

[54] **ELECTRO-MECHANICAL SWITCHING SYSTEM**

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[58] Field of Search **123/148 E**

[56] **References Cited**

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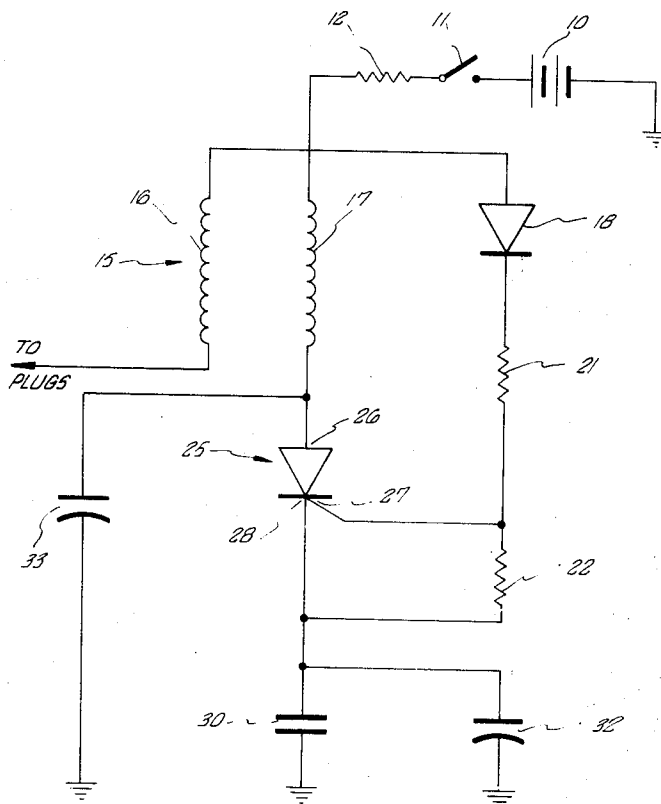
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[57] **ABSTRACT**

An electronic switching system having particular utility in ignition systems for internal combustion engines is disclosed. A silicon controlled rectifier in series with the inductor coil and breaker points is utilized to isolate the breaker points from the ignition coil and to carry out the make and break functions. Should the SCR fail as by shorting, the ignition system will continue to operate as a conventional ignition system.

