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INTERNAL COMBUSTION ENGINE IGNITION SYSTEM

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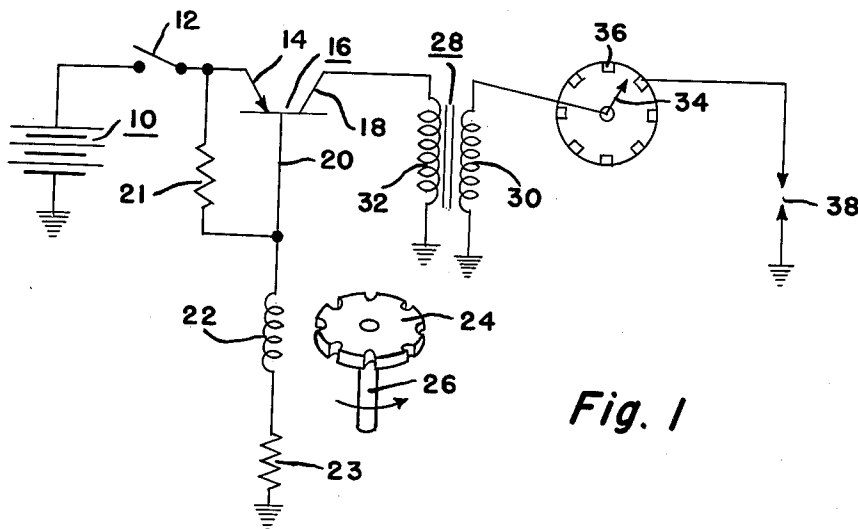


Fig. 1

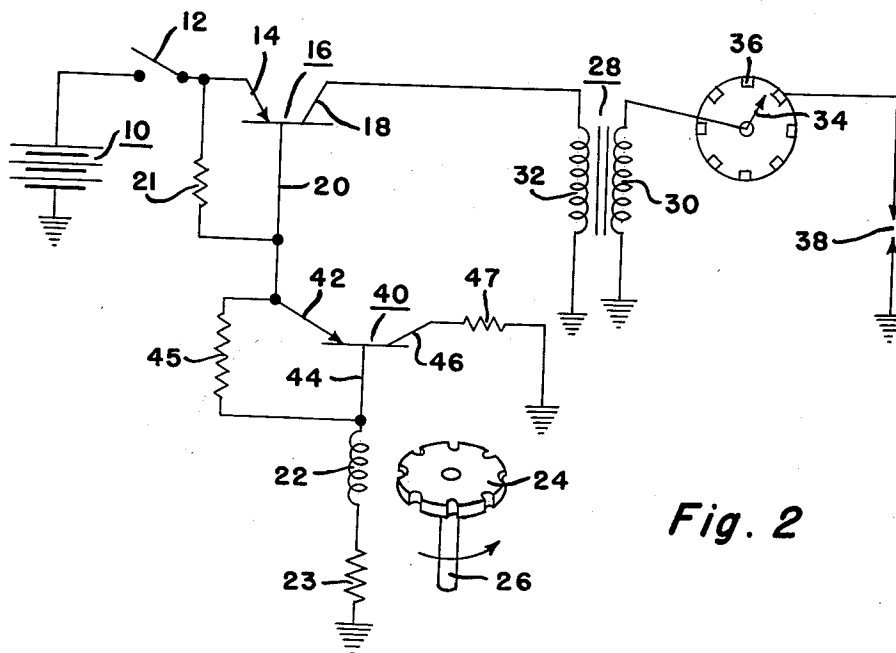


Fig. 2

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INTERNAL COMBUSTION ENGINE IGNITION SYSTEM

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This invention relates to ignition systems for internal combustion engines and more particularly to an ignition system that employs a semi-conductor such as a transistor for controlling the current flow through the primary winding of an ignition coil.

In some ignition systems, for example, of the type shown in the patent to Giacoletto, 2,878,298, breaker points have been employed to control the conductivity of the transistor connected with the primary winding of an ignition coil. In another type of ignition system, illustrated in French patent, 1,137,949, and in the patents to Hartman, 2,852,588, and to Johnson, 2,852,589, a pulse generator is used to control the conductivity of a transistor connected with the primary winding of an ignition coil.

