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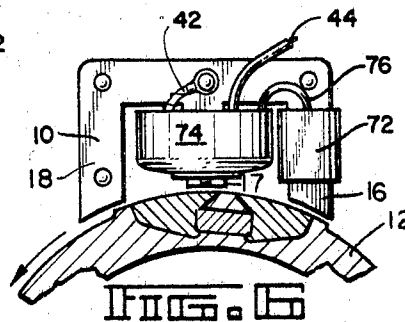
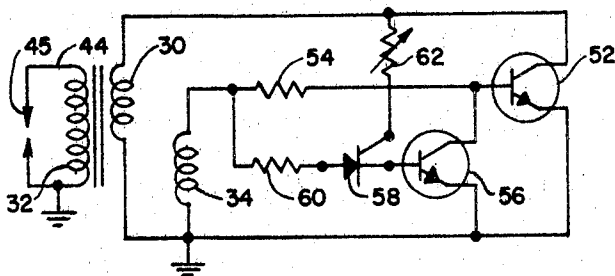
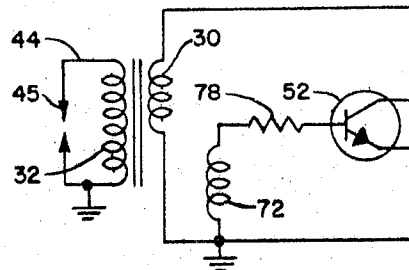
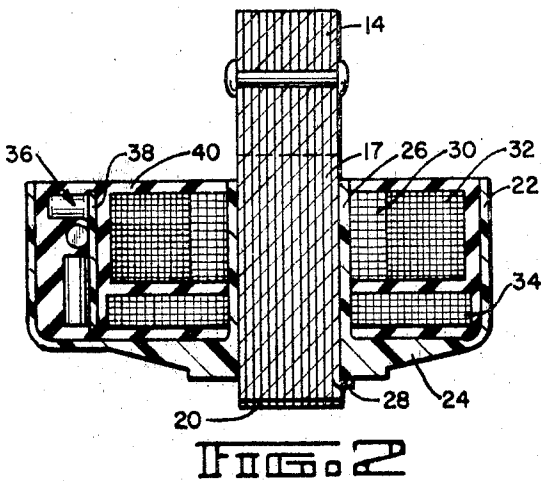
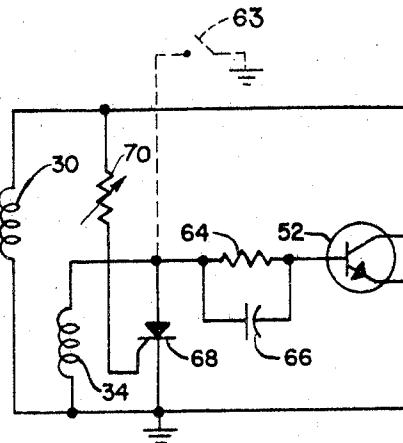
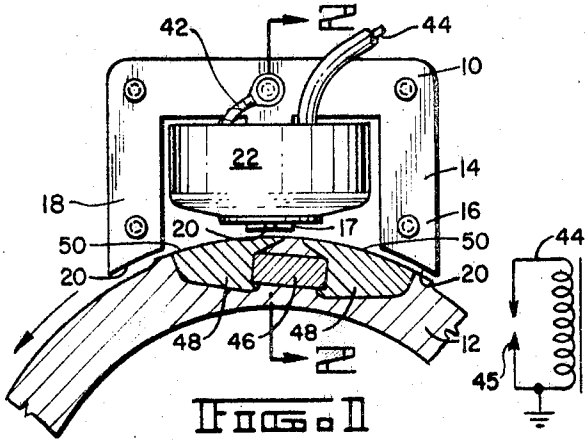
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BREAKERLESS MAGNETO IGNITION SYSTEM

Filed March 3, 1966

2 Sheets-Sheet 1



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BREAKERLESS MAGNETO IGNITION SYSTEM

