United States Patent

Oishi

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[54] CAPACITOR DISCHARGE TYPE IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES

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[51] **Int. Cl.**.....**F02p 3/06**
[58] **Field of Search**.....123/148 E; 315/209

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[57] **ABSTRACT**

A capacitor discharge type ignition system for internal combustion engines comprising an ignition coil whose primary winding is connected at one end thereof to one terminal of a discharge capacitor, has an intermediate tap connected through a switching element to the other terminal of the capacitor, and is connected at the other end thereof to the aforesaid other terminal of the capacitor through a diode inserted in the polarity opposite to that of the switching element or a series circuit consisting of a diode of the above-mentioned polarity and a choke coil.

2 Claims, 3 Drawing Figures

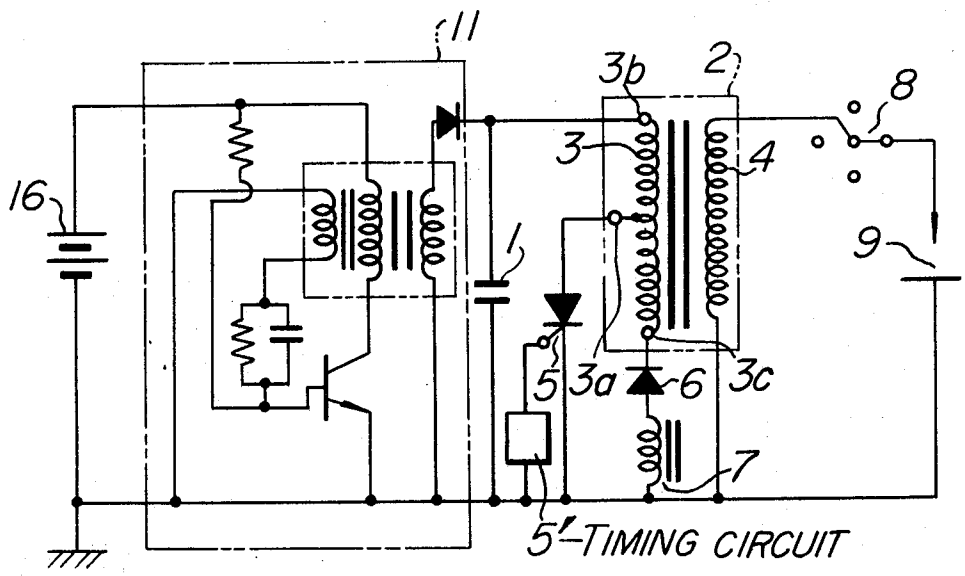


FIG. 1 PRIOR ART

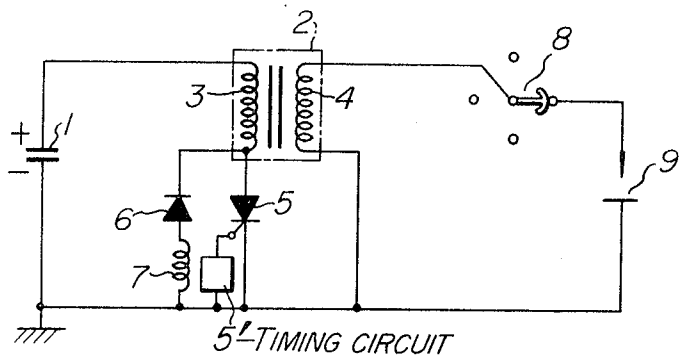


FIG. 2

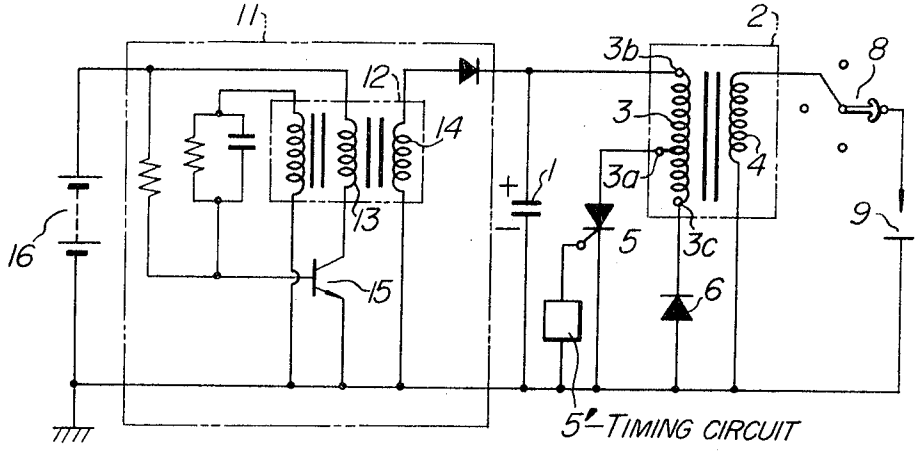
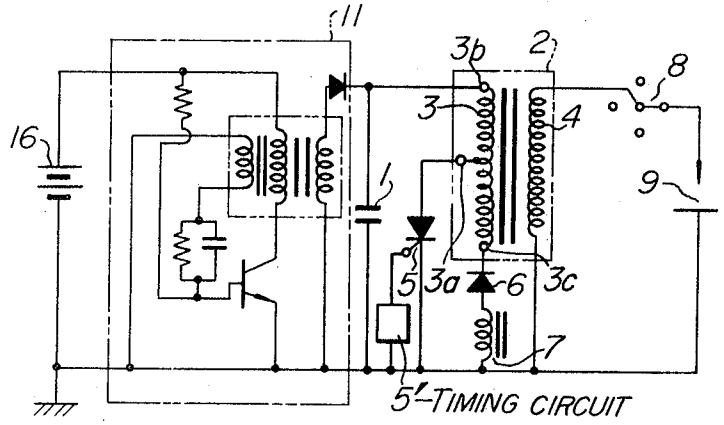


FIG. 3



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CAPACITOR DISCHARGE TYPE IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to improvements in a capacitor discharge type ignition system for internal combustion engines.

2. Description of the Prior Art

The prior art capacitor discharge type ignition systems for internal combustion engines are of the construction shown in FIG. 1, comprising a discharge capacitor 1, an ignition coil 2 having a primary winding 3 and a secondary winding 4, a silicon controlled rectifying element 5 (hereinafter referred to as SCR) serving as a switching element, a timing circuit 5' generating trigger pulses in the ignition time of an engine, a diode 6 for the AC spark operation, a choke coil 7 for maintaining the spark, a distributor 8 and a spark plug 9.

