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Haubner et al.

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[45] **July 15, 1975**

[54] **TRANSISTORIZED MAGNETO IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES**

[75] Inventors: **Georg Haubner**, Berg; **Walter Hofer**, Schwabach; **Peter Schmaldienst**, Nurnberg, all of Germany

[73] Assignee: **Robert Bosch G.m.b.H.**, Gerlingen, Schillerhohe, Germany

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Mar. 23, 1973 Germany 2314559

[52] **U.S. Cl.** .... **123/148 E;** 315/209
[51] **Int. Cl.**[2] **F02P 3/02**
[58] **Field of Search** ..... 123/148 E, 148 CD, 149 D; 310/70

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Primary Examiner—Wendell E. Burns
Assistant Examiner—James W. Cranson, Jr.
Attorney, Agent, or Firm—Flynn & Frishauf

[57] **ABSTRACT**

To control conduction of a semiconductor element, typically a transistor, in the primary circuit of an ignition coil, by rapidly blocking the conduction to generate a high voltage potential, a current sensitive element, typically a resistor of less than about one ohm is located in the primary circuit to provide a control signal depending on the current flowing through the primary, the resistor being connected in parallel with the control circuit of a switching transistor having its emitter-collector path connected in parallel with the control circuit of the ignition transistor. Preferably, the ignition transistor is a composite Darlington-connected transistor pair.

18 Claims, 2 Drawing Figures

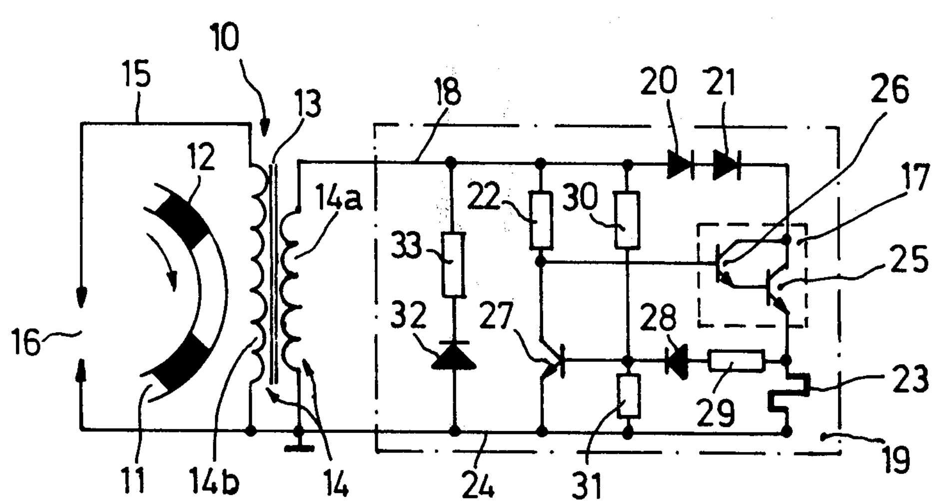

FIG. 1

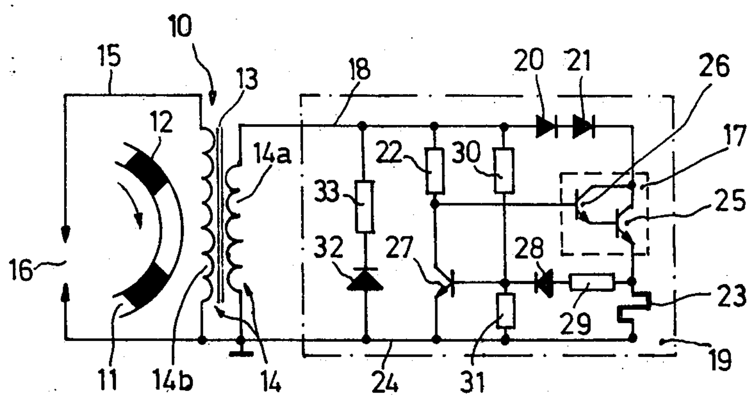
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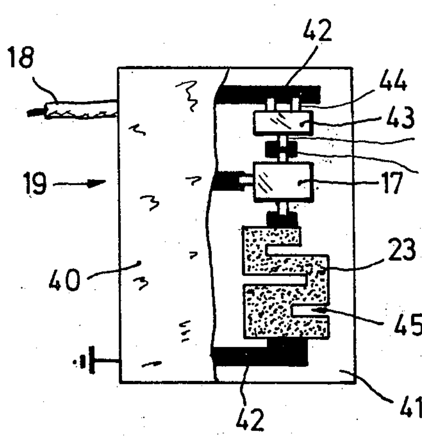
FIG. 2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TRANSISTORIZED MAGNETO IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES

