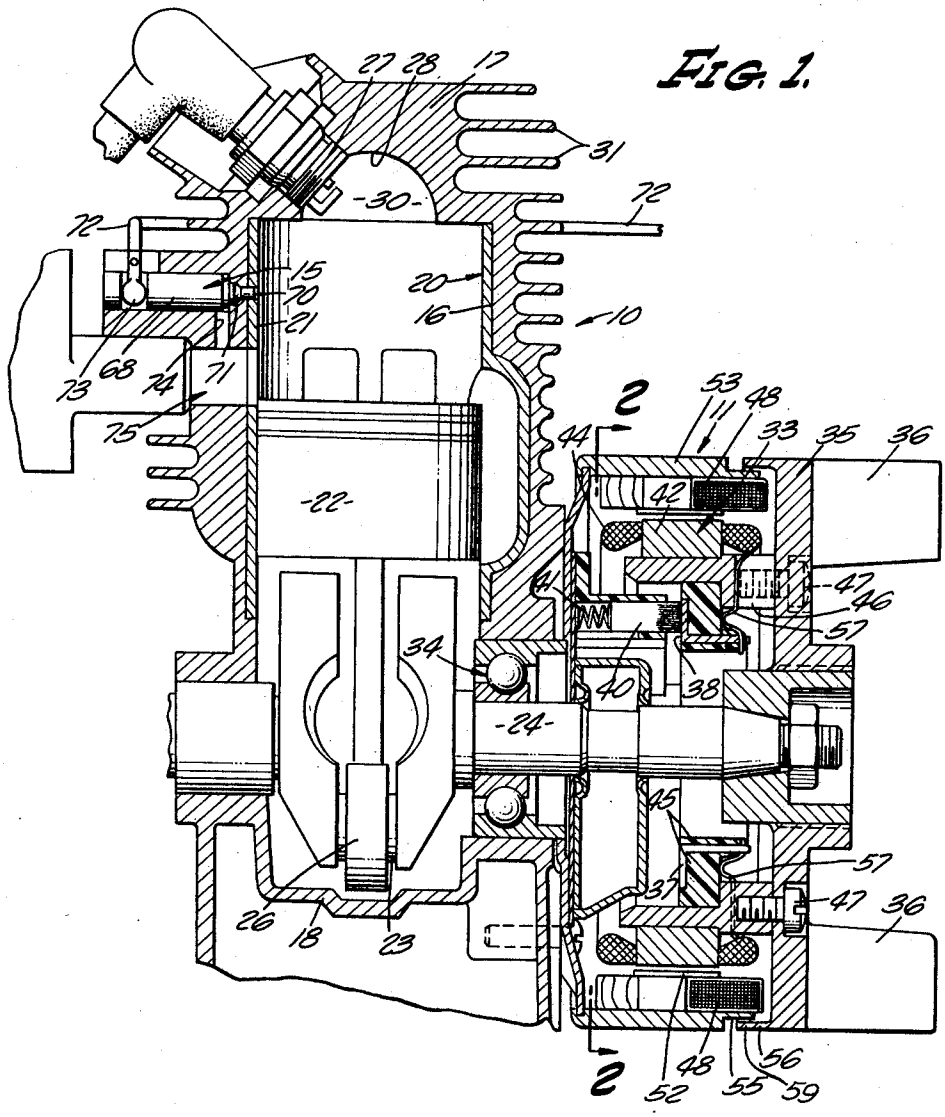
Feb. 24, 1970 W. B. BURKETT ET AL 3,497,706

ELECTRICAL STARTER SYSTEM FOR GASOLINE ENGINES

Original Filed April 19, 1966 4 Sheets-Sheet 1

FIG. 1.



