for starting purposes, and open the decompression valve so as to reduce engine compression.

While continuing to grip the chain saw hand grip means with one hand, the operator ensures that the movable means is positioned so as to maintain the engine starting condition and reduced engine compression.

After the engine has started, and while continuing to grip the hand grip means, the operator causes the movable means to move to a release position, the maintenance of the starting condition is terminated, and engine compression is increased. In addition, while continuing to grip the hand grip means with one hand, the operator may manipulate the throttle trigger so as to develop an appropriate engine operating speed.

Another aspect of the invention relates to an electrical starter system of the type referred to including a direct current (DC) motor and generator, a battery such as a secondary battery, for powering the motor generator to start the gasoline engine, an electric circuit for controlling charging of the battery from the motor-generator, a decompression means for the cylinder of the engine to facilitate starting and reduce the power required to be furnished by the motor, and a unitary interlocking control button for controlling starting, normal operation and off position of the chain saw.

Still another aspect of the present invention pertains to a DC motor and generator in combination with an internal combustion engine having a decompression valve to reduce the torque required to be furnished by the motor to start the gasoline engine.

Yet another aspect of the present invention involves a DC motor and generator of the type described having compound field windings arranged in such a way that the windings are in aiding relationship when the device is operated as a motor, thus, to provide a high output torque while the windings are electrically arranged in bucking relationship when the device operates as a generator to reduce the output for battery charging current.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

FIG. 1 is a side view, with parts in cross-section, of a chain saw gasoline engine including a decompression valve and DC generator and motor;

FIG. 2 is a sectional view taken on line 2—2 of FIG. 1, and illustrating the commutator segments of the rotor, armature windings and field windings of the motor generator;

FIG. 3 is an elevational view taken essentially on line 3—3 of FIG. 2 and illustrating a portion of the field windings and pole shoes of the motor generator laid out flat;

FIG. 4 is a front view, with parts in section, illustrating particularly a three-position control button for controlling the operation of the starter system and a housing for the secondary cells making up the battery;

FIG. 5 is a fragmentary sectional view illustrating the control button with a linkage to a modified decompression valve and spring tending to return the control button into its unactuated or release position;

FIG. 6 is a fragmentary sectional view similar to that of FIG. 4 and illustrating the control button and ignition switch in the unactuated position;

FIG. 7 is a side view of the battery housing partly in section;

FIGS. 8 and 9 are schematic circuit diagrams illustrating diagrammatically the gasoline engine, generator, field windings, and an electric circuit for controlling the charging current of the battery, FIG. 8 illustrating the operation as a motor, while FIG. 9 depicts the operation as a generator;

FIG. 10 provides a perspective view illustrating the manner in which an operator is able to effect one handed support of a portion of chain saw hand grip means so as to concurrently condition an engine for starting, reduce engine compression, and stabilize the chain saw during the starting operation; and

FIG. 11 provides a top plan view of the FIGS. 4 and 10 chain saw, with this saw disposed in cutting position.

DESCRIPTION OF THE PREFERRED EMBODIMENT

General Chain Saw Structure

Referring now to the drawings, there is illustrated the electrical starter system of the present invention. The starter system includes essentially an internal combustion engine 10, shown particularly in FIG. 1, a DC motor and generator 11 shown particularly in FIGS. 1 and 2, a secondary battery which may consist of a plurality of nickel-cadmium cells 12 shown in FIG. 4 and used for energizing the motor 11, a control button 14, having a mechanical interlock for controlling starting of the engine 10 and its normal operation, and for turning off the engine and motor, and an electronic circuit in FIGS. 8 and 9 for controlling the charging of the battery 12. In order to facilitate the starting of the engine 10 there may be provided a decompression means shown generally at 15 in FIG. 1 and shown in modified form in FIG. 5. This may consist, as will be more fully explained hereinafter, of a compression relief valve which has been disclosed and claimed in the copending application to Wilford B. Burkett, Ser. No. 512,860, filed on Dec. 10, 1965, entitled "Compression Relief Mechanism for Starting Two-Cycle Engines" and assigned to the same assignee as is the present application.

Thus, the gasoline engine 10 is started by operating the control button 14 which closes an electric connection between the battery 12 and the DC motor 11 to drive the engine. In order to facilitate starting of the engine, the compression created by the piston of the engine within the cylinder may be relieved by a suitable decompression valve. After the engine has been started, an electrical starter switch is opened again by the manually operated control button 14, and the bat-

tery is recharged from the motor generator which operates as a generator driven by the engine. The battery charging current is then effectively disconnected when the battery voltage has reached a predetermined value. This is effected by the electrical battery charging circuit of FIGS. 8 and 9.

As is apparent from the foregoing description of FIG. 4, and as is shown in FIGS. 9 and 10, the unitized and interlocked, chain saw hand grip and control mechanism, previously described, facilitates one hand chain saw engine starting while maintaining operational safety.

