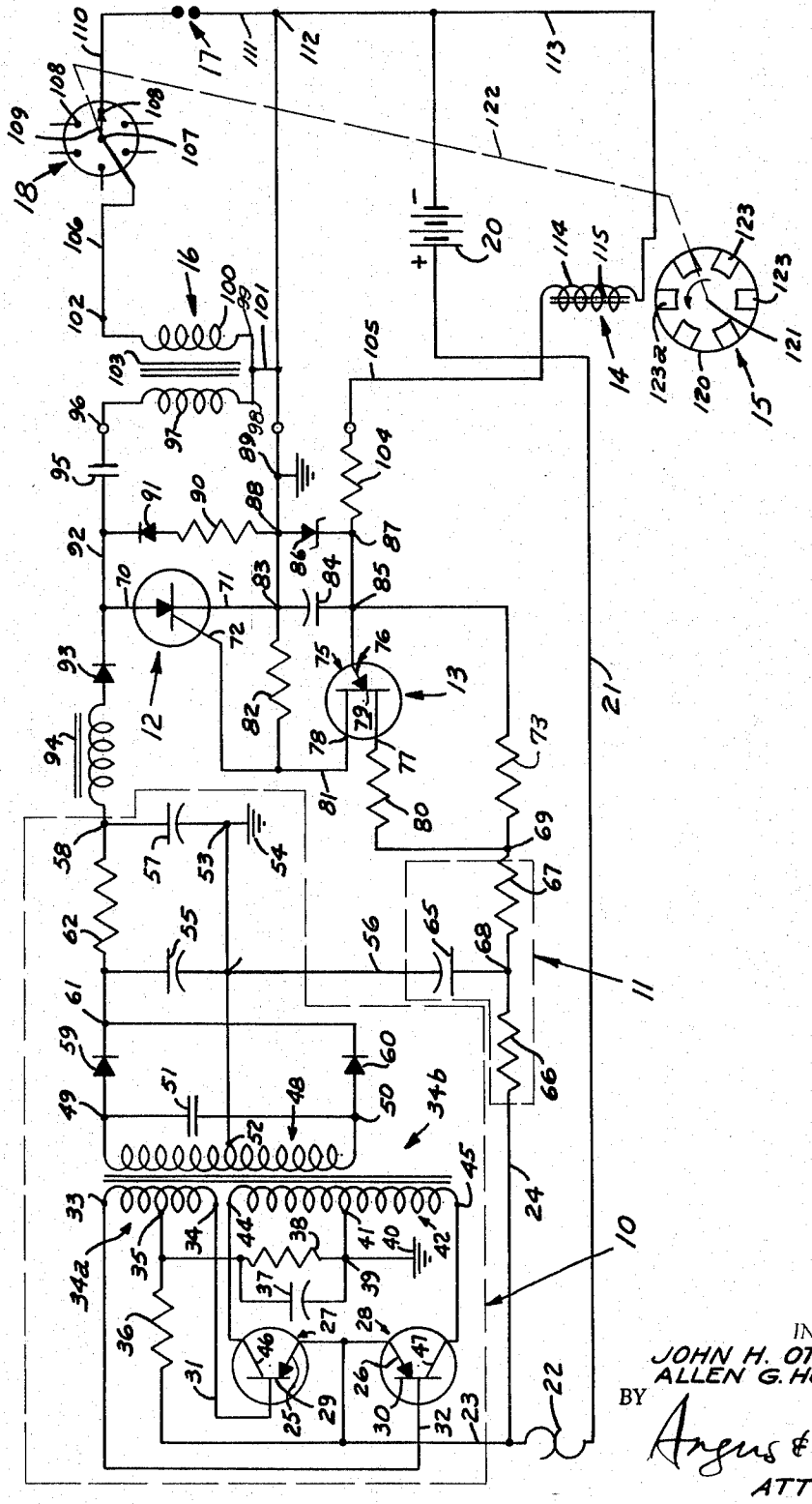
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CAPACITIVE DISCHARGE IGNITION SYSTEM
CAPABLE OF MULTIPLE SPARKING
AT SLOW-ENGINE SPEEDS
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CAPACITIVE DISCHARGE IGNITION SYSTEM CAPABLE OF MULTIPLE SPARKING AT SLOW-ENGINE SPEEDS

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This invention relates to ignition systems.

