United States Patent

[11] **3,566,188**

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[54] **TRIGGERED IGNITION SYSTEM**
3 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **315/209,** 315/218, 315/219, 315/223, 315/224, 315/240, 315/241, 315/242, 315/243, 123/148
[51] **Int. Cl.** **H05b 37/02**
[50] **Field of Search** ..... 315/209 (CD), 209 (T), 209 (SCR), 209 (M), 218, 219, 223, 224, 240, 241, 242, 243; 123/148, 148 (E), 148 (AC)

[56] **References Cited**

UNITED STATES PATENTS

2,697,184	12/1954	Lautenberger	315/177
3,297,911	1/1967	Quinn	315/214
3,312,860	4/1967	Sturm	315/223
3,318,296	5/1967	Hufton	123/148
3,418,990	12/1968	Lindell	123/148
3,427,502	2/1969	Minks	315/209
3,240,198	3/1966	Loudon et al.	315/209X
3,311,783	3/1967	Gibbs et al.	315/226

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ABSTRACT: This disclosure relates to an alternator-driven capacitor system for a two-cylinder engine. A main capacitor is connected across the output of the alternator. Separate discharge circuits for each of the spark plugs are connected in parallel to the capacitor and each includes a silicon-controlled rectifier and a pulse transformer. A trigger capacitor in series with a resistor is connected across the main capacitor. Paralleled trigger circuits are connected to the trigger capacitor and each includes a pulse transformer in series with a silicon-controlled rectifier. The pulse transformers are connected to fire a corresponding main-controlled rectifier. The controlled rectifiers of the trigger circuits are fired from a separate pulse generator driven in synchronism with the engine.

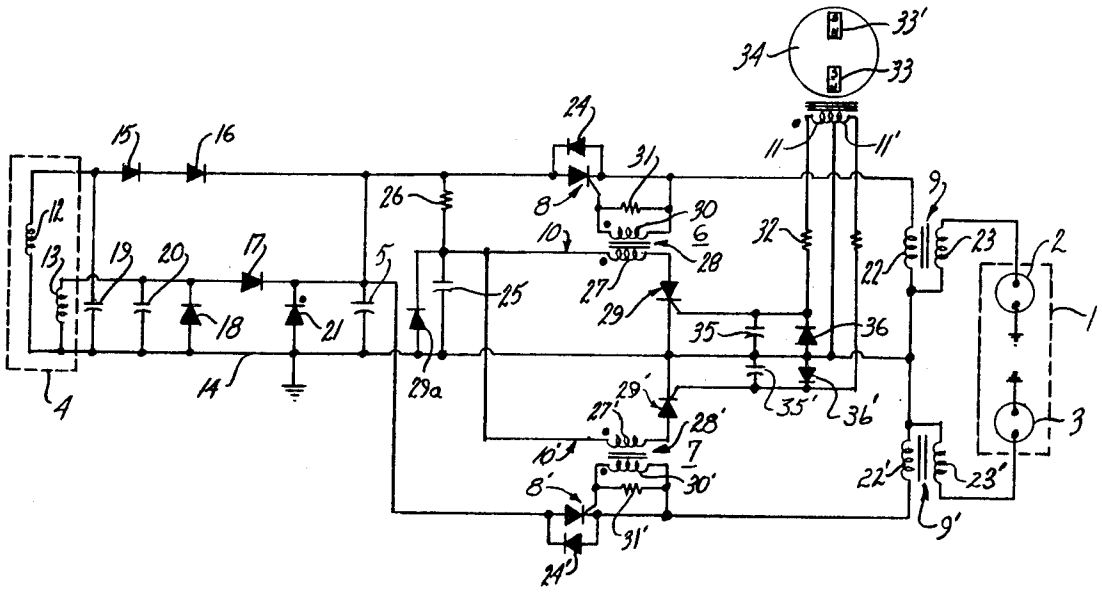
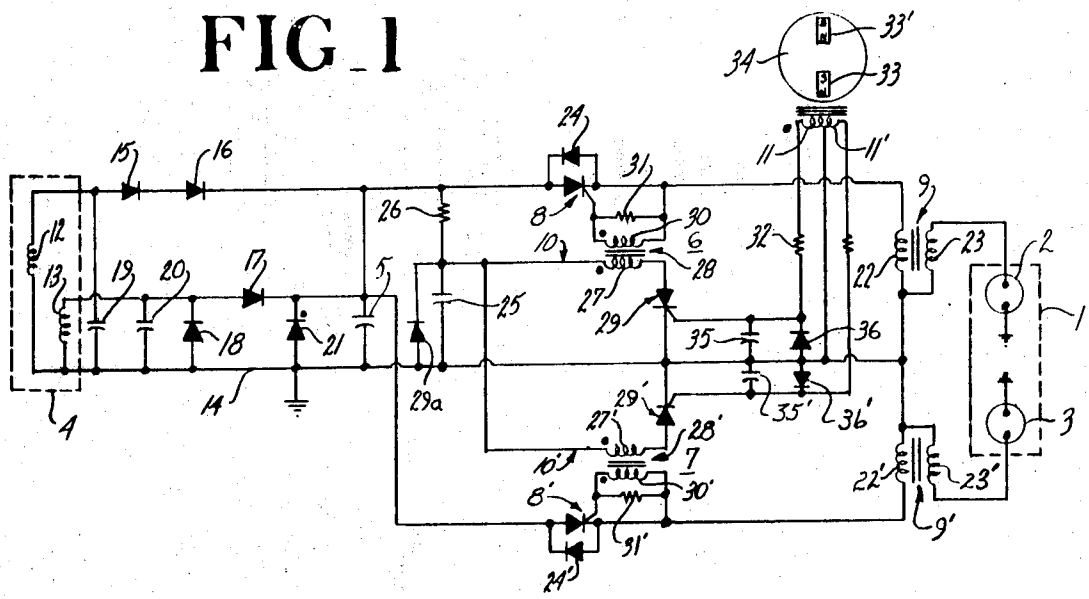