With one hand, an operator is able to grip a portion 4 of the chain saw hand grip means. While thus gripping the chain saw hand grip means portion 4, and generally encircling this hand grip means portion with several digits of this hand, the operator is able to use one digit, ordinarily a thumb, to manipulate the movable button means 14 to a starting position. With the button disposed in this starting position, the engine is concurrently conditioned for starting while engine compression is reduced. This manipulation of the movable button means 14 to a starting position serves to more the decompression means to an open position, so as to partially vent the working chamber of the engine cylinder of the chain saw. In addition, at least a portion of the engine is conditioned for starting.

As is implicit from the disclosures of parent application Ser. No. 13,806 and parent U.S. Pats. Nos. 3,405,293 and 3,497,706, this conditioning may entail the energization of an electrical starting mechanism or alternately may entail the conditioning of other engine starting elements. For example, the button 14 could be mounted so that it could be depressed and caused to engage the throttle mechanism, exemplified by the throttle trigger 90a, and pivotally position the throttle trigger so as to dispose the throttle in a starting condition.

As will thus be apparent, the operator may continue to grip the hand grip means portion 4 with one hand, with the depressed control button means 14 being operable to maintain reduced engine compression and maintain the engine at least partially conditioned for starting.

After the engine has been started, and while the operator continues to grip the hand grip means 4 in the manner obvious from the illustration of FIG. 4, the operator may condition the engine for normal operation. This may be effected by the operator utilizing one digit of the gripping hand to cause the release of the movable button means 14 and concurrently terminate the engine starting condition and reclose the decompression valve means 15.

At about the time that this conditioning of the engine for normal operation is being effected, and while the operator continues to grip and stabilize the chain saw 1 with one hand engaging the hand grip means portion 4, the operator may manipulate the throttle trigger 90a and appropriately develop or determine chain saw engine operating speed. All of this is made possible by the generally mutually contiguous positions of the hand grip means, movable button means and throttle trigger means, with the decompression valve being operationally interlocked with the button means.

Having described very briefly the general operation of the electrical starter system of the present invention,

the construction of the engine 10 will now be disclosed by reference to FIG. 1.

Engine Structure

The engine has been illustrated as an internal combustion engine having a single cylinder 16 and being of the two-cycle type. The engine includes an engine block 17 and a crankcase 18 therefor. The engine block 17 is provided with a cylinder liner 21 defining a cylindrical space 20.

Within the cylindrical space 20 is reciprocally mounted a piston 22 connected to the crank 23 of a crankshaft 24 by a connecting rod 25, one end of which is pivotally connected to the piston 22, while its opposite end is provided with a bearing 26 which in turn is connected to the crank 23 of the crankshaft 24.

The engine is also provided with a spark plug 27 disposed in a semi-spherical recess 28 arranged adjacent to and communicating with the cylinder 16. The spark plug 27 serves the usual purpose of igniting the fuel mixture in the combustion chamber 30 of the cylinder 16. This may be effected by any conventional ignition system. It will also be understood that the construction of the internal combustion engine 10 as disclosed herein is entirely conventional. The engine block 17 may be provided with cooling fins 31 to promote cooling of the engine which may have to run at a very high speed, as will be apparent in view of the fact that it is a single-cylinder, two-cycle engine.

Electric Starter

A portion of the DC motor and generator 11 is preferably directly connected or keyed to the crankshaft 24 of the engine 10. As pointed out before, the generator 11 requires very little space and is of very low weight. In order to drive the generator 11, the crankshaft 24 extends toward the right as viewed in FIG. 1 and has mounted thereon the rotor or armature 33, for example, by a key. The crankshaft 24 is rotatably mounted in a bearing 34 disposed in the engine block 17. The rotatable armature 33 further is connected to a flywheel 35 being provided with fins 36. The fins 36 operate as a fan to cause circulation of the air, thereby to cool the engine 10.

The rotatable armature 33 includes a plurality of commutator segments 37 having flat, radially extending surfaces 38 against which a pair of brushes 40 shown particularly in FIG. 2 are urged by springs 41. It will be noted that the two brushes 40 are disposed within an angle of about 45°. This is made possible because, as will be explained shortly, the number of field pole shoes is 8 so that the two brushes extend over more than one field pole shoe.

The armature 33 further includes a plurality of angularly spaced poles 42 which preferably are undercut as shown at 43 in FIG. 2 to provide space for the armature windings 44 and to minimize the danger of the armature windings 44 being forced outside of the poles 42 by the considerable centrifugal force developed by the rotating armature 33. The commutator segments 37 are cast or potted in a suitable insulating compound shown at 45 which further minimizes the danger of the armature exploding under the action of the centrifugal force.

It should be noted that the flat radially extending surfaces 38 of the commutator segments 37 provide for self-cleaning of the commutator. Any carbon residue

from the brushes is thrown off by the centrifugal force when the rotor rotates at high speed.

