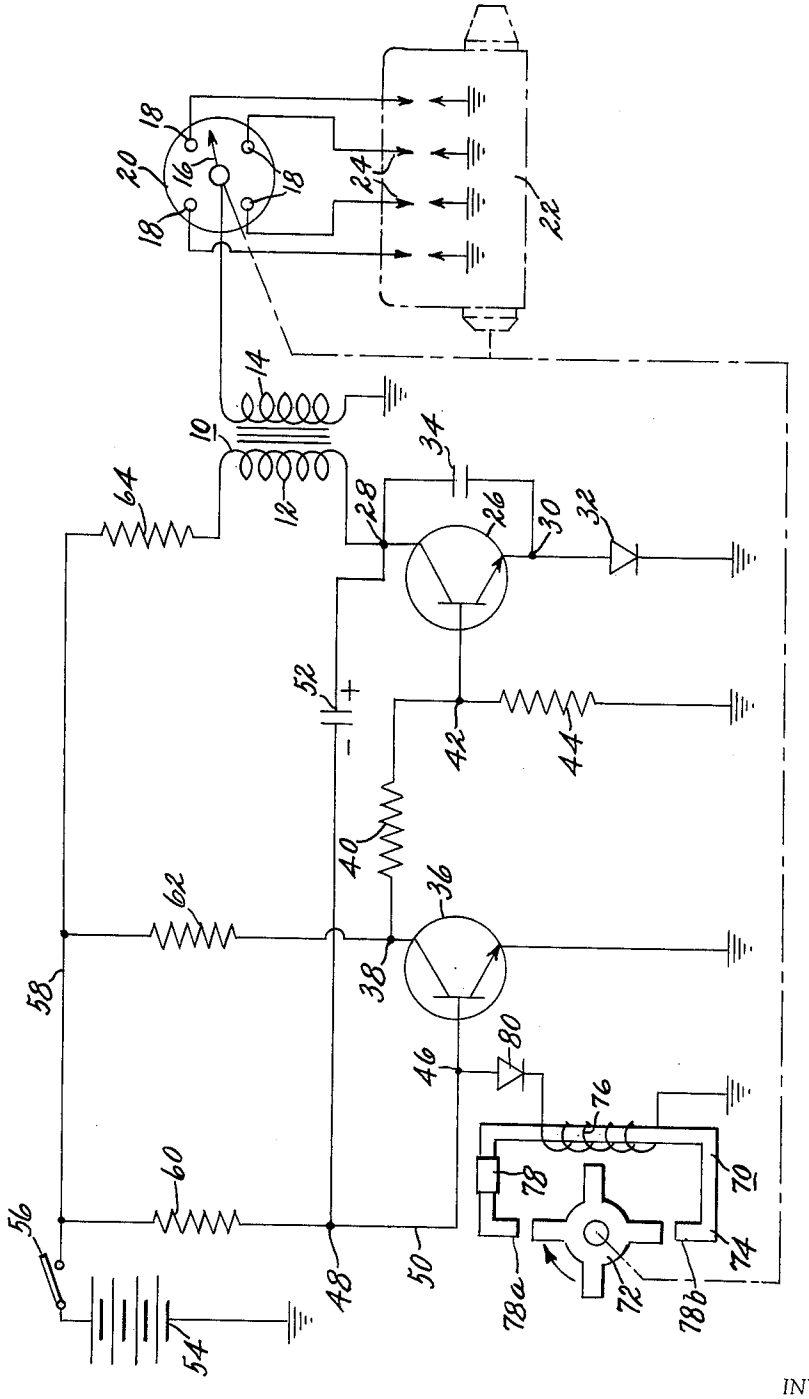
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SEMICONDUCTOR IGNITION SYSTEM

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SEMICONDUCTOR IGNITION SYSTEM

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This invention relates to a semiconductor ignition system and more particularly to a semiconductor ignition system which has the feature of reducing the amount of power required to operate it.