The present invention relates to an improved system of the type illustrated in the French patent, that is, a system where no breaker points are used in controlling the conduction of the transistor or semi-conductor.

It accordingly is an object of this invention to provide an ignition system for an engine wherein a transistor or other semi-conductor that controls primary winding current flow is normally biased to its conductive condition by the D.C. power source available on a motor vehicle and is rendered periodically non-conductive by a pick-up coil connected in the base circuit of the transistor and developing pulses of voltage as a permanent magnet passes the pick-up coil, the permanent magnet being driven by a distributor shaft that is in turn driven by the engine.

A more specific object of this invention is to provide an ignition system for an internal combustion engine including a transistor having an emitter-collector circuit connected between a power source, such as a battery, and the primary winding of an ignition coil, and further wherein a coil is placed in the base circuit of the transistor which has pulses of voltage induced therein as a permanent magnet passes the coil. In carrying this object forward, the transistor is biased to conduction by the battery and only becomes non-conductive when a pulse of voltage is generated in the coil.

Still another object of this invention is to provide an ignition system for an internal combustion engine wherein a transistor controls the current flow through the primary winding of an ignition coil and wherein the conduction of this transistor is controlled by a second transistor having its conductivity controlled by a pulse generating unit such as a coil that has pulses of voltage generated therein as a permanent magnet is moved with respect to the coil.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein preferred embodiments of the present invention are clearly shown.

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In the drawings:

Referring now to the drawings, FIGURE 1 is a schematic electrical diagram of an ignition system made in accordance with this invention.

FIGURE 2 is a schematic diagram of a modified ignition system made in accordance with this invention.

Referring now to the drawings and more particularly to FIGURE 1, the reference numeral 10 designates a storage battery which forms the power source for the ignition system of this invention. It will of course be appreciated that the storage battery may be charged from a suitable generator not shown on the motor vehicle and that under certain conditions the generator will supply power for the ignition system.

The storage battery 10 is connected with an ignition switch 12, and it is seen that one side of the ignition switch is connected with the emitter electrode 14 of a p.n.p. transistor generally designated by reference numeral 16. The transistor 16 has a collector electrode 18 and a base electrode 20.

The base electrode 20 of transistor 16 is connected with a coil 22 which has pulses of voltage generated therein by a rotatable permanent magnet assembly 24 which is connected with a distributor shaft 26. The permanent magnet assembly 24 may be formed for example with 8 pole tips in the case of an eight cylinder engine; and, as the distributor shaft 26 is rotated, pulses of voltage will be generated periodically in the coil winding 22. The distributor shaft 26 is of course driven by the engine and it thus can be seen that pulses of voltage will be generated in coil 22 which are an indication of the positioning of the crank shaft of the engine. As will become more readily apparent hereinafter, the pulses of voltage which are generated in the coil 22 are used to time the spark impulses applied to a spark plug.

The coil 22 is connected in series with a resistor 23, and it is seen that one side of this resistor 23 is grounded. A resistor 21 connects the emitter and base electrodes of transistor 20 to prevent open base operation of the transistor and possible damage thereto. From the circuit as thus far described, it can be seen that with the ignition switch 12 closed, the battery 10 is connected across the emitter and base circuit of transistor 16 and across the coil 22 and the resistor 23.

In FIGURE 1, the reference numeral 28 generally designates an ignition coil having a secondary winding 30 and a primary winding 32. The primary winding 32 is connected with the collector electrode 18 of the transistor and is also connected to ground as is shown. The secondary winding 30 has one side thereof connected to ground and has an opposite side thereof connected with a rotor contact 34 of the distributor. The rotor contact 34 cooperates with the contacts 36 formed in the distributor cap and the various contacts 36 are connected with spark plugs which fire the combustible mixture in the internal combustion engine. From FIGURE 1, it is seen that 8 distributor cap contacts 36 are illustrated and one of these is shown connected with a spark plug 38. It is to be understood that the other distributor cap contacts 36 are likewise connected with spark plugs and that the rotor contact 34 thus serves to supply spark impulses to the spark plugs 38 as it rotates. As in conventional practice, the shaft 26 of the distributor also rotates the rotor contact 34.

