

[54] CAPACITIVE DISCHARGE IGNITION SYSTEM

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[58] Field of Search 123/148 E, 179 P, 179 G; 315/209

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[57] ABSTRACT

An ignition system for internal combustion engines utilizing a capacitive discharge to supply energy to the spark plugs. Charging and discharging of the capacitor is controlled by a circuit utilizing a silicon controlled rectifier which operates in response to the contact breaker for turning on and in response to positive back-biasing for turning off. The system automatically adjusts spark characteristics to accommodate changes in engine environment and running conditions.

7 Claims, 2 Drawing Figures

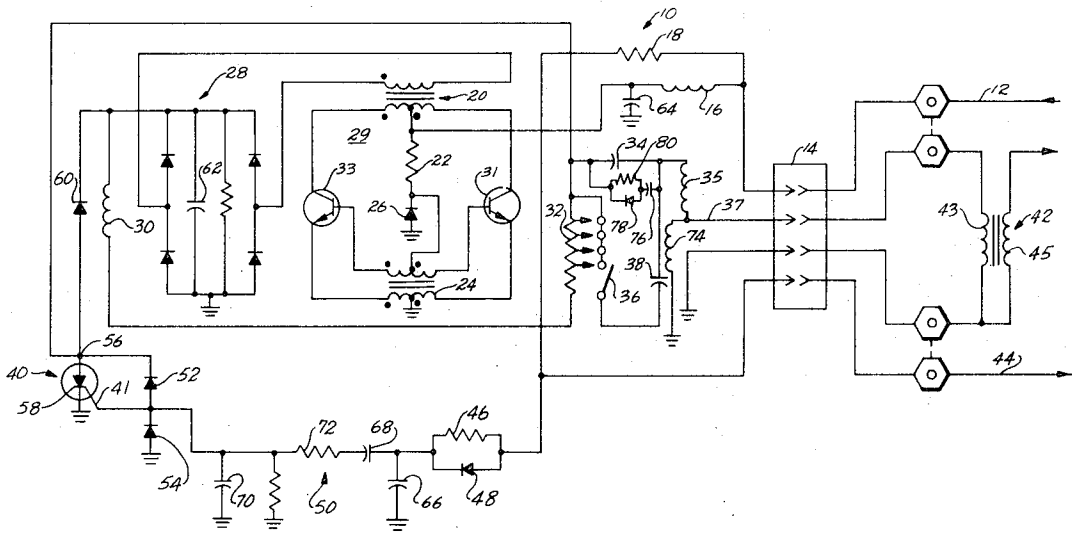


FIG. 2

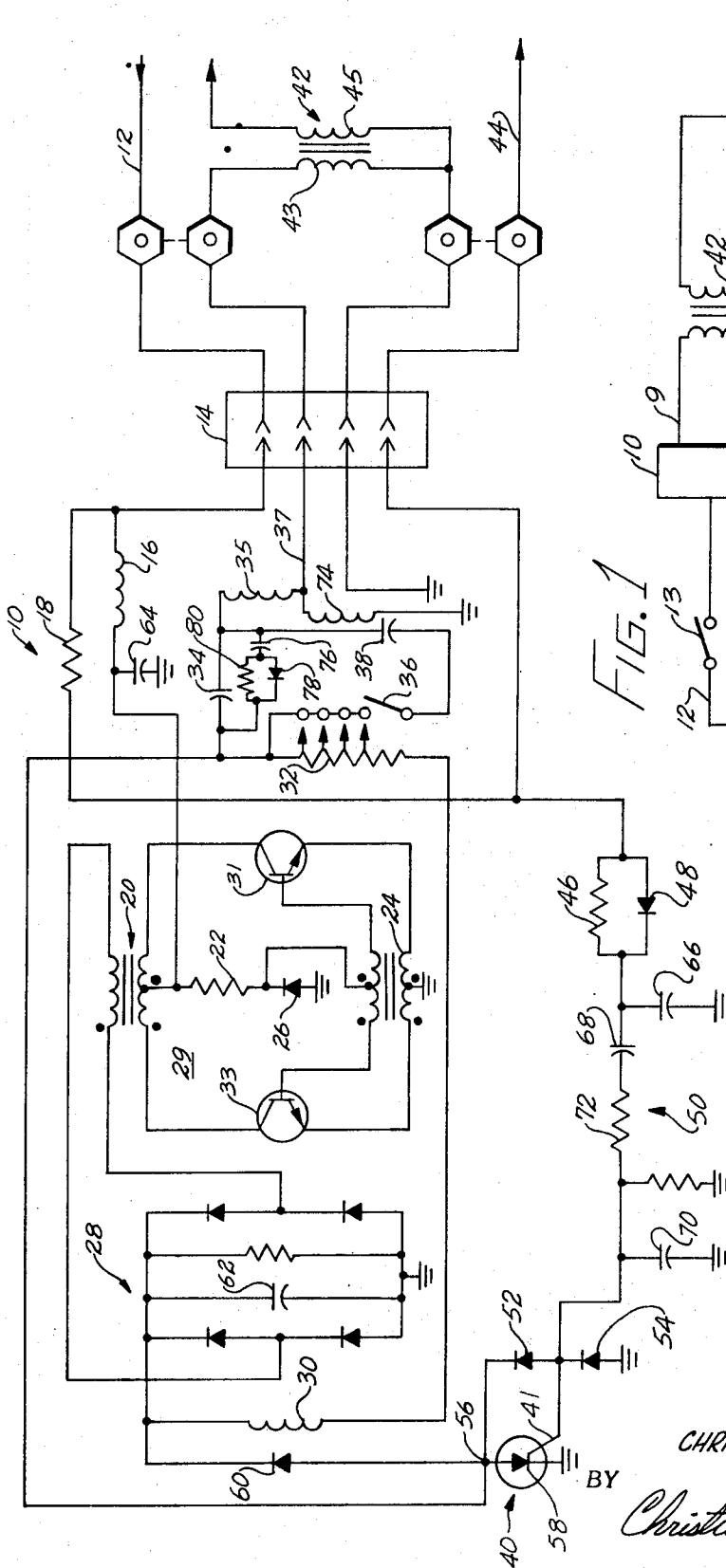
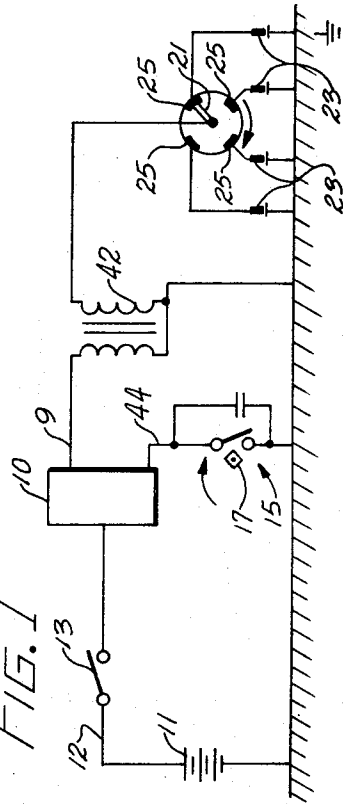


FIG. 1



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CAPACITIVE DISCHARGE IGNITION SYSTEM

DESCRIPTION OF THE PRIOR ART

The present invention relates to ignition systems for internal combustion engines and in particular to an ignition system utilizing a capacitive discharge to supply energy to the spark plugs of the engine.

Among the various ignition systems which have been tested and/or produced as equipment for automobiles, particularly those manufactured in the United States, the most common system is that generally known as the Kettering ignition system. In the Kettering system, the collapse of a magnetic field in the primary winding of an ignition coil induces a high voltage in a secondary winding of the coil which is transmitted via a distributing arrangement in sequence to a series of spark plugs to ignite a fuel mixture in the engine cylinders. The collapse of energy in the primary of the ignition coil is controlled by a contact breaker and cam arrangement with current flow being interrupted and a burst of energy supplied by the ignition coil each time the cam causes the contact breaker to open. Energy is supplied to the primary of the ignition coil from a conventional power source such as a 6 or 12 volt wet cell battery. In more recent versions of the Kettering system, electronic elements are utilized to perform certain switching functions as well as in power supplies which, in some instances, are being utilized in such ignition systems to improve operating characteristics. Such recent versions are generally referred to as "transistorized" ignition systems.

