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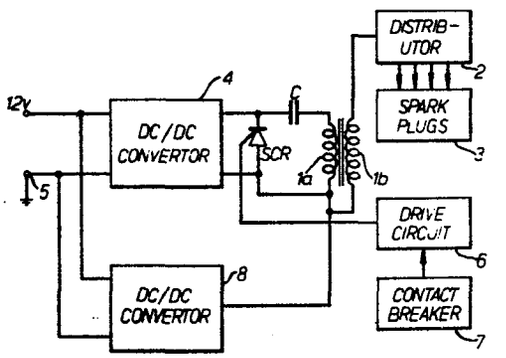
(54) **Ignition system.**

(57) An apparatus for producing spark ignition of an internal combustion engine, comprising an ignition coil having primary and secondary windings (1a, 1b), a capacitor (c) connected to the primary winding (1a), voltage generating means (4) for receiving a supply voltage (5:12V) and arranged to charge the capacitor to a voltage greater than the supply voltage, switching means (SCR) arranged to cause the capacitor (c) to discharge through the primary winding (1a) and thereby produce in the secondary winding (1b) a voltage pulse for producing spark ignition of the engine, and control means (8) arranged to apply to the output of the secondary coil a direct current capable of sustaining a spark established by said voltage pulse.



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"Ignition System"

This invention relates to improvements in and relating to apparatus for producing spark ignition of an internal combustion engine.

It is well known that the electrical sparks fed to the spark plugs of an internal combustion engine are conventionally produced by means of an ignition coil having its high voltage secondary winding connected to the engine's spark plugs through a distributor, and having its low voltage primary winding connected to a low voltage source, typically a 12 volt battery or an alternator system driven by the engine. An engine driven switching device, typically a mechanical contact breaker, produces interruptions in the current flowing in the coil's primary winding and consequently high voltage pulses are produced in the coil's secondary winding, which are applied to the spark plugs.

Recently, a proposal has been made to increase the energy of the sparks applied to the spark plugs, by connecting a capacitor to the primary coil of the winding, charging the capacitor to a voltage much higher than the conventional 12 volt supply voltage from the engine's battery and alternator, and discharging the capacitor through the coil's primary winding each time a spark is required. With such a capacitive discharge system, the total spark energy for each firing of a cylinder of the

engine, is increased substantially with respect to the conventional spark ignition apparatus, but the duration of the sparks produced by the system is much less than those produced by the conventional apparatus. Such shorter sparks can prove disadvantageous with certain engines, since the sparks may not produce a complete ignition of the fuel/air mixture.

I have now found that the sparks produced across a spark plug by the aforementioned capacitive discharge system, can be sustained after the discharge of the capacitor, by applying a high voltage direct current to the spark plug, and the present invention provides an apparatus for producing spark ignition of an internal combustion engine, comprising an ignition coil having primary and secondary windings, a capacitor connected to the primary winding, voltage generating means for receiving a supply voltage and arranged to charge the capacitor to a voltage greater than the supply voltage, switching means arranged to cause the capacitor to discharge through the primary winding and thereby produce in the secondary winding a voltage pulse for producing spark ignition of the engine, and control means arranged to apply to the output of the secondary coil a direct current capable of sustaining a spark established by said voltage pulse.

The control means can be arranged to operate to sustain each spark for substantially the entire operative firing period of the cylinder of the engine in which the spark is produced, thereby producing an improved combustion in the cylinder.

Each spark can be terminated for example by means of a switching device arranged to switch off said high voltage direct current after a predetermined spark duration, and the switching device can conveniently be responsive to the operation of the engine's distributor.

Alternatively, and preferably, the said high

voltage direct current is arranged to be of such a magnitude that the spark is extinguished automatically by a rise in gas pressure which occurs in the cylinder as a result of combustion of a fuel/air mixture therein by the spark. I have found that the voltage required to sustain the spark increases with increased gas pressure in the cylinder, and that by appropriately selecting the magnitude of said high voltage produced by the control means, it is possible to arrange for the spark discharge in the cylinder to become cut off by the increased gas pressure resulting from combustion of the fuel/air mixture in the cylinder. Thus, as the gas pressure increases as a result of the combustion, it reaches a level which precludes the said high voltage direct current from sustaining the spark, and consequently the spark is extinguished.

