IGNITION ARRANGEMENT FOR INTERNAL COMBUSTION ENGINES

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ABSTRACT OF THE DISCLOSURE

An arrangement for providing ignition pulses to fire spark plugs in internal combustion engines. A low voltage D.C. power supply charges a capacitor which stores the energy for generating ignition pulses having steep edges and a large amplitude. A D.C. voltage converter raises the level of the D.C. voltage supply to that suitable for charging the capacitor. The latter is connected across the primary winding of an ignition transformer whose secondary winding is connected across the spark plug to be fired. An oscillator in the form of an astable multivibrator produces a train of pulses applied to a thyristor type of circuit element one of which is connected in series with the primary winding of the ignition transformer. Another thyristor type of circuit element is connected between the D.C. voltage converter and the capacitor. The control electrode of the latter has also pulses applied to it by the astable multivibrator. A cam operated switch is connected in series with the control electrode of the thyristor in series with the primary winding of the ignition transformer. The cam which operates the switch is driven by the engine and periodically opens and closes the circuit so that ignition pulses are periodically produced.

BACKGROUND OF THE INVENTION

In ignition arrangements associated with the species of the present invention, a plurality of ignition sparks in the form of electrical discharges appear at the spark plugs during an ignition process. Each of the electrical discharges is produced by a voltage pulse having steep edges and a high pulse level or amplitude. As a result, the present invention assures that the compressed fuel-air mixture within the cylinder of the internal combustion engine is ignited with certainty. Such ignition is also assured when the mixture is of poor proportions and considerable deposits are present on the discharge electrodes of the spark plugs.

In an arrangement disclosed in the French patent 1,291,233 an oscillator delivers control pulses to the base of a power transistor by way of a capacitor, for the purpose of producing an ignition system. This transistor forms the discharge switch and lies in the discharge circuit of the ignition capacitor through its emitter-collector path. A disadvantage of this arrangement is that the oscillator is conductively coupled to that ignition capacitor plate which is not connected to ground potential. In modern capacitor ignition arrangements, the ignition capacitor becomes charged, through a charging arrangement, to a voltage of the order of 500—1000 volts. As a result, the oscillator also acquires this potential in relation to ground. Considerable insulation must therefore be provided for the oscillator parts. This condition applies even though the oscillator itself is driven by a voltage which is of the order of 100 times smaller than the charging voltage of the ignition capacitor. Furthermore, in the ignition arrangements of this type, the oscillator is based on the use of an astable multivibrator equipped with two transistors. Since the prevailing high voltages may damage the transistors, appropriate insulation is required which under these conditions is quite extensive. Such insulation, however, produces considerable problems with respect to heat conduction associated with the operation of the transistors. This arrangement known in the art, furthermore, requires that the oscillator produce a new oscillation at each ignition process. This particular condition of the oscillator can, however, not be met with certainty without applying auxiliary circuitry operating in conjunction with the oscillator.

It is an object of the present invention to provide an ignition arrangement which is controlled and designed so that the disadvantages in conventional arrangements are avoided. It is the object of the present invention that the charging and discharging processes of the ignition capacitor are determined in sequence so that sufficient energy is available to produce an ignition voltage pulse for every ignition process.

The objects of the present invention are achieved through the application of pulse transformers having primary and secondary windings. The primary windings of two of such pulse transformers are connected in series with the switching paths of amplifying elements within the oscillator. The secondary winding of one of the pulse transformers lies in the control circuit of the discharge switch. The secondary winding of the remaining pulse transformer is connected in the control circuit of a controllable electronic charging switch. The switching path or conducting path of the controllable electronic charging switch lies connected between the charging arrangement and the ignition capacitor.