In certain types of semiconductor ignition systems, it has been well known practice to connect a semiconductor such as a transistor in series with the primary winding of an ignition coil. The conduction of the semiconductor is controlled in synchronism with operation of the engine by breaker contacts, magnetic pick-ups or by other suitable means. In some of these ignition systems, the semiconductor such as the transistor is normally biased to conduct by the battery and is only turned off for short periods of time when ignition is required.

Although these systems provide good ignition timing, they have the disadvantage that the "on" time of the transistor is such that a considerable amount of current may be wasted. Thus when the engine is operating at low speed, the transistor or semiconductor may be turned on for a length of time that is greater than that required for proper build-up of magnetic flux in the ignition coil with a consequent waste of power.

In contrast to the above described ignition systems, it is an object of this invention to provide an ignition system wherein the interval of time that the primary circuit of the ignition coil is energized is maintained substantially constant at both high and low speeds of the engine.

Still another object of this invention is to provide a semiconductor ignition system wherein a semiconductor such as a transistor controls the current flow through the primary winding of an ignition coil and wherein means are provided for maintaining the "on" time of the semiconductor or transistor substantially constant at different engine speeds.

A further object of this invention is to provide a semiconductor ignition system wherein a semiconductor such as a transistor controls primary winding current and wherein this transistor or semiconductor is switched on by an engine driven timing device and is switched off by an electric timing circuit which maintains a predetermined constant time interval between the turn-on and turn-off of the semiconductor.

Still another object of this invention is to provide a semiconductor ignition system wherein a semiconductor such as a transistor controls primary winding current and wherein the semiconductor is triggered into conduction by a magnetic pick-up device and is switched off at a predetermined time interval following its beginning of conduction by an RC timing circuit which provides a constant time interval of turn-on regardless of the speed that the magnetic pick-up is driven.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein preferred embodiments of the present invention are clearly shown.

The single figure drawing is a schematic circuit diagram of a semiconductor system made in accordance with this invention.

Referring now to the drawing, the reference numeral **10** generally designates an ignition coil which is used to provide ignition pulses for an internal combustion engine. The ignition coil **10** has a primary winding **12** and a secondary winding **14** which are magnetically coupled in the usual manner. One side of the secondary winding **14** is connected directly to ground as shown. The opposite side of the secondary winding **14** is connected with a rotor contact **16** which cooperates with the electrodes **18** of a conventional distributor cap **20**.

The rotor contact **16** is driven by the engine **22**. The electrodes **18** of the distributor cap **20** are connected respectively with one side of the spark plugs **24** which are used to ignite the combustible mixture of the internal combustion engine **22**. In the drawing, a four cylinder engine has been shown but it will be appreciated that this invention can be used with engines having six, eight or more cylinders.

The ignition system of this invention employs a semiconductor switch means which in this case takes the form of an NPN transistor **26**. The collector electrode of transistor **26** is connected with junction **28** which is also connected to one side of the primary winding **12**. The emitter electrode of transistor **26** is connected with junction **30**. A diode **32** is connected between junction **30** and ground and it is seen that a capacitor **34** connects the junctions **28** and **30** and is therefore connected across the emitter and collector electrodes of the transistor **26**.

The ignition system has another semiconductor switch means which takes the form of an NPN transistor **36**. The collector electrode of transistor **36** is connected with junction **38**. A resistor **40** is connected between junctions **38** and **42**. The junction **42** is connected with the base electrode of transistor **26** and a resistor **44** is connected between junction **42** and ground.

The emitter electrode of transistor **36** is connected directly to ground as shown. The base electrode of transistor **36** is connected with junction **46**. The junction **46** is connected with junction **48** via the conductor **50**. A capacitor **52** is connected between the junctions **48** and **28**.

The direct current power source for the ignition system of this invention is illustrated as a battery **54**. The negative side of the battery is connected to ground whereas the positive side of the battery is connected to one side of a manually operable ignition switch **56**. The opposite side of the ignition switch is connected with conductor **58**.