The ignition of a compressed charge in a gas engine is conventionally accomplished by an electrical discharge inside the cylinder at a time at or near the maximum compression of the charge. Perhaps the best known ignition system is that which utilizes a breaker device which with a coil generates a surge of electricity to create a spark at the appropriate time.

There are many well-recognized disadvantages to the conventional ignition system, not the least of which is the decreasing reliability of the mechanical elements as speed of the engine increases. Accordingly, there have been many efforts made to create alternative systems. Such systems have as their objective to be just as reliable, if not more reliable, at higher speeds than at lower speeds, relatively simple and rugged in construction, and relatively trouble-free. It is an object of this invention to provide such a system.

Another objective of this system is to provide for a multiple spark at slow-engine speeds, such as at or near to starting of the engine, at which conditions a multiplicity of sparks is an advantage. This is attained in this invention while still providing an assurance of a spark at the precise moment needed at every engine speed.

Still another object of this invention is to provide an electronic system compitable with conventional ignition components.

An ignition system according to this invention includes a spark gap within an engine cylinder, an induction coil having a core and a primary and a secondary winding. Pulsing means is provided, the preferred embodiment of which is a pickup which has a core and a winding, and magnetic means movably disposed in adjacency to the pickup, so disposed and arranged to pass the pickup coil and induce a pulse therein at a frequency which is proportional to that of the engine's speed. A multi-vibrator and a power supply are also provided, along with trigger means which is actuable by pulses from the pickup. The frequency of the multi-vibrator is determined by itself, so that one or a plurality of pulses may emanate from the multi-vibrator, depending on the duration of the pulse from the pickup. The trigger means discharges power which was stored in the system into the induction coil whereupon a high-voltage current flows to the spark gap.

According to a preferred but optional feature of this invention, the trigger means is linked to the power supply through a choke coil.

According to still another preferred but optional feature of the invention, the trigger means comprises a gated diode, and the multi-vibrator comprises a unijunction transistor.

The above and other features of this invention will be fully understood from the following detailed description and the accompanying drawing in which the single figure is a combined schematic and physical drawing of the presently preferred embodiment of the invention.

The presently preferred embodiment of ignition system includes a power supply 10, a filter 11, trigger means 12, multi-vibrator 13, pulsing means comprising a pickup 14 and magnetic means 15, induction coil 16, spark gap 17,

and, optionally, a distributor 18. These elements will now be described in detail.

A battery 20, or other source of positive and negative potential, is connected by lead 21 to a circuit breaker or fuse 22. To the other terminal of the circuit breaker, there are connected leads 23 and 24. Lead 23 branches to connect to the emitters 25, 26 of a pair of PNP transistors 27, 28, respectively, which may conveniently by type 2N441. Bases 29, 30 of the transistors are connected by leads 31, 32, respectively, to terminals 33, 34 of one segment of a primary winding 34*a* of a transformer 34*b*. A suitable transformer is Triad TY81 manufactured by Triad Transformer Corporation at 4055 Redwood Avenue, Venice, California. This is a transformer suitable for transforming 12-volt D.C. current from the battery to an A.C. voltage to be rectified at about 200 volts, when used in combination with a pair of transistors.