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ELECTRICAL STARTER SYSTEM FOR GASOLINE ENGINES

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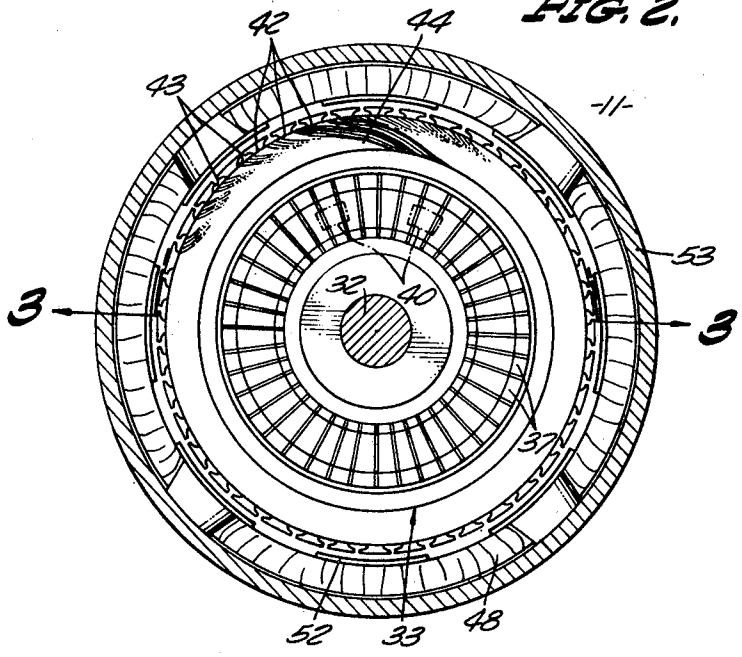
FIG. 2.



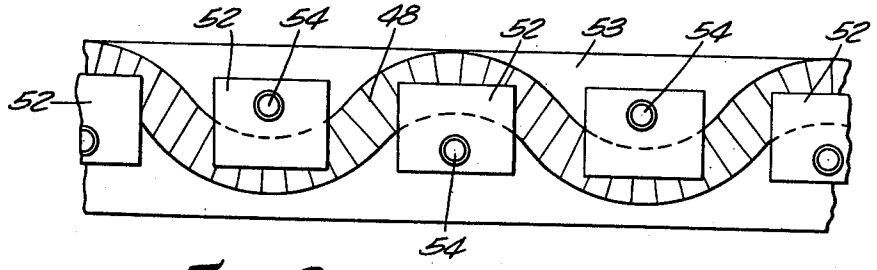


FIG. 3.

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ELECTRICAL STARTER SYSTEM FOR GASOLINE ENGINES

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FIG. 4.

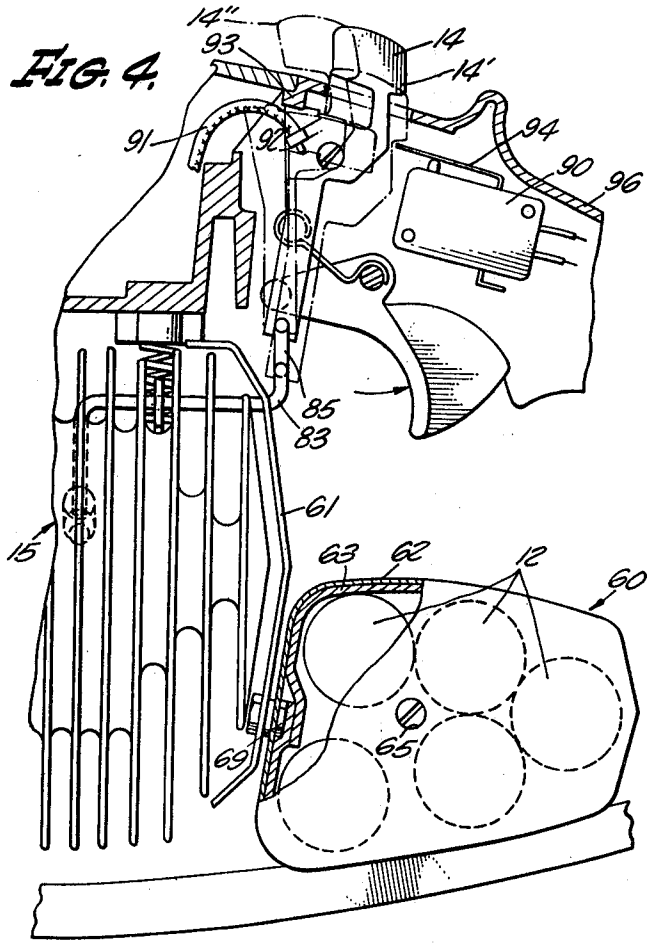
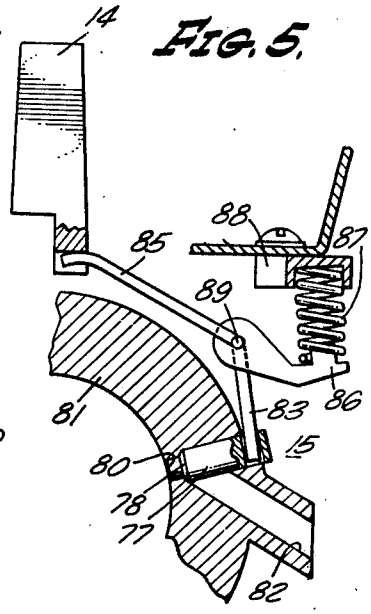