The present invention relates to a semiconductor controlled magneto ignition system for internal combustion engines, and more particularly to such a system in which a magneto provides ignition energy as well as control signals to provide a high voltage pulse for the ignition spark, at a predetermined time.

Magneto ignition systems which are solid-state controlled have previously been proposed; usually, the primary circuit of a magneto ignition system is connected to the switching path of an electronic semiconductor element which, at the proper instant, is controlled by means of a control signal to change from current conductive state to blocking state. Ignition coil operated systems function by opening the primary circuit of the ignition system which, previously, was closed. The circuit element which opens the connection may be a breaker contact; in solid-state systems, an ignition transistor is usually used. The magnetic field due to the primary current, when the ignition transistor was in conductive state, then collapses and induces a high voltage pulse in the secondary winding, which is connected by means of the ignition cable to a spark plug to provide the ignition spark. The ignition transistor can readily be controlled from conductive to blocking state in ignition systems where batteries are used to supply ignition power, since the requisite control voltages can be obtained from the terminals of the battery. In battery-less magneto ignition systems, however, a strong magnetic field must be generated in the ignition coil to practically short-circuit the primary current loop thereof, requiring substantial control voltages to change the ignition transistor from conductive to blocking state, which substantial voltages must be obtained also from the magneto.

Control voltages to control the ignition transistor can be derived from additional pulse generators located in, or connected to the magneto system itself, which additional pulse generator provides the requisite control signal to break the primary current circuit, at the proper instant of time. Such additional pulse generators are comparatively expensive and require additional space and components.

Transistorized magneto ignition systems have also been proposed in which a resistor is connected in series to the ignition transistor. A capacitor is connected in parallel to the resistor. When a positive voltage half wave is sensed in the magneto armature, the ignition transistor is connected to be in conductive state, and the capacitor is charged due to the voltage drop across the resistor, upon current flow in the primary circuit of the ignition system. The voltage on the capacitor, at the proper ignition time, then controls a control transistor to change to blocked state and, in turn, interrupts the control circuit of the ignition transistor. The resistance in the circuit which is necessary is in the order of from 2–4 ohms, in order to provide sufficient control voltage to block the control transistor. This resistor, of this magnitude, then forms an undesired loading on the primary circuit, resulting in a decrease in the amplitude of the primary current, generating heat which must be removed, and limiting the magnetic field in the ignition coil during the positive half wave. The high voltage pulse derived from the ignition coil then is limited, or throttled, since a smaller magnetic field was initially present, so that the rate of change of the field will be less than that which can be obtained in the absence of the resistor.

It is an object of the present invention to provide a contactless (breakerless) solid-state magneto ignition system in which the level of the primary current to be interrupted at the ignition instant is essentially independent from the control circuit, and the elements thereof connected in the primary current loop of the ignition circuit.

SUBJECT MATTER OF THE PRESENT INVENTION

Briefly, an element is located in the primary current loop or circuit of the ignition system which provides a control signal to a control switch, typically a switching transistor, which is so connected that its emitter-collector path is connected in parallel to the control curcuit or control path (for example emitter-base) of the solid-state element, typically the ignition transistor, connected in the primary of the ignition circuit.

The invention will be described by way of example with reference to the accompanying drawings, wherein:

FIG. 1 is a general schematic circuit diagram of an ignition system of the present invention, in which the control path, or control circuit of the solid-state switch in the primary current loop is bridged by a control transistor; and

FIG. 2 is a fragmentary illustration of a portion of a printed circuit, including part of the circuits of FIG. 1, when made in multi-chip form.