Center tap terminal 35 of this segment of winding is connected to one terminal of a resistor 36 which has a rating of 3 ohms, 2 watts. The other end of this resistor is connected to lead 23. The first mentioned terminal of resistor 36 is also connected to a capacitor 37 and a resistor 38, which capacitor and resistor are connected in parallel with each other. Capacitor 37 has a rating of 100 microfarads at 25 volts, and resistor 38 has a rating of 200 ohms, 2 watts. Junction 39, connecting one end of this parallel connection, is connected to ground 40 and also to center tap terminal 41 of still another primary winding 42 of transformer 34*b*.

Terminals 44, 45 of winding 42 are respectively connected to collectors 46, 47 of transistors 27 and 28.

The secondary winding 48 of transformer 34*b* includes a pair of terminals 49, 50, which are connected to each other across a capacitor 51, which has a rating of 0.005 microfarads at 1 kv. Center tap terminal 52 of secondary winding 48 is connected to junction 53 and through it to ground 54. A capacitor 55, having a rating of 8 microfarads at 350 volts D.C., is connected to junction 53 and also to filter 11, through lead 56. Another capacitor 57 has a rating of 8 microfarads at 350 volts D.C., and is connected to junction 53 and also to output junction 58 of the power supply.

Two rectifiers 59, 60 are connected to terminals 49, 50, respectively, and are mutually joined at junction 61, which junction is connected to one terminal of resistor 62, said resistor having a rating of 350 ohms at 20 watts. The other terminal of resistor 62 is connected to junction 53 which is the output point for the power supply.

Filter 11 includes a capacitor 65, having a rating of 50 microfarads at 25 volts. The filter also includes first and second resistors 66 and 67, which are connected at a junction 68 with the capacitor and with each other. One terminal of resistor 66 is connected to lead 24, and the other is connected to a junction 69. Resistors 66 and 67 have ratings of 10 ohms and 100 ohms at ½ watt, respectively.

Trigger means 12 comprises a gated diode, which in the preferred embodiment is a silicon-controlled rectifier (SCR) such as a Sarkes-Tarzian 3TCRH, 400-volt rating. This device includes anode, cathode, and gate terminals 70, 71, 72, respectively.

Multi-vibrator 13 comprises a unijunction transistor 75. This device is characterized as having a PN contact, referred to as an emitter 76, and two ohmic contacts 77, 78 at base 79. This type of device will, with proper circuitry, act as a self-contained multi-vibrator. Other types of multi-vibrators may be used in this device, but this is a simple and rugged device especially suitable for use with this invention. The presently preferred unijunction transistor for use in this circuit is a UJT, 2N1671. Ohmic contact 77 is connected to one terminal

of a resistor **80**, which resistor has a rating of 390 ohms, ½ watt. The other terminal of this resistor is connected to junction **69**.

Ohmic contact **78** is connected by lead **81** to gate terminal **72** of the trigger means. Lead **81** branches to connect to one terminal of a resistor **82**, which has a rating of 240 ohms, ½ watt. The other terminal of resistor **82** joins to junction **83** which is connected to cathode terminal **71** and also to one terminal of a capacitor **84**, which has a rating of 0.075 microfarad at 200 volts. The other terminal of capacitor **84** is connected to junction **85**, which junction is connected to emitter **76** of the unijunction transistor. A resistor **73** having a rating of 43 kilohms, ½ watt, is connected between junctions **69** and **85**. The resistance of resistor **73** is selected in conjunction with the value of capacitor **84**. These two elements determine the frequency of oscillation of the multivibrator.

A zener diode **86**, type 1N714 (which zener diode is optional) is connected between junction **87** and junction **88**, junctions **83** and **88** being interconnected. Junctions **83** and **88** are grounded at ground **89**.

One terminal of a resistor **90**, 1 ohm, 2 watt, is connected to junction **88**, and the other to one terminal of still another rectifier **91**, rectifier **91** preferably being type 1N2071. The other terminal of rectifier **91** is connected to lead **92**, which lead **92** also connects to the anode terminal **70** of trigger means **12** and to one terminal of a rectifier **93**, also type 1N2071. The other terminal of rectifier **93** is connected to a choke coil **94**. Choke coil **94** has a rating between 0.5 and 0.75 henries, 200 milliampere current rating.