FIG. 5.



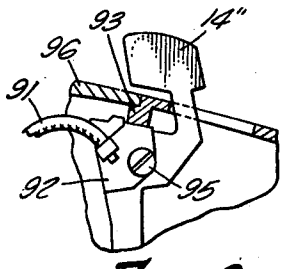


FIG. 6.

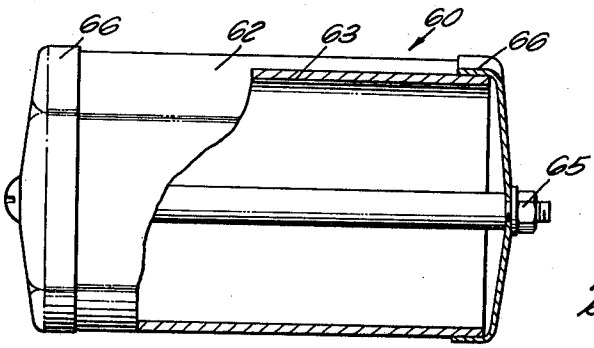


FIG. 7.

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ELECTRICAL STARTER SYSTEM FOR GASOLINE ENGINES

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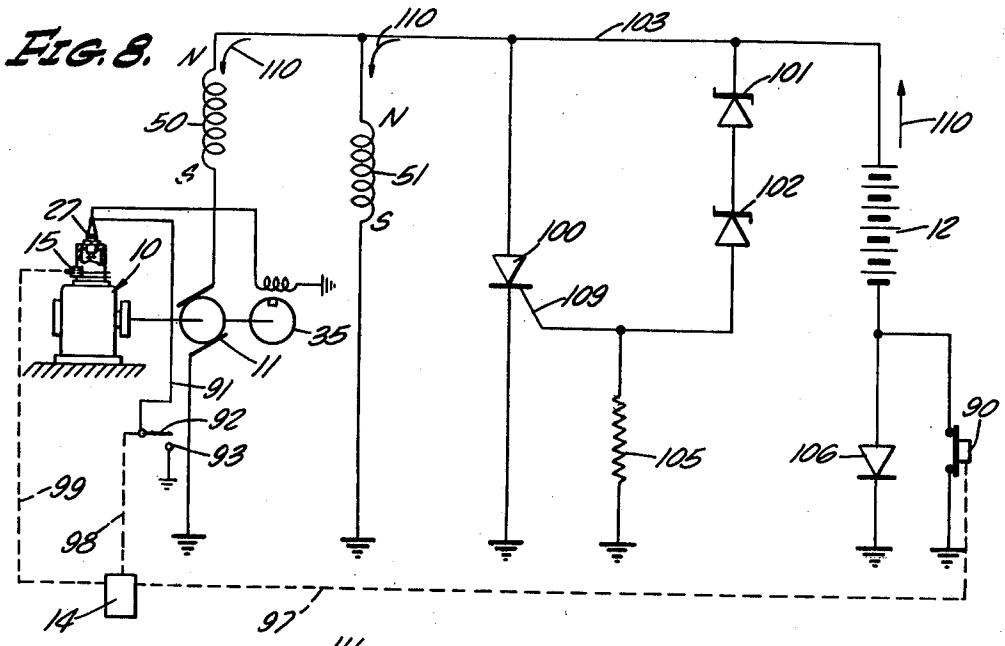
FIG. 8.