FIG_1



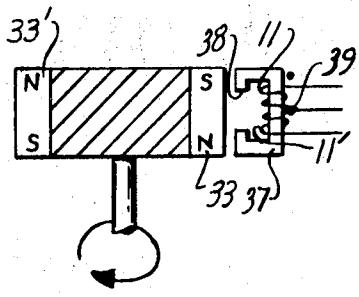


FIG_2

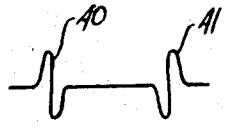


FIG_3

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TRIGGERED IGNITION SYSTEM

This invention relates to a triggered ignition system and particularly to an alternator driven capacitor discharge ignition system for an internal combustion engine and the like.

Capacitor discharge ignition systems have recently been suggested and developed for internal combustion engines and the like. A highly satisfactory alternator driven capacitor discharge ignition system is disclosed in applicant's copending application entitled "Alternator Driven Capacitor Power System" which was filed Jun. 13, 1968 with Ser. No. 736,789 wherein a pair of windings are provided for charging of a main igniting capacitor during one-half cycle of the alternator voltage and for triggering of a controlled rectifier to discharge such main capacitor during the alternate half-cycle. As disclosed therein, a distributor is employed to sequentially connect the main firing capacitor to the several spark plugs. Alternatively, a plurality of parallel firing circuits may be interconnected to the main firing capacitor with separate triggered switches for sequentially discharging the capacitor to the several spark plugs or other firing means. For example, in small internal combustion engines for snowmobiles and the like it may be desirable to provide separate firing circuits for each of the cylinders.

In triggered ignition systems and the like, the triggering pulse must have sufficient power to positively fire the controlled rectifier or other triggering means. Further, in an alternator driven system where the power is derived from the one alternator, it is important to maintain proper timing as well as to produce the desired triggering power.

