BREAKERLESS IGNITION SYSTEM WITH MAGNETO SUPPLY AND TRANSISTOR CONTROLS
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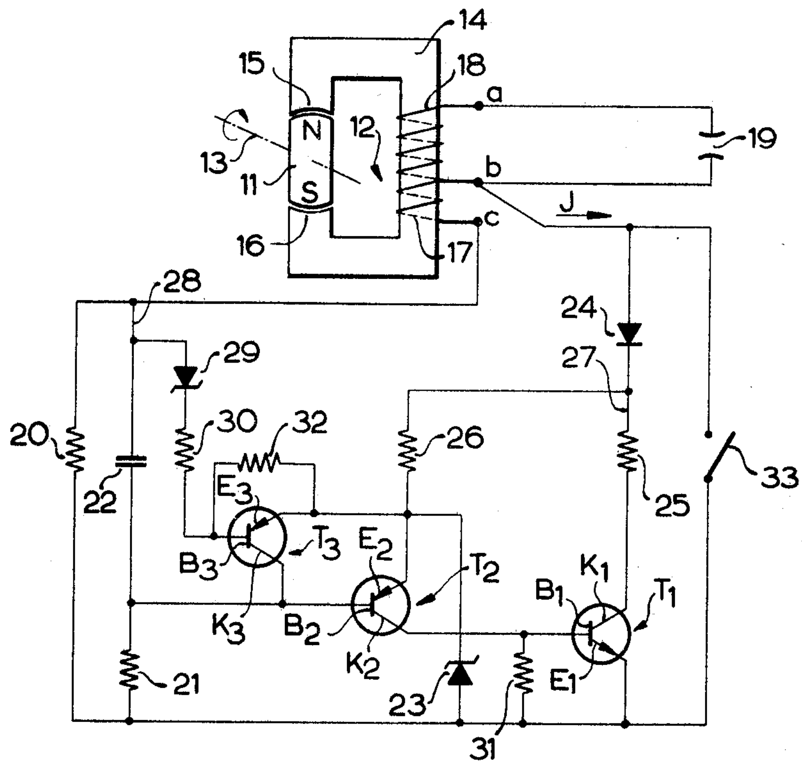

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BREAKERLESS IGNITION SYSTEM WITH MAGNETO SUPPLY AND TRANSISTOR CONTROLS

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ABSTRACT OF THE DISCLOSURE

An ignition arrangement for internal combustion engines in which the ignition coil is mounted upon a ferromagnetic core terminating in two pole pieces. These pole pieces partially surround a permanent magnet which is rotatably driven through the crank shaft of the engine. As a result of the motion of the permanent magnet the amount of flux linking the ignition coil is varied so as to induce periodic impulses in the coil. The spark plug to be fired is applied across the secondary winding of the ignition coil. The primary winding of the coil is connected to an electronic circuit having a plurality of controlled switching elements which may be in the form of transistors. The emitter-collector path of a first one of such transistors is connected in series with the primary winding and serves to interrupt the primary circuit. The base of this first transistor is connected to the emitter-collector path of a second transistor so that the state of the second transistor determines the control potential of the first transistor. The base of the second transistor is coupled to a resistor-capacitor network which, in turn, is connected to the primary winding of the ignition coil. Through rotation of the permanent magnet, the circuit of the primary winding is periodically interrupted so as to induce voltage impulses in the secondary winding for firing the spark plugs. This interruption of the primary circuit is accomplished without the use of any mechanical or movable switching contacts.

BACKGROUND OF THE INVENTION

In the ignition arrangement of the present invention, the ignition energy is obtained from a magnetic system which is made movable relative to an ignition coil. At least one spark plug is applied across the secondary winding of the ignition coil. In the primary winding of the ignition coil, a voltage is induced through interruption of the primary winding in a manner requiring no contacts.

The present invention is in the class of magnetic ignition devices which are particularly applicable for powering the ignition arrangement without the use of any battery.