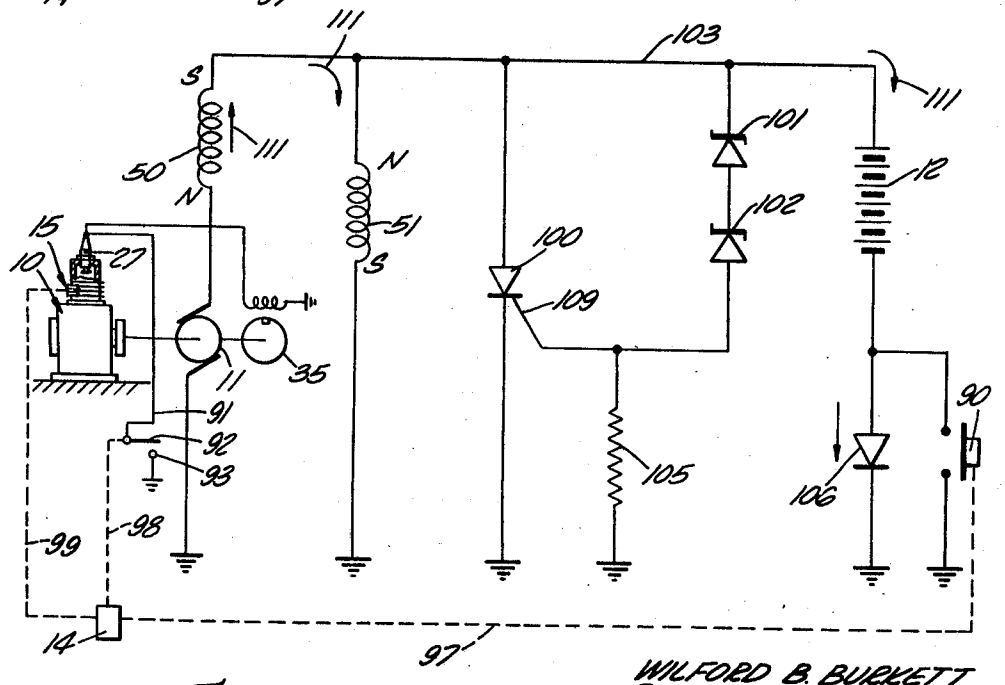


FIG. 9.

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United States Patent Office

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3,497,706

ELECTRICAL STARTER SYSTEM FOR GASOLINE ENGINES

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Original application Apr. 19, 1966, Ser. No. 543,583, now Patent No. 3,405,293. Divided and this application June 25, 1968, Ser. No. 739,798

Int. Cl. H02k 23/52

U.S. Cl. 290—31

3 Claims

ABSTRACT OF THE DISCLOSURE

A starter generator system for internal combustion engines includes a compound-wound, direct-current motor-generator, a blocking diode connected in series between the motor-generator and the battery which supplies the power for the motor and is recharged after the engine has started. A starter switch connected across the blocking diode for providing a path for starting current, a voltage-responsive cutoff circuit for terminating the charge of the battery. A decompression valve in the cylinder head of the engine, an ignition switch for the engine, and a unitary control means for simultaneously controlling the operation of the starter switch, decompression valve and ignition switch.

CROSS REFERENCES TO RELATED APPLICATIONS

This application is a divisional application of the copending application Ser. No. 543,583 (now Patent No. 3,405,293), filed Apr. 19, 1966, entitled "Electrical Starter for Gasoline Engines," assigned to the same assignee as the instant application.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates generally to an electrical system for starting gasoline engines and particularly relates to a direct-current motor and generator with associated mechanism energized by a secondary battery for starting a portable, internal combustion engine.

