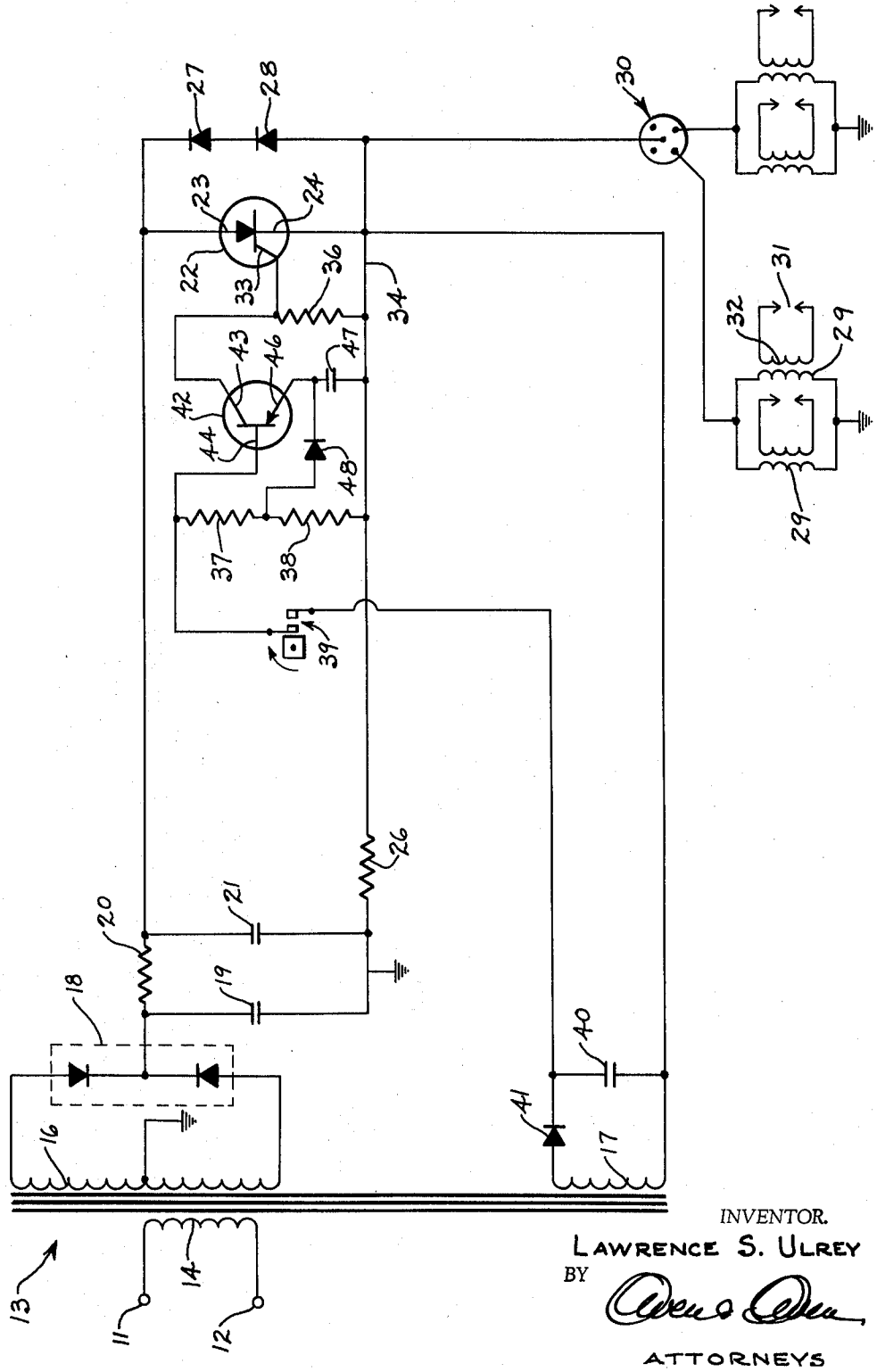
March 22, 1966 L. S. ULREY 3,242,420

IGNITION SYSTEM

Filed Nov. 13, 1962



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United States Patent Office 3,242,420 Patented Mar. 22, 1966

3,242,420

IGNITION SYSTEM

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Filed Nov. 13, 1962, Ser. No. 236,952
9 Claims. (Cl. 323—58)

This invention relates in general to electronic ignition systems and more specifically to such systems utilizing a semi-conductor triggering circuit.

