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IGNITION SYSTEM

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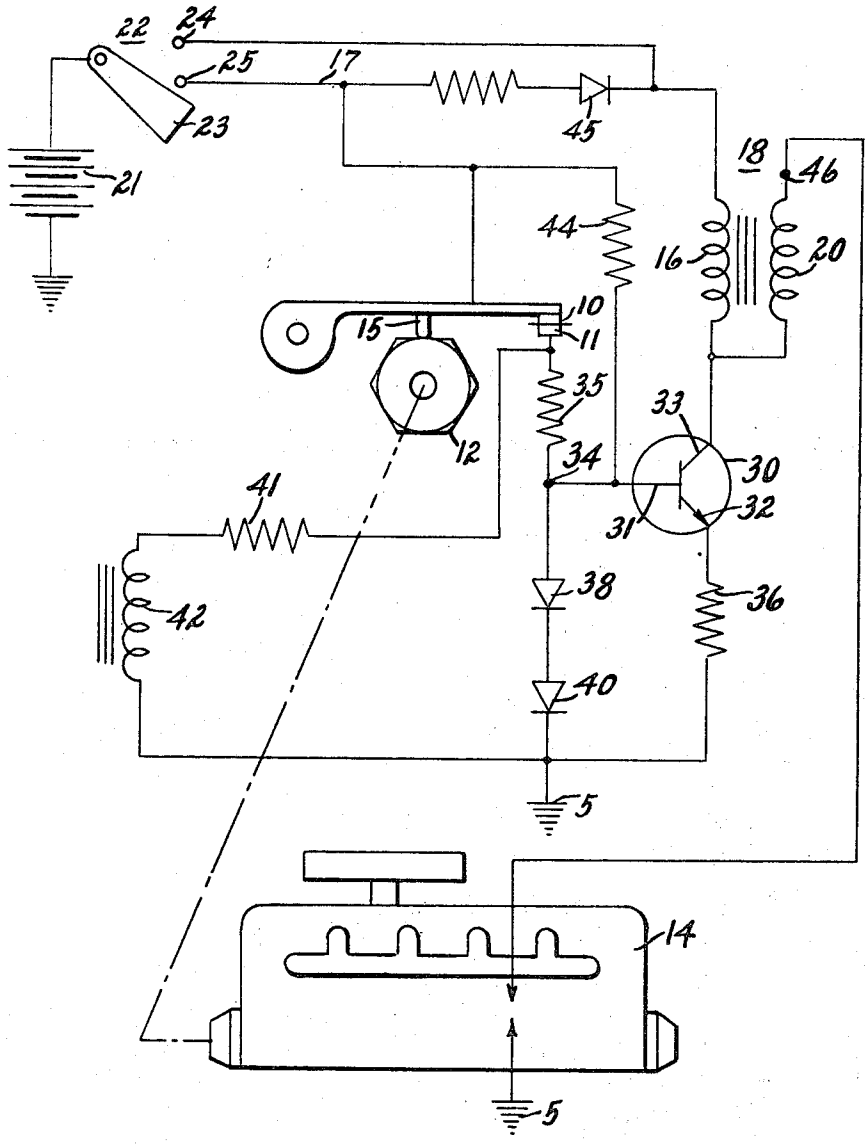

INVENTORS
ALBERT D. RITTMANN
JAMES E. SHEARER
BY Richard G. Stahr
HIS ATTORNEY

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IGNITION SYSTEM

Albert D. Rittmann and James E. Shearer, Kokomo, Ind., assignors to General Motors Corporation, Detroit, Mich., a corporation of Delaware

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ABSTRACT OF THE DISCLOSURE

An ignition breaker point operated transistorized ignition system which utilizes a transistor switch for establishing and interrupting the energizing circuit for the primary winding of the ignition coil and an inductor device for extiguishing the transistor upon the opening of the breaker points wherein the combination of a resistor connected in parallel with the breaker points for rendering the transistor switch reconductive before the points reclose and a diode connected in series with the current carrying electrodes of the transistor and the ignition coil primary winding for preventing oscillatory currents through the ignition coil primary provides for the rapid increase of current through the ignition coil primary and the combination of an emitter resistor and at least one diode connected in parallel with the base-emitter junction of the transistor switch and the emitter resistor provides a features for limiting current through the transistor switch.

The present invention relates to ignition systems for internal combustion engines and, more specifically, to an ignition system employing a semiconductor switching device which may be used with conventional ignition breaker points operated by a lobed cam.

With any ignition system for internal combustion engines, it is desirable to provide for a high build-up of energizing current through the primary winding of the ignition coil prior to each subsequent spark and with ignition systems in which a semiconductor device is employed as the ignition coil primary winding switch, it is desirable to include a feature which will automatically limit the current flow through the current carrying electrodes of this device.