The present invention is particularly directed to an improved and reliable capacitor discharge ignition system which has been particularly applied to an internal combustion engine for a snowmobile. In accordance with the present invention, a main firing capacitor is connected in a charging circuit to a suitable power source and in a discharge circuit through a main triggered switch means. The power source is preferably an alternator coupled to and driven by the internal combustion engine. A triggered circuit is provided including a capacitive storage means such as a control capacitor connected in circuit to the main firing capacitor and the power source through a circuit isolating control means. A pulsing circuit for the main switch means is connected across the control capacitive means of the triggered circuit in series with a suitable control switch means which is actuated in synchronism with the internal combustion engine. The control switch means is preferably a second triggered switch means such as a controlled rectifier or the like which will rapidly discharge the energy of the capacitive storage means. A separate pulse generator is coupled to the engine and connected to the control switch means. The control switch means responds to the leading edge of the engine generated pulse signal and provides rapid discharge of the control capacitor to fire the main triggered switch means and thereby provide rapid discharge of the main firing capacitor to provide a highly satisfactory ignition pulse to the engine. After the discharge pulse, the recharging of the main firing capacitor may be immediately begun to store sufficient energy for firing of the engine on the next cycle. The control capacitor is connected through the isolating means which reduces the charging current below the holding level of the control switch means such that the control switch means is only responsive to the engine synchronized control pulse. Consequently the circuit of the control capacitor can be connected directly to the main firing capacitor.

As applied to an alternator driven capacitor system for a snowmobile, the main capacitor was connected across a dual winding circuit generally in accordance with applicant's copending application. A separate discharge circuit for each of the spark plugs included a main firing control rectifier and a pulse transformer. The discharge circuits were connected in parallel across the main firing capacitor and each included a separate pulse forming network for firing of the control rectifier. Each pulse forming network included a pulse transformer in series with a second control rectifier connected across a common trigger capacitor. The second control rectifier was fired from a separate pulse generator in synchronism with the engine. The triggered capacitor was connected in series with an isolating resistor across the main firing capacitor. The resistance of the isolating resistor was selected with a sufficiently low resistance so that the trigger capacitor would charge to a sufficient level to fire the second control rectifier during the period between firing of the main firing rectifier but of a sufficiently high value to prevent establishment of the holding current through the resistor and the triggered control rectifier, which were connected in parallel to the triggered capacitor.

A Zener diode was connected in parallel with the main firing capacitor to limit the level to which it is charged and to bypass reflected voltages of the discharge circuit through the Zener diode and a conducting silicon controlled rectifier to dissipate the energy.

The drawing furnished herewith illustrates the best mode presently contemplated by the inventor for carrying out the subject matter of this invention and clearly discloses the above advantages and features as well as others which will be readily understood by those skilled in the art from the following description.

In the drawing:

FIG. 1 is a schematic circuit diagram of a capacitor discharge ignition system constructed in accordance with the present invention;

FIG. 2 is an illustration of novel pulse generating means for controlling the ignition system; and

FIG. 3 is a graphical illustration of the output of the generating means shown in FIG. 2.

Referring to the drawing, the present invention is shown applied to an internal combustion engine 1 having a pair of spark plugs 2 and 3. For example, the present invention has been applied to a two-cycle two-cylinder engine forming a part of a snowmobile. An alternator 4 is coupled to and driven in synchronism with the engine 1. The output of the alternator 4 is connected to charge a main firing capacitor 5 which is interconnected through separate paralleled discharge circuits 6 and 7 to the spark plugs 2 and 3.

The output circuit as previously noted for the respective spark plugs 2 and 3 is essentially identical and consequently the discharge circuit 6 for spark plug 2 is described in detail with the corresponding elements of the circuit 7 for spark plug 3 identified by corresponding primed numbers.

The circuit 6 includes a silicon-controlled rectifier 8 in series with a pulse transformer 9 connected across the capacitor 5 to provide a firing energy to the spark plug 2. A pulse-forming circuit or network 10 is connected to fire the rectifier 8 and includes a trigger coil actuated by alternator 4 to provide sequential and alternate firing of the controlled rectifiers 8 and 8' with a corresponding sequential and alternate discharge of the capacitor through the pulse transformers 9 and 9'. In the operation of the circuit, the main firing capacitor is charged during one or more positive half-cycles of the output of the alternator 4. The trigger coils 11 or 11' are pulsed to turn on the related SCR's 8 or 8' for discharging of the main capacitor preferably during the negative half-cycle.