Preferably, the control means comprises a d.c./d.c. converter for producing from a low voltage input supply, of typically 12 volts from the engine's battery or alternator system, a high d.c. voltage of typically 3000 volts. Also, the voltage generating means preferably comprises a d.c./d.c. converter for producing from said low voltage supply a charging voltage of typically 200 volts for the capacitor.

In order that the invention may be more fully understood and readily carried into effect, an embodiment thereof will now be described by way of example with reference to the single Figure of the accompanying drawing.

The apparatus comprises a conventional ignition coil 1 having a primary winding 1a and a secondary winding 1b connected through a conventional distributor 2 to spark plugs 3 of the engine. The primary winding 1a is connected in series with a capacitor C and a switching thyristor SCR.

The capacitor is charged to a voltage of typic-

ally 200 volts by means of a d.c./d.c. converter 4, which has its input connected to terminals 5 that are connected to a low voltage supply of typically 12 volts derived from the engine's battery and alternator system.

The thyristor SCR is fired by a drive circuit 6 responsive to operation of a contact breaker 7. The contact breaker can be of the conventional mechanical kind or of the photoelectric or magnetic types more recently developed.

Connected in series with the secondary winding 1b of the coil is a d.c./d.c. converter 8 which produces from the 12 volt supply a high voltage d.c. current of typically 3 KV.

Thus, in use of the apparatus, the capacitor C is charged by the converter 4, and upon operation of the contact breaker 7, the drive circuit fires the thyristor SCR causing the capacitor C to discharge through the primary winding 1a of the coil. As a result a high voltage pulse is induced by the coil's secondary winding, the pulse being applied to one of the spark plugs 3 through the distributor 2. The magnitude of the voltage pulse is sufficient to initiate a spark that ignites fuel/air mixture in a cylinder of the engine, but the discharge of capacitor only produces a voltage pulse of a short duration compared with the period in the engine's cycle that it is desirable to maintain the spark in order to optimise combustion of the fuel/air mixture in the cylinder.

The duration of the spark is however extended beyond the duration of the discharge of the capacitor, by the action of the converter 8. The high voltage d.c. output of the converter 8 is of insufficient magnitude alone to initiate the spark, but once the spark has been started by the high voltage pulse induced in the winding 1b, a high voltage direct current flows from the converter 8 to sustain the spark after the high voltage pulse has

died away, and effect a complete combustion of the fuel/air mixture in the cylinder.

As the combustion of the fuel/air mixture takes place in the cylinder, the gas pressure in the cylinder momentarily rises. The voltage required to sustain the spark increases with increased gas pressure, and this effect is used in the present apparatus to extinguish the spark. The magnitude of voltage produced by the converter 8 is selected so that the spark will be quenched when the gas pressure in the cylinder rises to a selected level which indicates a satisfactory combustion of the fuel/air mixture. When the given pressure level is reached, the voltage produced by the converter 8 will be insufficient to sustain the spark which will then be terminated. Clearly, the voltage level produced by the converter 8 will be selected to suit the operating characteristics of the engine concerned. Thus, with the described example of the apparatus of the invention, the high voltage pulse produced by the discharge of the capacitor need only be sufficient to initiate the spark, the spark being sustained by the d.c./d.c. converter 8.

Many modifications and variations of the described apparatus will be readily apparent to those skilled in the art. For example, to terminate the spark, a switching device could be provided to disconnect the converter 8 from the coil. The switching device could operate in response to operation of the contact breaker.

CLAIMS

1. An apparatus for producing spark ignition of an internal combustion engine, comprising an ignition coil having primary and secondary windings, a capacitor connected to the primary winding, voltage generating means for receiving a supply voltage and arranged to charge the capacitor to a voltage greater than the supply voltage, switching means arranged to cause the capacitor to discharge through the primary winding and thereby produce in the secondary winding a voltage pulse for producing spark ignition of the engine, characterized by control means arranged to apply to the output of the secondary coil a direct current capable of sustaining a spark established by said voltage pulse.

2. An apparatus in accordance with claim 1 and characterized by a switching device arranged to switch off said high voltage direct current after a predetermined spark duration.

3. An apparatus in accordance with claim 1 wherein the high voltage direct current is arranged to be of such a magnitude that the spark is extinguished automatically by a rise in gas pressure which occurs in the cylinder of the engine in which the spark occurs as a result of combustion therein of a fuel/air mixture by the spark.

