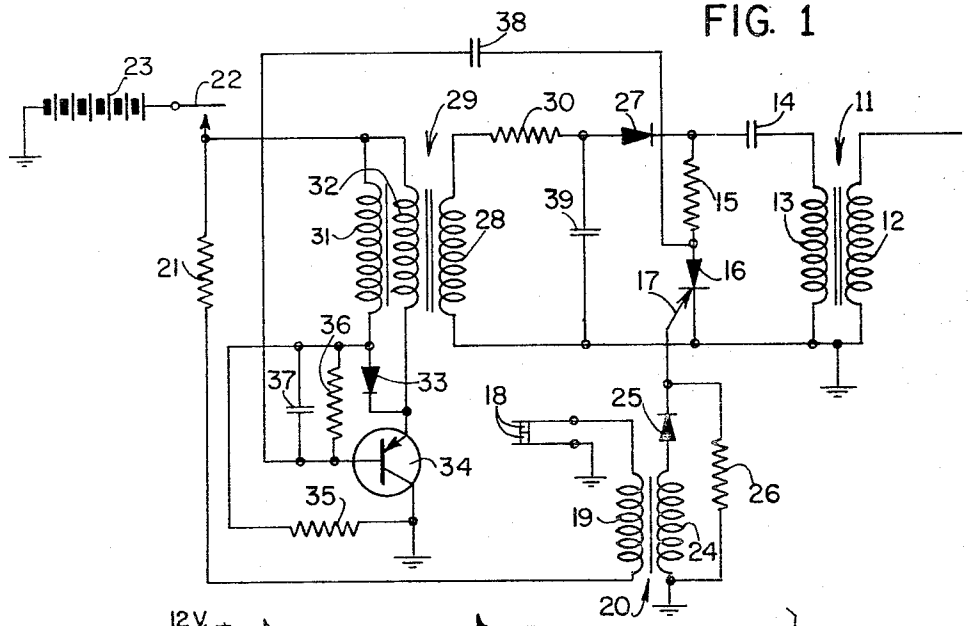
Feb. 7, 1967 C. L. SHANO 3,302,629

CAPACITOR DISCHARGE IGNITION SYSTEM WITH BLOCKING OSCILLATOR CHARGING CIRCUIT

Filed Sept. 21, 1964

FIG. 1



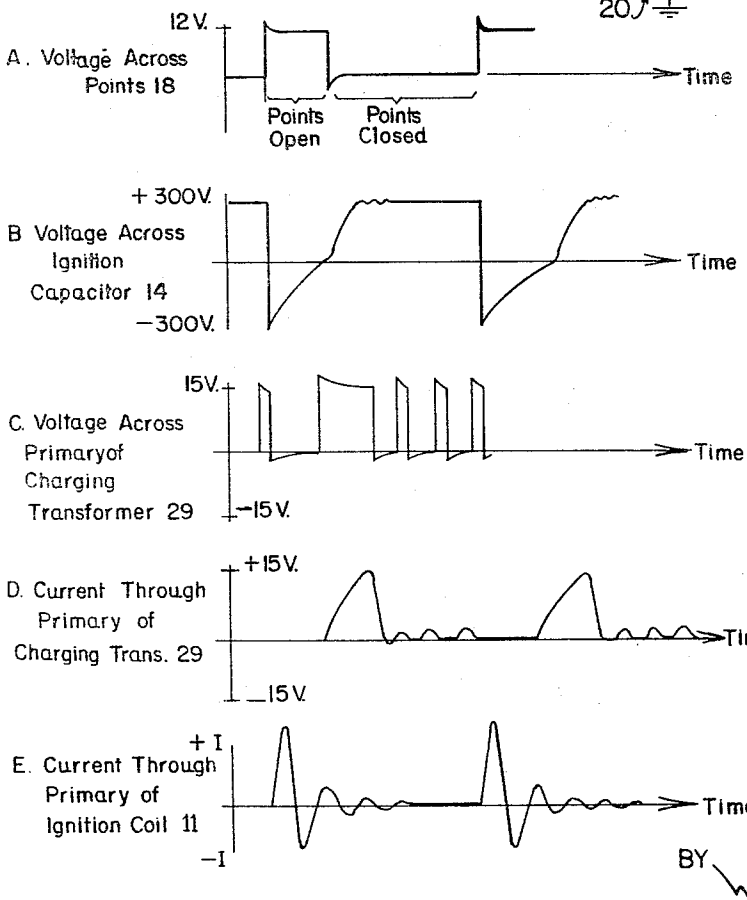


FIG. 2

Inventor
CHARLES L. SHANO
BY Mueller and Aichele
Attys.

