ABSTRACT OF THE DISCLOSURE

This invention is an improvement of the transistor assisted ignition system described in U.S. Patent 3,252,049 issued May 17, 1966. Addition of electrical elements to isolate the spark coil from the D.C. battery supply and to protect the transistor switch from excessive voltage peaks enhances efficiency and improves operating characteristics. Thermal runaway in the transistor is prevented by use of a pair of series connected diodes in the emitter circuit which insure instantaneous cut-off by neutralization of the "floating potential" and by application of a reverse voltage and current to reduce time delay to cut-off.

Background

This invention relates to internal combustion engine electrical distribution systems and has particular reference to transistor assisted ignition systems.

My U.S. Patent 3,252,049 issued May 17, 1966 describes and claims the basic concept of a transistor assisted ignition in which a transistor switching device is interposed between the distributor points and an auto-transformer which feeds the high voltage coil (by its magnetic high energy collapse) of an internal combustion engine. It has been found that certain improvements to the basic circuit as described, will act to increase the efficiency of the engine and prolong the life of the circuit.

Summary of the invention

In one such improvement, the battery supply is effectively disconnected from the high voltage by diode means thereby eliminating D.C. current in the primary section of the high voltage coil. In another improvement, the voltage spikes occurring in the auto-transformer are not permitted to reach the transistor, thereby preventing damage to the transistor. In a third circuit change, the cut-off diode in the transistor emitter circuit is kept energized at all times to insure instantaneous reaction of the diode to changes in the circuit operating condition.

Most importantly, however, it has been found necessary to employ a pair of series connected diodes in the emitter circuit rather than one diode alone for thermal protection of the transistor. A power transistor is built to handle heavy currents and by its very nature has appreciable internal capacitance. This characteristic creates a delay in the rise time to conduction and also a delay in the fall time to cut-off. This rise and fall time delay results in high heat dissipation within the transistor, the heating energy being taken from the power which could be used more advantageously as magnetic energy in the auto-transformer. In order to remove or minimize the delay time to cut-off, thereby reducing heat dissipation and augmenting the power to the auto-transformer, a reverse voltage and current at the transistor base is applied as an instantaneous step function when the base drive power is removed, i.e. the ignition breaker points are opened. This reverse power is supplied by the voltage drop across one of the emitter diodes. Also, a power transistor inherently develops internally what is termed a "floating potential" when it approaches cut-off. The polarity of this "floating potential" is such as to resist cut-off by tending to turn the transistor on. This "floating potential" is neutralized by the second emitter diode. Thus, one diode supplies the instantaneous reverse power in a step function while the other diode neutralizes the "floating potential." No single diode has been developed yet which can supply both voltages described above (unless two diodes are back-to-back in one case) therefore the series connected diodes must be employed. These and other circuit changes and their advantages will be made clear with reference to the accompanying drawings, in which:

FIGURE 1 shows the new circuit for an automotive system using a negative ground.

FIGURE 2 is similar to FIGURE 1, but for a positive ground system.

FIGURE 3 is a circuit for the prior art,

FIGURE 4 is an explanatory portion diagram of FIGURES 1 and 2, and FIGURE 5 is one modification of FIGURE 4.

Description of preferred embodiments

For a discussion of the prior art refer first to FIGURE 3. FIGURE 3 is essentially that of FIGURE 1 of Patent 3,252,049 leaving out certain extraneous material and renumbering the elements. Upon reference to the patent and the complete description contained therein, it will be apparent that closure of the breaker points 20 completes the base-emitter circuit of transistor 2 through resistor 1, diode 5, closed ignition switch 17, power supply 22 and ground 23. Ignition switch 17 is closed by energization of relay winding 4 by closure of switch 31. This energization of the base-emitter circuit brings the transistor 2 into a hard saturated condition, completing the emitter-collector through the primary turns 12a of auto-transformer 12, ballast resistor 15, ground 23, power supply 22 and diode 5. Thus, the primary winding 12a of auto-transformer 12 is energized whenever the distributor breaker points 20 are closed, and a strong magnetic field is built up in the laminated iron core of auto-transformer 12. When the distributor breaker points 20 are opened, the transistor 2 goes into a cut-off condition, presenting a very high resistance at the emitter-collector terminals, effectively opening the circuit of primary winding 12a. The collapsing magnetic field in transformer 12 produces a stepped up voltage across windings 12a and 12b of the transformer 12 which is connected to the primary winding 14a of the high voltage coil 14 of the existing ignition system. The secondary coil 14b of coil 14 is connected sequentially to the engine spark plugs by distribution means (not shown) creating a spark at the appropriate spark plug which continues until the energy stored in the magnetic core of transformer 12 is expended. The Zener diode 7 protects the transistor 2 from excessive high voltage peaks created in transformer 12.

The circuit just described has certain deficiencies which may detract from its universal application. These deficiencies are absent in the circuit of FIGURES 1 and 2, which circuit forms the basis of the present invention. FIGURE 1 shows a negative grounded system while FIGURE 2 shows a positive grounded system. With reference now to FIGURE 1, the efficiency of transfer of energy from auto-transformer 12 to primary winding is enhanced by removing the ballast resistor 15 from the circuit between windings 12b and 14a and placing it in series with power supply 22. This change will necessitate a change of the values of resistors 1 and 3 from those in the circuit of FIGURE 3, to provide the proper voltages to the PNP transistor 2. The more important change, however, is the addition of a diode 13 in the series circuit between the windings 12b and 14a whereby the D.C. circuit through windings 12b and 14a and transistor 2
to power supply 22 will be interrupted, so as to remove any reverse D.C. current from coil winding 14a through winding 12b. The effect of this diode 13 is to allow the energy of the magnetic field in the core of auto-transformer 12 to discharge in a pulse form into winding 14a thereby increasing the efficiency of energy transfer and to obtain optimum energy at the spark gap of the spark plugs.