Heretofore, quite complex electronic circuitry has been devised to realize these two desirable features. As electronic circuitry and components are expensive and since the use of semiconductor switching devices is becoming increasingly popular, the requirement of a simple, inexpensive ignition system which provides the two desirable features hereinabove set forth, is apparent.

It is, therefore, an object of this invention to provide an improved ignition system.

It is another object of this invention to provide an improved ignition system employing a semiconductor switching device.

It is another object of this invention to provide an improved ignition system employing a semiconductor switching device for use with conventional ignition breaker points which provides a greater build-up of energizing current through the primary winding of the ignition coil than is obtainable by the opening and closing of the breaker points.

It is an additional object of this invention to provide an improved ignition system which includes a feature for automatically limiting the current flow through a semiconductor device employed as the ignition coil primary winding energizing and de-energizing switch.

In accordance with this invention, an improved ignition system for use with conventional ignition breaker points is provided wherein the maximum current flow through a semiconductor device, employed as the energizing switch for the primary winding of the ignition coil, is automatically limited to a safe, predetermined value and the period during which the semiconductor device remains nonconductive after the ignition breaker points open is of a period of time less than that required to close the ignition breaker points.

For a better understanding of the present invention, together with additional objects, advantages and features thereof, reference is made to the following description and accompanying single figure drawing.

Referring to the figure, the ignition system of this invention is set forth in schematic form in combination with a pair of conventional ignition circuit breaker points **10** and **11** which are opened and closed by a lobed cam **12** which is driven by engine **14** and engages cam follower **15**, in a manner well known in the automotive art.

The primary winding **16** of a conventional ignition coil **18** is connected in series across a source of direct current potential, which may be a conventional storage battery **21**, through a conventional electric switch **22** having a movable contact **23** and two stationary contacts **24** and **25**, the current carrying electrodes of a semiconductor switching device **30**, a resistor **36** and point of reference or ground potential **5** which, since it is the same point electrically, has been referenced by this same numeral throughout the figure.

Switch **22** may be a conventional automotive type ignition switch having an "off" positon, as shown in the figure, a "crank" position with movable contact **23** closed to stationary contacts **24** and **25** and a "run" position with movable contact **23** closed to only stationary contact **25**. Switches of this type are well known in the art and are normally spring biased to return to the "run" position upon the release of pressure upon the ignition key.

Without intention or inference of a limitation thereto, the semiconductor switching device may be a type NPN transistor **30** having the usual current carrying electrodes, collector electrode **31** and emitter electrode **32**, and a control electrode, base electrode **33**, as schematically set forth.

With movable contact **23** of switch **22** closed to either or both stationary contacts, the current carrying electrodes, collector electrode **31** and emitter electrode **32**, of switching transistor **30** are connected in series with primary winding **16** of ignition coil **18** across the source of direct current potential, battery **21**, through resistor **36** and point of reference or ground potential **5**.

As the collector electrode **31** and emitter electrode **32** of transistor switch **30** are connected to the positive and negative polarity terminals, respectively, of battery **21** through movable contact **23** of switch **22** closed to either or both of the stationary contacts and point of reference potential **5**, respectively, this device is forward poled. The control or base electrode **33** of transistor **30** is connected to junction **34** between resistor **35** and the series combination of diodes **38** and **40**. The impedance values of diodes **38** and **40** and resistor **35** are arranged to provide a potential at junction **34** which is of a positive polarity in respect to the potential present upon the emitter electrode **32** of transistor **30**. As this is the proper potential polarity relationship to produce base-emitter current flow through a type NPN transistor, transistor **30** is normally conducting with the circuit energized.

To quickly extinguish or render transistor **30** nonconductive in response to each opening of ignition breaker points **10** and **11**, an inductor device **42**, connected in shunt across the base electrode **33** of transistor **30** through resistors **35** and **41** and point of reference potential **5**, is provided.

To provide for a maximum build-up of energizing current through the primary winding **16** of ignition coil **18**, it is necessary that the dwell time or the period of time during which transistor switch **30** is conducting be as long as possible. To realize the highly desirable long dwell time, it is mandatory that transistor switch **30** be nonconductive for the shortest possible time consistent with the establishment of a spark. To provide for the triggering of transistor switch **30** conductive even before the closure of ignition breaker points **10** and **11**, a resistor **44**, connected between line **17** and the base electrode **33** of transistor switch **30**, is provided.

As transistor **30** is first made conductive by resistor **44**, a condition of oscillation persists in ignition coil **18** as a result of its distributed capacitance, its inductance and a certain amount of retained energy from the previous spark. Diode **45** is provided to prevent this oscillatory energy from establishing current of the undesirable direction in primary winding **16** of ignition coil **18**, thereby effectively increasing the build-up of energizing current in the desirable direction.

