

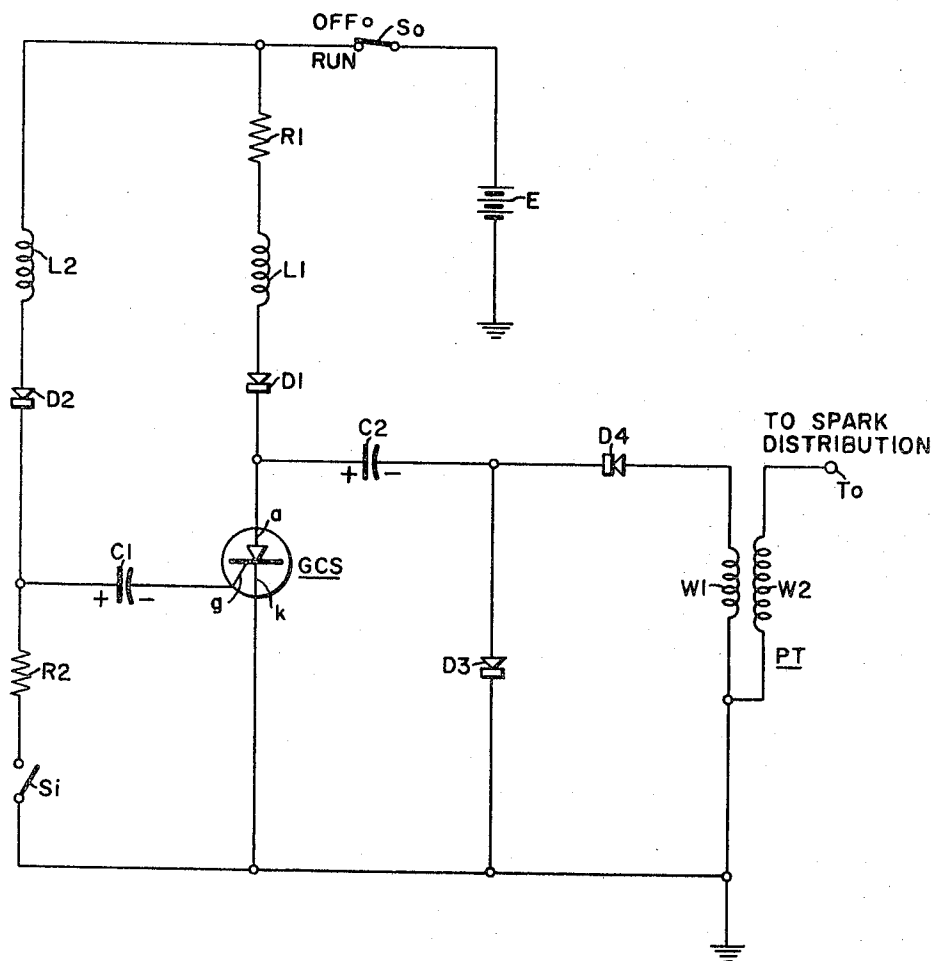
March 14, 1967

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3,308,801

CAPACITIVE DISCHARGE IGNITION SYSTEM

Filed July 23, 1964



WITNESSES

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1

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CAPACITIVE DISCHARGE IGNITION SYSTEM

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Filed July 23, 1964, Ser. No. 384,676

2 Claims. (Cl. 123-148)

The present invention relates to ignition systems, and more particularly to capacitive discharge emission ignition systems using a single semiconductor switching device.

The major limitations of presently known mechanical breaker point ignition systems for use in internal combustion engines are: low life expectancy of breaker points; lost spark energy due to poor switching of breaker points during cranking and as points degrade; and the slow rate at which the spark voltage is applied to the spark plugs. Mechanical breaker points as used today have a probable life expectancy of no more than 10,000 miles. The limited lifetime is principally due to the mechanical switching and the arcing produced in the switching operation. Ignition points commonly used in automobile engines operate at approximately 300 to 400 volts and carry current of the order of 3 to 6 amperes. Operating at such voltages and currents greatly reduces the lifetime of the points, the points being quickly degraded by the intensity of arcing produced at these voltage and current levels. Moreover, with the partial degradation of the points, for example, after 5,000 miles of usage, an impairment in the efficiency of operation of the engine results. This is due to the fact that spark energy is lost by poor switching of the breaker points after the points have been degraded somewhat, and lack of uniformity of switching in each of the switching cycles. This problem is especially severe during the cranking or start-up operation with the points switch at relatively low speeds and a large amount of spark energy is required to start the engine. In order for spark plugs to efficiently operate, it is necessary that a firing voltage of sufficient magnitude be provided. However, it is also required that this voltage be one that is rapidly increasing with time to conserve spark energy prior to the firing of the spark plug. Under less than ideal conditions, for example, if a spark plug is partially fouled, difficulty will be encountered in firing the plug unless a very rapidly increasing spark voltage is applied thereto. Under presently known mechanical breaker point-ignition coil systems, such a rapidly increasing spark voltage is not provided.