The armature is provided with a plurality of angularly spaced mounting lugs 46 through which extend screws 47 to connect the flywheel 35 with its fins 36 to the armature 33. Thus, the armature is spaced from the flywheel 35 to permit circulation of air about the entire rotor or armature, thereby to cool the motor generator.

The flywheel 35 must, of course, be dynamically balanced, as is conventional, and may be provided with magnets and counterbalancing weights along its rim to provide a magneto for the ignition system. However, this feature is optional.

The field windings, of which there are two, are disposed as shown at 48, particularly in FIG. 3, in sinusoidal form. This facilitates the winding of the two field coils because it is easier to wind them continuously rather than as separate pairs of field windings. The electrical connection of the two field windings shown at 48 in FIGS. 1 to 3 is more clearly illustrated in FIGS. 8 and 9. Thus, the motor-generator 11 has a series field winding 50 and a shunt field winding 51. This, of course, provides a compound DC motor, which, as will be explained hereinafter, is differentially compounded.

The field windings generally shown at 48 cooperate with and are mechanically held together by eight field poles or pole shoes 52 which are secured to a fixed housing 53 secured in any suitable manner to the crankcase 18 or engine block 17. Thus, the field windings 48 may be held by the field poles or pole shoes 52 by means of retaining screws 54.

The fixed housing 53 for the field windings 48 is of cylindrical shape, as clearly shown in the drawings, and is provided with an annular outer recess 55. This forms a seal with a cylindrical extension 56 of the flywheel 35 having a cooperating inner surface 59. This construction, as clearly shown in FIG. 1, provides a labyrinth seal to keep wood chips or sawdust out of the generator housing. At the same time the seal provides sufficient clearance to permit the flywheel and armature to rotate freely. Another feature of the generator of the invention are the jumper wires 57 interconnecting each of the armature windings to one of the commutator segments. It should be noted that each jumper wire 57 extends about the far side of each commutator segment and is soldered thereto.

The motor and generator 11 serves the purpose to start the engine 10 with the power derived from the batteries and thereafter recharges the batteries. It is designed to withstand high centrifugal force. It should be noted that the armature 33 which forms the rotor is of hubless design and is radially very thin. The weight has been reduced by providing just enough iron to carry the magnetic flux and just enough copper to carry the electric current. The motor may have a diameter of about 4.4 inches compared to a thickness of 1.4 inches which corresponds to a ratio of diameter to thickness of slightly over 3 to 1. This, of course, represents a savings of space. The motor has eight field poles which provides high torque even at low speeds. This is, of course, essential for starting the engine.

Having now described the engine and the motor, the manner of mounting the battery will now be described.

The battery used with the motor generator 11 is a secondary battery and preferably consists of nickel-cadmium cells. There may be ten such cells, each being rated nominally at 1.2 volts. These cells may, for exam-

ple, be disposed in a housing 60 shown particularly in FIGS. 4 and 7. Thus, the battery housing 60 may be secured to a shroud 61 enclosing the engine. As shown in the drawings, the battery housing 60 may have an outer, open-ended cover 62 within which is disposed an overlapping piece of insulating sheet material 63, the ends of which are secured to each other and to the engine shroud 61 by a suitable insulated bolt 69. Another nut and bolt assembly 65 secures the two end caps 66 to the main cover 62. Five cells are visible in FIG. 4 within the battery housing 60. Two of these cells are put end-to-end so that there is a total of ten secondary cells jointly forming the battery 12.

It should be noted that the battery 12 may also be used for other purposes, that is, other than energizing the electric motor 11. They may be used, for example, to drive a pump or chain saw sharpener. It should be noted that a current of 5 amps. may be taken from the generator when the engine is running at full speed. This requires only about 0.1 horsepower from the engine. The entire weight of the motor-generator 11 and the ten cells forming the battery 12 is between 3 and 3 1/2 pounds.

Before describing the construction and operation of the control button 14, the purpose and construction of the decompression valve 15 will now be described.

Decompression Valve

As shown particularly in FIG. 1, there is provided a valve body 68 disposed in the engine block 17 and communicating with the cylinder lining 21 having a suitable aperture 70. As disclosed in the prior application of one of the applicants previously referred to, the valve body 68 preferably is provided with a conical outer portion 71, which prevents clogging of the valve port and which provides cleaning of the port as the valve is closed. The valve may be actuated by a linkage 72 including a semi-spherical head 73 disposed in a suitable recess of the valve body 68.

When the valve is opened it will provide a path from the valve port 70 to a passage 74 which in turn communicates with the exhaust 75.