In the operation of the ignition circuit illustrated in

FIGURE 1, when the ignition switch 12 is closed, the primary winding 32 of the ignition coil will be immediately supplied with current. The reason for this is that the power source 10 biases the emitter and base circuit of transistor 16 in such a fashion that the transistor becomes substantially conductive from emitter to collector. In this connection, it is to be pointed out that the resistance of the coil winding 22 and the resistor 23 are so selected that enough base current flows to cause the transistor 16 to become fully conductive from emitter to collector whenever the ignition switch 12 is closed.

If the engine is now cranked by a suitable starter, not shown, it will be apparent that the permanent magnet assembly 24 will be rotated as well as the rotor contact 34. With the permanent magnet assembly 24 rotating, pulses of voltage are generated in the coil 22 and these pulses of voltage oppose the flow of current in the base circuit and thus periodically cut off conduction of the transistor between emitter and collector. When the transistor 16 becomes non-conductive between emitter and collector, a high voltage is generated in the secondary winding 30 which is transferred to the spark plug 38 via the rotor contact 34 to cause a spark to jump across the electrodes of the spark plug. It thus is seen that the transistor 16 is always conductive except when the ignition switch 12 is open and during the time when a pulse of voltage is induced in the coil winding 22. It will, of course, be appreciated that the pulses of voltage induced in the coil winding 22 are periodic and vary in accordance with the rotation of the distributor shaft 26. It thus is seen that the spark impulses to the spark plugs will be properly timed by the rotation of the permanent magnet assembly 24.

Although a transistor has been illustrated for controlling the current flow to the primary winding 32 of the ignition coil, it will be appreciated that any other semiconductor having a pair of current carrying terminals and a control terminal could be used in place of the transistor.

Referring now to FIGURE 2, a modified ignition system for an internal combustion engine is illustrated. In this figure, the same reference numerals have been used to identify the same parts as those used in FIGURE 1. In the circuit of FIGURE 2, a second transistor generally designated by reference numeral 40 is employed which has an emitter electrode 42, a base electrode 44 and a collector electrode 46. It can be seen that the base electrode 20 of transistor 16 is connected with the emitter electrode 42 of transistor 40. The collector electrode 46 of transistor 40 is connected to ground through resistor 47 while the base electrode 44 is connected to one side of the coil 22 which has voltage pulses induced therein by rotation of the permanent magnet assembly 24. A resistor 45 connects the emitter and base electrodes of transistor 40 and serves the same purpose as resistor 21.

In the operation of the circuit illustrated in FIGURE 2, transistors 16 and 40 will both be conductive between emitter and collector when the ignition switch 12 is closed. The transistor 16 will be conductive at this time since its base current is determined by the conductivity of the emitter to collector circuit of transistor 40. It thus is seen that with the ignition switch 12 closed, current builds up in the primary winding 32 of the ignition coil 28. When a pulse of voltage is generated in the coil 22 tending to oppose the base current flow from the base of transistor 40, the transistor 40 has its conduction reduced or becomes substantially non-conductive between emitter and collector. Since the transistor 40 controls the base current of transistor 16, the base current of transistor 16 will be substantially cut off to likewise cut off conduction between emitter 14 and collector 18. This will then serve to substantially open a circuit between battery 10 and the primary winding of ignition coil 32 and a pulse of voltage will be generated in the secondary winding 30 which is applied to rotor 34 and to the spark plug 38. The continued generating of pulse type voltages in the

coil 22 will thus serve to periodically turn off the transistor 16 to cause a proper firing of the spark plugs 38.

The system of FIGURE 2 has certain advantages over the system of FIGURE 1 in that less triggering voltage is required in order to turn off the transistor 16. This makes it possible to simplify the magnetic triggering system including the permanent magnet 24 and the coil winding 22.