United States Patent Office

3,302,629

Patented Feb. 7, 1967

3,302,629

CAPACITOR DISCHARGE IGNITION SYSTEM WITH BLOCKING OSCILLATOR CHARGING CIRCUIT

Charles L. Shano, Morton Grove, Ill., assignor to Motorola, Inc., Franklin Park, Ill., a corporation of Illinois

Filed Sept. 21, 1964, Ser. No. 397,824
5 Claims. (Cl. 123—148)

This invention relates to ignition systems for internal combustion engines, and more particularly to an improved ignition system utilizing the capacitor discharge principle.

Capacitive discharge ignition systems, that is, those systems which utilize a capacitor for intermittently discharging and causing current flow through an ignition coil, have been proposed over a long period of time. Such systems have been recognized as theoretically superior to other types of ignition systems, but as a practical matter, capacitor discharge systems have not been satisfactory. Many of the capacitive discharge systems proposed to date have been complex and have required excessive amounts of power for their operation. Often such systems have failed to produce adequate voltage at high speeds and were unstable over variations in temperature and supply voltage.

Accordingly, it is an object of this invention to provide an improved, low cost ignition system for an internal combustion engine.

Another object of the invention is to provide a capacitive discharge system which provides adequate firing voltages at high speed, while utilizing a minimum of power.

Still another object of the invention is to provide an ignition system utilizing the capacitive discharge principle, and which is stable and provides sufficient charge voltage to the storage capacitor over variations in source voltage and temperature.

A feature of the invention is the provision of a firing circuit for an ignition coil which includes a capacitor in series with the ignition coil, a circuit for rapidly charging the capacitor, and a semiconductor controlled rectifier for discharging the capacitor in timed relation with the internal combustion engine.

Another feature of the invention is the provision, in a capacitive discharge ignition system, of a rectifier coupling the secondary winding of a transformer to the capacitor, and of a switch connected in series with the primary winding of the transformer across a source of potential, which switch is turned on in synchronism with the firing of the capacitor and is turned off independently of such firing by energy storage means.

Still another feature of the invention is the provision, in a capacitive discharge ignition system, of a transformer coupled to the discharge capacitor by a rectifier, and of a blocking oscillator connected to energize the primary winding of the transformer, which blocking oscillator controls the conduction time of charging current to the capacitor independently of control of the firing of the capacitor.

In the drawing:

FIG. 1 is a schematic diagram of an ignition system constructed in accordance with the invention; and

FIG. 2 is a set of curves illustrating the operation of the system with respect to time in degrees of crankshaft revolution.

In accordance with the invention, an ignition system for an internal combustion engine includes an ignition coil for supplying high voltage firing pulses to the internal combustion engine and a firing circuit for the coil. The firing circuit has a capacitor connected in series with the ignition coil and has a charging circuit for applying a voltage to the capacitor for charging the same. A semiconductor controlled rectifier is connected in series with the capacitor and the ignition coil, and mechanical breaker points operable in synchronism with the internal combustion engine are coupled to the semiconductor controlled rectifier through a transformer and turn the rectifier on to discharge the capacitor through the ignition coil in synchronism with the internal combustion engine.

The charging circuit for the capacitor includes a rectifier coupled to the capacitor and a transformer with a secondary winding coupled to the rectifier. The primary winding of the transformer is connected to a blocking oscillator which causes conduction through the primary winding for energizing the secondary winding and charging the capacitor for a given period of time. Means are provided for synchronizing the turn on of the blocking oscillator with the firing of the ignition capacitor. The turn off of the blocking oscillator, however, is independent of the breaker points and the firing of the ignition capacitor.

