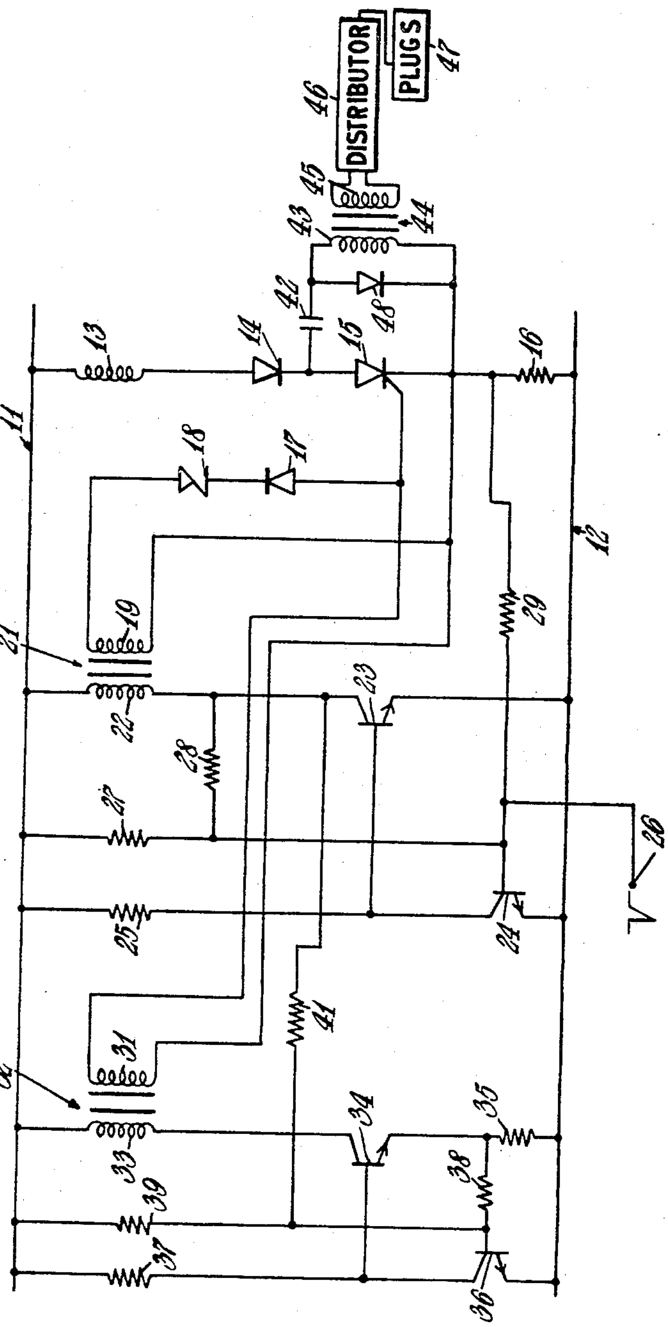
Oct. 22, 1968 B. L. PHILLIPS ET AL 3,406,672

SPARK IGNITION SYSTEMS

Filed March 8, 1966



United States Patent Office

3,406,672

Patented Oct. 22, 1968

1

3,406,672

SPARK IGNITION SYSTEMS

Brian Leslie Phillips, Handsworth, and Derek Stanley Adams, Acocks Green, England, assignors to Joseph Lucas (Industries) Limited, Birmingham, England, a British company

Filed Mar. 8, 1966, Ser. No. 532,712

Claims priority, application Great Britain, Mar. 10, 1965, 10,110/65

2 Claims. (Cl. 123—148)

ABSTRACT OF THE DISCLOSURE

In a spark ignition system for an internal combustion engine, an inductor is connected in series with a switch across a battery. The switch is closed at periodic intervals by the engine through the intermediary of a transformer, and when it closes energy is stored in the inductor, this energy later being used to produce a spark at a plug of the engine in timed relationship thereto. When the current flowing in the inductor reaches a predetermined value, a circuit is rendered operative to turn the switch off through the intermediary of a second transformer, so that the energy stored in the inductor each time the switch closes is constant.

This invention relates to spark ignition systems for internal combustion engines.