5 Claims, 1 Drawing Figure



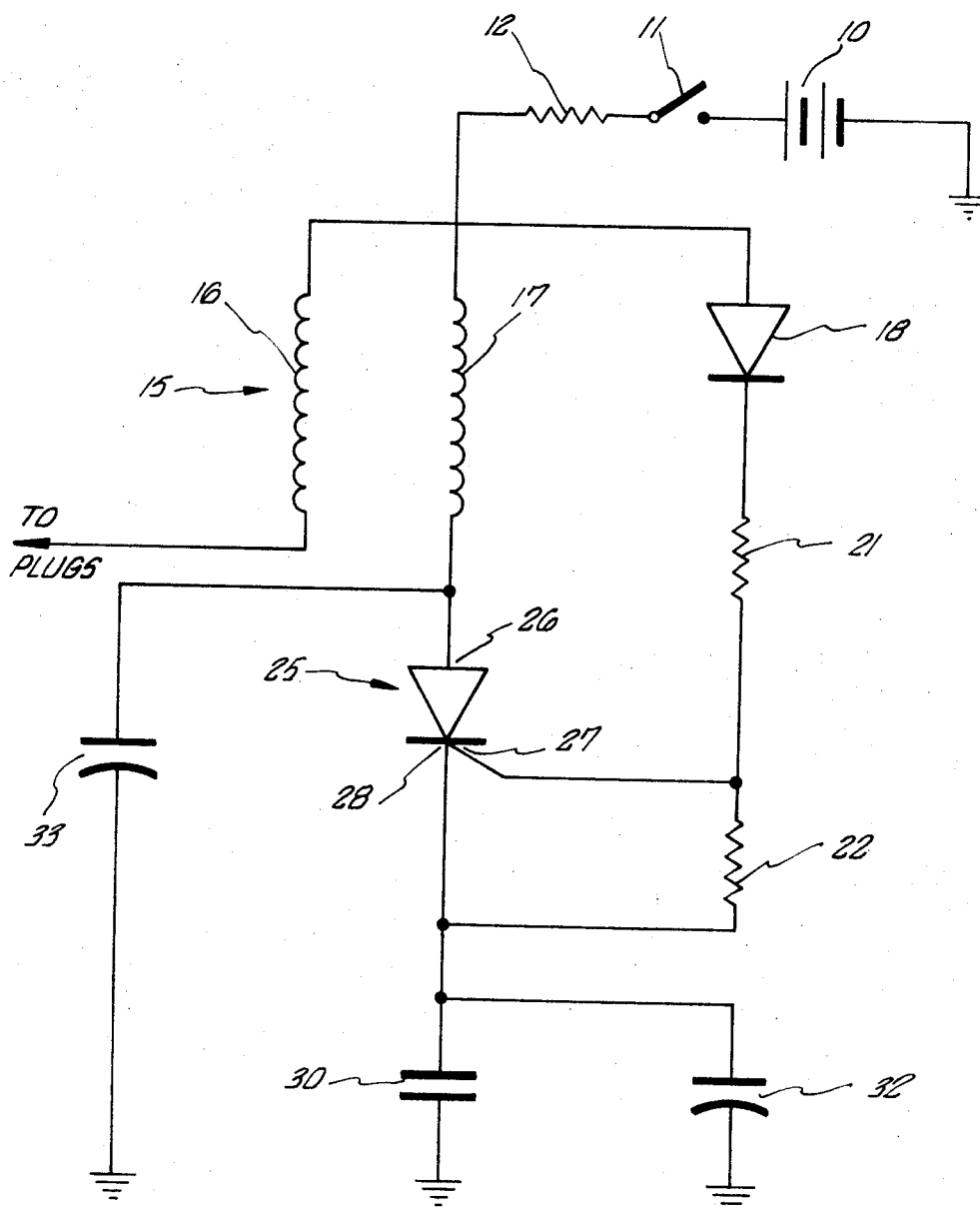


FIG. 1.

ELECTRO-MECHANICAL SWITCHING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates in general to a solid state assisted switching system in which a switch makes and breaks a ringing inductive load and, more particularly, to a new and useful ignition system for internal combustion engines and the like.

2. Description of the Prior Art

The standard ignition system of the automotive industry utilizes an ignition coil which has a primary winding and a secondary winding. The ignition coil secondary winding is connected via a suitable distribution means to the engine's spark plugs. The ignition coil primary winding is connected in series with a source of DC power, typically the automobile battery, and a set of breaker contacts. The breaker contacts open and close in synchronism with the motor in accordance with a predetermined sequence typically controlled by a mechanical means such as a breaker cam.

In such an ignition system the spark energy for the plugs is supplied by the DC battery which is stored and subsequently released by the ignition coil, at an appropriate voltage level, to jump the spark gap. In operation, closure of the points causes current to flow in the primary of the ignition coil and results in the build up of a magnetic field. Opening of the points causes the sudden collapse of the field which results in a high induced voltage in the secondary winding of the ignition coil. A capacitor is typically connected across the points to limit the rate of the field collapse to limit arcing of the contacts to an acceptable level. Frequently a ballast resistor is connected in series with the configuration thus described to limit the saturation current of the ignition coil primary.

The basic ignition system above described has proven extremely useful and has remained substantially unchanged in form and function for many years. Among its advantages are its extreme simplicity of design, reliability and economy.

The basic ignition system, however, has several important disadvantages. For example, substantial voltages appearing across the breaker contacts result in oxidation, erosion, and pitting of the contacts. The contacts thus require frequent maintenance and replacement to enable continued efficient performance of the ignition circuit. Arcing of the points also reduces available spark energy because it acts as a load on the tuned circuit formed by the ignition coil primary and the capacitor connected across the points. The dissipation of available energy, while important at all engine speeds becomes most significant at higher engine RMP's. This is so since at high engine speeds the contacts are closed for only a relatively short time period. Current build up through the ignition coil primary does not normally reach full saturation value before the points are opened. Thus, the available output voltage is reduced from its optimum value. Any further dissipation of energy as by arcing of the points further reduces available spark energy.

Numerous and varied attempts have been made to eliminate the deficiencies of the standard ignition system. In one approach transistor switching circuits are employed with the points carrying only control or bias current. Some systems do away with the breaker points completely and use magnetic or optical pick-ups and

pulse amplifiers to control the output transistor. These systems, however, require the transistor switch to be operated at high voltage and current levels. Transistors capable of meeting such criteria are extremely expensive and require elaborate compensation techniques such as special coils, diode protection, etc.