The ignition system **10** of FIG. **1** is designed for a single-cylinder internal combustion engine. The ignition system **10** has a rotating system of magnets **11**, on which a plurality of uniformly distributed, alternately poled magnets **12** are placed. These magnets may, for example, be secured to the flywheel of the internal combustion engine (not shown) and be driven thereby. They cooperate with an ignition armature **13**, located on the housing of the internal combustion engine. The armature **13** has windings **14** thereon. The windings **14** are split into a primary **14***a*, and a secondary **14***b*. The secondary **14***b* is connected over an ignition cable **15** with the spark plug **16**. The primary **14***a* of the ignition armature **13** is connected to a primary circuit which includes a transistor unit **17**, connected as a pair of transistors **25, 26** in a Darlington circuit. One terminal of the primary **14***a*, as well as of the secondary **14***b* and of the spark plug **16** is connected to chassis or ground, forming a chassis bus **24**. The other terminal of the primary ignition coil **14***a* is connected to a primary ignition circuit connection **18** which connects to the electronics **19** of the ignition system. The connection **18** has two series connected diodes **20, 21** in series with the collector terminal of the transistor unit **17**. The base of the transistor unit **17** is connected over a resistor **22** with the anode of diode **20**, and hence with line **18**, and to the terminal of the primary winding **14***a* of the armature **13** which is not connected to chassis.

The primary circuit of the ignition system further includes a circuit element which provides a control signal which varies in dependence on the current flowing in the primary circuit. This element is a low-ohmic resistor **23**. Preferably it is in the order of about 0.5 ohm. The voltage across this small resistance provides a control signal when the primary current in the primary circuit loop which includes primary coil **14***a* has reached a certain value which is at the maximum, or close to the maximum of the current flow therein. The control resistor 23 is connected in series with the switching path, that is, the emitter-collector path of the main transistor 25 of the Darlington unit 17. The Darlington unit 17 itself includes an npn ignition transistor 25, the emitter-collector path of which is directly connected in the ignition loop, and a control transistor 26, the collector of which is connected to the collector of the transistor 25, and the emitter of which is connected to the base of the transistor 25. The control circuit of the transistor unit 17 is thus formed by the base of the auxiliary transistor 26 and the emitter of the ignition transistor 25.

A switching npn transistor 27 has its emitter-collector path connected in parallel to the circuit formed by the control circuit of the unit 17, in series with the resistor 23. The base of the switching transistor 27 is connected to the free terminal of the resistor 23, that is, to the terminal which is not connected to chassis but rather to the emitter of the transistor 25 of unit 17. A forwardly polarized diode 28 and a resistor 29 connect the base of the switching transistor 27 to the junction between resistor 23 and the Darlington unit 17. The base of the switching transistor 27 further is connected to the tap point of a voltage divider formed of resistors 30, 31 and connected across buses 18, 24, that is, in parallel to the primary coil 14*a*. The negative voltage half wave in the primary circuit of the system is bridged by a diode 32, in series with a resistor 33, and connected to be forwardly polarized with respect to the negative half wave.

Operation: Upon starting of the internal combustion engine, the magnet system 11 is rotated in the direction of the arrow, so that the permanent magnets 12 provide a change of magnetic flux in the armature 13, which therefore generates sequential positive and negative half waves. A positive half wave sensed in the primary winding 14*a* is transmitted over resistor 22 to the base of the Darlington transistor unit 17. The emitter of the unit 17 is connected to chassis over the resistor 23. As the voltage in the primary circuit rises, base current begins to flow which switches the transistor unit 17 into conductive state, since the unit 17 is connected to the chassis bus 24 over the resistor 23. The primary circuit is now closed over the diodes 20, 21, the emitter-collector (or main current) path of the ignition transistor 25 of unit 17, and the resistor 23. The voltage drop in the diodes 20, 21 which arises is merely that which is necessary to hold the transistor unit 17 in conductive state. The primary circuit is, practically, short-circuited and the current may rise to its maximum value which, in an example, is about 3A. The ignition armature current will provide a substantial armature reaction, however, causing the primary voltage to be sharply attenuated.