In its preferred form, the invention makes use of a semi-conductor device known as a gate controlled switch. This device is similar to the semi-conductor device called a controlled rectifier, but has the additional property that it can be switched off by a negative current flowing between its gate and cathode, whereas a conventional controlled rectifier can only be switched off by a reverse voltage between its anode and cathode. The gate controlled switch can handle currents of the same magnitude as the controlled rectifier, and should not be confused with devices such as the trigistor which operates in a similar manner, but can handle only very small anode-cathode currents. The gate controlled switch is one example of a semi-conductor switch, which term is hereby defined to means a semi-conductor device having a control terminal, and a pair of main terminals, signals applied to the control terminal determining whether or not the switch conducts. In the case of a gate controlled switch, the main terminals are the anode and cathode and the control terminal is the gate. If a transistor is used, the collector and emitter constitute the main terminals and the base the control terminal. It will be noted that the definition excludes, for example, a controlled rectifier, even though a controlled rectifier has the necessary three terminals, because although the gate signal applied to a controlled rectifier initiates conduction, turning off of the controlled rectifier can only be effected by reversing its anode-cathode voltage.

A spark ignition system according to the invention includes a semi-conductor switch controlling the production of the required sparks, and a pair of transformers providing signals to the control terminal of said switch for turning the switch on and off respectively.

The accompanying drawing is a circuit diagram illustrating one example of the invention.

Referring to the drawing, there are provided positive and negative lines **11**, **12** connected in use to a vehicle battery. Connected in series across these lines are an inductor **13**, a diode **14**, a gate controlled switch **15** and a resistor **16**. The switch **15** is a semi-conductor device having the properties of a controlled rectifier with the additional property that anode-cathode current can be switched off by a negative gate-cathode current.

2

Connected between the gate and cathode of the switch **15** in series with a diode **17** and Zener diode **18** is the secondary winding **19** of a transformer **21** the primary winding **22** of which has one end connected to the line **11** and its other end connected to the collector of a transistor **23**, the emitter of which is connected to the line **12**, and the base of which is connected to the collector of a transistor **24**. The transistor **24** has its emitter connected to the line **12**, its collector connected to the line **11** through a resistor **25** and its base connected to a terminal **26**, through a resistor **27** to the line **11**, through a resistor **28** to the collector of the transistor **23**, and through a resistor **29** and the resistor in series to the line **12**.

The gate and cathode of the switch **15** are further interconnected through the secondary winding **31** of a transformer **32** having its primary winding connected between the line **11** and the collector of a transistor **34** having its emitter connected to the line **12** through a resistor **35** and its base connected to the collector of a transistor **36**. The transistor **36** has its emitter connected to the line **12**, its collector connected through a resistor **37** to the line **11**, and its base connected to the line **12** through a resistor **38** and the resistor **35** in series, and to the line **11** and the collector of the transistor **23** through resistors **39** and **41**, respectively.

The anode and cathode of the switch **15** are interconnected through a capacitor **42** in series with the primary winding **43** of an ignition transformer **44**, the secondary winding **45** of which is connected through a distributor **46** to the plugs **47** of the engine in turn. The winding **43** is bridged by a diode **48**.

In order to understand the operation of the circuit, consider a point in a cycle at which the switch **15** is off and the capacitor **42** is charged. In this condition the transistors **24** and **36** are on, but the transistors **23**, and **34** are off. Thus, no current flows in the winding **22** or the winding **33**.

At the instant when a spark is required, any convenient known means operated by the engine causes a negative signal to appear at the terminal **26**. This signal turns the transistor **24** off, and so the transistor **23** is turned on, and current builds up in the winding **22**. The rising current produces an E.M.F. in the winding **19**, but this E.M.F. is blocked by the diode **17**.

When the transistor **23** is switched on, the transistor **36** tends to switch off and the transistor **34** tends to switch on. The transistors **34**, **36** act in conjunction with their associated components to cause a pulse to be applied to the winding **33** until the transistor **23** is turned off in a manner to be described. By virtue of the connections of the circuit, this pulse will have an amplitude independent of the battery voltage, and so a substantially constant current is fed by the winding **31** to the switch **15** to turn it on. The Zener diode **18** prevents the turn-on current from flowing through the winding **19**.