A slight modification of the decompression valve 15 is shown in FIG. 5 to which reference is now made. Here the valve body 77 again has a conical end portion 78 disposed in a valve port 80 in the wall of the cylinder 81. The port 80 communicates with a passage 82 which in turn is connected to the exhaust. The valve body 77 is operated by means of a rod 83 extending through a suitable aperture in the valve and is pivoted at 89 to a lever 85 which in turn is connected to the control button 14. Thus, when the control button 14 is depressed, the rod 83 is rotated in a counterclockwise direction and the valve body 77 opens. At the same time a lever 86 is moved upwardly against the force of a spring 37 having one end fixedly mounted at 88.

It is the purpose of the decompression valve 15 to relieve the pressure of the gas above the piston 22 when the piston moves upwardly. This, of course, will reduce the work required to start the engine. However, it should be emphasized that such a decompression valve may not always be necessary.

Starter Button

Referring now particularly to FIGS. 4 to 6, the construction and function of the control button 14 will now be explained. This control button 14 has the purpose to

control the ignition system of the engine, the decompression valve 15 and the starter switch 90 shown in the circuit of FIGS. 8 and 9. To this end the control button 14 must have three different positions. One for starting the engine, the second for the normal operation of the engine and the third one for the off position. In the start position of the control button, the ignition switch to be presently described should be on so that the spark plug 27 may be supplied by the ignition system with electrical energy to produce sparks, the decompression valve 15 should be open and the starter switch 90 closed. After the engine has been started, the starter button must be released to permit it to move into its operating position. In that position the ignition is still on, the decompression valve is now closed which is, of course, necessary for the proper operation of the engine while the starter switch 90 is open. Finally, in the off position, the ignition switch is off as well as the starter switch, which is open, while the decompression valve remains closed.

Thus, as shown in FIG. 4, the control button 14 has an operating position 14 shown in full lines. It has a start position shown in dot and dash lines at 14' and it has an off position also shown in dot-dash lines at 14''. Thus, in order to start the engine the control button 14 is moved first from position 14'' to 14 and is then pressed down into position 14'. This will cause opening of the valve body 77 as previously described against the action of spring 87. At the same time, the switch 90, which is the starter switch, is closed by pressing down its lever 94. The ignition system includes an insulated wire 91 electrically connected to the metallic bracket 92 secured to the control button 14 by a screw 95. Hence the wire 91 and bracket 92 are movable with the control button 14. The bracket 92 is adapted to contact electrically a metallic extension 93 of the metallic housing 96, thereby to ground the wire 91. This in turn disables the ignition system.

After the engine has been started, the control button is released from position 14' and is forced by the action of spring 87 to move upwards into position 14. In the operating position 14 of the control button, wire 91 and bracket 92 are still spaced from the portion 93 of the housing. Hence, in this position the ignition is still on while the valve 77 is allowed to close again. At the same time the starter switch 90 is opened.

In order to stop the engine, the control button is moved into position 14'' which turns the ignition off. This is shown particularly in FIG. 6 where the wire 91 and bracket 92 are electrically connected with the metallic extension of the housing 96. This grounds the wire 91 and, hence, the ignition is turned off. At the same time the valve remains closed and the starter switch remains open.

By virtue of its U-shaped profile, as shown in FIG. 6, movable button means 14 is operable to lockingly engage handle ledge portion 93, when button 14 is in position 14''. This locking engagement prevents upward movement of button 14, out of the position 14' and insures the maintenance of this position.

It will thus be seen that there is a mechanical interlock which causes the starter switch 90 to close at the same time the decompression valve 15 is opened and vice versa. On the other hand, the ignition remains on while the engine is started and when the engine is running.

BATTERY CHARGING

Reference is now made to the circuit shown in FIGS. 8 and 9 for controlling the charging of the battery 12 by the generator 11. The circuit of FIG. 8 illustrates the starting of the engine while that of FIG. 9 shows the operation when the battery is being charged.

In the circuit of FIGS. 8 and 9, the decompression valve 15, ignition switch 92, 93 and the control button 14 have been shown schematically. Therefore, in FIG. 8 the decompression valve 15 is shown in the open position while the ignition switch 92, 93 is also open to turn the ignition on. The starter switch 90 is closed. The dotted connection 97 schematically indicates that the control button 14 controls the starter switch 90. Similarly, the dotted connection 98 shows how the ignition switch 92, 93 is controlled by the control button 14. It will be seen that when the ignition switch is closed, ground is connected to wire 91. Finally, the dotted connection 99 shows the control of the decompression valve 15 by the control button 14.

An electronic switch 100 which may, for example, be a silicon-controlled rectifier, is connected across the shunt winding 51 of the generator 11, one terminal of which be grounded as shown as well as one terminal of the generator. A pair of Zener diodes 101 and 102 are connected between the lead 103 interconnecting the series winding 50 and the shunt winding 51 and the gate or control electrode 109 of the silicon-controlled rectifier 100. It will be apparent that one of the Zener diodes 101, 102 may be omitted. A resistor 105 may be connected between the control gate 109 and ground. The battery 12 is connected in series with the lead 103 and a diode 106 which is so poled as to prevent current flow from the battery 12 to the generator 11 unless the switch 90 is closed, the switch 90 being connected across the diode 106.