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FIG. 7

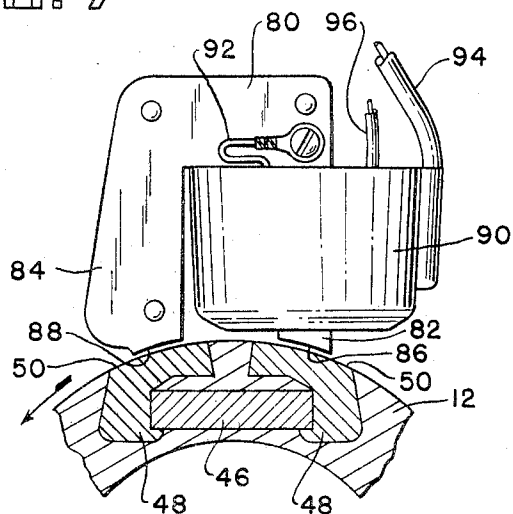
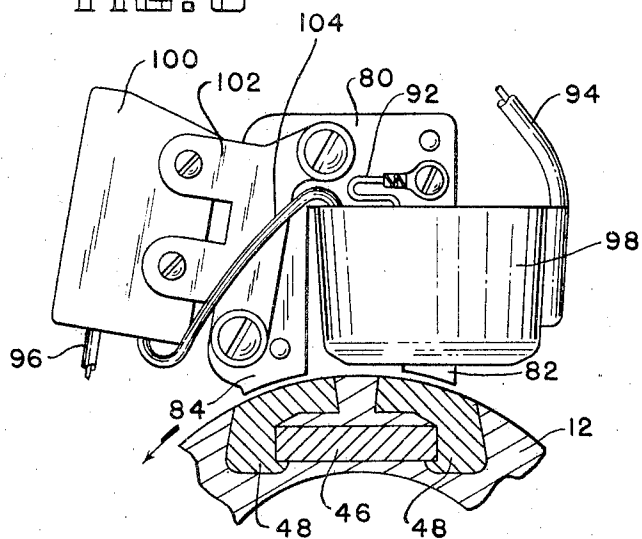


FIG. 8



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**BREAKERLESS MAGNETO IGNITION SYSTEM**  
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22 Claims

## ABSTRACT OF THE DISCLOSURE

A breakerless ignition system includes an energizing coil in which electrical energy is induced by a rotating permanent magnet to provide power for creating a spark at the spark gap device. The timing of the application of the power to the spark gap device is controlled by an electronic control circuit including an electronic switch device and a control coil which supplies triggering signals to the latter. The control coil is so located that the same permanent magnet used to excite the energizing coil also excites it.

This invention relates to magnetos and magneto ignition systems, and deals more particularly with an improved magneto and associated electrical circuit requiring no mechanically operated breaker for the production of an ignition spark.

The general object of this invention is to provide a magneto ignition system, and magneto therefore, having no moving parts except for the rotor used for varying the magnetic flux passing through the ignition coil.

Another object of this invention is to provide a magneto which may be produced at relatively low cost and having a long service life.

A still further object of this invention is to provide a magneto ignition system wherein the magneto and most other parts of the system may be contained in a small, compact unit.

Other objects and advantages of the invention will be apparent from the following description and from the drawings forming a part hereof.

The drawings show preferred embodiments of the invention and such embodiments will be described, but it will be understood that various changes may be made from the constructions disclosed, and that the drawings and description are not to be construed as defining or limiting the scope of the invention, the claims forming a part of this specification being relied upon for that purpose.

Of the drawings:

FIG. 1 is an elevational view of a magneto embodying the present invention, the rotor being shown in section to reveal the structure of the magnet assembly.

FIG. 2 is an enlarged vertical sectional view through the stator of FIG. 1 and is taken on the line 2—2 of FIG. 1.

FIG. 3 is a circuit diagram showing the arrangement of the electrical elements of the magneto of FIG. 1.

FIG. 4 is a circuit diagram illustrating an alternative arrangement of circuit elements for the magneto of FIG. 1.

FIG. 5 is a circuit diagram showing the arrangement of electrical elements for another embodiment of this invention.

FIG. 6 is a view generally similar to FIG. 1 but shows a magneto adapted to use the electrical circuit of FIG. 5.

FIG. 7 is an elevational view of a magneto comprising another embodiment of this invention.

FIG. 8 is an elevational view of a magneto comprising still another embodiment of this invention.

Turning now to the drawings and first considering FIGS. 1, 2 and 3, the present invention is there shown to be embodied in a magneto comprising a stator 10 and a rotor 12. The stator 10 and the rotor 12 may take various different forms and shapes without departing from the broader aspects of the invention, but in the illustrated case, the stator 10 is mounted externally of the rotor 12 and includes a stator core 14 made up of a number of laminations of sheet material secured together by rivets or other suitable fastening means and providing three generally parallel stator poles 16, 17 and 18. These poles are spaced angularly of the rotor 12 and have arcuate end faces 20, 20 closely spaced in relation to the outer surface of the rotor.

The stator 10 also includes a coil unit 22 mounted on the center pole 17 of the core 14. As shown best in FIG. 2, the coil unit 22 includes a generally cup-shaped plastic housing or container 24 having a central chimney 26 which is received relatively snugly on the pole 17. The housing 24 is suitably fixed to the pole by any convenient means such as a tab 28 cut and bent outwardly from one of the outer laminations of the core. In accordance with conventional magneto practice the cup-shaped housing 24 contains a primary magneto coil 30 consisting of a relatively few number of turns of wire and also includes a secondary magneto coil 32 comprising a much larger number of turns of wire.