In conventional arrangements for magnetic ignition in internal combustion engines, the opening of the primary circuit of the ignition coil is accomplished through a mechanical interrupting switch which is actuated by a cam rotatably driven by the internal combustion engine. The contacts of the interrupting switch, however, become abraded or pitted and covered with oil films after an extended period of operation. This state of the contacts then results in unreliable operation of the ignition process.

In the German Patent 958,971 a magnetic ignition arrangement is disclosed in which the opening of the primary circuit of the ignition coil is accomplished without any moving contacts. A magnetically controlled semiconductor is provided, in connection with this arrangement, in which the ohmic resistance value is increased at the instant of ignition. Taking into account the structural

design of this semi-conductor, the latter is situated in a magnetic circuit. The flux of this magnetic circuit is varied through a movable magnetic member driven by the internal combustion engine. The arrangement is such that when the magnetic flux increases, the resistance magnitude of the semi-conductor increases.

A semi-conductor of this type is very temperature sensitive. However, in view of the condition that it is to be situated in the vicinity of a member moved and coupled by the internal combustion engine, it is necessary to locate the semi-conductor near the engine which becomes considerably heated. The operating characteristics of this semi-conductor are thereby influenced in an undesirable manner, since the ignition process can be commenced at an incorrect instant of time. It is not possible to locate the semi-conductor more remotely from the engine due to the prevailing magnetic stray fields. These stray fields will interfere with the realization of a satisfactory ignition voltage impulse at each time. Aside from this, the generation of the ignition voltage impulse is also influenced in an undesirable manner, since the primary circuit cannot be fully interrupted without the application of further measures. This is because the resistance of such a semiconductor can only be raised to a terminal value through such magnetic effects. As a result, the remaining current is compensated through considerable circuit complexity involving an increased number of circuit elements.

Accordingly it is an object of the present invention to provide an ignition arrangement in which the primary circuit of the ignition coil is also opened without movable contacts, but at the same time avoids the undesirable characteristics of the arrangement known in the art.

The object of the present invention is achieved through the application of a first controlled electronic switch for the purpose of opening the primary circuit of the ignition coil. The switching path of this first electronic switch is connected to a monitoring resistor. This resistor, in turn, is associated with a series circuit comprising a limiting resistor and a controlled capacitor. One terminal or electrode of this controlled capacitor is joined to one terminal of the monitoring resistor, and this junction is also connected to one terminal of the primary winding on the ignition coil. The other terminal of this primary winding is connected to the limiting resistor and the controlled electrode of a second controlled electronic switch. The switching path of this second electronic switch provides the controlled potential for the controlled electrode of the first electronic switch.

SUMMARY OF THE INVENTION

An ignition arrangement for internal combustion engines in which the voltage holds for firing the spark plugs of the engine is generated without the use of mechanical or moving contacts. The spark plug is applied across the secondary winding of an ignition coil. The primary winding of the ignition coil is wound upon the same ferromagnetic core and magnetically linked with the secondary winding. The ferromagnetic core terminates in two pole pieces surrounding a movable permanent magnet. This permanent magnet is mechanically coupled to the crank shaft of the engine and driven thereby. The circuit of the primary winding of the ignition coil includes a first controlled electronic switch which interrupts the primary circuit so as to induce a voltage impulse in the secondary winding. This controlled electronic switch can be in the form of a transistor in which the controlled electrode is the base and the switching path of the transistor is the emitter collector path. The primary circuit of the ignition coil also includes a monitoring resistor which is, in turn, connected to a series circuit consisting of a controlled capacitor and a limiting resistor. One terminal or electrode of the controlled capacitor is connected to the monitoring resistor as well as one terminal of the primary winding. The other terminal or electrode of the controlled capacitor is connected to the controlled electrode of the second controlled electronic switch which may also be in the form of a transistor. The switching path of this second electronic switch or transistor is connected to the controlled electrode of the first electronic switch. As a result, the switching path of the second electronic switch applies controlled potential to the first electronic switch. The arrangement is such that through the action of the rotating permanent magnet, the circuit of the primary winding becomes periodically interrupted without the use of moving switching contacts. The spark plugs applied across the secondary winding thus receive induced voltage impulses with high reliability.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