In operation, when the SCR 5 is triggered upon the impression of an ignition signal to the gate, the discharge capacitor 1 is discharged through the primary winding 3 of ignition coil 2 to induce a high voltage across the secondary winding, thereby causing a spark to pass across the gap of the spark plug 9. Thereafter, the polarity of the charge in the capacitor 1 is reversed to the polarity opposite to that illustrated in the figure by the free oscillation of the current flowing through the primary winding 3, and then the capacitor 1 is re-discharged through the diode 6 and the choke coil 7 and returns to the original polarity, thereby reproducing a second spark in the spark plug 9. When the number of turns of the primary winding 3 is decreased to reduce the inductance of the primary winding 3, the discharge of the capacitor 1 is repeated at a higher frequency, so that an extremely strong igniting action of the spark plug is attained even when the electrodes of the spark plug 9 are contaminated. An increase of the frequency of discharge of the capacitor 1, however, results in a decrease of the duration of an individual spark across the gap between the electrodes of the spark plug 9, which gives rise to the problem of failure in firing. The duration of the spark may be increased to some extent by increasing the inductance of the choke coil 7, but in doing so, a substantial portion of the discharge voltage during the reverse discharge after the reversal of the polarity of the charge in the capacitor 1 comes to be applied across the terminals of the choke coil 7, which is not magnetically coupled to the secondary coil 4, thus eventually decreasing the spark duration instead of advantageously increasing it.