The voltage drop across the resistor 23 is connected over resistor 29 and diode 28 to the base of the switching transistor 27. When the primary current reaches a predetermined value, for example about 3A, transistor 27 responds, that is, the threshold level of the switching transistor 27 is exceeded and it begins to become conductive. The switching path of the switching transistor 27 is connected parallel to the control circuit of the transistor unit 17. Thus, the base current of the transistor unit 17 is increasingly short-circuited over the main current (emitter-collector) path of the switching transistor 27, so that less base current can be applied to the unit 17 which quickly will control the switching transistor 25 to change into blocked condition. As soon as the primary current decreases, primary voltage rises immediately and is transferred over resistors 30, 31 to the base of the switching transistor 27. As the voltage on the base of the switching transistor 27 rises, the transistor 27 quickly becomes conductive. In actual practice, transistor 27 will rapidly switch over to conductive state, which completely short-circuits the control path of the transistor unit 17, so that switching transistor 25 will block and the main switching path (emitter-collector) of the ignition transistor will abruptly and completely block and effectively become an open circuit. This substantial change in current flow — occurring rapidly — in the primary of the armature 13 provides a substantial change in field which is transformed by secondary 14*b* to a high voltage pulse which results in an ignition pulse and hence a spark at spark plug 16. The positive voltage plus arising in the primary 14*a* is not applied to the transistor 17, since the voltage divider 30, 31 has controlled transistor 27 to be conductive, thus effectively short-circuiting the control circuit, or control path of the transistor unit 17.

As the positive voltage half wave in the primary circuit decreases, the response level of the base of the switching transistor 27 will be passed in a negative direction, and switching transistor 27 will again block. This terminates bridging, or short-circuiting of the control path of the transistor unit 17. The subsequent negative voltage half wave is bypassed by diode 32 and resistor 33, which provide a load on the armature during the half wave of such extent that high voltages which might cause a misfire, or a stray pulse in the secondary winding 14*b* of the armature 13 are effectively suppressed.

The electronics 19 can be made as a single compact, replaceable unit, as seen in FIG. 2. An insulating carrier plate 41 is embedded in a potting compound 40, the carrier plate 41 carrying a printed circuit. Potting compound 40 is partly broken away to illustrate conductor strips 42, the resistor 23, as well as the transistor unit 17 and a diode unit 43 including diodes 20, 21. The diode unit 43, comprising the two diodes 20, 21, and the transistor unit 17 may be separate discrete components having connecting tabs 44, 44′ to form connections for the printed circuit conductors 42, and connecting strips 42′, to permit soldering or otherwise connection in a single integrated printed circuit unit. The resistor 23 is part of the printed circuit. It may be a thick-film element, or may be a thin-film element, depending on the method to make the printed circuit. The resistor 23 preferably is so constructed that its resistance value can be changed by removing indentations 45 therefrom, of greater or lesser extent, for example by removal of material by means of sand blasting, a laser beam, or the like.

Various changes and modifications may be made. The resistor 23 may, for example, be made from doped semiconductor material, which can be combined with further electronic elements of the ignition system in a single integrated circuit. This is a desirable alternative, since the temperature-dependent changes in resistance in the control circuit of the switching transistor 27 are thus effectively compensated. Temperature-dependent changes in resistance might otherwise result in undesirable change in the ignition timing, that is, in the instant at which ignition occurs with respect to the specific rotary position of the engine, and hence the magnetic system **11**. Forming resistor **23** as a semiconductor element having a suitable temperature coefficient can then effectively compensate temperature-dependent changes in the switching transistor **27**. The resistor **23** is then formed of a plurality of pn junctions. The resistance of resistor **23** is, preferably, less than about 1 ohm, and desirably in the order of about ½ ohm, or so.

The ignition armature **13** may be made without a high voltage winding. This arrangement is desirable if space adjacent the rotating element **11** of the internal combustion engine is a premium. A separate ignition coil is then needed, the primary winding of which is connected in circuit with the armature. The transistor unit **17** and the switching transistor **27** may also be replaced by various other electronic elements or systems. The necessary feature of the present invention, that is, switching a switching transistor in dependence on a control signal derived from the primary current must be maintained, the switching transistor having its main current path connected in parallel to the control path of the main controlling semiconductor element, that is, the element corresponding to transistor unit **17** in the primary current circuit or loop of the ignition system.