In accordance with the present invention, the housing 22 also includes a third coil 34, referred to herein as a control coil, which is located at a different point along the length of the center stator pole 17 than the primary coil 30 and is so arranged as to be located closer to the rotor 12 than the primary coil 30. The control coil 34, as hereinafter described in more detail, forms a part of an electrical circuit for controlling the flow of current through the primary coil 30. Also included in this circuit are a number of other electrical elements which, as shown in FIG. 2, may be of relatively small size and which may also be contained within the housing 24. In FIG. 2 these additional circuit elements are indicated generally at 36 and are shown mounted on a small mounting board 38 located to one side of the coils 30, 32 and 34. All of the parts contained in the housing 22 are held in place relative to one another, and are sealed from the atmosphere, by a quantity of potting material 40 received in the housing and surrounding all of the parts therein. A ground wire 42 is connected to the coil unit for use in grounding one side of each of the three coils 30, 32 and 34 to the associated engine structure, and a high-tension conductor 44 is also connected to the coil unit and is used to electrically connect the high-tension side of the secondary coil 32 to a spark plug, indicated at 45 in FIG. 3.

The rotor 12 is carried by a part moved in synchronism with the associated engine and may comprise a part of a flywheel attached to the engine crankshaft. Included in the rotor is a permanent magnet device for establishing a varying magnetic flux in the stator core 14 as the rotor is rotated. As shown in FIG. 1, this permanent magnet device comprises a magnet 46 and two pole pieces 48, 48 located on opposite sides of the magnet and having pole faces 50, 50 located on the outer surface of the rotor, which are spaced angularly of the rotor and provided with opposite magnetic polarities by the magnet 46. That is, one pole piece 48 is poled magnetically north and the other is poled magnetically south. If the rotor 12 is rotated in the direction of the arrow in FIG. 1, it will be understood that the magnet 46 and pole pieces 48, 48 operate to establish a magnetic flux in the stator core which first passes through the leading stator core pole 16 and the middle stator pole 17 and then, after further rotor

rotation, is switched so as to pass through the middle stator pole 17 and the trailing stator pole 18, the change of flux in the middle stator pole 17 being first in one direction and then in the opposite direction. This changing flux in the middle stator pole 17 induces voltages in the primary magneto coil 30 and in the control coil 34 and, as described in more detail hereinafter, a control circuit of which the control coil 34 is a part operates to control the flow of current through the primary coil 30. The control circuit operates such that at an identical angular position of the rotor, during each revolution, a low resistance circuit is completed through the primary coil and then opened suddenly when the current flow through the primary coil is at or near a maximum value, thereby inducing a high voltage in the secondary coil 32 sufficient to generate a spark at the spark plug 45.

The switching or opening and closing of the circuit through the primary coil 30 is accomplished by an electronic switch device which may be electrically biased to either a conducting state or a nonconducting state, and the bias for this device is in turn supplied by an associated control circuit which includes the control coil 34. FIG. 3 shows the presently preferred arrangement of such a switch and control circuit, and in referring to this figure the illustrated switching device comprises an NPN power transistor 52 having its emitter and collector terminals directly connected respectively to opposite sides of the primary coil 30. The control circuit for the transistor 52 includes a first, or ON-biasing, circuit connected between the base and emitter terminals of the transistor 52 for applying a bias voltage or current to the transistor which is derived from the control coil and which varies in accordance with variations in the voltage appearing across the control coil. Also included in the control circuit is a second, or OFF-biasing, a circuit for removing the biasing current from the transistor when the voltage across the primary magneto coil 30 exceeds a predetermined value. The first, or ON-biasing, circuit comprises the control coil 34 in series with a resistor 54, the resistor 54 being located between the control coil 34 and the base terminal of the transistor 52. The second, or OFF-biasing, circuit includes a shunt circuit connected between the base and emitter terminals of the transistor 52 and consisting of another electronic switch device in the form of a second NPN transistor 56. The collector terminal of the transistor 56 is connected to the base terminal of the transistor 52 and the emitter terminal of the transistor 56 is connected to the emitter terminal of the transistor 52. For controlling its state of conduction or resistance in accordance with the voltage across the primary coil 30, the transistor 56 has connected to its base terminal a biasing circuit comprising a controlled rectifier 58 and a resistor 60 connected in series with each other between the base terminal of the transistor 56 and a point located between the control coil 34 and the resistor 54. The control or gate terminal of the controlled rectifier 58 is in turn connected through a resistor 62 to the ungrounded side of the primary coil 30, the resistor 62 preferably being one which is adjustable prior to the potting of the circuit to enable the triggering of the controlled rectifier 58 to be set in the factory to occur at a desired primary coil voltage.