Still another type of ignition system which has gained some popularity is a system referred to as a capacitive discharge system. In such a system, rather than utilizing the collapse of a magnetic field to generate a high voltage pulse at the secondary side of an ignition coil, the system utilizes a capacitor as the primary energy source. Energy is supplied thereto for storage until released as a high energy pulse to the spark plugs. Typically, such ignition systems include a vibrator or inverter utilizing vacuum tubes or semiconductor devices in the circuit between the battery and the energy storage capacitor. Under control of the contact breaker points and an electronic switching device such as a silicon controlled rectifier, the capacitor previously charged by the inverter is then discharged into the primary side of an ignition coil causing a high voltage pulse to be produced on the secondary side of the coil and a high voltage spark at the plugs.

Heretofore, capacitive discharge ignition systems have had problems associated with them due to the method of discharging the capacitor into the coil. Such problems are products of the actual design of the system and are not due to any inherent problem in this type of ignition system. There is no theoretical reason why an ignition system utilizing the discharge of a capacitor cannot perform at a level of reliability which is comparable to the best performance of the more conventional systems thereby making available the superior spark quality of capacitive discharge ignition systems and their ability to produce firing of the spark plugs despite changes in plug condition whether due to age, wetting or fouling in a unit of satisfactory reliability.

SUMMARY OF THE PRESENT INVENTION

The present invention provides an ignition system for internal combustion engines comprising a high voltage power supply connected to capacitive means for storing electric power. Means for coupling the capacitive means to an ignition coil are provided and control circuit means including an electronic switch is coupled to the coupling means and the capacitive means for closing the switch to discharge the capacitive means. Finally, means for positively opening the electronic switch is provided for causing the capacitive means to be recharged.

In prior art capacitive discharge ignition systems, significant problems have been encountered in turning off an electronic switch utilized to release energy from the energy storage capacitor, in protecting the switch and in obtaining reliable recharging of the capacitor. In the two general approaches heretofore adopted, the first has utilized the principle of interrupting power from the inverter and the second has operated on the principle of back-biasing the switch (which is normally a silicon controlled rectifier) by means of currents which are produced in the ignition coil. Each approach is subject to difficulties. In the former, it is virtually impossible to accurately know when to turn the inverter on and off and be able to do it rapidly enough. This is due to the changing inductive properties of the coil and changing engine speeds. If the inverter is turned on too soon after the capacitor discharge, the SCR becomes locked on and the ignition system ceases to operate. If the turnon is delayed too long, there is insufficient time to recharge the capacitor for satisfactory firing of the next spark plug. The latter approach utilizes the inductance of the ignition coil which is subject to unpredictable change and, therefore, cannot be relied on to turn off the switch. In addition, a significant change in the condition of the coil, such as a short across a pair of terminals or wetting of the terminals can also produce a current surge which could damage or destroy the electronic switch.

The present invention avoids the problems previously characteristic of capacitive discharge ignition systems and provides a system which utilizes the good qualities of a silicon controlled rectifier as the electronic switch controlling the discharge of energy from the capacitor while providing additional supporting circuitry to overcome the aforementioned problems. Shut-off of the silicon controlled rectifier is achieved by a back-bias technique, but instead of relying only upon transient current within the ignition coil after a discharge of the capacitor to accomplish this result, the circuit of the present invention provides additional means for insuring that the SCR is back-biased a sufficient length of time to produce shut-off regardless of changes in the characteristics or parameters of the ignition system, particularly changes in the ignition coil. The circuit, moreover, embodies within it the capability of channeling the residual energy which is left in the ignition coil after production of the spark to begin the recharging process of the energy storage capacitor. Positive shut-off of the SCR is further assured by the provision of diode circuitry connected to the silicon controlled rectifier in a specific manner. This diode circuitry also acts to reduce or eliminate any residual magnetism in the core of the ignition coil. The system

embodies within itself positive protection for the electronic switch against the possibility of damage due to sudden current or voltage surges, occurrences which are a significant cause of SCR failure. Finally, positive protection against the possibility of the SCR firing at the wrong time is provided by means of a control circuit coupled between the breaker points of the ignition system and the semiconductor switch.

DESCRIPTION OF THE DRAWINGS

These and other advantages enumerated above will be better understood by reference to the following figures wherein:

FIG. 1 is a circuit diagram of an ignition system utilizing the capacitive discharge circuit of the present invention; and

FIG. 2 is a schematic diagram of the capacitive discharge circuit.