SUMMARY OF THE INVENTION

An object of the invention is to increase the spark duration, while at the same time obtaining a strong spark, even with contaminated spark plug electrodes by ensuring rapid rising of the output voltage on the secondary side of the ignition coil, by means of such a construction that the total inductance of the primary side of the ignition coil, namely the turn ratio of the ignition coil, is different between the forward discharge and the subsequent reverse discharge of the discharge capacitor, which is attained by having the primary winding of the ignition coil connected at one end thereof to one terminal of the discharge capacitor, providing the primary winding with an intermediate tap which is connected with the other terminal of the discharge capacitor through a switching element such as an SCR and having the primary winding of the ignition coil connected at the other end thereof to the aforesaid other terminal of the capacitor through a diode inserted in the polarity opposite to that of the switching element or a series circuit consisting of a diode of the above-mentioned polarity and a choke coil.

Another object of the invention is to prevent, by means of the aforesaid choke coil, the reduction of the output voltage on the secondary side of an ignition coil due to a short-circuit current caused by a voltage induced across the additional portion of the primary winding during the forward discharge of the discharge capacitor.

According to the invention, as the primary winding of the ignition coil is connected at one end to one terminal of the discharge capacitor, is provided with an intermediate tap which leads to the other terminal of the capacitor through a switching element and is connected, at the other end thereof, to the aforesaid other terminal of the capacitor through a diode inserted in the polarity opposite to the switching element or a series circuit consisting of a diode of the above-mentioned polarity and a choke coil, during the conduction period of the switching element, the discharge current from the capacitor flows through the intermediate tap and the switching element. During this period the turn-ratio of the secondary to the primary windings is high with the excellent effect that the initiation of the discharge of the capacitor is extremely improved, and that the voltage induced across the secondary winding is sufficiently high to produce an extremely strong spark, even with contaminated electrodes of the spark plug. During the reverse discharge period of the capacitor after the polarity reversal thereof, the entire turns of the primary winding are available for operation to give a lower turn-ratio, the entire voltage across the capacitor is applied across the ends of the total primary winding, and the inductance is increased by the added primary winding portion, thereby causing a large current to flow through the secondary winding to ensure extending the duration of the spark in the spark plug with excellent results.

Further, through the co-operation of the choke coil with the additional portion of the primary winding, it is possible to prevent the reduction of the output voltage on the secondary side during the forward discharge of the capacitor.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a circuit diagram of a conventional capacitor discharge type ignition system.

FIG. 2 is a circuit diagram of a preferred embodiment of the capacitor discharge type ignition system according to the present invention.

FIG. 3 is a circuit diagram of another embodiment of the capacitor discharge type ignition system according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will now be described in conjunction with the illustrated embodiments. With reference to FIG. 2, where the reference numerals 1 to 5, 5', 6, 8 and 9 designate the respective circuit elements identical with or equivalent to those shown in FIG. 1, the primary winding 3 is provided with an intermediate tap 3*a*, which is connected through as SCR 5 to one terminal of the discharge capacitor 1. Numeral 11 generally designates a DC-to-DC converter including a step-up transformer 12 having a primary winding 13 and a secondary winding 14, a switching transistor 15 and a source battery 16.

In the operation of the ignition system of the foregoing construction according to the present invention, a charge stored in the discharge capacitor 1, upon triggering of the SCR 5, is discharged through the intermediate tap 3*a* of the primary winding 3 of the ignition coil 2 with a very short rise time. Because of this, a high voltage is induced across the secondary winding 4 to produce a spark between the electrodes of the spark plug 9. Subsequently, a charge which has been stored in the discharge capacitor in the polarity opposite to that illustrated in the figure is discharged through the diode 6 and the total turns of the primary winding 3 to recover the previous polarity. As a result, high voltage is again induced across the secondary winding 4, producing a spark between the electrodes of the spark plug 9.

In the operation as described above, when a spark is produced at the spark plug 9 upon the triggering of the SCR 5, the number of turns of the primary winding coupled to the secondary winding is the number of turns of a portion between the terminals 3*b* and 3*a* within the total primary winding 3 between the terminals 3*b* and 3*c*, being divided by the inter-

mediate tap 3*a*, thereby resulting in a greater turn ratio of the secondary winding 4 to the primary winding 3 than the case of the primary number of turns of the total primary winding 3 between the terminals 3*b* and 3*c*, and the inductance of the portion between the terminals 3*b* and 3*a* is lower than that of the total primary winding between the terminals 3*b* and 3*c*, so that the initiation of the discharge of the capacitor 1 is extremely favorable, inducing a sufficiently high voltage across the secondary winding to produce an extremely strong spark, even when the electrodes of the spark plug 9 are contaminated.