This battery charging circuit has been disclosed and claimed in the copending application to Burkett and Jackson, Ser. No. 530,129, entitled "Voltage-Cut-Off Circuits" and filed on Feb. 25, 1966. As explained therein, the two Zener diodes 101, 102 and the resistor 105 provide a voltage divider connected essentially across the battery 12. This voltage divider is so arranged that it will fire the silicon-controlled rectifier 100 by applying the appropriate voltage on its control gate 109 when the voltage across the battery 12 has reached a predetermined value. The reason for providing two Zener diodes 101 and 102 in series has been explained in the copending application of the applicants.

The diode 106 prevents current flow in the direction shown in FIG. 8 by the arrows 110, unless it is bypassed by the closed starter switch 90.

MODE OF STARTING

Electrical Aspects

The operation of the electrical starter system of the present invention will now be explained. In order to start the engine, the control button 14 is moved from its inoperative position 14'' back into position 14 and is then pushed down into position 14'. This, as explained before, will open the decompression valve 15. At the same time it will turn on the ignition 92, 93 and close the starter switch 90.

Closing of the starter switch 90 bypasses the diode 106 and permits current flow from battery 12 in the direction shown by arrows 110 through the shunt winding

51 to ground and through the series winding 50 and the armature windings of motor 11. Accordingly, the two windings 50 and 51 are connected in an aiding relationship. Therefore, the magnetic poles on the windings 50 and 51 are so arranged that like poles, such for example as the north (N) poles are adjacent the lead 103. Accordingly, the DC generator and motor operates as a motor and drives the engine 10 to start it. Since the two field windings 50 and 51 are now arranged in an aiding relationship the motor-generator 11 is operated as a motor with a high output torque, thus giving maximum mechanical output of shaft power to start the engine.

After the engine has been started, the control button 14 is released again and is urged from position 14' by spring 87 into its normal operating position 14.

The movement of the control button 14 into its normal operating position closes the decompression valve 15 again as previously explained. At the same time the starter switch 90 is opened again as shown in FIG. 9. This, of course, will prevent the flow of current from battery 12 in the direction shown by arrows 110 because this current flow is blocked by the diode 106. However, opening of the starter switch 90 still permits recharging of the battery 12 which will now be explained.

Since the engine 10 is now running, it drives the motor generator 11 to operate as an electric DC generator. The output current flows in a direction shown by arrows 111. Thus, the total current flows through the series winding 50 and a portion flows through lead 103 into battery 12. Another portion of the output current flows through shunt winding 50 and hence to ground. Therefore, the two windings 50 and 51 are now arranged in a bucking relationship. As a result, unlike magnetic poles of the windings 50 and 51 are disposed adjacent the lead 103, for example the south (S) pole of winding 50 and the north (N) pole of the winding 51.

Therefore, it will be apparent that the electrical output current of the generator 11 is now limited. This is a desirable result because it limits the current charging the battery 12. It has been found by test that this is an efficient manner of recharging the secondary battery 12 which may consist of nickel-cadmium cells.

A normal starting cycle consists of three seconds cranking or starting the engine 10 and a nine-second cycle recharging the battery 12. However, it has been found that the motor generator 11 can be operated as an electric motor for as long as two to three minutes to crank the engines without damaging the secondary battery consisting of ten nickel-cadmium cells. Ten such cells have a nominal voltage of twelve volts and can be charged with a current as much as eight amps. up to a voltage of about fifteen volts.

The engine 10 is cranked by the motor 11 at around 700 RPM (revolutions per minute). The engine starting speed is about 500 RPM while the maximum engine speed is 12,000 RPM. On the other hand, the motor generator 11 has been designed to withstand 23,000 RPM.

The amount of bucking that is provided when the circuit is operated as shown in FIG. 9 and hence the amount of output current may be controlled. To this end, the size of the shunt winding 51 may be increased or decreased.

As explained before, the entire chain saw may be stopped by putting the control button 14 into position 14''. This will turn the ignition off by closing switch 92,

93 and hence, stop the engine 10. At the same time the starter button 90 remains open and the decompression valve 15 remains closed.

It will be understood that the two Zener diodes 101 and 102 and the resistor 105 are so proportioned to trigger the silicon-controlled rectifier 100 when the voltage across the battery 12 has reached a predetermined value such, for example, as fifteen volts. This, in turn, will short-circuit the shunt winding 51. This prevents the generation of an output current from the generator 11 so that charging of the battery 12 is effectively stopped. This, of course, prevents damage to the battery 12 because the battery charging circuit shown in FIG. 8 responds to the voltage across the battery 12 and will shut off the charging current once the battery voltage has reached a preset value. Thus, on the one hand, the battery-charging circuit responds to the battery voltage, but on the other hand, the output current of the generator 11 is controlled by the proper proportioning of the field windings 50 and 51.