A resistor **60** is connected between conductor **58** and the junction **48**. Another resistor **62** connects the conductor **58** with the junction **38**. A resistor **64** connects the conductor **58** with one side of the primary **12** of the ignition coil **10**.

Although the direct current source **54** has been shown as a battery, it will be appreciated that on passenger cars and on certain other vehicles, a generator is provided which supplies ignition power and charges the battery when the engine is being driven at a predetermined speed. When cranking the engine, the battery **54** supplies the ignition power and will supply ignition power when the generator does not develop a voltage sufficient to charge the battery.

The ignition system of this invention has an engine driven timing device generally designated by reference numeral **70**. This ignition timing device includes a rotor **72** which is formed of magnetic material and which is driven by the engine **22**. The four arms of the rotor **72** control the flow of magnetic flux through a core element **74** which is formed of magnetic material. A pick-up coil **76** is wound on the core **74** and magnetic flux is caused to flow through the magnetic core **74** by a source of magnetic flux which takes the form of a permanent magnet **78**.

In actual practice, the magnetic pick-up **70** and the distributor cap **20** may be built into one unit and rotation of the motor contact **16** is synchronized with the rota-

tion of the rotor **72** and both of these elements are driven by the engine **22**.

It will be appreciated that as the rotor **72** rotates, the reluctance of the magnetic circuit is varied depending upon whether or not the arms of the rotor are aligned with the tips **78***a* and **78***b* of the core **74**. The voltage that is induced in the pick-up coil **76** will therefore vary as the ends of the arms of the rotor **72** become aligned and then go out of alignment with the tips **78***a* and **78***b* of the core **74**. The voltage that is generated in the pick-up coil **76** will be an alternating voltage due to variation in the reluctance of the magnetic cricuit as the rotor **72** rotates.

One side of the pick-up coil **76** is connected to ground as shown while the opposite side of this pick-up coil is connected to one side of a diode **80**. The opposite side of the diode **80** is connected with junction **46**.

When the ignition switch **56** is closed, the ignition system of this invention is energized. Current can now flow from conductor **58**, through resistor **60**, through junction **48**, through conductor **50**, through junction **46**, through diode **80** and then through the pick-up coil **76** to ground. Assuming that there is no voltage generated at this time in the pick-up coil **76**, the transistor **36** will be biased to a conductive condition in its emitter-collector circuit because the junction **46** is positive with respect to ground due to the voltage drop across diode **80** and the pick-up coil **76**. When the transistor **36** switches on in its collector-emitter circuit, current flows from conductor **58**, through resistor **62**, and then through the collector-emitter circuit of the transistor **36** to ground. The resistor **62** limits the current flow to a predetermined value through the transistor **36**.

With transistor **36** in a conductive condition, the junction **42** and the base of transistor **26** will be at a potential which biases the emitter and base electrodes of the transistor **26** such that the transistor **26** will be nonconductive in its collector-emitter circuit and no current can flow under this condition through the primary winding **12**.

When the transistor **36** is biased to conduct as when the junction **46** is positive with respect to ground, the capacitor **52** will be charged with the polarity indicated on the drawing. The charging circuit for the capacitor is from conductor **58**, through resistor **64**, through primary winding **12**, through the capacitor **52**, through junction **48**, through conductor **50** and then through the base-emitter circuit of transistor **36**. It can be seen from the foregoing that when the transistor **36** is biased to a conductive condition by the battery **54**, the capacitor **52** has an opportunity to charge to a potential of the polarity shown on the drawing.