SUMMARY OF THE INVENTION

An electronic ignition arrangement for use in internal combustion engines. The low voltage of a D.C. power supply is amplified in a D.C. voltage converter and applied, via a thyristor acting as an electronic switch, to a capacitor which provides the ignition energy. This ignition capacitor is in turn connected in parallel with the primary winding of an ignition transformer which includes the spark plug to be fired in its secondary winding. The primary winding of the ignition transformer also includes in its circuit path a controllable electronic switch in the form of a thyristor which permits the electrical path to the primary winding to be closed periodically under controlled conditions. An oscillator using an astable multivibrator provides a train of pulses at periodic intervals. The astable multivibrator is driven by two transistors each having the primary winding of a pulse transformer connected in series with its emitter-collector path. The secondary winding of one of the pulse transformers is connected to the control element or electrode of the controllable electronic switch or thyristor in series with the primary winding of the ignition transformer. The secondary winding of the other pulse transformer is connected to the control electrode of the thyristor or controllable electronic switch connected between the ignition capacitor and the charging circuit which is in the form of the D.C. voltage converter. A mechanical switch driven by a cam rotatably linked to the engine opens and closes the circuit leading to the control electrode of the controllable electronic switch in the secondary winding of the ignition transformer. For as long as the mechanical switch remains closed, ignition pulses are transmitted to the ignition transformer such that the latter produces corresponding pulses having steep and sharp edges and a high pulse level or amplitude.

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 circuit diagram showing the operating circuit elements as well as their interconnections to provide ignition pulses to spark plugs in accordance with the present invention.

**DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Referring to the drawing, the ignition arrangement in accordance with the present invention receives power from a D.C. power supply 1. The latter can be the conventional battery of the motor vehicle. The D.C. power supply 1 has its negative polarity terminal connected to ground, whereas its positive polarity terminal is applied to the electrical circuit elements of the ignition arrangement in the manner of the operating switch 2. When the switch 2 is closed, the positive and negative polarity terminals of the battery are applied and connected to the inputs 3 and 4 of the charging circuit 5. This charging circuit 5 may be in the form of a conventional D.C. voltage converter which provides its output terminals 6 and 7. Voltage several hundred times larger than the voltage applied to its input terminals 3 and 4. The output voltage of the charging circuit 5 is applied to an ignition capacitor 8. The ignition capacitor 8 is connected across a discharge circuit including the primary winding 9 of an igniter transformer or coil 10. The primary winding 9 is connected in series with a controllable electronic discharge switch 11 within the circuit path A' K'. A thyristor may be used for the discharge switch 11.

The ignition circuit is formed by the secondary winding 12 of the igniter transformer 10 and the spark plug 13. When the ignition arrangement is to be used in conjunction with an internal combustion engine having a plurality of cylinders, the ignition circuit can, of course, also include a corresponding plurality of spark plugs. In the case of such a plurality of spark plugs, these are applied in a predetermined sequence to the secondary winding 12 of the igniter transformer 10, through means of a conventional distributor.

The D.C. power supply 1 is also connected across an oscillator 16 when the operating switch 2 is closed. The oscillator 16 has input terminals 14 and 15 connected across the power supply upon closure of the switch 2. The oscillator 16 may, for example, be in the form of an astable multivibrator having two npn transistors 17 and 18 which are used as amplifying elements. The bases B' and B'' lead to the positive polarity terminal of the power supply by way of resistors 21 and 20 respectively. The collectors C' and C'' of the transistors 17 and 18 are coupled to the negative polarity terminal of the power supply 1 by way of resistors 22 and 20 respectively. At the same time, the collector C'' feeds back to the base B' through the capacitor 23. The emitters E' and E'' of the transistors 17 and 18 are connected to one end of the primary windings 25 and 26 of two separate pulse transformers 27 and 28, respectively. The other ends of the two primary windings 25 and 26 are connected to ground and hence to the negative polarity terminal of the power supply 1. Accordingly, the primary windings 25 and 26 of the two pulse transformers 27 and 28 are connected in series respectively with the emitter collector paths E' C' and E'' C'' of the charging switch 30.

The secondary winding 29 of the pulse transformer 27 lies in the control circuit of an electronic charging switch 30 which may also be in the form of a thyristor in this particular selected example. This control circuit lies between the cathode terminal K' and the control electrode S' of the charging switch 30. The preferred design includes a diode 31 connected in series with the secondary winding 29 of the pulse transformer 27, for the purpose of transmitting only positive pulses to the control electrode S' of the charging switch 30. It is also desirable to connect a capacitor 32 across the control path S'K' of the charging switch 30. This capacitor diverts undesirable oscillations from the control electrode S' to the cathode K'. The control potential is established in a simple manner by providing a resistor 33 connected in parallel to the control path S'K' of the charging switch 30.

