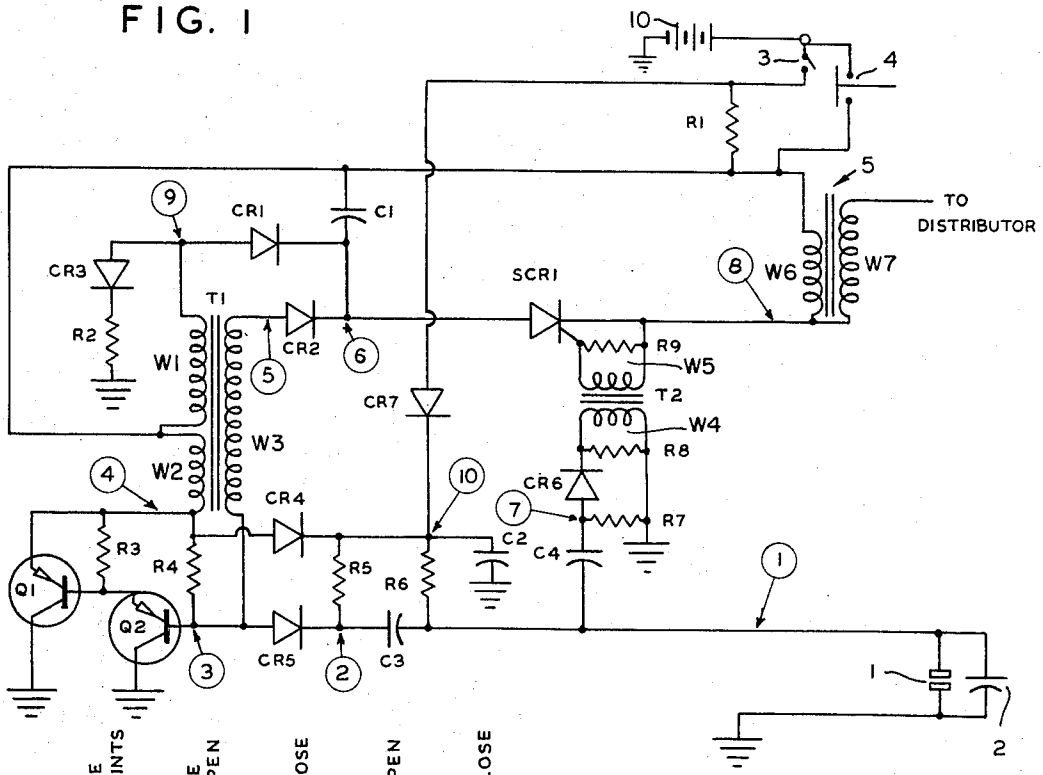
Dec. 10, 1968 W. A. DAMMANN 3,415,234

ELECTRONIC IGNITION SYSTEM

Filed June 6, 1966

FIG. 1



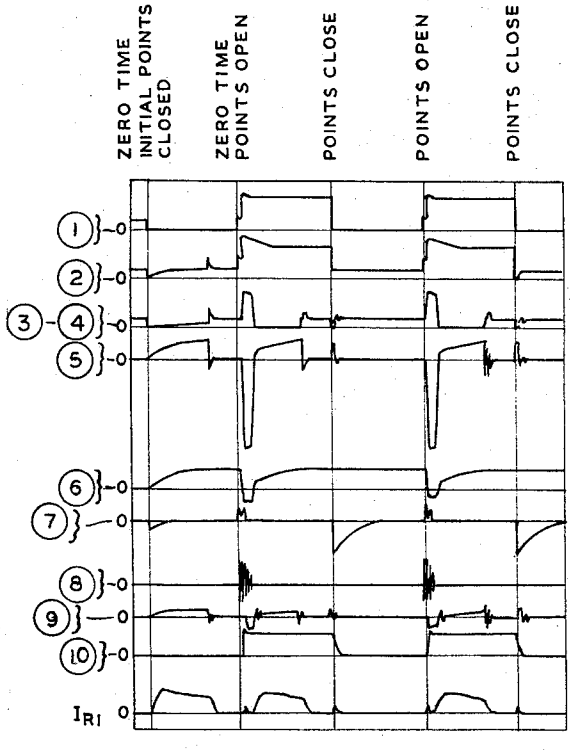


FIG. 2

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ELECTRONIC IGNITION SYSTEM

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ABSTRACT OF THE DISCLOSURE

An ignition system has a primary capacitor which is charged when distributor points are closed and discharged through an ignition coil when the points are opened. The charging and discharging of which is under control of the secondary of a transformer with resettable core and the discharge of the capacitor is under control of a silicon controlled rectifier whose gate is coupled with a triggering transformer the action of which is dependent on the charge and discharge of a secondary capacitor, the charging and discharging of which is under control of the opening and closing of the distributor points. The circuitry is such that the charging current for the capacitor by the battery is reduced by utilizing the energy of the collapsing field of the first transformer.