When the primary circuit of the auto-transformer in FIGURE 3 is opened, the induced high voltage spike at the junction point of windings 12a and 12b will be applied to the collector-emitter circuit and can damage the transistor 17. The Zener diode 7, in this condition, the peak voltage applied to transistor 2 (when the breaker points 20 are opened) is reduced by connecting capacitor 6 across the collector and emitter leads, connecting RF choke 8 in series with the collector lead and by connecting another capacitor 10 across the total winding 12a and 12b of auto-transformer 12. The capacitor 10 integrates the voltage spike across the total winding 12a and 12b. The RF (radio frequency) choke 8 (air core) provides additional impedance to the fast voltage spike while capacitor 6 further integrates that portion of the voltage spike which would be reflected to the transistor 2. This integration adds to the total energy at auto-transformer 12 at the moment of power transfer.

A resistor of high impedance, resistor 9, is connected between diodes 5, 5e and ground 23 and maintains a steady current of from 50 to 100 milliamperes, more or less, to keep the diodes 5 and 5e in a conducting state during the transistor cut-off time so that the base of transistor 2 will see this cut-off voltage condition for the full duration of the cut-off time. Diode 5a has been added in series with diode 5 in the emitter circuit of transistor 2. As explained earlier, the voltage drop generated across diode 5a creates a step function reverse power which reduces and practically eliminates the delay time to cut-off in transistor 2 when the breaker points 20 are opened while the voltage drop across diode 5 is a reverse voltage for neutralizing the “floating potential” generated within transistor 2. FIGURE 2 is similar to FIGURE 1 in all respects except that the polarity of all polarized elements has been reversed. Thus, PNP transistor 2 of FIGURE 1 has been replaced by an NPN transistor 16, and the polarity of each diode 5, 5e and Zener diode 7 has been reversed.

FIGURES 1 and 2 show the improved basic circuit but many modifications therein are possible within the spirit of the invention. For example, the usual breaker points 20 as shown in FIGURE 4 are operated by a six lobed cam 30 driven by the shaft 31. It should be realized that intermittent energization of the base-emitter circuit of transistor 2 or 16 can be accomplished in many ways, one of which is that using breaker points (open and close cam operated) shown in FIGURE 4. Another example, FIGURE 5 shows a magnetic induction type of breaker circuit. Here a six lobed cam made of ferrous material 32 is rotated in close proximity to an induction 33 to vary the strength of a magnetic field provided by the stationary magnet 34 which is adjacent or within coil 33. This periodic variation of the magnetic field induces a pulsed voltage in the coil 33 which is amplified in an amplifier 35 if necessary and is then used to energize the base-emitter circuit of transistor 2 or 16. Alternatively, the breaker points of FIGURES 1, 2 or 3 may be replaced by photo-electric devices not shown but which act to complete the base-emitter drive circuit at appropriate times. Therefore, it is apparent that the use of actual switch contacts in the base-emitter circuit is not required and the invention is not so limited but any device which will alternately energize and de-energize the base-emitter circuit at the proper times can be used. The term “breaker,” as used in the claims, should be interpreted to cover all or any of these possible constructions. Also, it should be recognized that the energy storage transformer 12 need not be an auto-transformer only, but that in certain instances a two winding transformer may be preferable. Therefore any reference to the term primary and secondary transformer windings should not be limited to auto-transformer windings although such construction only is shown in the figures.

My claims are:

1. In a transistor assisted ignition system, having base, emitter and collector electrodes, breaker means for alternately energizing and de-energizing the base-emitter circuit of said transistor, an energy storing transformer having a primary winding and a secondary winding, said primary winding being connected between the collector in series and the emitter of said transistor in series with unidirectional power supply and said secondary winding being connected to ignition devices in said ignition system, whereby energization of said base-emitter circuit causes energy to be stored in said transformer, and de-energization of said base-emitter circuit causes said stored energy to be discharged into said ignition devices, a pair of diodes connected in series, interposed between said emitter electrode and said power supply in the forward direction to provide a reverse voltage at said base electrode and to neutralize the floating potential developed internally of said transistor whenever said base-emitter circuit is de-energized by said breaker means.

2. Apparatus as in claim 1 including first capacitor means connected across said primary winding and second capacitor means connected across said secondary winding.

3. Apparatus as in claim 2 including inductive means connected between said transformer primary winding and said first capacitor means.

4. Apparatus as in claim 1 including resistor means connected between the junction of said emitter electrode and said diodes and said power supply to maintain sufficient current through said diodes at such times that said base-emitter circuit is de-energized by said breaker means to insure cut-off of said transistor for the full duration of such times.

5. Apparatus as in claim 1 wherein said energy storage transformer is an auto-transformer and including second transformer means interposed between said energy storage transformer and said ignition devices, and a diode connected between said transformers in the reverse direction to thereby eliminate a direct electrical path between said unidirectional power supply and said second transformer (ignition coil).

6. Apparatus as claimed in claim 1 in which said breaker means includes an induction coil connected between said base and emitter electrodes, a magnet adjacent or within said coil and means for periodically varying the magnetic field in said coil due to said magnet to produce a varying voltage across said coil.

7. Apparatus as claimed in claim 6 means connected between said induction coil and said base electrode.

8. Apparatus as in claim 1 including Zener diode means connected between said collector and emitter electrodes or between collector and base electrodes.

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