These above disadvantages and limitations of presently known mechanical breaker point ignition systems may be overcome through the use of ignition systems using a semiconductor device as disclosed herein as a gate controlled switch (GCS). The gate controlled switch, or as it is sometimes called a semiconductor thyatron or a semiconductor switch having turn off characteristics, is a four layer, three terminal, solid state switching device having characteristics similar to those of the conventional silicon controlled rectifier (SCR). The GCS possesses the desirable characteristics of the SCR such as: high blocking voltages, high surge ratings and pulse turn-on. But, moreover, the GCS has the unique ability of turning off by the application of a negative pulse voltage to its gate electrode, without the necessity of reducing the anode-cathode current to below the hold value. This unusual gate turn-off characteristic provides very desirable results when utilized in ignition circuits and more particularly in ignition circuits of the capacitive discharge type.

2

It is therefore an object of the present invention to provide a new and improved ignition system utilizing a gate controlled switch.

It is a further object of the present invention to provide a new and improved capacitive discharge ignition system utilizing a single gate controlled switch.

It is a further object of the present invention to provide a new and improved ignition system utilizing a gate controlled switch which provides long lifetime for breaker points, low loss in spark energy and a high quality spark voltage output.

Broadly, the present invention provides an ignition system in which a gate controlled switch is rendered non-conducting by the closing of a set of ignition points. Energy is then stored in an energy storing device, with the energy being discharged through the gate controlled switch when the ignition points are again opened. The energy thus discharged is transferred through an ignition coil to be utilized as a spark voltage.

These and other objects and advantages of the present invention will become more apparent when considered in view of the following specification and drawing, in which:

The single figure is a schematic diagram showing the capacitive discharge ignition system of the present invention.

Referring to the single figure, it is assumed that initially an off-run switch S_o is in its closed position and a set of ignition points S_i is in its open position. The set of ignition points S_i are shown schematically and may for example be the common mechanical breaker variety which open and close in timed sequence in response to rotation of the camshaft of an internal combustion engine. A battery E , which may be a 12 volt multicell type commonly used in automobiles, has its negative terminal grounded and its positive electrode connected to the off-run switch S_o . Connected to the other end of the switch S_o is a series circuit including a current limiting resistor R_1 , an inductor coil L_1 and a diode D_1 . The ignition circuit includes a single gate controlled switch GCS having an anode electrode a , a cathode electrode k and a gate electrode g . The anode electrode a of the gate controlled switch GCS is connected to the cathode electrode of the diode D_1 . The cathode electrode is grounded as is one end of the set of ignition points S_i . With the ignition points being in the open condition, the gate controlled switch GCS will be conductive, current flow being provided from the battery E , through the switch S_o , the resistor R_1 , the inductor L_1 , the diode D_1 , and through the anode-cathode circuit of the gate controlled switch GCS to ground. Also connected to the off-run switch S_o is a charging circuit including the series combination of an inductor coil L_2 and a diode D_2 . Connected between the cathode electrode of the diode D_2 and the gate electrode g of the gate controlled switch GCS is a capacitor C_1 . With the set of ignition points S_i open, the capacitor C_1 will charge to the polarity as shown through the charging circuit.

Upon the closing of the set of ignition points S_i , the capacitor C_1 will discharge through a resistor R_2 connected between the capacitor C_1 and one end of the ignition points S_i , the other end of the ignition points being connected to ground. The circuit components are so selected that the capacitor C_1 will charge to a voltage of approximately 30 volts. Upon discharging through the resistor R_2 on the charging of the switch S_i , a current of approximately 1 ampere passes through the switch S_i .

Comparing these values to the 3 to 6 amperes at 300 to 400 volts usually applied to mechanical ignition points, it can readily be seen that the present ignition system will have a substantially longer lifetime. It has been shown by tests to have a lifetime of approximately five times that of the ordinary breaker ignition point system.

The capacitor C1 discharging from the gate electrode *g* of the gate controlled switch GCS to ground, at which the cathode electrode *k* of the gate controlled switch is connected, causes the gate controlled switch to be rendered non-conductive, that is, the gate controlled switch is turned-off with an open circuit being provided between its anode and cathode electrodes. The rapid decrease of current in the circuit including the gate controlled switch, which has a turn-off time of approximately 3 microseconds, will induce a high voltage in the inductor coil L1 which is connected in series with the gate controlled switch. The voltage induced in the inductor coil L1 due to the rapid change of current in that circuit will be of the order of 400 volts.