This invention relates to the operation of internal combustion engines, and is especially adapted for a high performance engine. It more particularly relates to an electronic ignition system of the capacitor discharge type and to the electronic circuit used for charging the capacitor.

A primary object of this invention is to provide for immediate charging of the capacitor after its initial charge and discharge.

Another object of this invention is to include a triggered silicon controlled rectifier in the discharge circuit of the capacitor to the ignition coil of the ignition system.

Still another object of this invention is to provide a unique triggering circuit for the silicon controlled rectifier dependent on the closing of the distributor points.

A further object of this invention is to provide the use of a transformer including a resettable magnetic condition of the core.

These and other objects will become apparent from the following description in conjunction with the accompanying drawing in which:

FIG. 1 is a schematic of an ignition system utilizing the present invention; and,

FIG. 2 illustrates various waveforms of the ignition system during the operation thereof, taken by an oscilloscope reading at the points indicated in FIG. 1.

The circuit of FIG. 1 includes as main elements thereof transformers T1 and T2, transistors Q1 and Q2, crystal diodes CR1 to CR6 inclusive, silicon controlled diode SCR1, capacitors C1 to C4 inclusive and resistors R1 to R9 inclusive connected into a conventional part of an ignition circuit including a battery 10, ignition switch 3, ignition coil 5, contact points 1 of a distributor and associated spark reducing capacitor 2. Also there is included as an additional part to the conventional part of the ignition circuit a starting switch 4 movable with the engine starting switch.

Assuming that capacitor C1 is discharged, as will become later apparent and the starting switch 4 is closed, current will flow from the positive pole of the battery 10 through the switch 4, winding W1 of transformer T1, diode CR3, current limiting resistor R2 and back via ground to the negative pole of battery 10. This will produce a flux in the core of transformer T1 in one direction. The transformer T1 is a magnetically resettable

transformer, its core utilizing a memory type of ferromagnetic material, that is one in which the direction of magnetism will be retained until a pulse of current in an associated core will reverse the direction of its magnetism. After the engine had been started and pressure on the starting switch is released, current to the primary W1 will flow via resistor R1. The resistor R1 is utilized since when the engine is running at battery charging speed, the voltage on the transformer primary would be higher except for the resistor. The flow of current via resistor R1 is through ignition switch 3.

As the engine operates, the distributor points periodically close and open. Starting with the points 1 open, current will flow to the capacitors C2 and C4 through various paths, the main path being via winding W2 of transformer T1, through diode CR4 to capacitor C2 and further via resistor R6 to the lower plate of capacitor C4 providing a positive potential which is coupled through capacitor C4 to the bottom of diode CR6. Capacitor C4 will charge through resistor R7, diode CR6, winding W4 and resistor R8 to ground. See FIG. 2, curve ⑦. The next part of the cycle occurs when the points close. When the closing occurs a current pulse through the transformer winding W2 takes place as follows: from battery 10, positive pole, through winding W2 of transformer T1, transistor biasing resistor 4, diode CR5, direct current blocking capacitor C3, charging the capacitor, contact points 1 to ground and back to the negative pole of the battery. This results in a drop of potential at the junction of resistor R4 and the base of PNP transistor Q2, rendering transistor Q2 conductive. When transistor Q2 becomes conductive, the potential at the junction of the biasing resistor R3 for PNP transistor Q1 is lowered, resulting in lowering of potential also at the base of transistor Q1 and rendering it conductive. Emitter to base current in cascade can now flow through the transistors Q1 and Q2 establishing a charging circuit for capacitor C1 as is explained shortly hereafter. Furthermore the current strength in winding W2 is increased by reason of current flow in the collector circuits of the transistors aiding the strength of magnetizing current through the winding W2.