Lead **92** also connects to the first terminal of capacitor **95**, which has a rating of 1 microfarad at 600 volts D.C. The other terminal of capacitor **95** is connected to the first terminal **96** of the primary winding **97** of induction coil **16**. Second terminal **98** of the primary winding is connected to second terminal **99** of the secondary winding **100**. A center tap **101** between the two second terminals is connected to ground **89**. The secondary winding (which has a greater number of turns than the primary winding) has a first terminal **102**. The induction coil includes a core **103** of magnetic material.

One terminal of a resistor **104** is connected to junction **87** and the other to a lead **105**. Resistor **104** has a rating selected to suit the installation, for example, in this case, 56 kilohms; however, this resistance is one which is subject to selection in order to compensate for tolerance errors in the system. Lead **106** connects the first terminal of the secondary winding on the induction coil to the center post **107** of distributor **18**.

Pickup coil **14** may conveniently have a soft iron core, and comprise about 10,000 turns of 0.002" O.D. copper wire, varnish insulated, wound over a core about 1/16" O.D. resulting in about 3000 ohms D.C. resistance. The pickup coils is about ⅜" long.

Distributor **18** is conventional and includes a plurality of contacts **108**, one for each spark gap (that is, one for each cylinder), with lead extending between the respective spark gap and contact. A rotary blade **109** sequentially interconnects the contacts so as to make sequential connections between the center post and the spark gaps.

It is to be understood that were this device to be utilized in connection with a one-cylinder engine, then no distributor would be necessary, and there would simply be a direct connection between lead **106** and **110**, which lead **110** indicates a connection to a single spark gap **17**. Obviously, were only one spark gap to be utilized, then no distributor is necessary. It will also be understood that a plurality of pickup coils could be utilized, one for each of the spark gaps so that instead of distributing the output derived from a signal derived from a single pickup coil through a distributor having a multiplicity of positions, it would be equally possible to derive signals from a plurality of pickup coils and to provide a respective multi-vibrator, trigger means and induction coil for each individual spark gap.

Spark gap **17** (for example, a standard spark plug) has a pair of terminals, one of which is connected to lead **110**, and the other of which is connected to lead **111**, lead **111** going to ground **89**. Similarly, each of the other spark gaps in the illustrated embodiment would have its own equivalent of lead **110** attached to a respective one of contacts **108**, and have its other terminal brought back to connect to junction **112** and through it to ground **89**.

To junction **112**, there is connected the other terminal of battery **20**, this being the battery's connection to ground. Also a lead **113** extends from the negative side of the battery through winding **114** of pickup **14**. Pickup **14** includes a core **115** of magnetizable material. The other terminal of winding **114** is connected to lead **105**.

The pulsing means produce a pulse in pickup **14** by the action of magnetic means **15**. Means **15** is shown as including a body **120** revolving around a center **121** in the direction illustrated by the arrow. Similarly, for convenience, an indicia **122** illustrates that the blade **109** of the distributor and the body **120** is interconnected for mutual and synchronous rotation. A convenient location for body **120** is on the shaft of the distributor, although it could equally well be placed on the crankshaft of the vehicle or at any other place where a magnet will be brought periodically into near registration with the pickup coil so as to pass by the same and induce a current therein.

Magnets **123** are shown imbedded in body **120**, with their north poles all facing radially outward from the center. For a 6-cylinder engine, there will be six of these magnets; for an 8-cylinder, eight; and for a 1-cylinder engine, only one. It has been found that it is desirable to have a flux density at the surface of the poles at least equal to about 400 gauss in order to cause a suitable pulse to be generated in the pickup winding, which is a coil wound around a core of magnetizable material. As is well known, the passage of a magnet past the coil as indicated will cause a sine wave pulse to be generated, which has a positive and a negative component. It is further evident from the aforesaid that there will be six of these pulses for every revolution of body **120** so that, with proper mechanical interlinkages, one of these pulses will occur just as blade **109** touches a contact **108** respective to a selected spark gap **17**.