Gripping, Stabilizing and Interlocked Actuating Aspects

While the integrated, engine starting conditioning, chain saw stabilizing, and engine working chamber decompressing operations are implicit from the foregoing discussion alone, the FIG. 4 illustration alone, or the disclosure of parent U.S. Pat. No. 3,405,293, recapitulation or summarization of this integrated chain saw starting concept is appropriate, and will be effected with reference to FIGS. 1, 4, 10 and 11.

In effecting this integrated and stabilized chain saw starting operation, and as shown in FIG. 10, the operator manipulates a chain saw 1 which includes the chain saw engine 10 operable to drive a cutter chain 3. Cutter chain 3 is driven by a conventional chain saw drive means 2, with the cutter chain 3 being supported on a conventional chain saw guide bar 5 as shown in FIGS. 10 and 11. This guide bar extends generally longitudinally of handle means 4 and the axis of engine piston reciprocation.

The engine 10, as shown in FIG. 1, includes cylinder wall means 16a, with a chain saw cylinder head means 16b closing one end of the chain saw cylinder wall means 16a. The chain saw piston 22 is reciprocally mounted in the chain saw cylinder wall means 16a for reciprocation along an axis extending axially of the chain saw cylinder wall means 16a. The chain saw crankshaft 24, in the conventional manner, connects the chain saw piston means 22 with the chain saw cutter chain drive means 2.

The chain saw hand grip means portion 4 extends generally longitudinally of the axis of reciprocation of the chain saw piston means 22 and is displaced generally longitudinally of the chain saw engine 10 in relation to this axis of piston means reciprocation.

The apparatus manipulated by the operator, as shown in FIGS. 1 and 4 and/or 10 and 11, includes a unique chain saw control means.

This chain saw control means includes the chain saw decompression port 70. This decompression port 70 is disposed in a longitudinally intermediate portion of the chain saw cylinder wall means 16a. The port 70 is operable, when open, to facilitate starting of the hand held chain saw by providing communication between the atmosphere and the interior of the chain saw cylinder wall means. This communication is effected by the vent

means 74 and 75 which provide a vent path extending from the chain saw decompression port 70 to the atmosphere.

The normally closed chain saw decompression valve 15 is operable to close the chain saw decompression port, when the decompression valve body 77 is disposed in the closed valve position shown in FIG. 1 and FIG. 5.

The chain saw control means includes, as one component, the chain saw engine starting condition control means 90. As is implicit in this overall disclosure, and in the disclosure of parent U.S. Pat. No. 3,405,293, the chain saw engine condition control means 90 may also and/or alternately include the throttle trigger 90a. Both the electrical starting means 90 and the throttle trigger means 90a are substantially contiguous with the hand grip means 4 and are individually or in unison operable to control a starting condition of the chain saw engine.

The movable button means 14, which is also substantially contiguous with the chain saw hand grip means 4, is operable to permit releasable positioning of at least a portion of the chain saw engine starting control means (i.e., exemplified by each or both of elements 90 and 90a) in a selected position determining a starting condition of the chain saw engine 10.

The chain saw control means previously discussed also includes the transmitting or linkage means comprising elements 83, 85 and 89 which are integrated in a common linkage element and which extend so as to connect the movable button means 14 with the chain saw compression relief valve means 15. This linkage means is operable to hold the chain saw compression relief valve means 15 in an open position when the button means 14 is depressed to the chain saw engine starting condition determining position 14'.

This linkage means 83, 85, 89, is supported adjacent the chain saw engine 10 and is operable to transmit chain saw compression relief valve opening and closing force from the button means 14 to the relief valve means 15. In this context it will be appreciated that the cylinder head means 16b, the decompression port 70, and the button means 14 are located in generally mutually displaced relation longitudinally along the axis of piston reciprocation.

As will also be appreciated, the chain saw throttle controlling trigger means 90a, which is included in the chain saw starting condition control means, is carried by the hand grip means 4 as shown in FIGS. 4, 10 and 11, and is mounted generally adjacent the movable button means 4.

The chain saw decompression port means 70 is spaced from the chain saw cylinder head means 16a and is operable to be cyclically covered by the chain saw piston means 22 during reciprocating movement of the chain saw piston 22 toward the chain saw cylinder head means 16b.

The chain saw hand grip means 4, the engine starting condition control means, which may comprise elements 90 and/or 90a, and the movable button means 14, at least in part, are generally mutually contiguous, and are located in generally longitudinally displaced relation, as shown in FIG. 4, from the chain saw crankshaft 24 with respect to the axis of piston reciprocation. These integrated chain saw starting mechanisms are operable to facilitate simultaneous manual gripping or holding of the chain saw 1 while effecting chain saw

starting in the stabilized manner previously described and discussed in parent U.S. Pat. No. 3,405,293.