A capacitor C2 is connected to the anode electrode *a* of the gate controlled switch GCS. This capacitor thus will charge to approximately the voltage induced in the coil L1. The diode D1 prevents the capacitor C2 from discharging back through the circuit including the battery E. Moreover, since the gate controlled switch is in its off condition the capacitor C2 will store this energy until the gate controlled switch GCS is turned-on. A diode D3 is connected between the other side of the capacitor C2 and ground to provide a low impedance path to ground so that the capacitor C2 may rapidly charge to the full potential induced in the coil L1. Upon reopening the ignition points *Si* a voltage will be induced in the inductor L2 due to the rapid change of current brought about by the breaking of the circuit including the ignition switch *Si*. The capacitor C1 will then be charged to the voltage induced in the coil L2 to the polarity as shown. The charge will be held by the diode D2. The charging of the capacitor C1 will serve to supply the next turn-off pulse for the gate controlled switch when the ignition points *Si* again close. However, more important the charging of the capacitor C1 applies a positive pulse to the gate electrode *g* of the gate controlled switch GCS thus rendering the gate controlled switch conductive.

The gate controlled switch GCS being turned-on will provide a low impedance discharge path therethrough for the discharge of the capacitor C2. The energy stored in the capacitor C2 will thus be transferred to a step-up pulse transformer PT. The transformer PT may be of the type well known in the art to provide a high voltage output pulse from its secondary winding in response to a lower voltage pulse being applied to its primary winding. The pulse transformer PT has a primary coil or winding W1 which has one end connected to the cathode electrode *k* of the gate controlled switch GCS at ground potential. The other end of the primary winding, W1 is connected through a diode D4 to the capacitor C2. The diode D4 is poled with its cathode electrode toward the capacitor C2 so that no voltage will be applied to the winding W1 when the gate controlled switch GCS is in its non-conductive, turned-off state. Also the diode D4 will prevent possible oscillation of the circuit including the capacitor C2 and the winding W1. The voltage induced in the winding W1 from the discharge of the capacitor C2 will then be transferred to a secondary ignition winding or coil W2 of the pulse transformer PT through transformer action. One end of the secondary winding W2 is grounded. The other end supplies an output pulse to be applied to the distributor, for example, an engine for use as the firing voltage of the spark plugs of the engine. Being a step-up pulse transformer, the output from the winding W2 will be a high voltage output of the order of 10 to 20 kilovolts having a rapidly increasing magnitude with time. The output from the secondary ignition winding W2, is then taken from an output terminal to be applied

to a spark distribution circuit, not shown. The output of the winding W2 will be a high voltage pulse rapidly increasing with time. Such a pulse will be of a high quality for the production of the arcing of a spark plug due to its rapid increase with time and its high magnitude within a short period of time. This will provide improved performance because of the easier firing of spark plugs by applying a rapidly increasing pulse voltage thereto.

With the capacitor C1 being charged as in the initially assumed condition of the circuit and the gate controlled switch GCS in its conductive state, the cycle may be repeated through the closing of the set of ignition points *Si* to discharge the capacitor C1 and turn-off the gate controlled switch GCS and the rest of the cycle repeating as described above.

Although the present invention has been described with a certain degree of particularity, it should be understood that the present disclosure has been made only by way of example and that numerous changes in the details of the circuitry and assembly and the combination and arrangement of the elements and parts may be resorted to without departing from the scope and the spirit of the present invention.

I claim as my invention:

1. An ignition system comprising: a gate controlled switch having an anode-cathode circuit and a gate circuit; a first capacitor device connected in the anode-cathode circuit of said gate controlled switch; a first charging circuit connected in the anode-cathode circuit of said gate controlled switch; a second capacitor device connected in the gate circuit of said gate controlled switch; a second charging circuit including an inductive device connected to said second capacitive device for charging said second capacitive device; switch means connected to said second capacitive device, said second capacitive device being discharged by the closing of said switch means to render said gate controlled switch non-conductive and induce a first voltage in said first charging circuit, said first capacitive device being charged to said first voltage; conversion means including a primary coil connected to said first capacitive device and a secondary coil; upon opening said switch means a second voltage being induced in said inductive device of said second charging circuit and being applied to the gate electrode of said gate controlled switch to render said gate controlled switch conductive, with said first capacitive device being discharged through said gate controlled switch to apply said first voltage to the primary coil of said conversion means and induce an output spark voltage in said secondary coil.

2. A capacitor discharge ignition system operative with a source of direct current comprising: a gate controlled switch having anode, cathode and gate electrodes; a first capacitive device connected to the anode electrode of said gate controlled switch; a first charging circuit including a first inductive device connected between said source and the anode electrode of said gate controlled switch; a second capacitive device connected to the gate electrode of said gate controlled switch; a second charging circuit including a second inductive device connected to said second capacitive device for charging said second capacitive device; a set of ignition points connected to said second capacitive device, said second capacitive device being discharged by the closing of said set of ignition points to render said gate controlled switch non-conductive and induce a first voltage in said first inductive device, said first capacitive device being charged to said first voltage; a step-up pulse transformer including a primary coil connected to said first capacitive device and a secondary ignition coil; upon opening said set of ignition points a second voltage being induced in said second inductive device and being applied to the gate electrode of said gate controlled switch to render said gate controlled switch conductive, with said first capacitive device being discharged through said gate controlled switch to apply said first voltage to the primary coil of said step-up transformer and induce

a high, rapidly increasing with time, output spark voltage
in said secondary ignition coil.

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5

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