Power supply **11**, capacitor **95**, and primary winding **97** are connected in a "first series circuit." Trigger means **12**, capacitor **95**, and primary winding **97** are connected in a "second series circuit." It is evident that the capacitor and the primary winding form portions of both series circuits.

The operation of the system will now be described. The operation of power supply **10** requires no detailed description here. Alternating current is generated in the primary windings by the interaction of the two transistors **27**, **28**. The output of this power supply passes through rectifiers to output junction **58**, where the output is direct current. It has been found desirable to provide the filter **11**, because the signal input from pickup **14** is only on the order of about 50 millivolts, which is about equivalent to the noise level of a power supply of this type. This device will readily produce an output voltage of 200 volts to the choke coil.

In accordance with the standard operation of a choke coil, the field builds up when charging and, when the core is saturated, the field will collapse which about doubles the voltage, and produces at lead **92**, a voltage of about 400 volts. The rating of the choke coil is selected such that its resonant frequency is higher than any of the frequencies which occur within the rest of the system in operation, so that the performance of the system will not be limited by the resonant frequency of the choke itself.

Now assuming for a moment that magnet **123***a* is just

passing the pickup, the following is the operational situation. At this time, blade **109** will interconnect the center post and lead **110**. Also, at this time, a sine wave voltage will be imposed upon lead **105** but will pass through resistor **104**. Blade **109** touches the respective contact for a period of time at least equal to that during which the pulse is generated. Passage of the negative component will, by virtue of its connection with junction **85**, and emitter terminal **76**, cause the multi-vibrator to oscillate. The free-running frequency of the illustrated multivibrator is about 600 cycles. This is roughly equivalent to an engine speed of about 9500 r.p.m. for an 8-cylinder motor, or about 12,000 r.p.m. for a 6-cylinder motor, both top speeds for these classes of engines.

When the multi-vibrator oscillates, then the signal which it produces in lead **81** is applied to the gate terminal of the trigger means which causes the trigger means (SCR) to conduct. Before this occurred, the choke will have charged capacitor **95**, and that charge now awaits discharge through the trigger means **12**. The discharge connection is through junctions **83** and **88** to ground **89**. The other discharge flow is through the primary winding of the induction coil, and lead **101** to ground **89**. This induces a higher voltage in the secondary which is conducted through the distributor, if there is one, to spark gap **17**, this circuit being completed to ground **89** through lead **111**.

When there is no pulse from pickup **14**, the multivibrator ceases to oscillate, which renders the trigger means non-conductive. Then the choke coil again charges the condenser.

The zener diode **86** is provided to limit the level of the input signal so that the unijunction transistor (multivibrator) cannot be saturated by the pickup.

From the foregoing, it will be seen that the trigger means will be actuated by the multi-vibrator at a frequency determined by the multi-vibrator and concurrent with the times at which a negative portion of a pulse from pickup **14** is present so as to actuate the multivibrator. Accordingly, there is a speed at which the magnet is moving so rapidly past the pickup that it will actuate the multi-vibrator for only one pulse to the trigger means. This is the upper limit of the velocity of the system, and is selected so as to be at or above the maximum speed of the engine involved.

Similarly, as the speed decreases, then a signal of sufficient amplitude to actuate the multi-vibrator will remain on the multi-vibrator for a period of time longer than one of its single pulses whereupon the trigger means may be actuated for a period longer than one pulse, and in fact may be several pulses, which in turn will pass several spark discharges through the respective spark gap. Accordingly, this device provides the advantage of multi-sparking at low and starting speeds, while it always guarantees a hot spark suitably timed at the most rapid of the speeds.