An electrical schematic diagram showing the electromagnetic members operating in conjunction with the electronic switching elements for providing voltage impulses to spark plugs, in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawing the ignition energy is derived in the arrangement of the present invention, through the combination of the magnetic system having a permanent magnet **11** moving relative to an ignition coil **12**. The magnet **11** is mechanically coupled to the internal combustion engine to a coupling linkage denoted by the dash-dot line **13**. By means of this mechanical coupling the permanent magnet **11** is rotated in correspondence with the speed of the internal combustion engine (not shown). The ignition coil **12** is wound upon a ferromagnetic core **14** which is mounted stationarily in relation to the magnet **11**. The ferromagnetic core **14** has pole pieces **15** and **16** surrounding partially the magnet **11**. The ignition coil **12** has a primary winding **17** and a secondary winding **18**. At the output terminals *a* and *b* of the secondary coil **18**, a spark plug **19** is connected. The essential circuit elements within the primary circuit of the primary winding **17**, include a first electronic control switch T_1 and a monitoring resistor **20**. The electronic switch T_1 has a switching path through the electrodes K_1 and E_1. The monitoring resistor **20** is connected across a switching path K_1–E_1 of the first electronic switch T_1. The direction of current flow is denoted by J. This denoted direction of effective current flow is to be assumed as that direction in which the current flows when the ignition process is in effect.

Connected across the monitoring resistor **20**, is a series circuit including a limiting resistor **21** and a control capacitor **22**. One terminal of the capacitor **22** is joined to one terminal of the monitoring resistor **20**, and the junction is, in turn, connected to one terminal *c* of the primary winding **17**. The other terminal of the capacitor **22** is connected to both the resistor **21** and the control electrode B_2 of a second electronic control switch T_2. This second electronic switch has a switching path E_2–K_2, which provides control potential for the control electrode B_1 of the first electronic switch P_1.

A switching element **23** is connected across the terminal E_1 of the first electronic switch T_1, and the terminal E_2 of the second electronic switch T_2. This switching

element **23** conducts current only when the applied voltage has a predetermined value or level. A Zener diode may, for example, be used for the switching element **23**. One or more conventional diodes may, however, be used for this purpose when biased with corresponding threshold voltage.

A protective diode **24** is connected to the terminal *b* leading to the monitoring resistor **20** by way of the primary winding **17**. This terminal *b* is also a common terminal for the secondary winding **18**. A control resistor **25** is connected between the diode **24** and the terminal K_1 of the first electronic switch T_1. A second control resistor **26** is connected to the electrode E_2 of the second electronic switch T_2 and to the junction between the diode **24** and resistor **25**. This junction is denoted by the reference numeral **27**. Through this arrangement of the resistor **26** the control potential for the first electronic switch T_1 is derived. The diode **24** serves as a protective means for the ignition arrangement by protecting the latter against inverted operation.

It is of particular advantage to proved a third electronic controlled switch T_3 in conjunction with the second electronic switch T_2. The switching path E_3–K_3 is connected in parallel or across electrodes E_2 and B_2 of the electronic switch T_2. The control electrode B_3 of the third electronic switch T_3 is connected to the junction of resistor **20** and capacitor **22**, by way of a switching element **29**. This junction of capacitor **22** and resistor **20** is denoted by the reference numeral **28**. A switching element **29** becomes conducting only when the applied voltage attains a predetermined value or level. A Zener diode is selected as an example for this purpose. It is desirable to connect a resistor **30** in series with a switching element **29**.

The ignition arrangement may be realized in a simple manner by making the first electronic switch T_1 as an npn transistor. The second electronic switch T_2 is in the form of a pnp transistor, whereas the third electronic switch T_3 is also of the pnp transistor type. A resistor **31** is connected across the base-emitter path of the transistor T_1, while a resistor **32** is connected across the base-emitter path of the transistor T_3. These resistors **31** and **32** serve the purpose of establishing the magnitude of the controlled potentials for these transistors T_1 and T_3.