Referring now to FIG. 1, an ignition transformer **11** has a secondary winding **12** coupled to the center post of a distributor, not shown, as is well known in the art. Secondary winding **12** is grounded at the opposite end as is the corresponding end of primary winding **13**. Transformer **11** might also be an auto-transformer. The ungrounded end of primary winding **13** is coupled to one side of an ignition capacitor **14**. The other side of ignition capacitor **14** is connected through a resistor **15** to the anode of a semiconductor controlled rectifier **16**. Controlled rectifier **16** has a control gate or region **17** for controlling the conduction thereof, and when controlled rectifier **16** is conductive, a circuit path is completed through the series combination of capacitor **14**, resistor **15**, controlled rectifier **16** and the primary winding **13** of transformer **11**.

Pulses are applied to the control region or gate **17** of controlled rectifier **16** by means of a pulse circuit. This pulse circuit is comprised of a pair of breaker points **18**, connected in series with the primary winding **19** of a transformer **20**, through a resistor **21** and an ignition switch **22**, to a source of direct current potential, storage battery **23**. Breaker points **18** open and close in synchronism with the internal combustion engine, as is well known in the art. Transformer **20** includes a secondary winding **24**, which is connected through a rectifier **25** to gate **17** of controlled rectifier **16**. A resistor **26** couples the gate **17** to ground for temperature stability.

Assuming for the present that a charge is placed on ignition capacitor **14** at the proper times, the operation of the ignition system is as follows. With breaker points **18** closed, a current flow limited by resistor **21** occurs in primary winding **19** of transformer **20**. Transformer **20** is wound such that this produces a negative potential at the rectifier end of secondary winding **24**, which has no effect on controlled rectifier **16**. When the points **18** open, however, the collapsing field in primary winding **19** produces a positive pulse in secondary winding **24**, which is applied through rectifier **25** to gate **17** of controlled rectifier **16**. When a signal pulse of proper polarity causes semiconductor controlled rectifier **16** to turn on, capacitor **14** is short circuited through resistor **15** and controlled rectifier **16**, with resistor **15** limiting the peak current through controlled rectifier **16**. Almost the full voltage across ignition capacitor **14** appears across primary winding **13** of ignition coil **11** in a very short time, causing a rapid build up of current as shown by curve E of FIG. 2. This action induces high voltage in the secondary winding **12** of ignition coil **11** according to the turns ratio of the ignition coil. This high voltage pulse is then applied to the center post of the distributor for

firing the fuel mixture in the respective cylinders of the internal combustion engine. The distributor points illustrated in the pulsing circuit are for the purpose of discussion only. Other systems for producing an appropriate pulse for application to transformer **20** for developing a timely output voltage in secondary winding **24** might also be utilized within the scope of this invention.

The charging circuit for the ignition capacitor **14** operates to charge the capacitor in less time than the time between the point closures for adequately high voltage and minimum power utilization, even at very high speeds. A diode **27** is connected to capacitor **14** and is coupled to the secondary winding **28** of a transformer **29** by means of a current limiting resistor **30**. Transformer **29** has two primary windings **31** and **32**. Both of these windings are coupled at one end to ignition switch **22**. The other end of primary winding **31** is coupled through a diode **33** to the emitter region of transistor **34**, and also through a resistor **35** to ground. The corresponding end of primary winding **32** is connected directly to the emitter region of transistor **34**. The parallel combination of the resistor **36** and the capacitor **37** connect the primary winding **31** to the base region of transistor **34**. Transistor **34**, in conjunction with transformer **29**, bias network resistor **36**, and capacitor **37**, constitutes a blocking oscillator whose art and function are well known. Diode **33** provides backswing limiting in such a fashion that the oscillator repetition rate and duty cycle are not materially affected. The transistor **34** may be a low voltage type which is essential for low cost. Capacitor **37**, in shunt with resistor **36**, provides and permits a very low current drain when capacitor **14** is fully charged. Resistor **36** is of a value which is adjusted for optimum power output of the oscillator when required during the charging period of ignition capacitor **14**. Capacitor **37** acts in such a way as to reduce the natural repetition rate of the blocking oscillator circuit. In doing so, it reduces the reactance of the oscillator primary coil **31** of transistor **29** when capacitor **14** is not charged. Since capacitor **14** is a short circuit at that time, zero load is reflected into the primary winding by the secondary which causes a high primary current flow because of regeneration through the base of transistor **34** and winding **31**.