There have been proposed in the prior art numerous circuits and devices to serve as electronic ignition systems in internal combustion engines. In fixed installations particularly in which large size engines are operated, continuous operation is oftentimes scheduled for weeks or months at a time without shutdown and with a minimum of maintenance or care. In engines of this type, there has been a problem in providing an accurately controlled timing for the firing of spark plugs to operate the engines. Especially in systems involving dual ignition, timing problems were generated when dual or single breaker points became burned due to large currents flowing therein. The burning of breaker points actually altered the spacing resulting in poor timing and a resultant decrease in engine efficiency.

Furthermore, past attempts to provide electronic ignition systems have, among other approaches, sought to utilize capacitor charging circuits coupled with step-up transformers to fire a triggering device. Such circuits use rather high currents and suffer from arcing of breaker points due to the interrupting of inductive currents.

It is an object of the present invention to avoid objections to ignition systems for internal combustion engines by furnishing improved trigger circuitry.

A still further object of the present invention is to provide a trigger circuit for a controlled discharge device which becomes isolated from the power source during firing. This object is accomplished by providing a usual pair of breaker points or contacts. Upon closure, the power source is permitted to charge a trigger capacitor coupled to a semi-conductor device which is biased to a cut-off condition. Upon opening of the breaker points, the semi-conductor device is permitted to provide trigger current through a resistive load circuit which enables the firing of the controlled discharge device to energize the appropriate spark plug.

Another object of the present invention is to eliminate transformers in the trigger circuits of controlled discharge devices to eliminate inductive loads and the inductive voltage kick resulting from the collapsing magnetic field when driving current is removed.

A further object of the present invention is to minimize peak current flow through breaker points.

A still further object of the present invention is to time the trigger or gate pulse, and consequent spark plug firing, with the opening of the breaker points.

Another object of the present invention is to provide an improved ignition firing system which may be incorporated quite simply into existing breaker point operated engines. It is understood, however, that the breaker points may be eliminated, if desired, to be substituted with an electronic switch. Such switches are known which may be timed by magnetic impulses from an engine flywheel.

The invention finds especial application in large engines having a number of cylinders most often ranging from four to twelve and which operate at relatively slow speeds of about 300 revolutions per minute. Such engines may be capable of providing normal outputs of from 3000 to 8000 horsepower. Such large engines oftentimes operate with dual ignition system and it is understood that extremely high energies must be delivered to the spark plugs with unfailing operation.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawing wherein is shown a preferred embodiment of the present invention.

In the drawing, the single figure is a schematic circuit diagram of an ignition system connected in accordance with the present invention.

Referring now to the drawing, the power supply may include appropriate batteries or may include a standard form of electronic supply such as is illustrated. An incoming pair of terminals **11**, **12** may be connected to a source of the usual 117 volt, 60 cycle, alternating current. Transformer **13** includes primary winding **14** and a pair of secondary windings **16** and **17** for a high and low voltage supply respectively. Secondary winding **16** has its center-tap connected to a common engine and electrical ground circuit and includes the usual full wave silicon rectifiers **18** and filter capacitor **19**. An RC circuit includes resistor **20** and capacitor **21** connected to ground across filter capacitor **19**. The time constant of this RC circuit is such as to permit a controlled discharge device to become cut off between its respective firings. It is understood that the values of elements **20** and **21** may be appropriately varied to achieve proper operation.

A silicon controlled rectifier **22** is illustrated with its anode **23** and cathode **24** connected in series with dropping resistor **26** across capacitor **21**. Protective diodes **27** and **28** across the controlled rectifier protect it from high back voltages generated by the ignition transformer primary windings **29**. The primary windings are shown paralleled to provide dual ignition although it is understood that single ignition systems are within the realm of utilization of the present invention. A distributor **30** is illustrated, it being understood that a desired number of engine cylinders may be driven. The spark gap **31** of the respective spark plugs is connected across the secondary windings **32** which provide appropriate energy for firing the plugs. Although the distributor is shown in the primary winding circuit, it may instead be in the secondary circuit if so desired.

The silicon controlled rectifier receives its trigger signal at its gate electrode **33** which is connected to the cathode line **34** through resistor **36**. A voltage divider includes resistors **37** and **38** with one end connected to line **34** and the other end connected to the timing or breaker points **39**. Power supply secondary winding **17** establishes a low voltage direct current supply across capacitor **40** in conjunction with silicon rectifier **41**. The negative side of capacitor **40** is connected to line **34** whereas the positive side connects through the breaker points **39** to the upper end of the voltage divider. A PNP transistor **42** includes a collector electrode **43**, a base electrode **44**, and an emitter electrode **46**. The base **44** connects to the upper end of resistor **37** whereas the collector connects to the gate **33** of controlled rectifier **22**.