While the embodiments of the present invention as herein disclosed, constitute a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. An ignition system for igniting the combustible mixture in an internal combustion engine comprising, a source of unidirectional power, a transistor having emitter, base and collector electrode, an ignition coil having a primary winding and a secondary winding, a spark plug connected with the secondary winding of said ignition coil, a pulse generating device having a coil winding, a breakerless biasing circuit for said transistor normally rendering it conductive between emitter and collector energized across said power source and including in a series connection the emitter to base circuit of said transistor, and said coil winding, and means connecting the collector electrode of said transistor with the primary winding of said ignition coil.
2. An ignition system for controlling the firing of a spark plug in an internal combustion engine comprising, a source of unidirectional power, a transistor having emitter, base and collector electrodes, an ignition coil having a primary winding and a secondary winding, a base current controlling resistor, means connecting the secondary winding of said ignition coil with said spark plug, a pulse generating device including a coil winding, means connecting said emitter electrode with one side of said power source, means connecting the base electrode of said transistor in series with said coil winding and said base current controlling resistor, and means connecting the collector electrode of said transistor with the primary winding of said ignition coil.
3. An electrical ignition system for causing a spark plug to be fired in an internal combustion engine comprising, a source of power, a transistor having emitter, base and collector electrodes, an ignition coil having a primary winding and a secondary winding, means connecting said secondary winding with said spark plug, a pulse generating device including a coil winding and a member, one of which is rotatable in synchronism with said engine, a breakerless biasing circuit for said transistor rendering it normally conductive energized across said power source and including a series connection, the emitter to base circuit of said transistor, said coil winding and a resistor, the resistance of the circuit connected with said base electrode being of such a value that said transistor is normally conductive between emitter and collector, the voltage output of said coil winding being sufficient to reduce the current flow through said base circuit to a value to render said transistor substantially non-conductive between emitter and collector when a pulse of voltage is induced in said coil winding, and means connecting the collector electrode of said transistor with the primary winding of said ignition coil.
4. An ignition system for causing a firing of a spark plug in an internal combustion engine comprising, a direct current power source, a three terminal semiconductor having a pair of current carrying terminals and a control terminal, the conductance of said semiconductor between said current carrying terminals being a function of the current flow in a circuit connected with said control terminal, an ignition coil having a primary winding and a secondary winding, means connecting said secondary winding with said spark plug, means connecting one of said current carrying terminals with the primary winding of said ignition coil, a pulse generating device including a coil winding and a magnetic member

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that is rotatable in synchronism with said engine, and a circuit for normally biasing said semi-conductor to its conductive state between its current carrying terminals including in a series connection said power source, one of said current carrying terminals, said control terminal and said coil winding, the voltage pulses generated in said coil winding being sufficient to cause temporary non-conduction between the current carrying terminals of said semi-conductor as said magnetic member rotates in synchronism with said engine and operating as the sole means for causing said temporary non-conduction when said ignition system is in operation.

5. An ignition system for firing the spark plug of an internal combustion engine comprising, a source of direct current power, an ignition coil having a primary winding and a secondary winding, means connecting said secondary winding with said spark plug, a first transistor having emitter, base and collector electrodes, means connecting the emitter-collector circuit of said first transistor in series between said power source and the primary winding of said ignition coil, a second transistor having emitter, base and collector electrodes, means connecting the emitter electrode of said second transistor with the base electrode of said first transistor, means connecting the emitter-base circuit of said second transistor with said source of power in such a manner that said second transistor is normally conductive in its emitter-collector circuit thereby rendering said first transistor simultaneously conductive in its emitter-collector circuit, and means connected in the base circuit of said second transistor for driving said transistor substantially fully conductive and fully non-conductive in synchronism with the said engine.

6. An ignition system for firing a spark plug in an internal combustion engine comprising, a source of direct current power, a first transistor having emitter, base and collector electrodes, an ignition coil having a primary winding and a secondary winding, means connecting said secondary winding with said spark plug, means connecting the emitter to collector circuit of said first transistor between said power source and the primary winding of said ignition coil, means including a second transistor for controlling the conduction of said first transistor in synchronism with said engine, means connecting said transistors with each other and with said source of power in such a manner that they are both normally biased to a state of conduction in their emitter-collector circuits and are both intermittently cut off simultaneously in their emitter-collector circuits to cause a firing of the spark plug.