The pulse provided in primary winding **32** by conduction of the blocking oscillator transistor **34** induces a pulse in secondary winding **28** which is sufficient to charge ignition capacitor **14** and supply the losses in the balance of the circuit. Capacitor **14** is fully charged by the first pulse in transformer **29** (compare curve B with curves C and D in FIG. 2). The circuit constants are such that full voltage appears across ignition capacitor **14** in less than two milliseconds (see curve B of FIG. 2). This is less than the time between the openings of points **18**, even at high engine speeds, permitting full charge to build up on capacitor **14** before discharge (compare curves A and B). Full firing voltage is maintained accordingly. When capacitor **14** is fully charged, secondary winding **28** is open circuited. The current pulse magnitude is limited to the exciting current of the primary winding only and is correspondingly low. The primary current and voltage are shown in curves C and D of FIG. 2. Resistor **30** limits peak forward current through diode **27** to a safe value.

After discharge of capacitor **14**, a negative voltage appears across the capacitor and across the controlled rectifier **16**. When the voltage at the anode of controlled rectifier **16** is negative, diode **27** is reversed biased but cannot conduct appreciably through secondary winding **28**. Capacitor **39**, which is a much smaller value than capacitor **14**, can be used an A.C. return to damp the negative voltage through diode **27** and thus supress the reverse voltage across controlled rectifier **16**. Capacitor **38** is connected from the juncture between resistor **15** and controlled rectifier **16** to the base region of transistor **34** for synchronizing the blocking oscillator such that a negative pulse is applied to the base of transistor **34** to drive it on immediately following the discharge of capacitor **14**.

The advantages provided by the foregoing described system are considerable. Capacitor **14** may be charged to its maximum steady state high voltage value in less than two milliseconds. With 13.2 volts input, the voltage applied to ignition capacitor **14** will exceed 300 volts, or the equivalent of 45 millijoules energy stored in a one microfarad capacitor. With distributor points **18** not operating, the system current is less than 0.5 ampere at 13 volts input. The blocking oscillator is sufficiently stable such that it will operate over a voltage range of from 3 to 25 volts and over a temperature range of −40 to +200° F. using a germanium power transistor for transistor **34**. The ignition system is capable of using any presently available ignition coil and is particularly adaptable to work with a specially designed coil of low basic cost.

It may therefore be seen that the invention provides an improved capacitive discharge ignition system for an internal combustion engine. The system is low in cost, stable and adequate in operation, and utilizes a minimum of power.

I claim:

1. In an ignition system for an internal combustion engine, which system has an ignition coil for supplying high voltage firing pulses to the internal combustion engine and pulse means operable in synchronism with the internal combustion engine, a firing circuit for providing intermittent current flow in the ignition coil to produce firing pulses therein, including in combination, capacitor means, blocking oscillator charging means coupled to said capacitor means and including an electron control device having input and output circuit means, inductance means connected between said input and output circuit means and providing regeneration action in said electron control device, controlled rectifier means connected in series with said capacitor means and the ignition coil, means for triggering said blocking oscillator charging means coupled between said controlled rectifier means and said input circuit means, and means for coupling said controlled rectifier means to the pulse means to turn said controlled rectifier means on said capacitor means thereby discharging in response to a pulse from the pulse means, through said ignition coil for producing a firing pulse therein.

2. In an ignition system for an internal combustion engine, which system has an ignition coil for supplying high voltage firing pulses to the internal combustion engine and breaker points operable in synchronism with the internal combustion engine, a firing circuit for providing intermittent current flow in the ignition coil to produce firing pulses therein, including in combination, capacitor means, blocking oscillator charging means coupled to said capacitor means and including an electron control device having input and output circuit means, inductance means connected between said input and output circuit means and providing regeneration action in said electron control device, a semiconductor controlled rectifier, means for triggering said blocking oscillator charging means coupled between said controlled rectifier and said input circuit means, means for connecting said controlled rectifier in series with said capacitor means to the ignition coil, said controlled rectifier having a control region responsive to pulses applied thereto for controlling the conduction thereof, a transformer having a secondary winding connected to said control region and having a primary winding, and means for connecting said primary winding to the breaker points to produce pulses in said secondary winding to turn said controlled rectifier on and discharge said capacitor means through the ignition coil for producing a firing pulse therein.