A firing capacitor **47** joins the emitter **46** to line **34**. There is also a diode **48** with its cathode connected to emitter **46** and its anode connected to the junction of resistors **37** and **38**.

In operation, capacitor **21** becomes charged and applies its potential across the anode and cathode circuit of the controlled rectifier **22**. However, the device remains turned off since no gate pulse is provided to electrode **33**. When the breaker points close, the low voltage D.C. supply is available across resistors **37** and **38**. Diode **48** is poled in its forward direction and conducts to charge firing capacitor **47**. The capacitor may charge to two-thirds of the supply voltage according to the values of re-

sistors 37 and 38 in the divider leg. Transistor 42 does not conduct as long as the breaker points are closed since base electrode 44 is more positive than emitter 46. When the points open, base current from firing capacitor 47 can flow through resistors 37 and 38 and the transistor 42 switches quickly to its conducting state. Collector current flowing through resistor 36 provides a sufficient voltage pulse to fire controlled rectifier 22. It is understood that pulse duration is easily adjustable by substituting various size capacitors in place of capacitor 47.

It is well known that a silicon controlled rectifier is analogous to a gas thyratron. It is also contemplated that this invention may use a thyratron if desired and the form of the invention would remain the same. The term "controlled discharge device" is intended to apply to either device. The device 22 has an anode to cathode potential which blocks the flow of current. It may be switched into its high conducting mode by a small pulse, typically one and one-half volts and thirty milliamps applied from gate to cathode. Once the device is triggered into its high conduction state, it will continue conduction indefinitely after removal of the gate signal until the anode current is interrupted for about 20 microseconds after which the device will regain its forward blocking capabilities. The turning off of the device in the present invention is accomplished by utilizing the back voltage generated by the ignition transformer. The time constant of the firing circuit is such that the firing signal applied to the gate is gone by this time. When the controlled rectifier becomes blocked again, capacitor 21 is permitted to become charged in readiness for the next successive breaker point firing. It is recognized that high energy pulses are generated due to the extremely low voltage drop of one or two volts and the fact that the current is limited only by the external circuit impedance and supply voltage.

While I have described my invention using a PNP transistor, it is understood that an NPN type may be used with appropriate polarities being altered to provide a positive gating pulse. Other modifications will readily occur to those skilled in the art, and it is intended that my invention is to be limited only by the appended claims.

What I claim is:

1. In an electronic ignition circuit: first means including a gated device having a gate electrode and which device is caused to be conductive when a predetermined voltage is applied to said gate electrode, a transistor having emitter, base, and collector electrodes and which is conductive when a voltage of predetermined polarity relative to its emitter and collector is applied to its base, a pair of terminals, means for supplying voltage of said predetermined polarity to one of said terminals and for supplying voltage of the opposite polarity to the other of said terminals, interrupter means for periodically applying and removing said voltages to respective terminals, said other one of said terminals being connected to said base, a diode connecting said other one of said terminals to one of the emitter and collector electrodes of said transistor for communicating the polarity of said other terminal to said one of said emitter and collector electrodes, a condenser in series between said one of said terminals and said diode and said one of said emitter and collector electrodes, and means communicating the other one of said emitter and collector electrodes to said first mentioned means and effective for causing said gated device to be conductive when said interrupter means is opened and said condenser is discharged through said transistor.

2. In an electronic ignition circuit: first means including a gated device having a gate electrode and which device is caused to be conductive when a predetermined voltage is applied to said gate electrode, a transistor having emitter, base, and collector electrodes and which is conductive when a voltage of predetermined polarity relative to its emitter and collector is applied to its base, a pair of terminals, means for supplying voltage of said predetermined polarity to one of said terminals and for

supplying voltage of the opposite polarity to the other of said terminals, interrupter means for periodically applying and removing said voltages to respective terminals, said one of said terminals being connected to said base, a diode connecting said other one of said terminals to one of the emitter and collector electrodes of said transistor for communicating the polarity of said other terminal to said one of said emitter and collector electrodes, a condenser in series between said one of said terminals and said diode and said one of said emitter and collector electrodes, resistor means connecting said base to said one of said electrodes, and means communicating the other one of said emitter and collector electrodes to said first mentioned means and effective for causing said gated device to be conductive when said interrupter means is opened and said condenser is discharged through said transistor.