In the illustrated embodiment of the invention, the alternator 4 is generally constructed in accordance with applicant's previously referred to copending application and includes a first winding 12 having a relatively low number of turns and a second winding 13 having a relatively high number of turns. The windings 12 and 13 are connected to provide a common charging of the main firing capacitor 5 with a controlled characteristic as more fully disclosed in applicant's copending application.

In the illustrated embodiment of the invention one side of the windings are connected to ground line 14. The opposite side of the winding 12 is connected in series with a pair of diodes 15 and 16 to the positive side of the capacitor 5, the opposite side of which is connected to the common ground line

14. The winding 13 is connected at one end to ground line 14. The opposite end is connected in series with a diode 17 to the positive side of the capacitor 5. A clipping diode 18 is connected directly across the winding to bypass or clip the negative half cycle.

In the illustrated embodiment of the invention, transient protective capacitors 19 and 20 are shown connected directly across the respective windings 12 and 13 to bypass high transient voltage signals. Further, a Zener diode 21 is connected directly across the main firing capacitor 5 to control the maximum voltage to which it is charged by alternator 4 and also functions as more fully described hereinafter to bypass reflected voltages from the output circuits 6 and 7 and dissipate the energy of such reflected voltages in the Zener diode 21 and one of the controlled rectifiers 8 or 8'.

The pulse transformer of discharge circuit 6 includes a primary winding 22 connected in series with the anode to cathode circuit of the controlled rectifier 8 directed across the capacitor 5 with the one side of the primary winding grounded. The secondary 23 of the pulse transformer 9 is connected directly to the spark plug 2. A protective diode 24 may be connected across the controlled rectifier 8.

The gate of the controlled rectifier 8 is connected in the trigger circuit 10 which is actuated by the trigger coil 11 and constructed in accordance with the present invention, as follows.

A trigger capacitor 25 is connected in series with an isolating impedance element 26 directly across the paralleled output of the alternator windings 12 and 13 and across the main firing capacitor 5. The illustrated impedance 26 is shown as a resistor connected between the positive side of the main firing capacitor 5 and the positive side of the trigger capacitor 25. The trigger capacitor 25 is connected to be charged simultaneously with the main firing capacitor 5 through the resistor 26. As more fully developed hereinafter, the resistor 26 serves to permit proper charging of the capacitor 25 for subsequent firing of the controlled rectifier 8 while essentially isolating the capacitor 25 from the charging circuit during the discharging of the capacitor 25.

The primary winding 27 of a trigger pulse transformer 28 is connected in series with a trigger-controlled rectifier 29 directly across the trigger capacitor 25. A diode 29*a* is connected across the trigger capacitor 25 to prevent the inductance of primary 27 from charging the capacitor in a negative direction. Diode 29*a* may be a Zener-type diode, if desired, to reduce the required rating of the control rectifiers 29 and 29'. The secondary winding 30 of the transformer 28 is connected across the gate to cathode circuit of the main control rectifier 8. A parallel resistor 31 may be also connected across the gate to cathode circuit to reduce the sensitivity of rectifier 8 to spurious input signals.

In operation when the trigger rectifier 29 is fired, it will rapidly discharge the capacitor 25 through the primary 27 of the pulse transformer 28 and provide a pulse signal to the gate of the main rectifier 8 to turn it on and rapidly discharge the main firing capacitor 5. In the illustrated embodiment of the invention, the trigger signal coil 11 is connected in series with a resistor 32 across the gate to cathode circuit of the trigger control rectifier 29. A magnet 33 is secured to the engine flywheel 34 and thus rotates in synchronism with the alternator 4 and is sequentially coupled to the coil 11 by the rotation of the flywheel and alternator 4 to provide sequential pulsing of the gate circuit of the rectifier 29 and a corresponding sequential discharging of the trigger capacitor 25.

In the illustrated embodiment of the invention, a transient protective capacitor 35 and a protective diode 36 are shown connected in parallel across the gate to cathode circuit of the control rectifier 29.