By closing the switch **33**, the ignition processes for the operation of the internal combustion engine can be initiated.

In operation, the magnet **11** moves with its north and south poles past the pole pieces **15** and **16** and thereby induces an increasing voltage in the ignition primary winding **17**. If this voltage is such that it tends to produce current flow in the direction J, then the increase in the voltage results in current flow through the protective diode **24**, the second control resistor **26**, the control path E_2–B_2 of the second electronic switch T_2, the limiting resistor **21**, and the monitoring resistor **20**. This current flow, in this manner functions to open the switching path E_2–K_2 of the second electronic switch T_2. Through the switching path E_2–K_2, the control potential of the control electrode B_1 of the first electronic switch T_1, is also increased in positive direction. As a result, the switching path K_1–E_1 of this electronic switch T_1 also becomes mildly conducting. Current can thereby also flow through the circuit path established by the protective diode **24**, the first control resistor **25**, the switching path K_1–E_1, and the monitoring resistor **20**. The potential of the junction point **28** is thus made negative, and this negative potential is transmitted, by way of the control capacitor **22**, to the control electrode B_2 of the second electronic switch T_2. Accordingly, the circuit path E_2–K_2 of the electronic switch T_2 is brought into the conducting state. Independent of this the switching path K_1–E_1 of the first electronic switch T_1 is also brought fully into the conducting state.

The control capacitor **22** is designed so that it is fully charged when the current in the primary winding of the ignition coil **12** attains the desired value for realizing the ignition spark. When the control capacitor **22** is fully charged, the potential of the control electrode B_2 of the second electronic switch P_2, increases rapidly in the positive direction. As a result, the switching path E_2–K_2 as well as the switching path K_1–E_1 of the first electronic switch T_1, becomes non-conducting or cut-off. This causes a momentary interruption in the primary circuit of the ignition coil **12**. In consequence of this, a high voltage impulse appears in the secondary winding **18** of the ignition coil **12**. This high voltage impulse produces an electrical jump at the electrodes of the spark plug **19**.

At the instant of interruption, however, the voltage in the primary winding **17** increases rapidly at the same time. It is necessary, therefore, to prevent the second electronic switch T_2 and thereby also the first electronic switch T_1, to again be turned on or brought into the conducting state. The switching element **23** is provided for this purpose.

The instant of ignition is established more precisely through the application of the third electronic swtch T_3 in conjunction with the switching element **29**. The switching element **29** assures that the primary circuit is always switched at one and the same magnitude of current. This results from the condition that the switching element **29** monitors the voltage across the resistor **20**, which depends upon the current in the primary circuit. At the instant that the predetermined voltage level has been attained, the switching element **29** becomes suddenly conducting. As a result, a negative potential appears at the control electrode B_3 of the third electronic switch T_3. This negative potential causes the switching paths E_3–K_3 of the switch T_3 to be in the conducting state. The control path E_2–B_2 of the second electronic switch T_2 is thereby short-circuited, and the switching path E_2–K_2 of this switch T_2 is cut-off or turned-off. The same situation prevails for the circuit switching path K_1–E_1 of the first electronic switch T_1, which is also turned-off or non-conducting. This is due to the interruption of the primary circuit of the ignition coil **12**, as described above.

If, as a result of slow rotation of the magnet **11**, the predetermined voltage level for the switching element **29** is not attained, the control capacitor **22** provides for interruption of the primary circuit.

The ignition arrangement, in accordance with the present invention, has the particular advantage that the instant of ignition is automatically advanced wih increase in speed of the internal combustion engine. This is due to the condition that when the rotational speed of the engine increases, the magnitude of the current at which interruption of the primary circuit is depended upon, is more rapidly attained.