In considering the operation of the FIG. 3 circuit, assume first that the rotor is rotating in the direction of the arrow of FIG. 1 and that the magnet of the rotor is spaced some distance from the magneto stator. At this instant no magnetic flux changes occur in the stator core and no voltages are induced in any of the coils 30, 32 and 34. The transistors 52 and 56 and the controlled rectifier 58 all have zero biases and are in inactive conditions. When the magnet and its associated pole pieces are thereafter moved past the stator pole end faces a changing magnetic flux is established in the stator core with the change of flux in the center pole 17 being first in one direction and then in the opposite direction as previously explained.

If the change of flux in said one direction is taken to be in the positive direction and if the change of flux in the opposite direction is taken to be in the negative direction, then the change of flux in the center pole 17 during each cycle may be described in more detail as involving first a relatively slow increase from a zero to a positive value, then a relatively rapid decrease from said positive value to a negative value, and then a relatively slow increase from said negative value back to a zero value. During the two periods of relatively slow increase relatively low voltages are induced in the primary coil 30 and in the control coil 34. During the period of rapid decrease, however, relatively higher voltages are induced in the coils 30 and 34, and the windings of these coils are in such directions that, as viewed in FIG. 3, the upper end of each coil is of a positive polarity relative to the lower end during the period of rapid flux change. Therefore, the voltage induced in the control coil 34 during the period of rapid flux change biases the transistor 52 to its ON or conducting state and the voltage induced in the primary magneto coil 30 establishes a forward collector-emitter current through the same transistor. Due to the fact that the control coil is physically located on the center pole 17 in front of or closer to the rotor than the primary coil 30, the voltage induced in the control coil is slightly ahead of the voltage induced in the primary coil 30. Therefore, the voltage induced in the control coil 34 biases the transistor 52 to its fully conducting state at an early point in the build-up of induced voltage in the coil 30 so that a maximum amount of power is contained in the magneto output. Both the voltage appearing across the magneto coil and the current passing therethrough increase during the build-up of induced voltage in the coil, and this also increases the voltage on the control terminal of the controlled rectifier 58.

The controlled rectifier 58 initially is nonconducting so as to maintain the shunt transistor 56 in a nonconducting state. However, the value of the resistor 62 is so selected that at some time before the voltage across the primary coil reaches its maximum value the voltage on the control terminal of the controlled rectifier reaches its triggering or gate voltage and the rectifier is thereupon biased or triggered to its conducting state causing it to conduct forward base current to the shunt transistor 56. This biases the transistor 56 to a conducting state and thereby shunts the base of the power transistor 52 to its collector terminal, rapidly switching the power transistor 52 to its nonconducting state and interrupting the flow of current through the primary magneto coil 30. The variable resistor 62 is adjusted to cause triggering of the controlled rectifier 58 at a primary coil voltage slightly below the peak of the primary coil voltage curve obtained at low speed operation of the rotor so as to assure operation throughout each cycle even at low speeds and so that the interruption of current flow occurs when the current is at a high value, thereby including the desired high-tension voltage in the secondary coil 32. A primary objective of the circuit is to obtain as rapid switching of the power transistor 52 as possible and for this reason the resistor 54 is employed to avoid over-saturation, and therefore reduced switching speed, of the transistor 52 at high speed operation. That is, the value of the resistor 54 is so chosen as to be low enough to provide adequate bias for the transistor 52 at low rotor speeds and at higher rotor speed limits the current flowing to the base of the transistor 52 to avoid undue saturation.

Control of the transistor 52, or other electronic switching device used to control the primary coil current, may be obtained in various different ways other than that shown in FIG. 3 and, by way of example, FIG. 4 shows a circuit wherein the switching transistor 52 is controlled by a circuit which includes a controlled rectifier and no additional transistor. Referring to FIG. 4, the circuit there shown includes a first, or ON-biasing, circuit connected between the base and emitter terminals of the transistor

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52 and including the control coil 34 and a resistor 64, the resistor 64 being connected in series with the control coil 34 and being located between the control coil 34 and the base of the transistor 52. Connected in parallel with the resistor 64 is a capacitor 66. An OFF-biasing circuit is also provided and includes a controlled rectifier 68 which is connected, through its main terminals, in parallel with the control coil 34. The control terminal of the controlled rectifier 68 is connected to the ungrounded side of the primary coil 30 through a variable resistor 70.

Considering the operation of the FIG. 4 circuit, as the flux in the center stator pole 17 goes through its period of rapid change, a voltage is induced in the control coil 34 which slightly leads the voltage induced in the primary magneto coil 30. The induced voltage of the control coil biases the transistor 52 to its conducting state and allows it to conduct primary coil current. As the primary coil current increases, the voltage appearing on the controlled rectifier also increases and at a predetermined value of primary coil voltage, as determined by the setting of the adjustable resistor 70, the controlled rectifier 68 is triggered to its conducting state. This, in turn, shuts the terminals of the control coil 34 and thereby removes the biasing current from the transistor 52 to bias the latter to a cut-off or non-conducting state, this in turn interrupting the flow of current through the primary magneto coil and inducing the desired high-tension voltage in the secondary magneto coil 32. At the time of switching the capacitor 66 increases the switching speed of the transistor 52 by rapidly removing saturation charge from its base terminal.