In the reverse discharge of the capacitor 1 after the polarity reversal thereof, a discharge current flows through the diode 6 and the total turns of the primary winding 3 of the ignition coil 2 between the terminals 3*c* and 3*b*. In this case, the gap of the spark plug 9 is in an ionized state due to the previous spark discharge, so that a spark may be produced at a lower voltage across the electrodes of the spark plug 9. Besides, in the reverse discharge, the total turns of the primary winding 3 between the terminals 3*c* and 3*b* are coupled to the secondary winding 4 with a lower turn ratio as compared to the turn ratio for the previous forward discharge wherein only a portion of the primary winding 3 between the terminals 3*b* and 3*a* is coupled to the secondary winding 4. This causes a larger current to flow through the secondary winding 4 with a sacrifice in the induced voltage thereacross. Further, when the capacitor is discharged after the reversal of the polarity, the total voltage across the capacitor 1 is effectively applied across the total primary winding 3 between the terminals 3*b* and 3*c*, which has an increased inductance, so that the integral of a current flowing through the secondary winding 4 is increased to extend the duration of the spark produced at the spark plug 9.

It is to be understood that, in place of the SCR 5 in the foregoing embodiment, a triac, a gate-turn off thyristor, etc., may as well be used for the switching element.

By way of numerically exemplifying the system according to the invention, with the ignition coil 2 having a primary winding 3 of 50 turns for the portion between the terminals 3*b* and 3*a* and 150 turns for the portion between the terminals 3*a* and 3*c* and the secondary winding 4 of 3,750 turns, and with a spark plug having gap of 0.8 millimeter, it is possible to extend the length of the spark duration to 250 microseconds, which is extremely long as compared to 100 microseconds when employing the conventional system.

Another embodiment of the invention will now be described with reference to FIG. 3. It comprises a discharge capacitor 1, an ignition coil 2 with a primary winding 3 and secondary winding 4, an SCR 5, a diode 6, a choke coil 7, a distributor 8 and a spark plug 9. The primary winding 3 is provided with an intermediate tap 3*a* connected to one terminal of the discharge capacitor 1 through the SCR 5. Numeral 11 designates a DC-to-DC converter, and numeral 16 designates a battery.

With respect to its operation, when the ignition time of the engine is reached an ignition signal is fed to the gate of the SCR 5 to trigger the SCR 5, whereupon a charge stored in the discharge capacitor 1 by the DC-to-DC converter begins to be discharged through the intermediate tap 3*a* of the primary winding 3 of the ignition coil 2 and the SCR 5. As a result, a high voltage is induced across the secondary winding 4 to produce a spark across the gap of the spark plug 9. The operation so far is the same as the conventional capacitor discharge type ignition system, maintaining the feature of producing an output voltage having a short rise time and of producing a strong spark even with contaminated electrodes of the spark plug 9. In the subsequent period a maximum reverse voltage is reached across the discharge capacitor 1 due to the free oscillation caused in the ignition coil 2, whereupon a reverse discharge commences through the choke coil 7, the diode 6 and the total primary winding 3 between the terminals 3*c* and 3*b*, again inducing a high voltage across the secondary winding 4 of the ignition coil 4 to produce a spark across the gap of the spark plug 9 by way of the distributor 8. At this time, the gap of the spark plug 9 is ionized due to the previous ignition, so that the spark may be initiated by a fairly low voltage. When the discharge capacitor 1 recovers the previous forward polarity and the voltage rises to a maximum, the SCR 5 is already turned off, so no further current flows.