DESCRIPTION OF A SPECIFIC EMBODIMENT

A function and circuit diagram of an ignition system is shown in FIG. 1. The positive pole of a battery 11 is connected by an input connection 12 through an ignition switch 13 to a capacitive discharge ignition system 10 according to the present invention. A first output 9 of capacitive discharge system 10 is connected to the primary winding of an ignition coil 42 and a second output 44 to the ignition or contact breaker points 15. The secondary winding of coil 42 is connected to a rotor 21 of a conventional distributor which, in turn, has a plurality of contacts 25, each connected to a spark plug 23. As will be described in more detail in conjunction with FIG. 2, the ignition system of FIG. 1 utilizes the discharge of energy from a storage capacitor within system 10 through coil 42 and rotor 21 to the spark plugs 23. Cam 17 of the contact breaker rotates and opens the breaker points causing the storage capacitor to discharge and energy to be supplied to the plugs. System 10 also includes circuitry whereby the discharge path from the energy storage capacitor is interrupted to permit capacitor recharging for the next succeeding spark interval.

A capacitive discharge ignition system 10 according to the present invention is shown in schematic form in FIG. 2. Power from a source such as a 12-volt battery is supplied by an input connection 12 and a four pin plug 14 on the unit. An inductor 16 is connected between the input connection 12 and an inverter or oscillator 29. Inverter 29 includes a pair of transformers 20 and 24 having center tapped primary and secondary windings, respectively, with the center taps being connected to one another by a resistor 22. Inductor 16 is connected to the side of resistor 22 adjacent transformer 20. A diode 26 connects the side of resistor 22 opposite transformer 20 to ground. Inverter 29 further includes a pair of transistors 31, 33 having their base electrodes connected to opposite ends of the secondary winding of transformer 24, their collector electrodes to opposite ends of the primary winding of transformer 20 and their emitter electrodes to the opposite ends of the primary winding of transformer 24.

The output of inverter 29 is taken from the secondary winding of transformer 20 and connected to the input terminals of a full wave rectifier 28. The output of rectifier 28 is in turn connected by means of an induc-

tor 30 and a resistor 32 to an energy storage capacitor 34. The side of resistor 32 adjacent capacitor 34 is also connected by means of a temperature sensitive switch 36 to a second energy storage capacitor 38 and through a parallel diode 78-resistor 80 combination to a third energy storage capacitor 76. Capacitors 34, 38 and 76 are in turn connected in common to one side of an inductor 35, the opposite of which is connected by a circuit connection 37 through plug 14 to the primary winding 43 of ignition coil 42. An inductor 74 is connected between the side of inductor 35 opposite the common connection thereof to the three energy storage capacitors 34, 38 and 76 and a circuit ground or common point. The portion of the circuit just described traces the path of energy supplied from the battery through the energy storage capacitor of the system of the present invention preparatory to discharge and the supplying of energy through the ignition coil to the spark plugs to provide combustion of the fuel mixture in the engine cylinders.

The control portion 39 of the circuitry of the present invention comprises a silicon controlled rectifier 40 and a pulse shaping circuit 50 which is connected between a gate electrode 41 of SCR 40 and lead 44 extending through plug 14 to the breaker points 15. Control circuit 39 is also connected on one side by means of a circuit connection from the anode 56 of the SCR to the side of resistor 32 common to capacitor 34 at one side and on its other side to a resistor 18 and the power input connection 12. When the breaker points are closed, current flowing from the battery through plug 14 and resistor 18 is shorted to ground through the points. When the points open, current from the battery is directed through the pulse shaping circuitry 50 of control circuit 39 and thence to the gate electrode 41 of the silicon controlled rectifier 41 (SCR) to cause the SCR to be turned on. A discharge path for energy in storage capacitor 34 is thereby provided, the path including the primary 43 of ignition coil 42, inductor 35, capacitor 34 and SCR 40. Upon discharge and energy flow, a high voltage pulse is induced in the secondary winding 45 and an ignition spark produced at one of the engine spark plugs.