3. In an ignition system for an internal combustion engine having an ignition coil for providing high voltage firing pulses to the engine and, pulse means providing pulses in synchronism with the internal combustion engine, a firing circuit for providing intermittent current flow in the ignition coil to produce firing pulses therein, including in combination, a storage capacitor and first switch means adapted for connection in series with the ignition coil, means for connecting said first switch means to the pulse means for intermittently closing said first switch means in response to pulses applied thereto to permit said storage capacitor to discharge and cause current flow in said ignition coil, a transformer having first and second primary windings and a secondary winding, rectifier means connected in series between said secondary winding and said storage capacitor, and blocking oscillator circuit means for intermittently energizing said secondary winding to charge said storage capacitor through said rectifier means after discharge of said storage capacitor, said circuit means including second switch means connected in series with said first and second primary winding across a source of potential, and triggering means for said blocking oscillator circuit means coupled between said first switch means and said second switch means for sensing the closure of said first switch means and causing closure of said second switch means in synchronism therewith, said circuit means further including energy storage means for accumulating energy and causing said second switch means to open after a given amount of energy has accumulated to stop current flow through said primary winding, said energy storage means operating to cause said second switch means to open after a given period of time independently of the pulse means.

4. In an ignition system for an internal combustion engine having an ignition coil for providing high voltage firing pulses to the engine, a firing circuit for providing intermittent current flow in the ignition coil to produce firing pulses therein, including in combination, a storage capacitor and switch means adapted for connection in series with the ignition coil, pulse means connected to said switch means and providing pulses thereto in synchronism with the internal combustion engine for intermittently closing said switch means in timed relation with the internal combustion engine to permit said storage capacitor to discharge and cause current flow in said ignition coil, a transformer having first and second primary windings and a secondary winding, rectifier means connected in series between said secondary winding and said storage capacitor, and blocking oscillator circuit means for intermittently energizing said secondary winding to charge said storage capacitor through said rectifier means after discharge of said storage capacitor, said circuit means including a transistor having base, emitter, and collector regions, bias means connected to said base region, said emitter and collector regions being connected in series with said second primary winding across a source of potential, said first primary winding being connected between said source of potential and said bias means, and triggering means connected between said base region of said transistor and said switch means for sensing the closure of said switch means and causing conduction of said transistor in synchronism therewith, said circuit means further including energy storage means connected to said base region of said transistor for accumulating energy and biasing said transistor off after a given amount of energy has accumulated to stop current flow through said primary windings said energy storage means operating independently of said pulse means to cause said transistor to cease conduction after a given period of time.

5. In an ignition system for an internal combustion engine having an ignition coil for providing high voltage firing pulses to the engine, a firing circuit for providing intermittent current flow in the ignition coil to produce firing pulses therein, including in combination, a storage capacitor and a semiconductor controlled rectifier adapted for series connection across the ignition coil, pulse means connected to said semiconductor controlled rectifier and providing pulses thereto in synchronism with the internal combustion engine for causing intermittent conduction of said semiconductor controlled rectifier in timed relation with the internal combustion engine to permit said storage capacitor to discharge and cause current flow in said ignition coil, a transformer having first and second primary windings and a secondary winding, a rectifier connected in series between said secondary winding and the juncture between said storage capacitor and said semiconductor controlled rectifier, a blocking oscillator including a transistor having base, emitter and collector regions, said emitter and collector regions being connected in series directly with said second primary winding, a rectifier connecting said first primary winding with said emitter region, capacitor means and resistor means connecting said first primary winding with said base region, further resistor means connecting said first primary winding with said collector region, and triggering capacitor means connecting said base region with the juncture between said storage capacitor and said semiconductor controlled rectifier for synchronizing the conduction of said transistor with the conduction of said semiconductor controlled rectifier and holding said blocking oscillator activated for a period of time which is substantially less than the time between the pulses of said pulse means.

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MARK NEWMAN, *Primary Examiner.*

LAURENCE M. GOODRIDGE, *Examiner.*