The circuits of FIGS. 3 and 4 are both designed for use in situations where the control coil is physically arranged so that the voltage induced therein is generally in phase with or only slightly ahead of the voltage induced in the primary magneto coil. In some instances, however, the control coil may be so physically placed as to have a voltage induced therein which is so phased in relation to the voltage in the primary magneto coil that the voltage of the control coil may be used to bias the electronic switching device both on and off, thereby eliminating the need for a separate OFF-biasing or shunt circuit. Such an arrangement of the control coil may be obtained for example by placing the control coil on either the leading pole 16 or the trailing pole 18 of the stator core 14, and FIGS. 5 and 6 show an arrangement wherein the control coil, indicated at 72, is located on the leading pole 16 of the stator core.

Referring to FIGS. 5 and 6, these figures show a magneto which, except for the different location of the control coil and a simplified control circuit, is generally similar to the magneto of FIGS. 1 and 2, and parts which are similar to the magneto of FIGS. 1 and 2 have been given the same reference number as in FIGS. 1 and 2 and need not be redescribed. The primary and secondary magneto coils of the FIGS. 5 and 6 magneto, are mounted on the center stator pole 17 and are part of a coil unit 74. The coil unit 74 may also physically house other components of the control circuit and is connected to the control coil 72 by a conductor 76. In the electrical circuit of the magneto the switching device for controlling the flow of current through the primary magneto coil 30 comprises an NPN switching transistor 52 which is controlled by a biasing circuit connected between its base and emitter terminals and comprising solely the control coil 72 and a resistor 78 connected in series with one another. In the operation of the magneto of FIGS. 5 and 6, as the rotor magnet passes the stator a voltage is induced in the control coil 72 by the changing flux in the stator pole 16 and another voltage is induced in the primary coil 30 by the changing flux in the stator pole 17. The flux in the pole 16 flows in only one direction and starting from a zero flow rises to a maximum flow and then returns to a zero flow. The voltage induced in the

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control coil 72 has one polarity during the period of increasing flux in the pole 16 and an opposite polarity during the period of decreasing flux. The period of decreasing flux in the pole 16 starts at the same time as the period of decreasing flux in the center pole 17 but, due to the fact that the flux in the center pole 17 decreases beyond zero and reverses in direction, the period of decreasing flux in the pole 16 is terminated prior to the end of the period of rapidly changing flux in the center pole. The flux in the pole 16 and the induced voltage in the control coil 72 in fact reach zero at approximately the same time as the rate of flux change in the pole 17 and the voltage induced in the primary coil 30 are at their maximum values. The control coil 72 is further wound in such a direction that during the period of decreasing flux in the pole 16 its ungrounded terminal has a positive polarity relative to its other terminal so that the voltage induced in the control coil during this period biases the transistor 52 to its on condition. The transistor is therefore rendered conducting at the start of the main induced voltage rise in the primary coil 30 and, as is desired, is returned to its non-conducting state at approximately the instant of maximum induced primary coil voltage when the control coil induced voltage returns to zero.

It should also be noted here that in the various embodiments of the invention shown in the accompanying drawings the arrangement of the primary magneto coil and the control coil is such that the same permanent magnet assembly of the rotor is used for inducing the required voltages in both coils. Although this is the presently preferred arrangement, the invention in its broader aspects is not necessarily limited to this arrangement and if desired separate magnets or magnet assemblies may be used for inducing voltages in the primary magneto coil and in the control coil.

As shown by the broken lines of FIG. 4, an additional conductor, including a normally open switch 63, may be connected between the ungrounded side of the control coil 34 and ground. The switch 63 is manually operable and provides a remote shut-off for stopping the associated engine. That is, when the switch 63 is closed, the control coil is shunted to ground to inhibit operation of the control circuit, the transistor 52 therefore remaining non-conducting. Although not shown, the same type of remote shut-off may also be applied to the other circuits shown in FIG. 3 and FIG. 5.

It should, of course, be understood that this invention is not limited to a magneto having the particular type of stator construction shown in FIGS. 1 and 6 of the drawings. A basic part of the invention, however, resides in the fact that the control coil is mounted on the stator core in such a manner that at least during part of the active cycle of flux change through the primary magneto coil, the flux circuit also passes through the control coil so that voltages are induced in the control coil which induced voltages are used to control the opening and closing of the circuit through the primary magneto coil, and which induced voltages, due to such arrangement of the control coil, are maintained in proper synchronism with the voltages induced in the primary magneto coil.