It is evident from the comparison of the foregoing operation with the operation of the conventional system that the reverse discharge of the discharge capacitor 1 after the polarity reversal thereof, which is made through choke coil 7, diode 6 and the primary winding 3 in the conventional system, is also made through choke coil 7, diode 6 and the total primary winding 3 between the terminals 3*c* and 3*b* according to the invention. Due to the fact that, the discharge capacitor 1 of the reverse polarity is discharged through a path such as mentioned above the following two effects may be attained simultaneously. The first effect is that the period of the free oscillation caused by the charge stored in the discharge capacitor 1, the choke coil 7 and the total primary winding between the terminals 3*b* and 3*c* can be extended. Particularly, the co-operation of the primary winding portion between the terminals 3*a* and 3*b* and the choke coil 7 makes it possible to control the period of free oscillation over a fairly wide range. The second effect is that the turn ratio of the secondary to the primary is reduced for the reverse discharge, since the total turns of the primary winding between the terminals 3*b* and 3*c* are coupled to the secondary winding of the ignition coil 2. Thus, in the discharge process of the stored charge of the reverse polarity, a much larger current (the integral value) can be made to flow through the spark plug 9 than the case that only the primary winding portion between the terminals 3*a* and 3*b* is coupled. Besides, the voltage across the total primary winding between the terminals 3*b* and 3*c* is sufficiently high as compared with the voltage across the choke coil 7, so that there is no possibility that the output voltage on the secondary side of the ignition coil is too low to produce a spark through the spark plug 9 as in the case of employing a choke coil 7 having an extremely high inductance. By virtue of the foregoing two effects, it is possible to attain a sufficiently long duration of spark across the gap of the spark plug 9 for the reverse discharge of the discharge capacitor 1.

Further, the co-operation of the portion of the primary winding between the terminals 3*a* and 3*c* of the ignition coil 2 and the choke coil 7 has the following great advantage.

It is required that, during the discharge of the charge having the reverse polarity in the discharge capacitor 1, voltages of the same polarity with the positive pole on the sides directed to the diode 6 are respectively induced across the portion between the terminals 3*a* and 3*b* and the portion between the terminals 3*c* and 3*a* of the primary winding 3 of the ignition coil 2. While, during the forward discharge of the discharge capacitor 1, a voltage is induced across the primary winding portion between the terminals 3*a* and 3*c* with the positive pole on the anode side of the SCR 5 which is connected with the terminal 3*a*. Since the SCR 5 is conductive in this case, a short-circuit current due to the voltage induced across the primary winding portion between the terminals 3*a* and 3*c* tends to flow through the SCR 5. However, as the choke coil 7 is connected in series with the primary winding portion between the terminals 3*a* and 3*c* according to the invention, the short-circuit current is prevented by the inductance of the choke coil 7. Consequently, in the forward discharge process, the reduction of the output voltage on the secondary side by the influence of the primary winding portion between the terminals 3*a* and 3*c* may be prevented. By way of a numerical example, with the primary winding 3 of 50 turns for the portion between the terminals 3*a* and 3*b* and 150 turns for the portion between the terminals 3*a* and 3*c*, the secondary winding 4 of 3,750 turns and the choke coil 7 of about 2 mH, the output voltage on the secondary side could be made 26 KV as compared with 22 KV in the case without the choke coil 7.

I claim:

1. A capacitor discharge type ignition system for combustion engines, comprising:

means including a capacitor for storing and discharging ignition energy alternately in first and second directions,

an ignition coil having a primary winding with first and second serial portions and having an output winding with a greater number of turns than said primary winding and being magnetically coupled to both of said portions,

means including unidirectional switching means coupling said first primary winding portion across said capacitor,

means for turning said switching means alternatively on and off to cause first direction current from said capacitor to pass, when said switching means is on, through said first portion only of said primary winding to cause a rapid rise in the voltage across said output winding, and

means, including a unidirectional device poled oppositely to said unidirectional switching means and coupling said second portion of the primary winding to said condenser so that all of said primary winding is electrically connected across said capacitor when said unidirectional switching means is turned off as aforesaid to cause second direction capacitor current to flow through said primary winding, for decreasing the step-up ratio of the primary winding to said output winding and causing a larger current to then flow through the output winding for a prolonged period of time than when the first direction current flows through said primary winding.

2. A system as in claim 1 wherein first direction capacitor current tends to circulate from said unidirectional switching means through said unidirectional device and said second primary winding portion to induce in the output winding a voltage in opposition to the voltage induced therein by the first direction current in the first primary winding portion, the improvement of:

means including a choke coil serially connected to said unidirectional device for substantially eliminating said opposition voltage.

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