The circuit also incorporates within itself a mode of operation for turning the SCR off after a surge of energy from capacitor 34 has been supplied responsive to opening of the breaker points. The method of turning the SCR off according to the present invention is to back-bias the SCR, i.e., reverse the voltage so that the current attempts to go up through the SCR from ground toward capacitor 34. Since SCR 40, capacitor 34 and the primary winding 43 of coil 42 which acts as an inductor are in series, there is a natural tendency for the desired back-biasing to occur. After the initial spark energizing surge of power from storage capacitor 34, the side of the capacitor adjacent coil 35 assumes a positive charge and has a tendency to drive current down through the coil and up through the SCR (reverse direction), the net effect of this circuit action being to shut the SCR off.

To assure positive shut-off, it is necessary that the SCR be back-biased a predetermined minimum length of time (the specified SCR turnoff time) after every discharge of the capacitor. To obtain such assurance, a coil 35 of a predetermined inductance is inserted in se-

ries between the primary 43 of coil 42 and the energy storage capacitor 34. Due to the additional inductance contributed by coil 35, the series SCR 40-capacitor 34-primary winding 43 circuit now maintains its back-biasing polarity a sufficient length of time to insure that the SCR will turn off even in the extreme case where the inductance of winding 43 goes to zero. Thus, despite any problem which may lower the inductance of the primary of coil 42, for example, water splashed on the coil, a short-circuit causing the hot side of the coil to be grounded to the case, grease and road grime build-up or carbon tracking from the high voltage terminal, in short, any problem tending to reduce the inductance of the primary of the ignition coil will not affect the back-biased turnoff capability of the circuit.

Inductor 74 is connected to the junction of inductor 35 and primary winding 43 for the purpose of further ensuring that the SCR is turned off. Under certain circumstances (particularly at high engine speeds), the primary of the ignition coil acts as if it were a very high inductance and severely retards the ability of capacitor 34 to discharge. Provision of inductor 74 provides an inductance in parallel with primary winding 43 and this limits the maximum inductance of the combination (even where the inductance of winding 43 appears to be infinite) to that of inductor 74. By proper choice of the inductance value of coil 74, discharge of the energy storage capacitor is still accomplished thereby assuring sufficient back-biasing current for SCR turnoff during the immediately subsequent back-biasing portion of system operation.

Inductor 35 provides an additional and important contribution to the ignition system by acting as a device for limiting current to the SCR. By providing an inductor of a predetermined magnitude, e.g., 270 micro-henries, the current through the SCR is maintained at a maximum of 60 amps or less, even where the inductance of winding 43 has gone to zero. Again, even under the most adverse circumstances of circuit operation, the current to the SCR is limited to a value which can easily be absorbed by the SCR. The net result of the provision of inductors 74 and 35 is that no change in ignition coil properties can cause the SCR to fail to turn off or to cause it to be damaged due to current surges.

The circuit of the present invention also incorporates the capability of utilizing the transient energy remaining in the circuit subsequent to each storage capacitor discharge to recharge capacitor 34 to a partial value of its total charge without the necessity of drawing energy from the oscillator 28 (inverter). Harnessing the residual energy in a circuit to partially recharge the energy storage capacitor is beneficial in reducing wear on the inverter circuit and battery current drain by drawing less current therefrom as well as in checking spark plug erosion were the transient energy not channeled back to capacitor 34.

The foregoing is accomplished by providing a pair of diodes 52 and 54 in series connected between a ground connection and the anode 56 of SCR 40. Upon turning on the SCR, a discharge path to ground is provided and current flows up through the primary of coil 42 and inductor 35 until the potential on the side of capacitor 34 adjacent coil 35 is reduced to zero. At this instant a significant amount of energy is stored in the primary of

coil 42 and in inductor 35 which, unless dissipated in some constructive manner, produces undesirable oscillation in the ignition system. Current continues to flow to winding 43 and inductor 35 and capacitor 34 charges in the opposite direction. At its maximum opposite charge (approximately + 350 volts relative to inductor 35) the current in inductor 35 and winding 42 is zero. The reverse charge on capacitor 34 then begins to drive current in the opposite direction through coil 35 and winding 42. By providing diodes 52 and 54, a current path is provided such that when the current reverses and begins to flow in the opposite direction through the inductor 35 and the primary of coil 42, storage capacitor 34 is thereby recharged to approximately 75 percent of its fully charged value without drawing power from the inverter. The current path through diodes 52, 54 also provides a means whereby any tendency of the coil to build up residual magnetism is reduced or eliminated as well as tending to protect against ignition coil insulation breakdown. (At the end of each discharge cycle the current through the coil has traced one nearly perfect sine wave pattern).