The pulse of current in the winding W2 establishes a voltage pulse in the high voltage secondary W3 of transformer T1 with the upper end of the secondary positive resulting in charging the capacitor C1 through the following circuit: from the upper end of winding W3 to the capacitor C1 charging the lower plate positive, through the capacitor C1, through the winding W2 of transformer T1, the cascaded emitter-base connections of transistors Q1 and Q2 and to the bottom of winding W3. This charging current maintains the bases of the transistors negative and since the collectors of the transistors are grounded, current flow through the transistors will be maintained as long as charging current flows through the capacitor C1. Upon cessation of current flow, the resistors R3 and R4 will reestablish a positive bias on the bases of the transistors and they will cut off. The charge on the capacitor C1 is the source of potential to create current flow through the primary of ignition coil 5. It cannot discharge otherwise due to the presence of diodes CR1 and CR2. It can discharge through the silicon controlled rectifier SCR1 when its gate is triggered.

The gate to the silicon controlled rectifier is under control of the trigger transformer T2, associated diode CR6 and capacitor C4 and, if desired, of resistance R8 and R9.

Prior to the opening of the distributor points 1, capacitor C4 completely discharges through resistance R7, connected to ground, the lower plate of capacitor C4 being grounded through the distributor points. The potential remains zero at the junction of capacitor C4 and the anode

of diode CR6, as shown by waveform #7, FIG. 2, until the points open.

When the points open, capacitor C4 having been completely discharged through resistance R7 when the points were closed, a positive pulse due to the current provided through resistor R6 is coupled through capacitor C4 and diode CR6 to the primary winding W4 of transformer T2 providing a proper pulse to gate the silicon controlled rectifier SCR1. The pulse triggers silicon controlled rectifier SCR1 into conduction and the charge on capacitor C1 discharges through the primary winding W6 of the ignition coil 5, thereby providing the required high voltage output to the distributor. Silicon controlled rectifier SCR1 remains conducting as capacitor C1 discharges through zero and during the time the ignition coil reverses polarity due to flywheel action or ringing. When the ignition coil 5 reverses polarity, capacitor C1 is charged negative with respect to diodes CR1 and CR2, and silicon controlled rectifier SCR1 cuts off during the time that the field of the ignition coil collapses in the positive direction.

The charge on capacitor C1 (now negative at the bottom of C1 as represented on the schematic) will try to discharge through diodes CR1 and CR2, but winding W3 of transformer T1 offers a higher impedance than winding W1; therefore, capacitor C1 will discharge through diode CR1 and winding W1 of transformer T1. This discharge current resets the direction of flux in the memory core of transformer T1. Diode CR3 is reverse biased, thereby preventing loss of reset current through resistor R2.

At the time of reset, the positive pulse occurring at the bottom of winding W2 of transformer T1 is coupled through diode CR4 to charge capacitor C2. The current is provided by transformer action from winding W2 of transformer T1 through the diode CR4 and capacitor C2, charging the upper plate of capacitor C2 positive. This reverse biases diode CR7, thereby eliminating any possibility of noise pulses coming from the primary power source to trigger the system. As soon as the core of transformer T1 is saturated, the EMF collapses and reverses polarity providing a negative polarity at the lower terminal of winding W3 of transformer T1 and the base of transistor Q2. The charging current for capacitor C1 at this time is provided by the energy of the collapsing field of transformer T1. By providing this initial charge, the current required from the primary power source is decreased and therefore the capacitor C1 charges faster. This polarity then starts the charging cycle of capacitor C1 through the conduction of transistors Q1 and Q2 as previously described. By using this recharging means for capacitor C1, the complete cycle time is shorter thereby increasing the possible maximum r.p.m. of the engine.

After the initial charging of capacitor C1, closing of the points 1 has no effect on the circuit operation, except to insure that capacitor C1 is charged, because capacitor C1 is normally charged immediately after discharge and is discharged when the points open, thereby keeping correct timing.

It is pointed out that resistors R8 and R9 in the transformer circuit T2 are provided to eliminate possible noise impulses feeding back from the coil.

Resistor R5 provides a slow discharge path for direct current blocking capacitor C3. R6 provides a charging current path for capacitor C4 at the time the points open. Resistor R7 provides a time constant to prevent positive pulses from being felt at transformer T2 due to possible point bounce.

The function of capacitor C2 is to provide a potential greater than the battery supply potential to reverse bias diode CR5 when the points are open (non conducting).

When diode CR5 is reverse biased, no signal, pulse or noise can be passed from any external source through diode CR5 to falsely trigger transistor Q2 into conduction.