To provide the current limiting feature which limits the maximum amount of collector-emitter current flow through transistor switch **30**, the series combination of diodes **38** and **40** is connected in parallel with the series combination of emitter electrode **32** of transistor switch **30** and resistor **36** between junction **34** and point of reference or ground potential **5**.

In operation, switch **22** is operated to the "crank" position at which time movable contact **23** is closed to stationary contacts **24** and **25** to energize the system. With ignition breaker points **10** and **11** closed, transistor switch **30** is conducting and energizing current flows through primary winding **16** of ignition coil **18** from battery **21**, through a circuit which includes closed switch **22**, primary winding **16**, the collector-emitter electrodes of transistor switch **30**, resistor **36** and point of reference potential **5**. As a cranking motor, not shown, begins to rotate engine **14** in a manner well known in the art, a lobe of cam **12** engages cam follower **15** and opens ignition breaker points **10** and **11**. As this arrangement is well known in the automotive art and forms no part of this invention, in the interest of reducing drawing complexity, the the cranking motor has not been shown in the figure.

As breaker points **10** and **11** open, the potential appearing across inductor **42** is reduced in magnitude and the resulting collapsing magnetic field induces a potential therein which is of a negative polarity at junction **34** in respect to point of reference or ground potential **5**. As this potential, applied across the base-emitter electrodes of transistor switch **30**, is of the incorrect polarity relationship to maintain base-emitter current flow through a type NPN transistor, this device is immediately extinguished. With transistor switch **30** in the nonconductive mode, the energizing circuit through which current is supplied to primary winding **16** of ignition coil **18**, is interrupted and the resulting collapsing magnetic field induces a high potential in secondary winding **20** thereof which appears across terminal **46** and point of reference potential **5**. As is well known in the automotive art, this high potential is directed by a conventional automotive type distributor, not shown, to the proper spark plug of engine **14**. As this arrangement is well known in the automotive art and forms no part of this invention, it has not been shown in the figure.

Simultaneously with the decay of the induced potential appearing across inductor **42**, current flow through resistor **44** and the base-emitter electrodes of transistor switch **30** triggers transistor switch **30** conductive. With the inclusion of resistor **44** in this unique circuit, transistor switch **30** is rendered conductive before the ignition breaker points **10** and **11** reclose as the lobe of cam **12** passes cam follower **15**. With this novel feature, the dwell time of this unique ignition system may be considerably lengthened in that the energizing circuit for primary winding **16** of ignition coil **18** is closed faster than would be possible with only the conventional ignition breaker points.

The sequence hereinabove described is, of course, repeated as each lobe of cam **12** passes under cam follower **15** to open ignition breaker points **10** and **11** as engine **14** is in the running mode with movable contact **23** of switch **22** closed to stationary contact **25**.

With movable contact **23** of switch **22** closed to stationary contact **25**, diode **45** is positioned in series with battery **21**, primary winding **16** of ignition coil **18** and the current carrying electrodes of transistor **30**. When transistor **30** is first rendered conductive by current flow through resistor **44** and the base-emitter electrodes thereof, there persists, from the previous spark, a certain amount of energy retained in the inductance and distributed capacitance of ignition coil **18**. Due to the bidirectional current conduction capability of transistor **30**, this retained energy tends, for a short time, to establish an oscillatory current through battery **21**, primary winding **16** of ignition coil **18** and transistor **30**. Diode **45** prevents current from flowing in a direction opposite to that induced by the battery. In so doing, the diode **45** allows a greater realization of the transistor conduction time in the accomplishment of a high energizing current in the primary winding **16** of ignition coil **18** prior to the next spark.

From this description, it is apparent that resistor **44**, by rendering transistor **30** conductive before breaker points **10** and **11** open, and diode **45**, by preventing oscillatory currents in the undesirable direction through primary winding **16** of ignition coil **18**, each independently provided for a greater buildup of energizing current through primary winding **16** prior to each subsequent spark. It is to be specifically understood, however, that the novel circuit of this invention is not to be construed as limited only to this combination as each may be employed separately to provide for increased primary winding **16** energizing current.

With energizing current flowing through primary winding **16** of ignition coil **18** and the collector-emitter electrodes of transistor switch **30**, a potential drop, which increases in magnitude with an increase in energizing current, appears across resistor **36**. When the magnitude of this potential drop reaches a magnitude substantially equal to the potential drop across one of diodes **38** or **40** with an increase of collector-emitter current flow, the base-emitter junction of transistor switch **30** becomes less forward biased and, as a result, base electrode current is diverted through conducting series-connected diodes **38** and **40**. With base current flow diverted through these diodes, transistor switch **30** is taken out of saturation, a condition which limits the amount of current flowing therethrough.