Diodes 52 and 54 perform a third function in assuring that the SCR 40 is shut off. Because there is approximately a 1 volt drop across each of the diodes and the cathode 58 of SCR 40 is permanently connected to ground, current up through diode 54 from ground (during the reverse current portion of circuit operation) produces a minus one volt (-1.0v.) potential with respect to ground on the gate 41 of the SCR and diode 52 produces a second 1 volt drop, simultaneously placing the anode at a potential of minus 2 volts (-2.0v.) with respect to ground and at a potential of minus 1 volt (-1.0v.) with respect to the gate electrode 41. The SCR is thus fully back-biased and is thereby shut off in the minimum time possible.

A further advantage of the circuit of the present invention is its ability to channel and dissipate high voltage energy spikes which would otherwise have the tendency to damage or destroy the SCR. Under normal operating conditions, when energy is supplied to the spark plug and an arc-over occurs, the energy supplied by the storage capacitor is dissipated in the spark plug gap and only a relatively small amount of energy is left in the secondary 45 of the ignition coil. However, when the circuit fails to produce a spark at the plug (no arc-over), e.g., when spark plug condition has seriously deteriorated, the energy which would ordinarily have been transmitted to the spark plug gap is stored as an extremely high voltage by the capacitive action of the spark plug wires and the ignition coil secondary. If not dissipated, this energy is reflected back to the ignition coil primary 43, capacitor 34 and SCR 40 as a high voltage spike. If a sufficient number of such high voltage spikes were allowed to be transmitted to the SCR, serious deterioration of the SCR result to the point where the SCR ultimately stops functioning.

Such an occurrence is prevented in the present circuit by inductor 35 which reflects approximately 80 percent of any pulse transmitted from winding 43 back toward this winding with the result that this 80 percent of the pulse exhausts itself by bouncing back and forth between inductor 35 and coil 43. This is the third function of inductor 35. The remaining 20 percent of the energy is transmitted through inductor 35 and capaci-

tor 34 and toward SCR 40. By providing a very low impedance escape path through diode 60 to filter capacitor 62 in the inverter, this transmitted energy is absorbed by capacitor 62 and never reaches the SCR.

Accidental firing of SCR 40 which could cause a premature engine damaging spark is prevented by the provision of several circuit components in a specific arrangement. In the first instance, a filter comprised of inductor 16 and capacitor 64 filter out any voltage spikes generated by inverter 20 and prevent such spikes from being transmitted to the SCR. The same filtering action exerted by inductor 16 and capacitor 64 also prevents any noise in the form of voltage spikes from the power source from being transmitted to the inverter, an important precaution in preventing such voltage spikes from passing through the inverter to the anode of the SCR.

A second precaution against premature SCR firing resides in the design of the pulse shaping circuit 50. As indicated earlier, the signal is transmitted to the gate electrode 41 of SCR 40 at the instant the points or breaker contacts open. When the points open, current flows through resistor 18 and through the parallel combination of resistor 46 and diode 48 and begins to charge capacitors 66 and 68. The charging time constant of capacitors 66 and 68 is chosen such that it allows enough current to pass through capacitor 68 to fire the SCR even at very low temperatures (-35°F.) but nevertheless will not pass voltage spikes over capacitor 66 and through capacitor 68 to the gate of the SCR.

Circuit 50 is also provided with a second stage comprising resistor 72 and capacitor 70. Assuming for the moment the possibility that a voltage spike does pass capacitor 66 and resistor 72, capacitor 70, which is connected in parallel circuit relationship with diode 54, acts to short circuit such spikes arriving at that point in the circuit to ground.

In addition to blocking all voltage spikes above a predetermined voltage, the parallel combination of resistor 46 and diode 48 also prevents point bounce from firing the SCR. Since point bounce occurs immediately after the points close and a signal has been transmitted through circuit 50 to the SCR, capacitors 66 and 68 are still in a charged condition and, due to the magnitude of resistance 46, have not had a chance to discharge. Therefore, voltage spikes generated due to point bounce will not be transmitted to the SCR since it is the process of charging capacitor 68 which causes the SCR to fire. The condition of capacitor 68 already being charged thus prevents transmission of the spike to the SCR. Other random voltage spikes introduced into the circuit, e.g., from the twelve volt source, are also not transmitted to the SCR because such spikes are diverted to pass through resistor 18 and through the closed set of breaker points to ground. By choosing resistor 18 of a sufficiently low value, electromagnetic pickup is not a problem and the resistor further determines the amount of current through the closed points such that sufficient heat is generated to keep the points clean but is limited to a value which will not produce significant wear.