The chain saw hand grip means portion 4 is operable to permit manual support of the chain saw 1 while an operator engages the button means 14 and concurrently 1) positions at least a portion of the chain saw engine starting condition control means in the previously noted starting condition determining position 14' and 2) positions the chain saw decompression valve means 15 in an open position so as to effect a reduced compression condition in the engine working chamber. While the chain saw hand grip means is thus engaged, the chain saw engine extends longitudinally away from the operator, as shown in FIGS. 4, and 10, along the axis of piston reciprocation.

The movable button means 14 and the throttle means 90a are positionally related on the chain saw hand grip means 4 so as to permit the operator, with one hand, and without releasing the chain saw hand grip means, to concurrently (1) grip and at least partially encircle a portion of the hand grip means 4, (2) actuate the button means 14 and (3) actuate the throttle trigger 90a with a single digit of the hand which engages the chain saw hand grip means 4.

As will also be appreciated, the chain saw engine 10 is operable to be started with the working chamber or interior of the chain saw cylinder wall means 16a being cyclically and alternately placed in communication with the atmosphere through the vent means 74-75 and isolated from this atmosphere in response to reciprocation of the chain saw piston 22.

SUMMARY OF MAJOR ADVANTAGES AND SCOPE OF INVENTION

A first and foremost advantage of the invention, entailed in the interlocking control and handle mechanism previously described, involves a concept of effecting portable chain saw starting while an operator is enabled to concurrently effect starting, engine stabilization, and engine decompression. This facilitates safe starting of an engine, minimization of vibration and erratic engine performance during starting, and reduces the likelihood of operator injury.

These advantages are particularly important when an operator is manipulating a chain saw in a position where the hand gripping the chain saw and effecting the operation of the integrated control system is extended away from the operator's body to a remote location.

Indeed, the history of the chain saw art, exemplified by a total failure to disclose this integrated starting concept including the interlocked operation of a decompression valve, evidences the unobviousness of the invention which uniquely and synergistically interacts to promote effective, safe and reliable starting of a portable chain saw.

Significantly, this integration of the various engine starting condition determining elements is effected without impairing the ability of the operator to immediately manipulate the chain saw engine throttle trigger so as to develop the starting chain saw engine from a starting to normal running condition, while concurrently gripping and stabilizing a hand grip means of the engine with one hand.

As will also be recalled from the foregoing discussion, and the locking concept discussed with reference to button 14, the movable means 14 may be provided

with a locking mechanism to releasably secure it in an appropriate engine conditioning position in relation to at least one aspect of this starting operation. This enables an operator to "lock-in" a particular engine condition without releasing his hand from the chain saw stabilizing position shown, for example, in FIGS. 11 and 10. However, this "lock-in" is effected without "locking" the throttle trigger, i.e., the trigger may be manipulated while the button remains locked or secured. In short, while button means 14 and the starting system are functionally integrated, the button means and throttle are not interlocked.

Within the spirit and intent of this disclosure, the button means of FIG. 4 may be employed, in its depressed portion, to merely abuttingly engage and pivot the throttle trigger and hold the throttle trigger and throttle in a "start" position. This functional integration of the throttle and button means is achieved without interlocking these components, as above indicated.

As will also be apparent, the self-locking character of the button means of FIG. 4 may be employed to secure the button means in a variety of engine condition determining position, relating, for example, to the commencement or termination of starting.

The stability during starting as afforded by the integrated control decompression and gripping concept of the present invention, is believed to be particularly significant in relation to chain saws not provided with anti-vibration means. Saws lacking anti-vibration means are particularly prone to vibration generation such that stabilization during starting contributes greatly to safety and reliability of the starting operation.

However, the invention may also enhance the starting of chain saws provided with vibration isolation system such as, for example, that disclosed in pending Frederickson et al. Application Ser. No. 750,082, filed Aug. 5, 1968, and entitled "Chain Saw with Vibration Isolation System," and assigned to the assignee of the present application. The disclosure of this Frederickson et al application is herein incorporated by reference.

In incorporating the integrated concepts of the present invention in a saw including a vibration isolating system, it would be appropriate to ensure that the linkage mechanism extending from the handle button to the decompression valve was itself provided with anti-vibration means so as to avoid the transmission of engine vibration through the linkage to the handle where the button was mounted. Such a mechanism might be provided by a linkage component operable to transmit button manipulating force to the decompression valve with this anti-vibration mechanism being arranged to dampen out or not transmit engine vibration to the handle button.

The invention and its attendant advantages will be understood from the foregoing description and it will be apparent that various changes may be made in the form, construction and arrangement of the parts of the invention without departing from the spirit and scope thereof or sacrificing its material advantages, the arrangement hereinbefore described merely by way of example and we do not wish to be restricted to the specific form shown or uses mentioned except as defined in the accompanying claims.