In the operation of the illustrated embodiment of the invention, the alternator 4 provides an output which charges the main firing capacitor 5 and the trigger capacitor 25. The charging of the trigger capacitor 25 is through the resistor 26. This resistor is particularly selected to establish, with the trigger capacitor 25, a time constant which allows charging of the capacitor 25 to a sufficient level for firing of the main control rectifier 8 within the charging period of the capacitor 5. However, it is further selected to have a sufficiently large value to effectively isolate the circuit of the transformer 28 and the controlled rectifier 29. Thus, when the magnet 33 and 33' actuates the trigger coil 11 to fire the controlled rectifier 29, a circuit is established to discharge the firing capacitor. However, the circuit for the controlled rectifier 29 through the pulse transformer is now connected in series with the resistor 26 directly across the alternator 4, which provides a holding current path through the controlled rectifier 29. If the output of the alternator 4 should go positive and initiate charging of the main firing capacitor 5 prior to resetting of the controlled rectifier 29, the rectifier 29 would remain conducting and bypass the capacitor 25 if the current in this path were at or above the holding current level. This may be particularly true where the firing of the engine is advanced to the latter portion of the negative cycle of the alternator output. In accordance with the present invention, however, the resistance of resistor 26 maintains the current from the alternator 4 through the resistor 26, the transformer 28 and the controlled rectifier 29 below the holding current level of the rectifier 29. Consequently, the conduction of rectifier 29 is completely controlled by the signal applied to the gate to cathode circuit by coil 11. Consequently, the charging of the main firing capacitor 5 can be initiated immediately after the discharge of the capacitor and independently of the conductive condition of the controlled rectifier 29 which are essentially responsive solely to the input pulse signal at the related gate. This allows a maximum charging period for the main firing capacitor 5 under all operating conditions.

The holding current level of the usual controlled rectifiers 29 and 29' is dependent on the gate to cathode impedance. The resistor 32 provides a resistance in the gate to cathode circuit and consequently the holding current level depends on the parameters of the rectifiers and the resistance of resistors 32 and 32' to permit varying of the holding current level.

The capacitors 5 and 25 are charged during the positive half-cycle of the output of the alternator 4 in accordance with the plurality of the diodes connected between the windings 12 and 13 and the capacitors. The trigger coils 11 and 11' are mounted adjacent the flywheel 34 and alternately pulsed by the associated magnets 33 and 33' to provide alternate firing of the controlled rectifiers 29 and 29' to thereby sequentially discharge the capacitor 25 through the alternate firing pulse transformers 28 and 28'.

This in turn results in the alternate triggering of the main controlled rectifiers 8 and 8' to alternately fire the spark plugs 2 and 3.

Although any suitable means can be employed for triggering of controlled rectifiers 29, a novel and highly satisfactory means is shown in FIGS. 1 and 2. The trigger coils 11 and 11' are wound as a single center tapped winding on a rectangular core 37 having an air gap 38. The center tap 39 of the winding is connected to the ground line 14 and the opposite ends of the winding are connected in series with the resistors 32 and 32' to the respective gates of the rectifiers 29 and 29'. The core 37 is mounted adjacent the periphery of the flywheel 34 as diagrammatically shown in FIG. 2. The pair of magnets 33 and 33' are located on diagrammatically opposite sides of the flywheel 34 and are thus sequentially and cyclically aligned with the air gap 38 of core 37. The magnets 33 and 33' are oppositely polarized with respect to the core 37 to establish oppositely directed magnetic flux through the core. As a result, the magnets induce oppositely phased alternating voltage pulses across the winding generally as shown in FIG. 3.

In FIGS. 1 and 2, the magnet 33 is aligned with the winding of coils 11 and 11' and produces a pulse signal as shown at 40 in FIG. 3. The pulse signal goes positive and then negative with respect to the dotted end of winding, as shown in FIG. 1 and 2. The positive portion of the pulse drives the rectifier 29 into conduction and rapidly discharges the capacitor 25. The

following negative portion biases the alternate rectifier 29' of the discharge circuit 7 to conduct. However, the capacitor 25 has discharged its energy and essentially no current or power is supplied to the transformer 28'.