An important characteristic of the ignition system of the present invention is its ability to produce a variable power pulse to the spark plugs of the engine to suit

varying engine conditions. Among other conditions encountered in a normal operation is a cold engine upon starting, a tendency of the spark plugs to foul when running the engine at low or idling speeds and wear and deterioration of the various components of the ignition system including the ignition coil and spark plugs. With respect to the first condition, it takes considerably more energy to start a cold engine than to run it, once warm, and, therefore, a substantially higher voltage from the energy storage capacitor during this interval is desirable. The starting problem is further compounded by the fact that the battery voltage is normally relatively low at the specific time when it is required that the energy storage capacitor voltage be high. As concerns the second condition it is also desirable to provide more energy to the spark plugs at low speeds since such increased energy has a tendency to burn fouling material which may be generated. In addition, if such fouling material does become deposited, there is still sufficient spark energy to fire the fuel mixture in the cylinder despite the energy drain caused by the presence of this material. As the following discussion will disclose, specific portions of the ignition system of the present invention have been designed to fulfill these desired requirements.

By providing a specific type of core material for transformers 20 and 24 of inverter 29, both of these transformers are provided with saturation effects that are voltage and current dependent. This feature is utilized to provide an inverter having a voltage characteristic which varies according to the varying requirements of the engine with which it is being used to vary the electric power supplied to the storage capacitor. Thus, a higher voltage on starting (engine cranking speeds) is provided, with a somewhat reduced voltage when the engine is idling or running slowly (low and intermediate engine speeds) and a still further reduced voltage is provided when engine revolutions have risen to a higher speed (normal engine running speeds) at which plug fouling is normally not a problem. In a typical case, the output voltage from the inverter for engine RPM's from 0 to 250 (starting) with an input voltage from the battery of from 7.5 to 16 volts is approximately 600 volts. When the engine RPM's are from 400 to 750, that is, idling and very low speed, the output voltage of the inverter is inversely proportional to engine speed in the range of 600 volts descending down to approximately 425 volts. When the engine RPM's increase to a value above 750, the inverter output voltage further drops to approximately 425 volts and remains at that value over the entire range of engine running speeds, thereby serving to maintain spark energy constant over this entire range. In contrast, in conventional Kettering ignition systems, spark energy decreases as engine RPM's increase, a serious disadvantage of such systems.

As a further means of increasing spark energy for example, in the situation of starting a cold engine, the circuit of the present invention increases spark energy and spark duration by increasing the value of the energy storage capacitor when the engine is cold. This is accomplished by providing a temperature sensitive switch 36 which is physically located in position adjacent to resistor 32. Since current in this resistor is proportional to engine RPM's, resistor 32 warms up at the rate

which closely approximates engine speed. Since the engine warms up at a rate roughly proportional to its speed, the increase in temperature of resistor 32 closely approximates the increase in engine temperature. When the temperature is below a critical value, switch 36 is closed and capacitor 38 is connected into the circuit increasing the available capacitance of the energy storage capacitor. After resistor 32 has warmed, and likewise the engine has warmed to the proper temperature, switch 36 opens and the value of the discharge capacitance is reduced by removing capacitor 38 from the circuit. Increasing the value of capacitance not only increases the amount of energy available for delivery to the spark plugs but also lengthens the duration of the ignition spark when the engine is cold due to the increased time constant of a circuit having an enlarged capacity.