The present invention has particular utility in connection with small, lightweight, internal combustion engines of the single cylinder, two-cycle type such as are used for portable chains saws. However, it will be understood that the utility of the present invention is not confined to this particular type of internal combustion engine, although it will be described in connection therewith.

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. All presently known chain saws must be started by manually pulling a rope starter wound on a pulley. Although electrical starter systems and their convenience are well known, it has not been possible in the past to utilize them for portable chain saws and other tools due to the severe space and weight problem. Since the normal weight of even a single-cylinder, two-cycle gasoline engine with related equipment including a saw chain is already appreciable, the additional weight of the equipment required for an electric starter system must be limited to a very few pounds.

SUMMARY OF THE INVENTION

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

Another object of the present invention is to provide 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 object of the present invention is to provide 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.

Still a further object of the present invention is to provide 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 or 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 gasoline engine including a decompression valve and DC generator and motor embodying the present invention;

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 electrical 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 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; and

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.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

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 battery 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.

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. 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 reciprocably 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.

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 a 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 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" compared to a thickness of 1.4" 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 12 volts. These cells may, for example, 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 3½ lbs.

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

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 **87** 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.

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.

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.

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 may 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.

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 motor 11. Accordingly, the two windings 50 and 51 are connected in series-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 series-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 51 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 tests 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 engine 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 of eight amps up to a voltage of about fifteen volts.

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

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 band, the output current of the generator 11 is controlled by the proper proportioning of the field windings 50 and 51.

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 wtihout 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. An electrical starter system for an internal combustion engine having an ignition switch, said system having a direct-current motor-generator operatively connected to said engine, said motor-generator having a series field winding and a shunt field winding connected so that the magnetic fields are aiding when the motor-generator operates as a motor and opposing when the

motor-generator operates as a generator, one end of each winding connected in common to an output terminal of the motor-generator, the other end of the series winding connected to one side of the armature of the motor-generator with the other side of the armature connected in common with the other side of the shunt field winding to a second output terminal of the motor-generator, a storage battery connected to the output terminals of the motor-generator throgh a switching means, an electronic switch connected in parallel to the shunt field winding across the output terminals of said motor-generator, said switch controlling the current of the shunt field winding depending upon the voltage across the storage battery, a diode connected in series with the storage battery to the output terminals of said motor-generator, said diode together with a starter switch connected in parallel thereto defining said switching means, and a unitary control element being movable between three positions, said element being mechanically coupled with the ignition switch and the starter switch such that in its first position it actuates both the ignition switch and the starter switch, and in its second position it actuates only the ignition switch, and in its third position both the ignition switch and starter switch are released.

2. A starter system for internal combustion engines having a decompression means according to claim 1 wherein the unitary control element is additionally coupled with the decompression means such that in its first position said means is opened, and in its second and third position, respectively, said means is closed.

3. An electrical starter system comprising:

an internal combustion engine having a cylinder;

a piston reciprocably mounted in said cylinder;

a crankshaft coupled to said piston and rotatable thereby;

an ignition system for said engine, including an ignition switch;

a direct-current motor generator directly connected to said crankshaft;

a battery consisting of secondary cells;

first electrical circuit means for normally preventing current flow from said battery to said motor-generator to operate it as a motor to start said engine;

second electrical circuit means for controlling the charging current from said motor-generator to said battery to stop said charging current when the battery voltage has reached a predetermined value;

decompression means operatively connected to said cylinder for reducing the pressure in said cylinder at will; and

control means associated with said ignition switch, said decompression means, and said first circuit means, said control means having three separate positions, whereby when said control means is put into the starting position, said ignition switch is on, said decompression means is open and said first circuit means is bypassed to connect said battery to said motor generator, and whereby, when said control means is in its normal operating position, current flow from said battery to said motor-generator is prevented to operate it as a motor, while said ignition switch remains on and said decompression means is closed and having an off position where said ignition switch is off, said decompression means is closed and current from said battery is prevented from flowing into said motor-generator to operate it as a motor.

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