FIGS. 7 and 8, for example, show another type of magneto construction, having a two-poled stator core, which may be used with control circuits such as shown in FIGS. 3 and 4. Referring first to FIG. 7, the magneto there shown includes a rotor 12 which is or may be similar to the rotor 12 of the magnetos of FIGS. 1 and 6, the rotor including a permanent magnet 46 and two pole shoes 48, 48 having end faces 59, 50 located adjacent the outer surface of the rotor. The stator of the magneto comprises a stator core 80 having two poles 82 and 84 respectively, providing end faces 86 and 88. Mounted on the pole 82 is a coil unit 90 generally similar to the coil unit 22 of FIG. 1. That is, the core unit 90 includes, inside of its housing, the primary and secondary windings

of the magneto, the control coil and the various components of the associated control circuit. A ground wire 92 is connected to the stator core and a high tension conductor 94 is connected to the core unit and is used to connect the high tension side of the secondary magneto coil to a spark plug in a conventional manner. The coil unit 90 is also provided with an additional lead 96 for connection to a remote shut-off switch such as the switch 63 shown in the circuit diagram of FIG. 4, the conductor 96 corresponding to the lead shown in broken lines in FIG. 4.

The direction of rotation of the rotor 12 in FIG. 7 is counterclockwise, as shown by the arrow. The operation of the magneto is generally similar to that of the magneto of FIG. 1, except that during the initial period of build up of flux in the leading pole 82 the flux is established only by leakage back to the trailing pole shoe 48 in the rotor. This means that the flux is not built up to as high a level as it is in the three pole core of FIG. 1, and therefore, during the period of flux reversal the total flux change in the leading pole 82 will be somewhat less than in the center pole of the FIG. 1 magneto. Nevertheless, this, or a similar, two poled core construction may be used where absolute minimum weight is of great importance and where low speed operation of the magneto is of little importance. This, for example, is often true in the case of chain saw engines which are normally cranked from 1,000 to 1,500 r.p.m., whereas other engines, such as those used for outboards and lawn mowers, generally have cranking speeds as low as 200 r.p.m.

FIG. 8 shows a magneto construction which is essentially the same as that shown in FIG. 8 except that in place of the coil unit 90, it includes a different coil unit 98 housing only the primary and secondary coils of the magneto and the control coil of the control circuit. The components of the associated control circuit are housed in a separate capsule 100 attached to the stator core 80 by a bracket 102. The ungrounded sides of the primary magneto coil and the control coil are connected to the capsule 100 by a suitable conductor 104, and also connected to the capsule is a conductor 96 for cooperation with a remote shut-off switch.

The invention claimed is:

1. In a magneto ignition system, the combination comprising a stator core, a magneto coil mounted on said stator core, means providing a circuit passing through said magneto coil, a rotor having a permanent magnet for producing a varying flux through said stator core, an electronic control circuit for opening and closing said circuit through said magneto coil to permit and interrupt the flow of current therethrough, said electronic control circuit including an electronic switch and a control coil mounted on said stator core so that the flux produced by said permanent magnet and which passes through said magneto coil also passes through said control coil throughout at least a portion of each revolution of said rotor to induce a trigger signal therein for triggering said electronic switch device which trigger signal is in phase with the signal induced in said magneto coil.

2. The combination defined in claim 1 further characterized by said stator having a pole on which both said magneto coil and control coil are mounted.

3. The combination defined in claim 1 further characterized by said stator having two angularly spaced poles both of which during a portion of each revolution of said rotor in combination with each other form part of a circuit for the flux established by said magnet, said magneto coil being mounted on one of said two poles and said control coil being mounted on the other of said two poles.

4. The combination defined in claim 1 further characterized by said electronic switch device being a transistor having base, emitter and collector terminals, said transistor being connected in series with said magneto coil through said emitter and collector terminals, and circuit

means connecting said control coil with said base terminal so that said transistor is biased to its conducting or nonconducting states by the voltage induced in said control coil.

5. The combination defined in claim 4 further characterized by said control circuit including a shunt circuit connected to said base terminal for shunting any ON-biasing signal therefrom when the voltage across said magneto coil exceeds a predetermined value.