The RC circuit of capacitor 32 and resistor 33, furthermore, provides for a predetermined form of the control pulses. The switching path of the charging switch 30 passes through this element between the anode terminal A'' and the cathode terminal K'. This switching path is connected to the charging circuit of the ignition capacitor 8. Thus, the switching path lies in the connection of the two outputs 6 and 7 of the charging circuit 5 leading to the ignition capacitor 8. When necessary, the charging circuit of the ignition capacitor 8 can include a limiting resistor 34 which is connected in series with the switching path A''K' of the charging switch 30.

The second pulse transformer 28 has a secondary winding 35 which lies in the control circuit of the electronic discharge switch 11. This control circuit of the discharge switch 11 provides a connecting branch between the control electrode S' and the cathode terminal K' of the switch 11. Connected in series with the secondary winding 35 of the pulse transformer 28 is a switch 36 which closes the control circuit at the instant of ignition. The switch 36 is operated by a cam 37 which is rotatably driven by the engine through suitable mechanical linkage. This particular operation of the switch 36 assures that the circuit is closed at the proper instant of time.

It is also desirable, in the case of the secondary winding 35 of the pulse transformer 28, to connect a diode 38 in series with this winding and the control electrode of the discharge switch 11, for the purpose of transmitting only positive pulses to the control electrode. Parallel to the control path S' and K' it is also desirable to provide a resistor 39 and capacitor 40. This RC network of a resistor 39 and capacitor 40 serves the same function as the RC network consisting of resistor 33 and capacitor 32.

The amplifying elements used in the foregoing example for the purpose of performing the charging and discharging functions are selected in the form of semiconductor elements. These can, of course, be replaced with electron tubes.

In operation, the switch 2 is closed and the oscillator 16 receives thereby an energizing voltage applied across its input terminals 14 and 15. As a result, the oscillator 16 provides output oscillations in the conventional manner, which have a frequency preferably of the order of 10 KHz. The action of the oscillator 16 produces the condition wherein current flows alternately through the circuit paths E' C' and E'' C'' of the transistors 17 and 18 respectively, and hence through the primary windings 25 and 26 connected thereto. The secondary windings 29 and 35 of the pulse transformers 27 and 28 also receive thereby alternating current flow corresponding to the current flow through the primary windings 25 and 26.

As long as the ignition process is not commenced so that the switch 36 remains open, the control circuit to the discharge switch 11 remains in the open circuit condition, only the control pulses from the secondary winding 29 of the pulse transformer 27 are used. These pulses from the secondary winding 29 are applied to the control electrode S' of the charging switch 30, and control the thyristor in a synchronized manner, the transmission state of the path A''K'. Upon closure of the switch 36, the charging circuit 5 also receives operating voltage at its input terminals 3 and 4 from the D.C. power supply 1. As a result, the ignition capacitor 8 receives an energy impulse during the interval that the charging switch 30 is closed. This energy impulse is limited through the limiting resistor 34.
The ignition process is carried out through the action of the switch 36 which, when closed, closes the control circuit of the discharge switch 11. As a result, the control pulses delivered by the secondary winding 35 of the pulse transformer 28 are applied to the control electrode $S'$ of the discharge switch 11. The path A'-K' is thereby placed into the conducting state when the charging switch 30 is in the open state. The ignition capacitor 8 can thus recharge during each interval of time that the charging switch 30 is closed. During each time interval that the discharge switch 11 is closed, the ignition capacitor 8 can then deliver relatively high energy to the primary winding 9 of the ignition transformer 10. As a result of delivering such a large amount of energy to the primary winding 9, the secondary winding 12 of the ignition transformer 10 provides a corresponding voltage pulse having steep edges and a high pulse level or amplitude. Such an ignition pulse applied across the spark plug 13 provides a very effective operating spark for the ignition function of the spark plug.

The ignition capacitor 8 is subjected to repeated charging and discharging processes for as long as the discharge switch 11 is in the closed state through the action of the switch 36. Thus, the ignition process may be maintained or continued for as long as the switch 36 is in the closed position. When the switch 36 becomes opened through the action of the cam 37, the control circuit to the discharge switch 11 is also opened and the ignition process is terminated. The capacitor 8 is now again charged until the next ignition process begins.