3. In an electronic ignition circuit: first means including a gated device having a gate electrode and which device is caused to be conductive when a predetermined voltage is applied to said gate electrode, a transistor having emitter, base, and collector electrodes and which is conductive when a voltage of predetermined polarity relative to its emitter and collector is applied to its base, a pair of terminals, means for supplying voltage of said predetermined polarity to one of said terminals and for supplying voltage of the opposite polarity to the other of said terminals, interrupter means for periodically applying and removing said voltages to respective terminals, a pair of resistors connected in series between said base of said transistor and said one of said terminals, a diode connecting the connection of said resistors to one of the emitter and collector electrodes of said transistor for communicating the polarity of said other terminal to said one of said emitter and collector electrodes, a condenser in series between said one of said terminals and said diode and said one of said emitter and collector electrodes, and means communicating the other one of said emitter and collector electrodes to said first mentioned means and effective for causing said gated device to be conductive when said interrupter means is opened and said condenser is discharged through said transistor.

4. In an electronic ignition circuit: first means including a gated silicon controlled rectifier having a gate electrode and which rectifier is caused to be conductive when a predetermined voltage is applied to said gate electrode, an inductance connected to said rectifier and through which inductance said rectifier controls a current discharge, a transistor having emitter, base, and collector electrodes and which is conductive when a voltage of predetermined polarity relative to its emitter and collector is applied to its base, a pair of terminals, means for supplying voltage of said predetermined polarity to one of said terminals and for supplying voltage of the opposite polarity to the other of said terminals, interrupter means for periodically applying and removing said voltages to respective terminals, said other one of said terminals being connected to said base, a diode connecting said other one of said terminals to one of the emitter and collector electrodes of said transistor for communicating the polarity of said other terminal to said one of said emitter and collector electrodes, a condenser in series between said one of said terminals and said diode and said one of said emitter and collector electrodes, and means communicating the other one of said emitter and collector electrodes to said first mentioned means and effective for causing said gated device to be conductive when said interrupter means is opened and said condenser is discharged through said transistor.

5. In an electronic ignition circuit: first means including a gated silicon controlled rectifier having a gate electrode and which rectifier is caused to be conductive when a predetermined voltage is applied to said gate electrode, an inductance connected to said rectifier and through which inductance said rectifier controls a current dis-

charge, a first condenser for applying a voltage when charged to said silicon controlled rectifier, a source of potential for charging said first condenser, means controlling the rate at which said source charges said first condenser, a transistor having emitter, base, and collector electrodes and which is conductive when a voltage of predetermined polarity relative to its emitter and collector is applied to its base, a pair of terminals, means for supplying voltage of said predetermined polarity to one of said terminals and for supplying voltage of the opposite polarity to the other of said terminals, interrupter means for periodically applying and removing said voltages to respective terminals, said other one of said terminals being connected to said base, a diode connecting said other of said terminals to one of the emitter and collector electrodes of said transistor for communicating the polarity of said other terminal to said one of said emitter and collector electrodes, a second condenser in series between said one of said terminals and said diode and said one of said emitter and collector electrodes, and means communicating the other one of said emitter and collector electrodes to said first mentioned means and effective for causing said silicon controlled rectifier to be conductive when said interrupter does not apply voltage to said other one of said terminals and said second condenser is discharged through said transistor.

6. In an electronic ignition circuit: means including a gated silicon controlled rectifier having a gate electrode and which rectifier is caused to be conductive when a predetermined voltage is applied to said gate electrode, an inductance connected to said rectifier and through which inductance said rectifier controls a current discharge, a first condenser for applying a voltage when charged to said silicon controlled rectifier, a source of potential for charging said first condenser, a first resistor controlling the rate at which said source charges said first condenser, a transistor having emitter, base, and collector electrodes and which is conductive when a voltage of predetermined polarity relative to its emitter and collector is applied to its base, a pair of terminals, means for supplying voltage of said predetermined polarity to one of said terminals and for supplying voltage of the opposite polarity to the other of said terminals, interrupter means for periodically applying and removing said voltages to respective terminals, said other one of said terminals being connected to said base, a diode connecting said other one of said terminals to one of the emitter and collector electrodes of said transistor for communicating the polarity of said other terminal to said one of said emitter and collector electrodes, a second condenser in series between said one of said terminals and said diode and said one of said emitter and collector electrodes, resistor means connecting said base to said one of said electrodes, and means communicating the other one of said emitter and collector electrodes to said first mentioned means and effective for causing said gated silicon controlled rectifier device to be conductive when said interrupter means does not apply voltage to said other one of said terminals and said second condenser is discharged through said transistor, said first resistor causing said first condenser to be charged at a rate slower than the rate of discharge of said first and second condensers.