6. In a magneto, the combination comprising a stator core, a magneto coil mounted on said stator core, a rotor rotatable relative to said stator core and including a permanent magnet for producing a magnetic flux through said stator core and said magneto coil which flux varies periodically in synchronism with the rotation of said rotor and which throughout one small portion of each revolution of said rotor undergoes a period of rapid change so as to induce a voltage in said magneto coil which rises from one value to another peak value throughout a portion of said period of rapid flux change, an electronic switch device connected in series with said magneto coil which electronic switch device may be electrically switched to either a relatively conducting state or a relatively nonconducting state in which states said device serves to respectively permit and interrupt the flow of current through said primary coil, and a control circuit connected with said electronic switch device for controlling said switch device in such a manner that it is maintained in its conducting state throughout a major portion of the period of said rising induced magneto coil voltage and is switched to its nonconducting state near the end of said period of rising induced magneto coil voltage, said control circuit including a control coil separate from said magneto coil and mounted on said stator core with said magneto coil so that throughout at least a part of said one small portion of each revolution of said rotor the circuit for the flux produced by said permanent magnet passes through both said magneto coil and through said control coil to induce a trigger signal in said control coil for triggering said electronic switch device which trigger signal is in phase with the signal induced in said magneto coil.

7. The combination defined in claim 6 further characterized by said stator core having three poles spaced angularly of said rotor, said permanent magnet being arranged to provide angularly spaced north and south magnetic poles on said rotor so that as said rotor is rotated a magnetic flux is established in said stator core which first passes through the leading and the middle ones of said stator core poles and then passes through the middle and the trailing ones of said stator core poles with the flux in said middle stator core pole being first in one direction and then in the opposite direction to provide said period of rapid flux change, and said magneto coil and said control coil both being mounted on said middle one of said stator core poles.

8. The combination defined in claim 7 further characterized by a secondary magneto coil also received on said middle one of said stator core poles, a housing carried by said middle one of said stator core poles which housing receives said first-mentioned magneto coil, said secondary magneto coil, said control coil and said electronic switch device, and a quantity of potting material received in said housing and surrounding the parts contained therein.

9. The combination defined in claim 6 further characterized by said stator core having three poles spaced angularly of said rotor, said permanent magnet being arranged to provide angularly spaced north and south magnetic poles on said rotor so that as said rotor is rotated a magnetic flux is established in said stator core which first passes through the leading and the middle ones of said stator core poles and then passes through the middle and the trailing ones of said stator core poles with the flux in said middle stator core pole being first in one direction and then in the opposite direction to provide said period of rapid flux change, said magneto coil being mounted on

said middle one of said stator core poles, and said control coil being mounted on one of the other two of said stator core poles.

10. The combination defined in claim 6 further characterized by said electronic switch device being a transistor having first and second terminals across which said transistor is connected in series with said primary coil, said transistor also having a third terminal and being biased to its conducting state when the voltage existing between said first and third terminals falls within one range of values and to its nonconducting state when said latter voltage falls within another range of values, and said control circuit including a circuit connected between said first and third transistor terminals for impressing a voltage therebetween which varies in accordance with the voltage induced in said control coil.

11. The combination defined in claim 10 further characterized by said control circuit comprising solely said control coil and a resistor connected in series with each other across said first and third terminals of said transistor.

12. The combination defined in claim 11 further characterized by said stator core having three poles spaced angularly of said rotor, said permanent magnet being arranged to provide angularly spaced north and south magnetic poles on said rotor so that as said rotor is rotated a magnetic flux is established in said stator core which first passes through the leading and the middle ones of said stator core poles and then passes through the middle and the trailing ones of said stator core poles with the flux in said middle stator core pole being first in one direction and then in the opposite direction to provide said period of rapid change of flux, said magneto coil being mounted on said middle one of said stator core poles and said control coil being mounted on the leading one of said stator core poles.

13. The combination defined in claim 10 further characterized by said control circuit comprising a first circuit connected between said first and third terminals which first circuit includes said control coil, a shunt circuit connected between said first terminal and a point on said first circuit between said control coil and said third terminal, said shunt circuit including a second electronic switch device which may be electrically switched to either a relatively conducting state or a relatively nonconducting state, and means for controlling said second electronic switch device in accordance with the voltage appearing across said magneto coil.

14. The combination defined in claim 13 further characterized by said second electronic switch device comprising a second transistor having first and second terminals through which said second transistor is connected to said shunt circuit as a series element thereof, said second transistor also having a third terminal connected to said means for controlling it in accordance with the voltage appearing across said magneto coil.

15. The combination defined in claim 14 further characterized by said first circuit including a resistor between said control coil and said third terminal of said first-mentioned transistor, said second transistor having its first terminal connected to said third terminal of said first transistor and its second terminal connected to said first terminal of said first transistor, and said means for controlling said second transistor in accordance with the voltage appearing across said magneto coil comprising a circuit connected between said third terminal of said second transistor and a point on said first circuit between said control coil and said resistor which latter circuit includes a controlled rectifier connected as a series element thereof and having a control terminal, and a circuit connecting said control terminal of said controlled rectifier to said first terminal of said first transistor.