Capacitor C2 is charged after the points open, during the reset time of transformer T1. Referring to FIG. 2, waveforms #3 and #4, a positive pulse is present at the bottom of winding W2 a short time (100 microseconds) after the points open. This positive pulse (approximately 40 volts) is coupled through diode CR4 and applied to capacitor C2, charging capacitor C2 to a positive potential (approximately 40 volts).

The function of diodes CR4 and CR7 is to enable capacitor C2 to hold its charge. After capacitor C2 is charged to a positive potential, which is greater than the battery potential, diodes CR4 and CR7 will be reverse biased also, enabling capacitor C2 to hold its charge as long as the points are open.

As can be seen in FIG. 1, the bottom of capacitor C4 will charge to the same potential. With the use of diodes CR4, CR5, CR7 when the points are open, there will not be a discharge path for capacitor C2.

The graph of FIG. 2 illustrates the various waveforms monitored at indicated points of FIG. 1, starting with the negative pulse applied when the distributor points are closed and the end result of the high voltage output applied to the distributor by the discharging of capacitor C1 when the points 1 are opened.

The system of the invention outperforms other systems tested with respect to output voltage, and the maintenance of higher output voltage at the higher r.p.m.'s.

It will be obvious to one skilled in the art that various changes may be made in the invention without departing from the spirit and scope thereof, and therefore the invention is not limited by that which is illustrated in the drawing and described in the specification, but only as indicated in the accompanying claims.

What is claimed is:

1. A capacitor charging and discharging ignition system comprising:
   - a power source;
   - breaker points in series with said power source;
   - a primary charging capacitor and an ignition coil;
   - a magnetically resettable transformer including first, second, and third windings;
   - an initial current path from said power source through a first diode and said first winding to said power source thereby providing an initial setting of said transformer in a proper magnetic condition;
   - a charging means for said primary capacitor operable on the closure of said breaker points and including a switching means in series with said second winding and said breaker points thereby providing an induced voltage in said third winding and allowing current to charge said primary capacitor through said third winding, said switching means and said second winding;
   - a switching device connected between said primary capacitor and said ignition coil, said switching device having activating means, said switching device preventing discharge of said primary capacitor to said coil unless said activating means is operated, said switching device providing a first discharge path for said primary capacitor through said ignition coil thereby producing an output for ignition purposes, said switching device remaining activated after the discharge of said primary capacitor thereby allowing said primary capacitor to be charged by current from said ignition coil;
   - a second discharge path for discharging said primary capacitor including a third diode and said first winding thereby resetting the magnetic condition of said transformer, the discharging of said primary condenser by said second discharge path providing a partial charging current for said primary capacitor from the collapsing field of said transformer thereby allowing a faster recharge of said primary capacitor.

2. A capacitor charging and discharging ignition system as in claim 1 and wherein said switching device includes a gated silicon-controlled rectifier.

3. A capacitor charging and discharging ignition sys-

tem as in claim 2 and wherein said silicon-controlled rectifier is gated on through a pulse transformer when said breaker points open.

4. A capacitor charging and discharging ignition system as in claim 1 and wherein said switching means includes series connected transistor switches.

5. A capacitor charging and discharging ignition system as in claim 4 and wherein said transistor switches include resistive biasing means to render said transistor switches non-conductive.

6. The invention of claim 1, and wherein said actuating means for said switching device includes an inhibiting means for said actuating means, said inhibiting means including a resistor-capacitor network, said network including a discharge path during the time that said breaker points are closed, thereby providing a time constant to prevent actuation of said actuating means due to possible point bounce.

7. The invention of claim 6, and wherein said capacitor and a diode provide a coupling path to actuate said switching device.

8. The invention of claim 1, and wherein said activating means includes a pulse transformer including a primary winding in series with a diode and a coupling capacitor, said pulse transformer including a secondary winding connected to said switching device, said actuating means thereby providing the coupling of a pulse from said primary winding to said secondary winding to activate said switching device when said points open.

9. An ignition system of the capacitor charge and discharge type comprising:

a power source;

a pair of breaker points in series with said power source;

a charging capacitor and an ignition coil;

a switching means to control the discharge of said charging capacitor;

a transformer;

means provided to charge said capacitor through said transformer; and,

means responsive to the discharge of said capacitor through said coil to provide a partial recharge of said capacitor through said transformer.

10. An ignition system as in claim 9 and wherein said transformer includes a core allowing a settable and resettable magnetic condition.

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