Through the condition that the ignition capacitor 8 is again charged during a time interval between two successive ignition processes, very effective ignition sparks are obtained at the beginning of the ignition process. Accordingly, the ignition of the fuel-air mixture is assured even when the mixture is of poor proportions and the electrodes of the spark plugs are soiled. The ignition of the fuel-air mixture, in this manner, is assured at the proper instant of time.

In accordance with the present invention, the oscillator 16 is not required to produce new oscillations with each ignition process. Furthermore, the oscillator must only be insulated with respect to the low voltage of the D.C. power supply of the non-conducting state of a particular type. Finally, as a result of the charging and discharging of the ignition capacitor 8 in an alternating manner, a voltage pulse having steep edges and high amplitude is produced for each one of the numerous ignition sparks required during the ignition process.

It will be understood that each of the elements described above, or two or more together, may also find a use in a number of other types of ignition arrangement for internal combustion engines.

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; ignition transformer means having a primary winding and a secondary winding, said secondary winding being connected to said spark plug means; ignition capacitor means connected to said primary winding of said ignition transformer for providing energy to said spark plug means; charging means for charging said ignition capacitor means; first controllable electronic switching means connected in series with said primary winding of said ignition transformer; actuating means coupled to said engine and connected to said first controllable electronic switching means for periodically actuating the latter from conducting to non-conducting states; oscillator means connected to said second controllable electronic switching means; pulse transformer means for each one of said amplifying means and having a primary winding connected in series with said amplifying means, the secondary winding of one of said pulse transformer means being connected in series with said actuating means; second controllable electronic switching means connected between said charging means and said ignition capacitor means, the secondary winding of the other one of said pulse transformer means being connected to said second controllable electronic switching means; first resistor means connected in parallel with the controlling electrode of said first controllable electronic switching means and the transmitting electrode thereof; and second resistor means connected in parallel with the controlling electrode and the transmitting electrode of said second controllable electronic switching means.

2. An ignition arrangement for internal combustion engines comprising, in combination, spark plug means; ignition transformer means having a primary winding and a secondary winding, said secondary winding being connected to said spark plug means; ignition capacitor means connected to said primary winding of said ignition transformer for providing energy to said spark plug means; charging means for charging said ignition capacitor means; first controllable electronic switching means connected in series with said primary winding of said ignition transformer; actuating means coupled to said engine and connected to said first controllable electronic switching means for periodically actuating the latter from conducting to non-conducting states; oscillator means connected to said second controllable electronic switching means; pulse transformer means for each one of said amplifying means and having a primary winding connected in series with said amplifying means, the secondary winding of one of said pulse transformer means being connected in series with said actuating means; second controllable electronic switching means connected between said charging means and said ignition capacitor means, the secondary winding of the other one of said pulse transformer means being connected to said second controllable electronic switching means, said oscillator means being an astable multivibrator.
4. The ignition arrangement for internal combustion engines as defined in claim 3, wherein said first and second amplifying means are each npn transistors.

5. A secondary arrangement of said primary ignition transformer means comprising, in combination, spark plug means; ignition transformer means having a primary winding and a secondary winding, said secondary winding being connected to said spark plug means; ignition capacitor means connected to said primary winding of said ignition transformer for providing energy to said spark plug means; charging means for charging said ignition capacitor means; first controllable electronic switching means connected in series with said primary winding of said ignition transformer; actuating means connected to said engine and connected to said first controllable electronic switching means for periodically actuating the latter from conducting to non-conducting states; oscillator means connected to said actuating means and providing pulsing means being connected in series with said actuating means and providing pulsing means applied to said first controllable electronic switching means through said actuating means, said oscillator means having a first and a second amplifying means; pulse transformer means for each one of said amplifying means and having a primary winding connected in series with said amplifying means, the secondary winding of one of said pulse transformer means being connected in series with said amplifying means; second controllable electronic switching means connected between said charging means and said ignition capacitor means, the secondary winding of the other one of said pulse transformer means being connected to said second controllable electronic switching means, said oscillator means being an astable multivibrator, said first and second amplifying means being in series with said oscillator means; and a D.C. power supply having a positive potential terminal and a negative potential terminal, the emitters of said transistors being connected to said negative potential terminal through said primary windings of said pulse transformers.