As the rotor **72** rotates, the time will come when a pulse of voltage is generated in the pick-up coil **76** which is positive on its grounded side and negative on its side connected with the cathode of diode **80**. A voltage of this polarity will drive the emitter of transistor **36** positive with respect to its base or at least equal to the potential of its base to cause the transistor **36** to switch off in its emitter-collector circuit. When the transistor **36** switches off in its collector-emitter circuit, current will flow from conductor **58**, through resistor **62**, through resistor **40** and then through resistor **44** to ground. In effect, the resistors **62**, **40** and **44** are now a voltage divider and a voltage drop will be developed across resistor **44** which is positive at junction **42**. The voltage developed across resistor **44** will bias the transistor **30** to its conductive state between its collector and emitter and current can flow from conductor **58**, through resistor **64**, through primary **12**, through junction **28**, through the collector-emitter circuit of transistor **26** and then through the diode **32** to ground.

From the foregoing, it can be seen that current will begin to flow through the primary winding **12** whenever a voltage is induced in the pick-up coil **76** which is of such a polarity as to switch off the transistor **36** and switch on the transistor **26**.

The transistor **36** will continue to be switched off and the transistor **26** will continue to be switched on even though the voltage in the pick-up coil **76** now goes to zero or reverses. The transistor **36** is maintained in a nonconductive condition by the potential accumulated by the capacitor **52** of the polarity shown on the drawing. Thus, the charge on the capacitor **52** is such as to drive the base of transistor **36** negative to maintain it in a nonconductive condition for a predetermined length of time.

The length of time that the transistor **36** can be maintained nonconductive and the transistor **26** conductive is determined by the values of the resistor **60** and the capacitor **52** and is determined by the RC time constant of these two elements. The capacitor **52** discharges through the collector-emitter circuit of transistor **26**, through diode **32**, through battery **54**, through the ignition switch **56** and then through the resistor **60** to the opposite side of the capacitor **52**. When the energy stored in the capacitor **52** has been dissipated to the point where the junction **46** goes positive with respect to ground, the transistor **36** will be switched back on causing the transistor **26** to be immediately switched off. When transistor **26** switches off, a high voltage is induced in the secondary winding **14** which causes one of the spark plugs **24** to be fired through the rotor contact **16** and one of the distributor electrodes **18**.

From the foregoing, it will be apparent that transistor **26** is switched on when a voltage of the proper polarity is induced in the pick-up coil **76**. The transistor **26** is then not switched off until the charge accumulated by the capacitor **52** has been reduced to a predetermined value. Since the discharging time of capacitor **52** is constant as determined by the RC time constant of the resistor **60** and the capacitor **52**, the time interval that the transistor **26** is switched on will remain constant to provide a constant "on" time for the primary circuit of the ignition system regardless of engine speed.

It will be appreciated that the switching on of the transistor **26** is initiated by the generation of a voltage in the pick-up coil **76** of the proper polarity and is terminated at a fixed time after initiation as determined by the RC time constant of resistor **60** and capacitor **52**. The magnetic pick-up **70** therefore has no effect in terminating the on time of the transistor **26** since this is accomplished by the electric RC timing circuit.

The output voltage of the magnetic pick-up **70** must have pulses that are spaced a sufficient interval of time which is at least as great as the constant on time of the transistor **26**. In other words, once the transistor **26** is switched on, the system should operate to maintain this transistor switched on for a time determined by the RC time constant of resistor **60** and capacitor **52**. During this interval of time, it is important that no voltage pulses be induced in the pick-up coil **76** that might switch the transistor **36** off and prolong the time interval that transistor **26** is switched on over and above the time set by resistor **60** and capacitor **52**. For this reason, it is important that the pulses developed in pick-up coil **76** which switch transistor **36** off be spaced in time an amount greater than the RC time constant of the resistor **60** and capacitor **52**.

The diode **80** being connected in series with the pick-up coil **76** prevents voltage pulses which are negative at ground and positive at the cathode of diode **80** from triggering the transistor **36**.