The system given as an example utilizes a center-tapped induction coil, which is perhaps the most commonly used type. However, other circuits and other types of induction coils may readily be substituted by persons skilled in the art. The system of the invention is adapted to provide current pulses to the primary winding of an induction coil. Any secondary circuit which completes a circuit through the spark gap is suitable.

This system is quite compatible with standard ignition installations. Most conveniently, it may be installed simply by adding a pickup coil adjacent to the rotor location, and substituting the magnetic means and rotor for the standard rotor and contact points.

Inasmuch as this system is actuated by pulses, it is evident that the actual source of the pulse is not critical. The most convenient pulse source is the magnetic means as shown. However, electro-optical means, such as a beam of light and a photo-sensitive cell, with means such as slits or mirrors for interrupting or transmitting the beam in pulses, would work electrically as well as in the place of the pulse means shown.

This device enables a rugged pulse and pickup system to be made wherein magnets may simply be potted in a rotatable device next to a rugged pickup coil. There are no mechanical devices subject to flutter, or any inherent inadequacy at any specific rate of operation.

This invention thereby provides a simple, effective, and highly efficient ignition system suitable for a wide range of engine types and numbers of cylinders.

This invention is not to be limted by the embodiments shown in the drawing and described in the description which is given by way of example and not of limitation, but only in accordance with the scope of the appended claims.

We claim:

1. An ignition system for an internal combustion engine to provide a spark in a spark gap disposed in an engine cylinder, whereby to ignite a combustible mixture in said cylinder, said system comprising: an induction coil which includes a primary and a secondary winding, said spark gap being operatively connected to the said secondary winding; capacitance means; power supply means providing a D.C. output; means connecting said primary winding, said capacitance means, and said power supply means in a first series circuit so as to charge said capacitor means; trigger means actuable by a control signal connected in a second series circuit with said capacitance means and said primary winding so as to allow said capacitance means to discharge through said primary winding only when said trigger means is actuated; a pulsing means for providing an electrical pulse of a duration proportional to engine speed; multi-vibrator means operatively connected to said pulsing means whereby to be actuable by said electrical pulse to produce an oscillatory control signal having a frequency inherent within the multi-vibrator means for the duration of said electrical pulse; means applying said oscillatory control signal to said trigger means; whereby said trigger means is repetitively actuated at said frequency of said oscillatory control signal, thereby repetitively discharging said capacitance means at said frequency of said oscillatory control signal during the time the electrical pulse actuates said multi-vibrator means.

2. An ignition system according to claim **1** in which a choke coil is included in the said first series circuit between the power supply and the capacitance means.

3. An ignition system according to claim **2** in which the pulsing means comprises a light source, means for pulsing said light source, and means responsive thereto to produce an electrical pulse to the multi-vibrator.

4. An ignition system according to claim **2** in which the pulsing means comprises a pickup coil comprising a winding and a core, and magnetic means so disposed and arranged as periodically to pass by said pickup winding and induce an electrical pulse therein.

5. An ignition system according to claim **2** in which the trigger means comprises a gated diode.

6. An ignition system according to claim **2** in which the multi-vibrator comprises a unijunction transistor including an emitter and two ohmic contacts, the pickup being connected to the emitter whereby the pulse from the pickup is impressed upon the emitter to cause the unijunction transistor to oscillate, one of the ohmic contacts being connected to the gated diode whereby to cause the gated diode to conduct current at the frequency of the unijunction transistor and during the time it oscillates.

7. An ignition system according to claim **5** in which the multi-vibrator comprises a unijunction transistor including an emitter and two ohmic contacts, the pickup being connected to the emitter whereby the pulse from the pickup is impressed upon the emitter to cause the unijunction transistor to oscillate, one of the ohmic contacts being connected to the gated diode whereby to cause the

gated diode to conduct current at the frequency of the unijunction transistor and during the time it oscillates.

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