4. An apparatus in accordance with claim 1 characterized in that the control means comprises a d.c. to d.c. converter for producing from a relatively low voltage supply said direct current for sustaining spark ignition.

5. An apparatus in accordance with claim 1 characterized in that said voltage generating means comprises a d.c. to d.c. converter arranged to charge the capacitor.

6. An apparatus in accordance with claim 1 characterized in that said switching means comprises a semiconductor switching means.

7. An apparatus in accordance with claim 6 characterized in that said switching means comprises a thyristor.

8. An apparatus in accordance with claim 7 characterized by an electrical drive circuit for responding to operation of the contact breaker of the engine, said drive circuit being arranged to operate said switching means.

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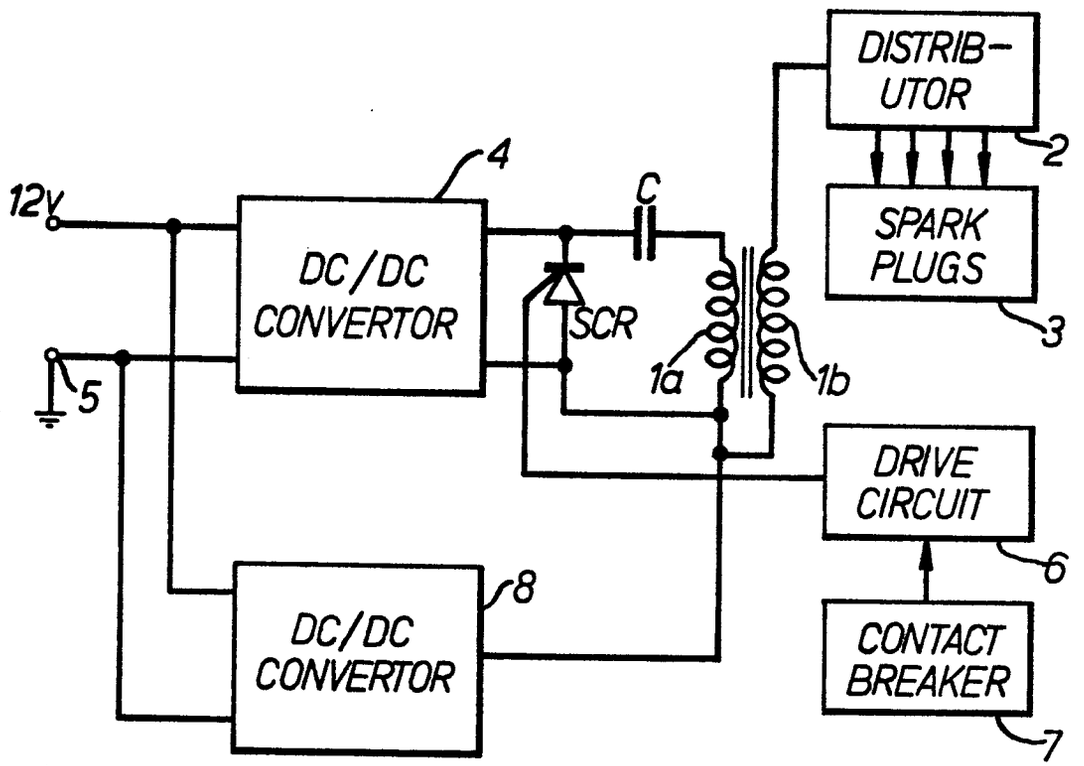
DISTRIB-
UTOR
2
SPARK
PLUGS
3
4
12V
DC/DC
CONVERTOR
C
SCR
1a
1b
5
DRIVE
CIRCUIT
6
8
DC/DC
CONVERTOR
CONTACT
BREAKER
7

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 78 30 0401

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	US - A - 3 921 606 (R. HAERT) * The document in its entirety *	1,2,4-8
	FR - A - 2 068 903 (THE BENDIX CORPORATION) * The document in its entirety *	1,2,4-8
	FR - A - 2 149 929 (R. BOSCH) * The document in its entirety *	1

CLASSIFICATION OF THE APPLICATION (Int. Cl.²)

F 02 P 3/08

TECHNICAL FIELDS SEARCHED (Int.Cl.²)

F 02 P 3/08

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	14-12-1978	GODIN

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