While the embodiments of the present invention as herein disclosed, constitute a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. An ignition control unit adapted to be connected with the primary of an ignition coil, with an engine driven timing device and with a source of direct current comprising, first and second transistors, said first transistor

being adapted to be connected in series with the primary winding of an ignition coil, means interconnecting said transistors whereby said first transistor is driven conductive when said second transistor is biased to a nonconductive condition, said second transistor being adapted to be connected with an engine driven timing device which is capable of causing said second transistor to be biased to a nonconductive condition, and a timing circuit connected with said second transistor for causing said second transistor to remain in a nonconductive condition for a predetermined fixed time following the biasing of said second transistor to its nonconductive state.

2. The ignition control unit according to claim 1 wherein the timing circuit includes a resistor and capacitor having a predetermined RC time constant.

3. The ignition control unit according to claim 1 wherein the base electrode of the first transistor is connected with the collector electrode of the second transistor.

4. An ignition system for an internal combustion engine comprising, an ignition coil having a primary winding and a secondary winding, a source of direct current, a first transistor having emitter, collector and base electrodes, means connecting the emitter and collector electrodes of said first transistor in series with said primary winding of said ignition coil and in series with said source of direct current, a second transistor having emitter, collector and base electrodes, an engine driven timing device connected with the base electrode of said second transistor and operative to cause said second transistor to be biased to a nonconductive condition, an RC timing circuit energized from said source of direct current when said second transistor is biased to a conductive state, said RC timing circuit being connected with the base electrode of said second transistor whereby said second transistor is maintained in a nonconductive condition for a predetermined length of time once it is switched to this condition by said engne driven timing devce, and means connecting the collector electrode of said second transistor with the base electrode of said first transistor.

5. An ignition system for an internal combustion engine comprising, first and second transistors, an ignition coil having a primary winding and a secondary winding, a source of direct current, means connecting the emitter and collector electrodes of said first transistor in series with said source of direct current and in series with said primary winding of said ignition coil, an engine drven timing device, means connecting the emitter and base electrodes of said second transistor with said engine driven timing device, a first circuit connected across said source of direct current including the emitter and collector electrodes of said second transistor, a second circuit connected in parallel with the emitter and collector electrodes of said second transistor, means connecting the base electrodes of said first transistor with said second circuit, and an RC timing circuit connected with the base electrode of said second transistor for maintaining said second transistor in a nonconductive condition for a time corresponding to the RC time constant of said RC timing circuit and following the biasing of said second transistor to its nonconductive state by said engine driven timing device.

6. An ignition system for an internal combustion engine, first and second transistors each having emitter, collector and base electrodes, an ignition coil having a primary winding and a secondary winding, a source of direct current, means connecting said primary winding and the emitter and collector electrodes of said first transistor in series with said source of direct current, an engine driven magnetic timing device having an output coil, a diode, a first current path connected across said source of direct current including the collector and emitter electrodes of said second transistor, a second current path connected across said source of direct current including in a series connection said diode and said output coil, said diode and output coil being connected across said base and emitter electrodes of said second transistor, means connecting the collector electrode of said second transistor with the base electrode of said first transistor, and a capacitor connecting the base electrode of said second transistor and the collector electrode of said first transistor, said capacitor being charged through the primary winding of said ignition coil and through the emitter and base circuit of said second transistor when said second transistor is biased to a conductive condition by the voltage generated in said output coil, the voltage accumulated by said capacitor maintaining said second transistor in a nonconductive condition for a predetermined fixed time following the biasing of said second transistor to its nonconductive condition by the voltage generated in said output coil.

7. An ignition system for an internal combustion engine comprising, first and second transistors, an ignition coil having a primary winding and a secondary winding, a source of direct current, a magnetic pick-up device having an output coil driven by said engine, means connecting said primary winding, the emitter and collector electrodes of said first transistor and said source of direct current in a series circuit, means connecting said first and second transistors in such a manner that said first transistor is switched to a conductive state when said second transistor is switched to a nonconductive state, means connecting said output coil with said second transistor, and an electric timing circuit for maintaining said second transistor in its nonconductive state after it has been switched to this state by a voltage generated in said output coil, said timing circuit maintaining said second transistor in its nonconductive state for a fixed time which is independent of engine speed.