Another, alternate, approach is exemplified by the so-called "capacitor discharge ignition systems." In this type of system, the battery voltage is typically stepped up to several hundred volts by a DC to DC converted and stored in a capacitor. The capacitor is discharged into the primary of the ignition coil, at the appropriate time, by an electronic switch. The capacitor energy is thus converted to a high voltage pulse in the secondary winding of the ignition coil. In this approach too, the points typically carry only control current. Capacitive discharge systems suffer from the disadvantage that they are generally extremely complex and costly. Further, a common disadvantage of most known alternate electronic schemes is that upon failure of any component the entire ignition system fails.

SUMMARY OF THE INVENTION

An electronic switching system is disclosed having particular utility in ignition systems for internal combustion engines. The system obviates many of the deficiencies of the prior art systems while remaining uncomplicated and economical.

In accordance with a preferred embodiment of the present invention a silicon controlled rectifier is utilized to isolate the breaker points from the ignition coil and to carry out the make and break functions. The anode and cathode of the silicon controlled rectifier are connected in series with the DC power source, primary coil and breaker points of a standard ignition system and located between the primary of the ignition coil and the points.

Means are provided for turning the SCR "on" responsive to the closing of the points. With the SCR conducting and the points closed the ignition coil primary current is carried by both the SCR and the points. Means are provided for turning the SCR "off" responsive to the opening of the points. The fly-back voltage generated by the ignition coil primary is thus sustained by the SCR and not by the points. Arcing of the points and the resultant energy dissipation and spark plug wear is minimized. Substantial additional energy is made available for application to the plugs which results in faster starts, more complete combustion of the fuel, lower gas consumption and a reduction in emitted pollutants.

As another unique feature of the present invention should the SCR fail, the ignition system will continue to operate as a conventional ignition system. The system circuitry results in a decrease in the wear characteristics of the points and an increase in the energy available for application to the plugs.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a circuit diagram of a preferred form of the invention as incorporated in an ignition system for an internal combustion engine.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, there is shown a circuit schematic of a preferred form of the invention as incor-

porated for use in an ignition system for internal combustion engines or the like. A DC battery 10 is positioned in series electrical configuration with an ignition switch 11, a ballast resistor 12, primary winding 17 of a transformer 15 and a make-break switch (breaker points) 30.

The secondary 16 of transformer 15 supplies current at high voltage to the spark plugs of the internal combustion engine in a manner well known in the art. A capacitor 32 is connected across the breaker points 30 as is also known in the art. The configuration thus described comprises the standard automotive ignition system.

In accordance with the present invention, a silicon controlled rectifier or similar switching device 25 is connected with its anode and cathode terminals 26 and 28 respectively between the primary of the transformer and the breaker points. From the other end of the primary winding 17 a diode 18 and resistor 21 are connected to the gate terminal 27 of the SCR. An optional resistor 22 is connected between the gate and the cathode of SCR 25. Resistor 22 reduces the sensitivity of the gate to voltage spikes in a manner well known in the art. A capacitor 33 is connected between the SCR anode and ground, as shown.

The system thus described operates as follows:

With the ignition switch closed, and the breaker points initially open, closure of the breaker points 30 allows gate current to flow from the battery 10 through diode 18 and resistor 21. The gate current turns "on" 27 the SCR after a small turn on delay corresponding to the time required to spread conduction and regeneration through the solid-state device's junctions. Initially points 30 "see" only the SCR gate current and whatever charge may be contained in capacitor 32 at the instant of point closure.

With the SCR 25 conducting and the points 30 closed, ignition coil primary current is carried by both the SCR and points up to the limit set by the ballast resistor 12 and the winding resistance of the ignition coil. The time period just described is referred to as dwell time. The current flowing through primary coil 17 stores energy therein. This energy is subsequently dissipated through secondary winding 15 upon opening of the breaker points 30 in a manner to be hereinafter described.

To initiate a spark the points 30 are opened causing a collapse of the magnetic field in the coil 17. Immediately after opening of the points 30 the SCR remains conducting since the ignition coil will not allow an instantaneous change of current flow. Capacitors 32 and 33 are thus charged until the magnetic field in the coil is depleted. In a typical embodiment capacitor 32 and 33 may be charged to approximately 300 to 350 volts.