With this arrangement, therefore, and by carefully selecting the value of resistor **36** relative to the potential drop across one of series-connected diodes **38** and **40**, the current flowing through transistor switch **30** may be automatically limited to a safe and predetermined value. It is to be specifically understood, however, that with other applications, a single diode may be used in place of the series-connected pairs **38** and **40** or, with other applications, more than two diodes may be required, depending upon the circuit requirements.

From this description, it is apparent that a reliable, inexpensive and simple ignition system having the two very desirable high primary winding energizing current build-up and current limiting features, is provided.

In this specification, a type NPN transistor was set forth as the semiconductor switching device. It is to be specifically understood that alternate switching devices having similar electrical characteristics or a type PNP transistor may be substituted therefor without departing from the spirit of the invention.

While a preferred embodiment of the present invention has been shown and described, it will be obvious to those

skilled in the art that various modifications and substitutions may be made without departing from the spirit of the invention which is to be limited only within the scope of the appended claims.

What is claimed is as follows:

1. An ignition system for internal combustion engines comprising in combination, a pair of ignition breaker points which are opened and closed in timed relationship with the engine; an ignition coil having primary and secondary windings; a semiconductor switching device having two current carrying electrodes and a control electrode; a first resistor; a first series circuit including at least said primary winding of said ignition coil, said current carrying electrodes of said semiconductor switching device and said first resistor adapted to be connected across a source of direct current potential; an inductor; a second series circuit including at least said ignition breaker points and said inductor connected in parallel with said first series circuit; means for connecting said control electrode of said semiconductor switching device to a point between said ignition breaker points and said inductor whereby said inductor is connected across said control electrode and one of said current carrying electrodes of said semiconductor switching device for extinguishing said device when said breaker points open; a second resistor; means for connecting said second resistor in parallel with said ignition breaker points for rendering said device reconductive before said breaker points reclose; at least one semiconductor device and means for connecting said semiconductor device across the said control electrode of said semiconductor switching device and said first resistor, the ohmic value of said first resistor being selected to be of a value which, with rated current flow through said semiconductor switching device, will produce a potential drop substantially equal to the potential drop across said semiconductor device whereby current flow through said semiconductor switching device is limited.

2. An ignition system for internal combustion engines comprising in combination, a pair of ignition breaker points which are opened and closed in timed relationship with the engine; an ignition coil having primary and secondary windings; at least one spark discharge device connected across said secondary winding; a normally conducting semiconductor switching device having two current carrying electrodes and a control electrode; a first resistor; a diode; a first series circuit including at least said diode; said primary winding of said ignition coil, said current carrying electrodes of said semiconductor switching device and said first resistor adapted to be connected across a source of direct current potential; an inductor; a second series circuit including at least said ignition breaker points and said inductor connected in parallel with said first series circuit; means for connecting said control electrode of said semiconductor switching device to a point between said ignition breaker points and said inductor whereby said inductor is connected across said control electrode and one of said current carrying electrodes of said semiconductor switching device for extinguishing said device when said breaker points open; a second resistor; means for connecting said second resistor in parallel with said ignition breaker points for rendering said device reconductive before said breaker points reclose; at least one semiconductor device and means for connecting said semiconductor device across the said control electrode of said semiconductor switching device and said first resistor, the ohmic value of said first resistor being selected to be of a value which, with rated current flow through said semiconductor switching device, will produce a potential drop substantially equal to the potential drop across said semiconductor device whereby current flow through said semiconductor switching device is limited.

3. An ignition system for internal combustion engines comprising in combination, a pair of ignition breaker points which are opened and closed in timed relationship with the engine; an ignition coil having primary and secondary windings; at least one spark discharge device connected across said secondary winding; a normally conducting transistor switching device having base, emitter and collector electrodes; a first resistor; a diode; a first series circuit including at least said diode, said primary winding of said ignition coil, said collector-emitter electrodes of said transistor switching device and said first resistor adapted to be connected across a source of direct current potential in that order; an inductor; a second series circuit including at least said ignition breaker points and said inductor connected in parallel with said first series circuit; means for connecting said base electrode of said transistor switching device to a point between said ignition breaker points and said inductor whereby said inductor is connected across said base-emitter electrodes of said transistor switching device for extinguishing said device when said breaker points open; a second resistor; means for connecting said second resistor in parallel with said ignition breaker points for rendering said transistor switching device reconductive before said breaker points reclose; at least one semiconductor device and means for connecting said semiconductor device across the said base electrode of said transistor switching device and said first resistor; the ohmic value of said first resistor being selected to be of a value which, with rated current flow through said transistor switching device, will produce a potential drop substantially equal to the potential drop across said semiconductor device whereby current flow through said transistor switching device is limited.

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RALPH D. BLAKESLEE, *Primary Examiner.*