What is claimed is:

1. A chain saw operable to be hand held comprising: a cutter chain;

an internal combustion engine operably connected to said cutter chain for driving said cutter chain including
 chain saw cylinder wall means,
 chain saw cylinder head means closing one end of said chain saw cylinder wall means,
 chain saw piston means reciprocally mounted in said chain saw cylinder wall means for reciprocation along an axis extending axially of said chain saw cylinder wall means, and
 a chain saw crankshaft;
 chain saw stationary hand grip means extending generally longitudinally of the axis of reciprocation of said chain saw piston means and displaced generally longitudinally of said chain saw engine in relation to said axis;
 chain saw control means including,
 a chain saw decompression port disposed in a longitudinally intermediate portion of said chain saw cylinder wall and operable, when open, to facilitate starting of said hand held chain saw by providing communication between the atmosphere and the interior of said saw cylinder wall,
 vent means extending from said chain saw decompression port to the atmosphere,
 a normally closed, chain saw compression relief valve operable to close said chain saw decompression port,
 chain saw engine starting conditions control means substantially contiguous with said chain saw hand grip means, and operable to control a starting condition of said chain saw engine,
 movable means substantially contiguous with said chain saw hand grip means and operable to permit releasable positioning of at least a portion of said chain saw engine starting condition control means in a selected position determining a starting condition of said chain saw engine,
 linkage means connecting said movable means with said chain saw compression relief valve to hold said chain saw compression relief valve in an open position when said movable means has positioned said portion of said chain saw engine starting condition control means in said chain saw engine starting condition determining position;
 chain saw throttle controlling trigger means, included in said chain saw starting condition control means, carried by said hand grip means, and mounted generally adjacent said movable means;
 said linkage means being supported adjacent said chain saw engine and operable to transmit chain saw compression relief valve opening and closing force from said movable means to said chain saw compression relief valve in said chain saw cylinder wall means,
 said linkage means including,
 an arm having a first end connected to an outer end portion of said compression relief valve and a second end connected to said movable means, and
 a pivot positioned between said first end and said second end; said arm being dimensioned with respect to said pivot such that a mechanical advantage is achieved by said second end connected to said movable means with respect to said first end connected to said compression relief valve whereby an operator may readily operatively ma-

nipulate said movable means and thus open and close said compression relief valve;
 said chain saw decompression port being spaced from said chain saw cylinder head means and operable to be covered by said chain saw piston means during reciprocating movement of said chain saw piston means toward said chain saw cylinder head mean;
 said chain saw hand grip means, engine starting condition control means, and movable means, at least in part, being generally mutually contiguous, located in generally longitudinally displaced relation from said chain saw crankshaft with respect to said axis of piston means reciprocation and operable to facilitate simultaneous manual holding and starting of said chain saw;
 said chain saw hand grip means being operable to permit manual support of said chain saw, with an operator engaging said movable means and concurrently positioning at least said portion of said chain saw engine starting condition control means in said starting condition determining position and said chain saw compression relief valve in said open position, and with said chain saw engine extending away from said operator along said axis of piston means reciprocation; and
 said movable means and said chain saw throttle controlling trigger means being positionally related on said stationary chain saw hand grip means so as to permit said operator, with one hand and without releasing said chain saw hand grip means, to grip and at least partially encircle a portion of said stationary hand grip means,
 to actuate said movable means, and
 to actuate said chain saw throttle controlling trigger means with a single digit member of said one hand;
 said chain saw engine being operable to be started with the interior of said chain saw cylinder wall means being cyclically and alternately, place in communication with said atmosphere through said vent means and isolated from said atmosphere in response to reciprocation of said chain saw piston means.
 2. A method of starting and operating a portable chain saw of the type including a cutter chain, an internal combustion chain saw engine operatively connected to said cutter chain, and a stationary hand grip positioned generally longitudinally extending with respect to a cylinder of said chain saw engine, said method comprising:
 gripping a portion of said hand grip means of the portable chain saw with one hand;
 while gripping said portion of said chain saw hand grip means with said one hand, manipulating movable means mounted on said portion of said chain saw hand grip means to concurrently provide and maintain a starting condition in at least a portion of an engine of said chain saw, and reduce the compression level in a combustion chamber of said engine;
 effecting said reduction of pressure in response to said manipulating which conditions at least said portion of said chain saw engine for starting including the steps of,
 opening a compression relief valve positioned into said combustion chamber by,

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actuating a lever connected with a mechanical advantage through a fulcrum to the compression relief valve;
 while gripping said portion of said hand grip means of said chain saw, maintaining said reduced engine compression and starting said chain saw engine; and
 after said starting said chain saw engine, and while continuing to grip said portion of said hand grip means of said chain saw with said one hand, causing said movable means to move to a release posi-

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tion and concurrently terminating the maintenance of said chain saw engine starting condition, and increasing the compression in said combustion chamber of said chain saw engine; and with said one hand, operating a throttle of said chain saw on said hand grip means generally adjacent said movable means, while continuing to grip said portion of said chain saw hand grip means with said one hand.

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