After the capacitors reach their maximum charge, current will flow from capacitor 33 back into the coil 17. This reverses current flow through the SCR and returns it to a blocking state. Capacitor 32, however, will retain its charge and prevent gate turn on by keeping diode 18 in the gate circuit reverse biased. Capacitor 33 and the ignition coil thereafter function as an isolated tuned circuit. This results in dissipation of the stored energy in an oscillatory manner and induces a high voltage into the secondary winding 16. This voltage is routed in the standard manner by distribution means, not shown, to the appropriate spark plug.

It will be apparent that the points 30 are disconnected or isolated from the high fly-back coil voltages after the initial quarter cycle of the inductive-capacitive ringing circuit. This is so since after SCR 25 is turned off it will revert to its forward blocking state and isolate the high inductor voltages from the points 30.

In this manner the high fly-back voltages do not cause significant dissipation of stored ignition coil energy via arcing across the points, as is experienced in standard ignition systems. A significantly higher percentage of the available energy thus finds its way to the spark plugs. The breaker points tend to last an appreciably longer time!

The system of the present invention has a further advantage in that a unique fail-safe feature is provided. This fail-safe feature stems from the typical failure mode of an SCR. It is known that should an SCR be subjected to either excessive current or temperature levels the SCR exhibits a tendency to short between its anode and cathode terminals rather than open. Should the SCR 25, as incorporated in the present system, experience such a failure mode the ignition system as a whole would still continue to operate since the remaining components would function as a standard ignition system.

Although the preferred embodiment of the present invention has been described in connection with an ignition system for use in an internal combustion engine it is not so limited. The principles above taught may be applied whenever a switch is required to make and break a ringing inductive load. The system of the present invention, it will be appreciated, is characterized by extreme simplicity and low cost of fabrication as well as by unique fail-safe characteristics and improved performance.

We claim:

1. In a spark ignition system including a DC source, an energy storing ignition coil and a make-break switch connected in series, the improvement which comprises: a silicon controlled rectifier having anode, cathode and gate terminals, said anode and cathode terminals being connected in series configuration between the ignition coil and the make-break switch; means responsive to the closing of the switch for applying a gate signal to said gate terminal to render said rectifier conductive, enabling current flow through the ignition coil to store energy therein; and

means responsive to the opening of the make-break switch for rendering said rectifier non-conductive, whereby the make-break switch will be isolated from the ignition coil thereby minimizing arcing across the switch and increase the efficiency of the ignition system.

2. The system of claim 1 wherein said gate signal applying means comprises:

a diode connected between the DC source-ignition coil junction and said gate terminal and poled to conduct gate current from the battery to said silicon controlled rectifier gate terminal responsive to the closing of the make-break switch.

3. The system of claim 2 wherein the make-break switch has a first terminal connected to said cathode terminal and a second terminal connected to a reference potential point, said means for rendering said rectifier non-conductive comprises:

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a first capacitor connected between said cathode terminal and the reference potential point; and
a second capacitor connected between said anode terminal and the reference potential point whereby said first and second capacitors will be charged subsequent to the opening of the make-break switch and thereafter back bias said silicon controlled rectifier to render it non-conductive, the ignition coil and said second capacitor functioning as an isolated tuned circuit after the silicon controlled rectifier is turned off.

4. In a system which includes a DC source of power, an energy storing inductor means and a periodically opening and closing make-break switch in series electrical configuration, the combination comprising:

a silicon controlled rectifier having anode, cathode and gate terminals, said rectifier anode and cathode terminals being connected in series electrical configuration between said inductor means and said make-break switch;

means for turning said silicon controlled rectifier on responsive to the closing of said make-break switch whereby energy from said source will be stored in said inductor; and

means for turning said silicon controlled rectifier off responsive to the opening of said make-break

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switch, whereby the make-break switch is electrically isolated from said inductor to prevent arcing across said switch.

5. An electronic ignition system for internal combustion engines, said system comprising:

a DC battery;

an ignition coil having primary and secondary windings;

a silicon controlled rectifier having anode, cathode, and gate terminals;

a pair of breaker points, said battery, ignition coil primary winding, anode and cathode terminals, and breaker points being connected in series electrical configuration with said anode and cathode terminals being connected between said primary winding and said breaker points, the breaker point remote from said cathode terminal being connected to a point of reference potential;

a first capacitor connected between said anode terminal and said reference point;

a second capacitor connected between said cathode terminal and said reference potential point; and

a diode connected between the primary winding terminal remote from said anode terminal and said gate terminal.

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