8. The ignition system according to claim 7 wherein the electric timing circuit is an RC network.

9. The ignition system according to claim 7 wherein the electric timing circuit includes a capacitor which is connected between the base electrode of said second transistor and a circuit that connects the collector electrode of the first transistor and one side of the primary winding of said ignition coil.

10. The ignition system according to claim 7 wherein a diode and said output coil are connected across said emitter and base electrodes of said second transistor.

11. An ignition system for an internal combustion engine comprising, first and second conductor means adapted to be connected with a source of direct current, an ignition coil having a primary winding and a secondary winding, a semiconductor switching device, means connecting said primary winding and said semiconductor switching in series across said conductors, an engine driven control means, a bias circuit controlled in synchronism with operation of said engine driven control means connected with said semiconductor switching device, said bias circuit being operative to bias said semiconductor switching device to a conductive condition when said engine driven control means is in a predetermined position, and a timing circuit coupled to said bias circuit, said timing circuit being operative through said bias circuit to maintain said semiconductor switching device in a conductive condition for a predetermined fixed length of time following the initiation of its conduction and independently of engine speed.

12. An ignition system for an internal combustion engine comprising, first and second conductor means adapted to be connected across a source of direct current, an ignition coil having a primary winding, first and second semiconductor switching devices, means connecting said first semiconductor switching device and said primary winding in series and across said source of direct current, a first bias circuit for said first semiconductor switching device connected across said conductor means and operative to bias said first semiconductor switching device to a nonconductive condition, a second biasing circuit for said second semiconductor switching device connected across said conductor means and op-

erative to bias said second semiconductor switching device to a conductive condition, means interconnecting said first semiconductor switching device and said second switching device whereby said first semiconductor switching device is switched to a conductive condition when said second semiconductor switching device is biased to a nonconductive condition, means driven in synchronism with said engine for periodically biasing said second semiconductor switching device to a nonconductive condition, and a timing circuit including a capacitor for maintaining said second semiconductor switching device nonconductive for a predetermined length of time following the biasing of said second semiconductor switching device to its nonconductive state.

13. An ignition system for an internal combustion engine comprising, first and second conductor means adapted to be connected across a source of direct current, an ignition coil having a primary winding, first and second transistors, means connecting the emitter and collector of said first transistor and said primary winding of said ignition coil in series with said conductor means, a biasing circuit connected across said conductor means and with the emitter and base of said first transistor for periodically biasing said first transistor to a nonconductive condition, means connecting the emitter and collector of said second transistor across said conductor means and in parallel with said biasing circuit, said second transistor when conductive shunting said biasing circuit to thereby bias said first transistor to a nonconductive condition, means connected with the emitter and base of said second transistor including means driven in synchronism with said engine for controlling the conduction of said second transistor, and a capacitor connected between the base of said second transistor and one of the emitter and collector electrodes of said first transistor, said capacitor being charged across said conductor means

by current flow through the emitter-base circuit of said second transistor and being discharged through the emitter-collector circuit of said first transistor, said capacitor when discharging being operative to hold said second transistor in its nonconductive state for a length of time determined by the rate of discharge of said capacitor.

14. An ignition system for an internal combustion engine comprising, a source of direct current, first and second conductor means connected across a source of direct current, a semiconductor switching device, an ignition coil having a primary winding and a secondary winding, means connecting said semiconductor switching device and said primary winding in series across said conductor means, a biasing circuit connected with said conductor means and with said semiconductor switching device for biasing said semiconductor switching device to a nonconductive condition by said source of direct current, engine driven control means, and a control circuit coupling said engine driven control means and said semiconductor switching device, said control circuit being operative to periodically trigger said semiconductor switching device to a conductive condition, and timing means coupled to said control circuit and operative to maintain said semiconductor switching device in a conductive condition for a predetermined fixed time following the beginning of its conductive cycle and independently of engine speed.

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