One hundred and eighty degrees later, the opposite magnet 33' moves past the core 37. The opposite polarization of magnet 33' generates an alternating pulse signal which goes negative and then positive with respect to the previously assumed polarity designation, as shown at 41 in FIG. 3.

The negative portion of the signal turns on the rectifier 29'. The capacitor 25' is sufficiently charged and thus discharges through the circuit of the pulse transformer 28' and rectifier 29'. The pulse transformer 28' applied the pulse to the main rectifier 8' and discharges capacitor 5 through the transformer 9'.

The positive portion of pulse 41 will turn on the rectifier 29. However, the energy in capacitor 25 has been discharged and consequently circuit 6 remains off.

The pulse generating thus provides a simple and inexpensive means for reliable sequencing a pair of controlled rectifiers or the like.

If the alternators output frequency is sufficiently higher than the engine-firing frequency, the phasing of the alternator may be random or continually varying compared to the trigger pulse, even through a somewhat smaller alternator can be used if the phasing is controlled. If the gate of the main rectifiers 8 or 8' is energized, either to create an output pulse or continues to be energized thereafter, during the positive portion of the output waveform of alternator 4 that positive cycle may be shorted out and of no effect in charging capacitor 5.

Since it is not possible to arbitrarily reduce the width of pulses 40 and 41, a purpose of the invention is to isolate the controlled rectifiers 8 and 8' from all except the leading edge of these pulses to allow greater time for the recharging of capacitor 5. This allows greater output under random phase conditions, or under synchronized phase conditions allows a greater phase variation between alternator 4 and alternator 34 including coils 11 and 11' and magnets 33 and 33'. This phase variation can be necessitated by timing advance when only means to rotate alternator 34 may be available, or due to manufacturing tolerances in the components involved.

Although the coils 11 and 11' are shown in the preferred novel construction of a single center tapped winding wound on a single core, any other suitable construction may be employed. For example, separate coils may be employed. Further, the magnets may be connected to a completely separate element driven in synchronism with the engine through any suitable means to sequentially couple the magnets to the coil means.

The present invention has been found to provide a highly reliable and long life ignition system which is particularly adapted to two-cylinder engines such as employed in a snowmobile or the like.

I claim:

1. A capacitor discharge ignition system, a first main firing capacitor, a first main controlled rectifier connected in series with the firing capacitor and defining a first discharge circuit to discharge said main firing capacitor, a second discharge circuit connected in parallel with the first discharge circuit to the main firing capacitor, said second discharge circuit to the main firing capacitor, said second discharge including a second main controlled rectifier means, a trigger capacitor, an isolating resistor connected in series with said trigger capacitor and in parallel with said main firing capacitor, an alternator connected to simultaneously charge said main firing capacitor and said trigger capacitor, a flywheel connected to said alternator, a pulse-forming circuit including a first pulse transformer in series with a triggering controlled rectifier connected across said trigger capacitor, said pulse transformer having a secondary winding connected to said first main controlled rectifier, said pulse-forming circuit including a second pulse transformer in series with a second triggering control rectifier, said second pulsing circuits connected to actuate the second main controlled rectifier, a pulse-generating means including means rotating in synchronism with said flywheel and including coil means for producing time-spaced pulses in accordance with each revolution of said flywheel, each pulse being an alternating current signal and having a sharp leading edge, means connecting said coil means to both said triggering controlled rectifier to periodically discharge said trigger capacitor, and said pulse-generating means establishing time-spaced alternating current signals and connected to both of said triggering control rectifiers for cyclically actuating said first and second triggering controlled rectifiers.

2. The ignition system of claim 1 having a voltage-sensitive means connected directly in parallel with said capacitor in series with the gated control switch and polarized to bypass reverse polarity voltages applied to said trigger capacitor.

3. The ignition system of claim 1 wherein said voltage sensitive means is a Zener diode means.

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,566,188 Dated February 23, 1971

Inventor(s) FLOYD M. MINKS

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, Line 25, cancel "through" and insert --- though ---;

CLAIM 1
Column 6, Line 15, cancel "to the";

Line 16, cancel "main firing capacitor, said second discharge".

Signed and sealed this 17th day of August 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR
Commissioner of Patents

FORM PO-1050 (10-69)