To provide an additional increase in spark energy and duration at low engine speeds (above the increase supplied by increased inverter output voltage at these speeds), a series-parallel circuit comprising a capacitor 76 in series with a parallel combination of a diode 78 and a resistor 80 is connected between the junction of resistor 32 and capacitor 34 on one side and between the junction of capacitors 34 and 38 on the opposite side thereby connecting capacitor 76 in parallel circuit relationship with capacitors 34, 38. The purpose of this circuit combination is to produce an additional measure of capacitance by means of capacitor 76 at low engine speeds (regardless of engine temperature) with the contribution of this portion of the circuit diminishing to essentially zero as engine RPM's reach and exceed 1,000. The operation of this portion of the circuit is as follows: At low engine speeds, as the SCR fires, capacitors 34 and 76 (and capacitor 38 when it is connected in the circuit) discharge providing an increase in energy to the plugs, the discharge of capacitor 76 being obtained through diode 78. By selective choice of the value of resistor 80, a time constant of this RC 80, 76 combination can be obtained such that at low engine speeds a significant charge can be built up on capacitor 76 but at higher engine speeds, discharge of capacitor 34 occurs so frequently as to prevent significant charge from being accumulated on capacitor 76.

Inductor 30 of the circuit of the present invention enhances the ability of the circuit to generate a spark despite the fact that the spark plugs may be fouled or wetted. The circuit action is accomplished because the SCR stays on for a longer period of time due to the fact that the effective inductance and resistance of the coil is increased before arc-over of the plug occurs and arc-over in a foul or wetted plug always takes longer than in a clean plug. By virtue of the SCR staying on longer, a voltage exists across inductor 30 for a longer period of time and thus a significant amount of energy is stored therein which, when the SCR is shut off, is transmitted through the plug gap, tending to flash or burn up the contaminating materials. The remaining portion of the energy in inductor 30 is transmitted to capacitor 34 to charge it at a rapid rate making it ready to provide a full measure of energy upon its next discharge despite being heavily drained on the previous discharge by the contaminated plug.

There is thus provided an ignition system in which the SCR is protected against damage from any even-

tuality, e.g., voltage or current surges and further a system is provided which adapts to changing engine conditions providing more or less energy as needed assuring maximum ignition capabilities and minimum wear on all system parts as well as minimum plug erosion. Whereas an ignition system designed to deliver maximum energy to the spark plugs at all times would perform satisfactorily in terms of its ignition capabilities, the same would not be true of its effect on the life and erosion rate of the spark plugs. By incorporating the features outlined in the preceding to automatically adjust and control the amount of energy delivered to the plugs during the various conditions to be encountered by the engine, the system of the present invention provides optimum amounts of energy for each such condition. The life of the plugs is thereby extended to an interval which is several times greater than the spark plug lifetime in conventional ignition systems or in any system which does not vary spark duration and intensity to suit engine needs.

What is claimed is:

1. An ignition system for internal combustion engines comprising:

a high voltage power supply;

a capacitive means for storing electric energy coupled to the power supply;

means for coupling the capacitive means to an ignition coil;

control circuit means including an electronic switch coupled to the coupling means and the capacitive means for closing the switch to discharge said capacitive means; and

first circuit means including an inductor coupled in series with the capacitive means and the ignition coil, said inductor having an inductance value of a magnitude sufficient to limit the current flowing through the electronic switch during discharge of the capacitor means independent of the effective inductance of the ignition coil and sufficient to back bias the switch after discharge of the capacitor means a sufficient length of time independent of the effective inductance of the ignition coil to thereby permit the capacitive means to be recharged.

2. An ignition system according to claim 1 wherein the electronic switch is a silicon controlled rectifier.

3. An ignition system according to claim 2 wherein the silicon controlled rectifier has an anode, a cathode and a gate electrode, including first means for biasing the gate negatively with respect to the cathode and second means for simultaneously biasing the anode negatively with respect to gate and cathode during the back biasing interval.

4. An ignition system according to claim 3 wherein said first and second biasing means are a pair of diodes, said pair of diodes being connected in series circuit relationship between a source of reference voltage and the anode of the silicon controlled rectifier, the gate of the silicon controlled rectifier being connected to the junction between the series connected diodes.

5. An ignition system according to claim 4 including second circuit means coupled to the first circuit means and the silicon controlled rectifier for preventing high voltage spike signals present in the ignition system from reaching the silicon controlled rectifier.

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6. An ignition system according to claim 5 wherein the second circuit means includes a unidirectional current carrying device connected so as to conduct current in a direction away from the silicon controlled rectifier.

7. An ignition system according to claim 6 including

an inductor connected in parallel with a primary winding of the ignition coil for assuring discharge of the capacitive means and sufficient back biasing current for the silicon controlled rectifier.

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