16. The combination defined in claim 15 further characterized by said stator core having three poles spaced angularly of said rotor, said permanent magnet being

arranged to provide angularly spaced north and south magnetic poles on said rotor so that as said rotor is rotated a magnetic flux is established in said stator core which first passes through the leading and middle ones of said stator core poles and then passes through the middle and the trailing ones of said stator core poles with the flux in said middle stator core pole being first in one direction and then in the opposite direction to provide said period of rapid flux change, and said magneto coil and said control coil both being mounted on said middle of one of said stator core poles, said control coil and said magneto coil being positioned at different points along the length of said middle stator pole with said control coil being closer to said rotor than said magneto coil so that the voltage induced in said control coil during said period of rapid flux change is slightly ahead of the voltage induced in said magneto coil.

17. The combination defined in claim 6 further characterized by said permanent magnet and stator core being so constructed and arranged that as said rotor is rotated relative to said stator core a magnetic flux is established in said stator core which in one part of said stator core undergoes said period of rapid flux change throughout one small portion of each revolution of said rotor, said magneto coil and said control coil both being mounted on said one part of said stator core so that during said period of rapid flux change voltages are induced in both said magneto coil and in said control coil which induced voltages are substantially in phase with one another, said electronic switch device comprising a transistor having first and second terminals across which said transistor is connected in series with said magneto coil, said transistor also having a third terminal and being biased to its conducting state when the voltage existing between said first and third terminals falls within one range of values and to its nonconducting state when said latter voltage falls within another range of values, and said control circuit comprising a first circuit including said control coil connected between said first and third transistor terminals for biasing said transistor to its conducting state as a result of the voltage induced in said control coil during the initial part of said period of rapid flux change, a shunt circuit connected between said first and third transistor terminals and including another electronic switch device, and means for controlling said latter electronic switch device in response to the voltage appearing across said magneto coil and in such a manner that said latter device is maintained in its nonconducting state during the initial portion of said period of rapid flux change and is switched to its conducting state when the voltage across said magneto coil rises to a predetermined value.

18. The combination defined in claim 6 further characterized by said stator core having only two poles spaced angularly of said rotor, said control coil and said magneto coil both being mounted on the same one of said two poles.

19. The combination defined in claim 1 further characterized by a housing received on a part of said stator coil and receiving both said magneto coil and said control coil, the components of said electronic control circuit also being contained within said housing.

20. The combination defined in claim 1 further characterized by said stator core having only two angularly spaced poles, said control coil and said magneto coil both being mounted on the same one of said two poles.

21. A breakerless ignition system for use with an engine employing a spark gap ignition device, said ignition system comprising a spark gap ignition device; means for generating electrical energy used to produce a spark at said spark gap ignition device, said means including a rotor adapted to be rotated in synchronism with the operation of the engine with which said spark gap ignition device is associated, a magnet assembly fixed to said rotor, said magnet assembly including a permanent magnet and

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two pole pieces each associated with and engaging a respective one of the two poles of said permanent magnet and each having a pole face extending along a circular path coaxial with said rotor so that as said rotor is rotated said pole faces are moved around said circular path, said two pole faces being angularly spaced from one another along said circular path, and a first coil positioned adjacent said circular path so as to have a changing voltage induced therein by said two pole faces of said magnet assembly during each revolution of said rotor; a triggering coil; and a control means electrically connected to said first coil and said triggering coil for controlling the application of said electrical energy to said spark gap ignition device in response to the voltage across said triggering coil, said triggering coil also being located adjacent said circular path so that said two pole faces of said magnet assembly during each revolution of said rotor also induce a changing voltage therein to operate said control means.

22. A breakerless ignition system as defined in claim 21 further characterized by a stator of magnetic material

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located adjacent said circular path and providing a low reluctance flux path for the flux of said permanent magnet as said magnet passes thereby, both said first coil and said triggering coil being mounted on said stator.

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U.S. Cl. X.R.

20 123—148, 149; 310—70; 315—218

UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,484,677 .Dated December 16, 1969

Inventor(s) Michael J. Piteo

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

Col. 3, line 35, after "OFF-biasing," omit --a--.  
Col. 4,  
line 56, "including" should read --inducing--; line 68,  
"dlevise" should read --device--.  
Col. 5, line 22, "shuts" should read --shunts--.  
Col. 7, line 49, "an an" should read --and an--;  
line 68, "mounted one" should read --mounted on--.  
Col. 8, line 28, "maner" should read --manner--;  
line 31, "noncnducting" should read --nonconducting--.  
Col. 9, line 3, "polies" should read --poles--;  
line 48, "oil" should read --coil--.  
Col. 10, line 7, "ine" should read --in--; line 51,  
"soil" should read --coil--.

SIGNED AND  
SEALED  
JUN 16 1970

(SEAL)

Attest:

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Attesting Officer

WILLIAM E. SCHUYLER, J  
Commissioner of Patent