7. An ignition system for firing a spark plug in an internal combustion engine comprising, a source of direct current power, a first transistor having emitter, base and collector electrodes, an ignition coil having a primary winding and a secondary winding, means connecting said secondary winding with said spark plug, means connecting the emitter-collector circuit of said first transistor between said power source and the primary winding of said ignition coil, a second transistor having emitter, base and collector electrodes, a pulse generating device including a coil winding and a member rotatable with said engine adapted to cause voltage pulses to be induced in said coil winding, means connecting the base electrode of said first transistor with the emitter electrode of said second transistor, means connecting the emitter-base circuit of said second transistor with said source of power in such a manner that said second transistor is normally conductive in its emitter-collector circuit thereby rendering said first transistor simultaneously conductive in its emitter-collector circuit, and means connecting said coil winding in the base circuit of said second transistor.

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8. An ignition system for an internal combustion engine comprising, a source of direct current power, a first transistor having emitter, base and collector electrodes, an ignition coil having a primary winding and a secondary winding, a spark plug, means connecting said secondary winding with said spark plug, means connecting the emitter-collector circuit of said first transistor between said power source and the primary winding of said ignition coil, a base circuit connected with the base electrode of said first transistor including a second transistor, means connecting the emitter-base circuit of said second transistor with said source of direct current power in such a manner that said second transistor is normally conductive in its emitter-collector circuit thereby rendering said first transistor simultaneously conductive in its emitter-collector circuit, and means for controlling the conductivity of said second transistor in synchronism with the operation of said engine.

9. In combination with an internal combustion engine, a spark plug for igniting the combustible mixture of said engine, an ignition coil having a primary winding and a secondary winding, means connecting said secondary winding with said spark plug, a transistor having emitter, base and collector electrodes, means connecting the collector electrode of said transistor with the primary winding of said ignition coil, a source of unidirectional power, means connecting the emitter electrode of said transistor with said source of power, a voltage generating device capable of supplying timing voltage pulses synchronized with operation of said engine and including a coil winding and a permanent magnet, and a circuit permanently connecting said base electrode with a side of said unidirectional power source opposite from the side connected with said emitter electrode and including said coil winding.

10. In combination with an internal combustion engine, a spark plug for igniting the combustible mixture of said engine, an ignition coil having a primary winding and a secondary winding, means connecting said secondary winding with said spark plug, a transistor having emitter, base and collector electrodes, a source of unidirectional power having a pair of terminals, voltage pulse generating means including a coil winding, an ignition switch, a circuit which is breakerless with the exception of said ignition switch connecting said pair of terminals of said source of unidirectional power, said circuit including said ignition switch, the emitter-base circuit of said transistor and said coil winding in a series connection, and means connecting the emitter-collector circuit of said transistor and the primary winding of said ignition coil in series and across the terminals of said unidirectional source of power, said transistor being normally conductive in its emitter-collector circuit and being rendered intermittently nonconductive by timing voltage pulses induced in said coil winding.

11. An ignition system for firing a spark plug of an internal combustion engine comprising, an ignition coil having a primary and a secondary winding, means connecting said secondary winding with said spark plug, a source of unidirectional voltage, first and second transistors each having emitter, base and collector electrodes, a circuit for energizing the primary winding of said ignition coil including in a series connection, said voltage source, said primary winding and the emitter-collector circuit of said first transistor, a base circuit connecting the base electrode of said first transistor with one side of said voltage source including the emitter-collector circuit of said second transistor, means connecting the emitter-base circuit of said second transistor with said voltage source in such a manner that said second transistor is normally conductive in its emitter-collector circuit.

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cuit thereby rendering said first transistor simultaneously conductive in its emitter-collector circuit, and timing means operating in synchronism with said engine for causing said second transistor to be intermittently substantially cut off in its emitter-collector circuit thereby causing a simultaneous reduction in conduction in the emitter-collector circuit of said first transistor.

12. The system according to claim 11 wherein the timing means includes a coil winding in which are induced timing voltage pulses.

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2,353,527
2,474,550
2,490,960
2,852,589
2,953,719

1,137,949

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References Cited in the file of this patent

UNITED STATES PATENTS

Touceda et al. ----- July 11, 1944
Short et al. ----- June 28, 1949
Hanchett ----- Dec. 13, 1949
Johnson ----- Sept. 16, 1958
Guiot ----- Sept. 20, 1960

FOREIGN PATENTS

France ----- Jan. 21, 1957