When the switch **15** is turned on, the capacitor **42** discharges through the winding **43** to produce the required spark. While the switch **15** is on, current builds up in the series circuit **13**, **14**, **15**, **16** until, when a predetermined current is reached, the voltage across the resistor **16** turns the transistor **24** on. The transistors **34**, **36** now revert to their original state, so removing the forward drive to the switch **15**, and the transistor **23** is turned off to break the current in the winding **22**. The resultant E.M.F. in the winding **19** provides a negative gate-cathode current to turn the switch off. The energy stored in the inductor **13** is now transferred to the capacitor **42** by way of the diode **48** and retained by the diode **14**, and it will be appreciated that the capacitor **42** will be charged to a voltage considerably in excess of battery voltage. The cycle is repeated when a further signal is received at the terminal **26**.

The resistors **27**, **29** provide compensation for changes in battery voltage, and the windings **13**, **22** are chosen to have a high inductance-resistance ratio. In this way, the current flowing through the winding **13** when the switch **15** is turned off is rendered substantially independent of battery voltage. The Zener diode **18** dissipates energy remaining in the winding **19** after the switch **15** is turned off.

In a modification particularly useful where the battery voltage may be extremely low, the resistors **25**, **27** are connected to the line **11** through an additional resistor, and a point intermediate the additional resistor and the resistors **25**, **27** is connected to the line **12** through a Zener diode.

As previously explained, a transistor can be used in place of a gate controlled switch, it then being necessary to ensure that the transistor remains saturated while it is on. This can be done by ensuring that sufficient base current is provided to saturate the transistor at any expected collector emitter current, or by incorporating a transformer to increase the base drive with increasing collector-emitter current. In the drawing current is provided to turn off the gate controlled switch, and it will be understood that where a transistor is used the removal of the drive current is sufficient to stop the transistor conducting. However, the use of the circuit shown is advantageous even with a transistor, because the reverse base-emitter bias ensures that the transistor switches off rapidly.

It will be appreciated that the idea of using two transformers to provide turn-on and turn-off pulses can be used in numerous other ignition systems, and has the advantage that more accurate control can be obtained than if a single transformer is used for both purposes.

Having thus described our invention what we claim as new and desire to secure by Letters Patent is:

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 in synchronism with the internal combustion engine and having an electrical source; a firing circuit for providing intermittent current flow in the ignition coil to produce firing pulses therein, including in combination, a capacitor; a gate controlled semiconductor switch connected in series with said capacitor and the ignition coil; said semiconductor switch having a gate region responsive to a pulse of a given polarity to turn on said semiconductor switch and responsive to a pulse of opposite polarity to turn off said semiconductor switch; an inductance and a diode connected in series with said semiconductor switch and said capacitor in parallel so that current flows through said inductance and diode and the semiconductor switch when said switch is on and flows into said capacitor when said switch is off; said diode being connected to prevent current flow from said capacitor through said inductance by discharge of said capacitor therethrough; a resistor; means connecting said series connected inductance, diode, and semiconductor switch in a series circuit with said resistor; means connecting said series circuit across said electrical source whereby current flows therethrough when said semiconductor switch is on; means coupled to the pulse means to apply pulses of the given polarity to said gate region to turn on said semiconductor switch and discharge said capacitor through said ignition coil for producing a firing pulse therein; a transformer having a primary winding and a secondary winding; means for connecting and disconnecting said primary winding to the electrical source; unidirectional current means connecting said secondary winding to said switch gate region for response to current flow in said primary winding on deenergization of said primary winding for applying a pulse to said gate region to turn off said semiconductor switch; and means responsive to the voltage across said resistor for disconnecting said primary winding from said electrical source whereby said semiconductor switch is turned off causing said inductance to discharge into said capacitor and charge the same.

2. An ignition system as defined in claim **1** wherein said means coupled to the pulse means comprises a second transformer having a primary winding and a secondary winding; means connecting said latter secondary winding to said switch gate region for turning on said switch in response to energization of said latter primary winding; circuit connecting means responsive to a pulse from said pulse means for energizing said latter primary winding; and means for deenergizing said latter primary winding in response to a predetermined voltage across said resistor.

References Cited

UNITED STATES PATENTS

2,847,489	8/1958	Short et al.
3,150,286	9/1964	Quinn.
3,271,593	9/1966	De Vilbiss.
3,306,275	2/1967	Hufton.
3,318,296	5/1967	Hufton.

LAURENCE M. GOODRIDGE, *Primary Examiner.*