6. An ignition arrangement for internal combustion engines comprising, in combination, spark plug means; ignition transformer means having a primary winding and a secondary winding, said secondary winding being connected to said spark plug means; ignition capacitor means connected to said primary winding of said ignition transformer for providing energy to said spark plug means; charging means for charging said ignition capacitor means; first controllable electronic switching means connected in series with said primary winding of said ignition transformer; actuating means coupled to said engine and connected to said first controllable electronic switching means for periodically actuating the latter from conducting to non-conducting states; oscillator means connected to said actuating means and providing pulsing means applied to said first controllable electronic switching means through said actuating means, said oscillator means having a first and a second amplifying means; pulse transformer means for each one of said amplifying means and having a primary winding connected in series with said amplifying means, the secondary winding of one of said pulse transformer means being connected to said second controllable electronic switching means, said oscillator means being an astable multivibrator, said first and second amplifying means being in series with said oscillator means; and a D.C. power supply having a positive potential terminal and a negative potential terminal, the emitters of said transistors being connected to said negative potential terminal through said primary windings of said pulse transformers.

7. An ignition arrangement for internal combustion engines comprising, in combination, spark plug means; ignition transformer means having a primary winding and a secondary winding, said secondary winding being connected to said spark plug means; ignition capacitor means connected to said primary winding of said ignition transformer for providing energy to said spark plug means; charging means for charging said ignition capacitor means; first controllable electronic switching means connected in series with said primary winding of said ignition transformer; actuating means connected to said engine and connected to said first controllable electronic switching means for periodically actuating the latter from conducting to non-conducting states; oscillator means connected to said actuating means and providing pulsing means applied to said first controllable electronic switching means through said actuating means, said oscillator means having a first and a second amplifying means; pulse transformer means for each one of said amplifying means and having a primary winding connected in series with said amplifying means, the secondary winding of one of said pulse transformer means being connected to said second controllable electronic switching means, said oscillator means being an astable multivibrator, said first and second amplifying means being in series with said oscillator means; and a D.C. power supply having a positive potential terminal and a negative potential terminal, the emitters of said transistors being connected to said negative potential terminal through said primary windings of said pulse transformers.

An ignition arrangement for internal combustion engines comprising, in combination, spark plug means; ignition transformer means having a primary winding and a secondary winding, said secondary winding being connected to said spark plug means; ignition capacitor means connected to said primary winding of said ignition transformer for providing energy to said spark plug means; charging means for charging said ignition capacitor means; first controllable electronic switching means connected in series with said primary winding of said ignition transformer; actuating means connected to said engine and connected to said first controllable electronic switching means for periodically actuating the latter from conducting to non-conducting states; oscillator means connected to said actuating means and providing pulsing means applied to said first controllable electronic switching means through said actuating means, said oscillator means having a first and a second amplifying means; pulse transformer means for each one of said amplifying means and having a primary winding connected in series with said amplifying means, the secondary winding of one of said pulse transformer means being connected to said second controllable electronic switching means, said oscillator means being an astable multivibrator, said first and second amplifying means being in series with said oscillator means; and a D.C. power supply having a positive potential terminal and a negative potential terminal, the emitters of said transistors being connected to said negative potential terminal through said primary windings of said pulse transformers. The collector resistor means connected between the collector of each transistor and said positive terminal of said power supply; base resistor means connected between the base of each of said transistors and said positive potential terminal; first capacitor means connected between the base of the transistor of said first amplifying means and the collector of said second amplifying means; and second capacitor means connected between the base of the transistor of said second amplifying means and the collector of the transistor of said first amplifying means.
9. The ignition arrangement for internal combustion engines as defined in claim 8, including diode means connected in series with each one of said secondary windings of said pulse transformer means for transmitting only positive pulses to said controllable electronic switching means.

10. The ignition arrangement for internal combustion engines as defined in claim 8, including cam means operating said actuating means and rotatably driven by said engine so that said actuating means is in the conducting state during the time interval when ignition of said spark plugs prevails.

References Cited

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