7. An ignition circuit for an internal combustion engine comprising: an ignition transformer for firing a spark discharge device, first means including a gated device for supplying a current flow in one direction to said transformer, said device being of a type having a gate electrode which causes said device to become conductive when a predetermined voltage is applied to said gate electrode and to remain conductive until the voltage drop across said device falls below a predetermined amount, a transistor having emitter, base, and collector electrodes and which is conductive when a voltage of predetermined polarity relative to its emitter and collector is applied to its base, a pair of terminals, means for supplying voltage of said predetermined polarity to one of said terminals and for supplying voltage of the opposite polarity to the other of said terminals, cyclic interrupter means for periodically applying and removing said voltages to respective terminals, said other one of said terminals being connected to said base, a diode connecting said other of said terminals to one of the emitter and collector electrodes of said transistor for communicating the said other terminal to said one of said emitter and collector electrodes, a first condenser in series between said one of said terminals and said diode and said one of said emitter and collector electrodes, means communicating the other one of said emitter and collector electrodes to said first mentioned means and effective for causing said gated device to be conductive when said interrupter means is opened and said condenser is discharged through said transistor, a second condenser arranged to discharge through said device and transformer, and means for charging said second condenser at a rate slower than the discharge of said second condenser and the cycle of said cyclic interrupter means.

8. An ignition circuit for an internal combustion engine comprising: an ignition transformer for firing a spark discharge device, first means including a gated device for supplying current flow in one direction to said transformer, said device being of a type having a gate electrode which causes said device to become conductive when a predetermined voltage is applied to said gate electrode and to remain conductive until the voltage drop across said device falls below a predetermined amount, a transistor having emitter, base, and collector electrodes and which is conductive when a voltage of predetermined polarity relative to its emitter and collector is applied to its base, a pair of terminals, means for supplying voltage of said predetermined polarity to one of said terminals and for supplying voltage of the opposite polarity to the other of said terminals, cyclic interrupter means for periodically applying and removing said voltages to respective terminals, said other one of said terminals being connected to said base, a diode connecting said other of said terminals to one of the emitter and collector electrodes of said transistor for communicating the said other terminal to said one of said emitter and collector electrodes, a first condenser in series between said one of said terminals and said diode and said one of said emitter and collector electrodes, means communicating the other one of said emitter and collector electrodes to said first mentioned means and effective for causing said gated device to be conductive when said interrupter means is opened and said condenser is discharged through said transistor, a second condenser arranged to discharge through said device and transformer, current supply means for supplying a direct current voltage across said second condenser, and a resistor between said current supply means and said second condenser, said resistor being of a value to require a greater length of time for the charging of said second condenser than the discharging of said second condenser through said transformer.

9. An ignition circuit for an internal combustion engine comprising: an ignition transformer for firing a spark discharge device, first means including a gated device for supplying a current flow in one direction to said transformer, said device being of a type having a gate electrode which causes said device to become conductive when a predetermined voltage is applied to said gate electrode and to remain conductive until the voltage drop across said device falls below a predetermined amount, a transducer having emitter, base, and collector electrodes and which is conductive when a voltage of predetermined polarity relative to its emitter and collector is applied to its base, a pair of terminals, means for supplying voltage of said predetermined polarity to one of said terminals and for supplying voltage of the opposite polarity to the

other of said terminals, cyclic interrupter means for periodically applying and removing said voltages to respective terminals, said other one of said terminals being connected to said base, a diode connecting said other of said terminals to one of the emitter and collector electrodes of said transistor for communicating the said other terminal to said one of said emitter and collector electrodes, a first condenser in series between said one of said terminals and said diode, and said one of said emitter and collector electrodes, means communicating the other one of said emitter and collector electrodes to said first mentioned means and effective for causing said gated device to be conductive when said interrupter means is opened and said condenser is discharged through said transistor, a second condenser arranged to discharge through said device and transformer, current supply means for supplying a direct current voltage across said second condenser, a resistor between said current supply means and said second condenser, said resistor being of a value to require a greater length of time for the charging of said second condenser than the discharging of said second condenser through said transformer, and a unidirectional current flow device in parallel with said first mentioned device and arranged to conduct current in a direction opposite to that of said first mentioned device to bypass kickback from said transformer across said first device.

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