Various other changes and modifications may be made within the scope of the inventive concept.

We claim:

1. Magneto ignition system for internal combustion engine having rotating magnet means and a primary winding coupled thereto to generated electrical ignition energy therein; a secondary winding connected to the primary winding to generate ignition spark energy, for connection to a spark plug of the internal combustion engine; and an ignition control circuit connected to the primary winding comprising

switching semiconductor means (**17**; **25**, **26**) having its main current-carrying path connected in series with the primary windins (**14***a*);

a controlled switching semiconductor (**27**) having its main current-carrying path connected in parallel to the circuit including the control electrode of the switching semiconductor means (**17**) to bypass current therethrough;

and means (**23**) sensing current flow through the primary winding, said current flow sensing means (**23**) being connected to the control electrode of said switching semiconductor means (**17**; **25**, **26**), to control the switching semiconductor means (**17**; **25**, **26**) by said sensing means (**23**) to become conductive when the sensing means senses current flowing at a predetermined level in the primary winding and through the switching semiconductor means.

2. System according to claim **1**, wherein the switching semiconductor means (**17**; **25**; **26**) and the controlled switching semiconductor (**27**) both comprise a transistor.

3. System according to claim **2**, wherein the control transistor (**27**) and the current sensing means (**23**) are relatively arranged and connected such that the control transistor becomes conductive at, or just below the maximum current flow through the main current path of the switching transistor means (**17**).

4. System according to claim **2**, wherein the sensing means comprises a resistor of up to about 1 ohm resistance, the voltage drop across the resistor forming a sensing signal connected to and controlling the control electrode of said control transistor (**27**).

5. System according to claim **4**, wherein the resistance of said resistor is in the order of about ½ ohm.

6. System according to claim **2**, wherein the switching transistor means comprises a transistor unit connected in a Darlington circuit.

7. System according to claim **6**, wherein the sensing means comprises a resistor in the order of up to about 1 ohm resistance, connected to chassis of the system with one terminal and to the Darlington-connected transistor unit with the other terminal.

8. System according to claim **2**, wherein the control switching transistor (**27**) has its base connected to the sensing means, said sensing means comprising a resistor connected to chassis with one terminal, and to the base of the control transistor with the other terminal.

9. System according to claim **8**, further comprising a diode (**28**) connected between the base of the control transistor (**27**) and the other terminal of the resistor (**23**), the diode being poled in conductive direction from the resistor (**23**) to the control transistor base.

10. System according to claim **8**, further comprising a resistor (**29**) connected between the base of the control transistor (**27**) and the other terminal of the resistor (**23**) forming the sensing means.

11. System according to claim **9**, further comprising a resistor (**29**) connected in series with the diode (**28**).

12. System according to claim **8**, further comprising a voltage divider (**30**, **31**) connected across the primary winding (**14***a*) and in parallel thereto, the tap point of the voltage divider being connected to the base of the control transistor (**27**).

13. System according to claim **2**, wherein the sensing means (**23**) comprises temperature responsive resistance means having a temperature coefficient which matches the temperature coefficient of the control transistor (**27**) to compensate temperature effects in the system.

14. System according to claim **1**, wherein the sensing means comprises resistance means (**23**) which includes doped semiconductor material, having a resistance in the other of up to about 1 ohm.

15. System according to claim **14**, wherein the control resistor (**23**) comprises a plurality of pn - junctions.

16. System according to claim **1**, wherein the sensing means comprises a resistor in the order of up to about 1 ohm formed as part of a printed circuit as a resistor film.

17. System according to claim **15**, wherein the resistor is formed as a resistor mass on the printed circuit, the resistance of which is adjusted by removing portions of said resistance mass.

18. System according to claim **14**, wherein the doped semiconductor material, and at least the switching semiconductor means form part of an integrated circuit.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,894,525

DATED : July 15, 1975

INVENTOR(S) : Georg HAUBNER et al

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

Claim 1, Column 5, lines 48, 49 change "con-ductive"to --non con-ductive --

Signed and Sealed this

Fourth Day of November, 1986

[SEAL]

Attest:

DONALD J. QUIGG

Attesting Officer

Commissioner of Patents and Trademarks