The limiting of the current, furthermore, provides for greater operating safety of the ignition arrangement, since no dangerous excessive voltages can appear. In the exemplary embodiment, the magnet **11** is rotatable and the ignition coil **12** is designed as stationary. It is however considered to be within the frame of the present invention, that the magnet **11** be made stationary and the ignition coil **12** be made rotatable together with its ferromagnetic core **14**.

The disclosed embodiment, furthermore, is shown to have only one spark plug **19** within the secondary circuit of the ignition coil **12**. It is quite possible to provide also a plurality of such spark plugs which precede their ignition impulse in predetermined sequence through the application of a conventional ignition distributor.

Electronic vacuum tubes or semi-conductor controlled rectifiers can, furthermore, be provided in place of the transistors T_1, T_2 and T_3.

The magnetic system can furthermore, be provided with a plurality of magnets, The design can be arranged so that the magnets are mounted in the form of a conventional rotatable magnetic disc.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of ignition arrangement for internal combustion engines, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characterisics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. An ignition arrangement for internal combustion engines comprising, in combination, spark plug means to be fired by said ignition arrangement; ignition coil means having a primary winding and a secondary winding, said secondary winding being connected to said spark plug means; magnetic means linked magnetically with said ignition coil means and coupled to said engine so as to be moved relative to said ignition coil means; first controlled electronic switching means having a controlled electrode for controlling the current flow through the switching path of said switching means, said switching path interrupting the circuit of said primary winding; monitoring resistor means connected to the switching path of said first controlled electronic switching means; limiting resistor means and controlled capacitor means connected in series to form a series combination connected to said monitoring resistor means, one terminal of said capacitor means being connected to said monitoring resistor means and said primary winding of said ignition coil means; and second controlled electronic switching means having a controlled electrode connected to said limiting resistor means and the other terminal of said capacitor means, said second electronic switching means having a switching path connected to the controlled electrode of said first electronic switching means and applying controlled potential thereto, so that the circuit of said primary winding of said ignition coil means is interrupted as a function of the motion of said magnetic means.

2. The ignition arrangement for internal combustion engines as defined in claim **1** including a threshold switching means connected to the switching path of said second electronic switching means and conducting current only when the voltage potential applied to said threshold switching means attains a predetermined level.

3. The ignition arrangement for internal combustion engines as defined in claim **2** including protective diode means connected to said primary winding of said ignition coil means and to the switching path of said first electronic switching means; and control resistor means connected to said protective diode means and to the switching path of said first electronic switching means, said protective diode means and said control resistor means forming a series circuit with the switching path of said first electronic switching means.

4. The ignition arrangement for internal combustion engines as defined in claim **3** including second control resistor means connected to the switching path of said second electronic switching means and to the junction of said protective diode means and said first control resistor means.

5. The ignition arrangement for internal combustion engines as defined in claim **4** including third electronic switching means having a control electrode connected to the junction of said monitoring resistor means and said control capacitor means, the switching path of said third electronic switching means being connected to the switching path of said second electronic switching means and to the control electrode of said second electronic switching means; and auxiliary threshold switching means connected between the control electrode of said third electronic switching means and the junction of said monitoring resistor means and said control capacitor means, said auxiliary threshold switching means conducting current only when the applied voltage potential exceeds a predetermined level.

6. The ignition arrangement for internal combustion engines as defined in claim **5** including scaling resistor means connected in series with said auxiliary threshold switching means.

7. The ignition arrangement for internal combustion engines as defined in claim **3** wherein said first electronic switching means comprises an npn transistor and biasing resistor means connected between the emitter and base of said npn transistor.

8. The ignition arrangement for internal combustion engines as defined in claim **3** wherein said second electronic switching means comprises a pnp transistor.

9. The ignition arrangement for internal combustion engines as defined in claim **5** wherein said third electronic switching means comprises a pnp transistor and biasing resistor means connected between the emitter and base of said pnp transistor of said third electronic switching means.

10. The ignition arrangement for internal combustion engines as defined in claim **1** wherein said magnetic means comprises a permanent magnet rotated by said engine and varying the flux linkages through said ignition coil means.

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