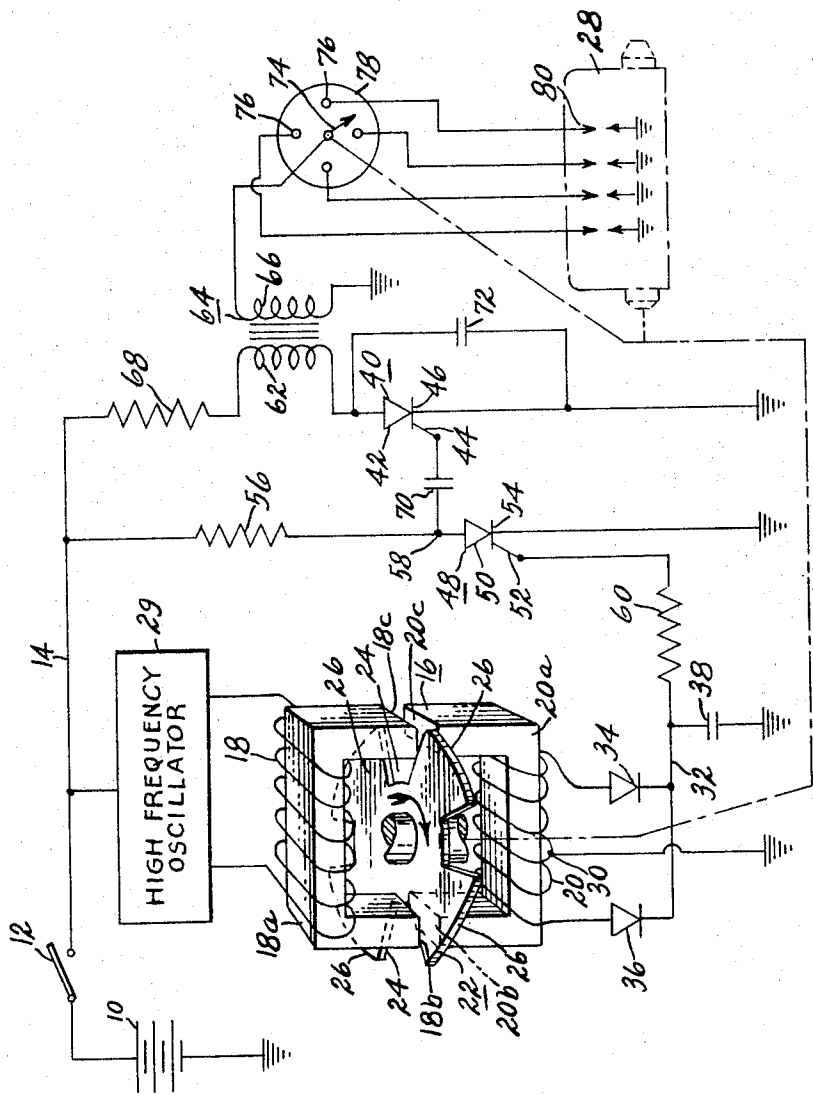


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SEMICONDUCTOR IGNITION SYSTEM

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SEMICONDUCTOR IGNITION SYSTEM

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This invention relates to semiconductor ignition systems and more particularly to semiconductor ignition systems wherein a semiconductor such as a controlled rectifier controls the current flow through the primary winding of an ignition coil.

One of the objects of this invention is to provide a completely breakerless ignition system for internal combustion engines wherein a semiconductor such as a controlled rectifier controls the current flow through the primary winding of an ignition coil and wherein the conduction of the semiconductor is controlled by an engine driven timing device which varies the magnetic coupling between two windings of a transformer.

Still another object of this invention is to provide an ignition system wherein a semiconductor controls current flow through the primary winding of an ignition coil and wherein this semiconductor is in turn controlled by a circuit that includes the secondary winding of a transformer, the voltage induced in the secondary winding being controlled by a rotatable timing wheel which varies the coupling between the primary and secondary windings of the transformer.

A further object of this invention is to provide an ignition system of the type described wherein the primary winding of the transformer is fed by the output of a high frequency oscillator which is energized from a source of direct current which also supplies current to the primary circuit of the ignition system.

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.

In the drawings:

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

Referring now to the drawing, the reference numeral 10 designates a source of direct current which is shown as a battery. One side of the source of direct current is grounded and the opposite side is connected with an ignition switch 12. The ignition switch controls the application of power to a conductor 14. In a motor vehicle system, the battery 10 is at times charged by a source of direct current which takes the form of an engine driven generator and it is intended that the terminology "source of direct current" as used in this application include either the battery or generator of any other source of direct current.

The timing device for the ignition system of this invention is generally designated by reference numeral 16. This timing device includes a transformer having a primary winding 18 and a secondary winding 20. The magnetic coupling between the primary winding 18 and the secondary winding 20 is varied by a rotatable timing wheel 22 having alternate notches 24 and lobes 26.

Although the timing device can take various forms, in one form the timing wheel 22 can be formed of a magnetic material and arranged such that the alternate notches and lobes vary the magnetic coupling between the primary winding 18 and the secondary winding 20. Thus, the primary winding 18 and the secondary winding 20 can be wound respectively on magnetic cores 18a

and 20a having pole faces 18b and 18c and 20b and 20c. The wheel 22 is rotated through the air gaps between the pole faces in such a manner that when a pair of notches are in the air gaps, a larger voltage is induced in the secondary winding 20 as compared to the situation where the lobes 26 are in the air gaps. Thus when a pair of lobes are in the air gaps, flux is shunted away from the core 20a and flows between pole faces 18b and 18c. It will, of course, be appreciated that other arrangements might be used to vary the magnetic coupling between the primary winding 18 and the secondary winding 20, it only being necessary that a voltage variation is achieved in the secondary winding 20 as the timing wheel 26 rotates. The timing wheel 26 is driven by the engine 28 so that the wheel is synchronized with the position of the pistons and cam shaft of the internal combustion engine 28.

The primary winding 18 is energized with an A.C. voltage by a high frequency oscillator or D.C. to A.C. converter designated by reference numeral 29. The high frequency oscillator 29 is energized from the battery 10 whenever the ignition switch 12 is closed and produces a high frequency A.C. voltage in the primary winding 18.

The power output of the timing device 16 depends upon transformer action and therefor provides sufficient power even at low speeds of rotation of the timing wheel 26 to trigger the ignition system. This arrangement should be distinguished from voltage pulse generators which utilize a permanent magnet and a rotor which varies the magnetic circuit between the permanent magnet and the pick-up coil because in the latter arrangement the amount of voltage developed in the pick-up coil is a function of the speed of rotation of the rotor. With applicants' arrangement, voltages are induced in the secondary winding due to the pulsating nature of the alternating current applied to the primary so that sufficient power is always available even at cranking or at low speed operation of the engine to properly trigger the semiconductor ignition system. It is important to have sufficient power to trigger the semiconductor ignition system in order to provide proper engine spark timing under all conditions of operation of the engine including the condition where the engine is being cranked to start the engine.

The secondary winding 20 has a tap at junction 30 which is grounded. The opposite ends of the secondary winding 20 are connected with conductor 32 by diodes 34 and 36. It will be appreciated that the diodes 34 and 36 provide a full wave rectifier for the A.C. voltage induced in secondary winding 20 and the D.C. output voltage of this full wave rectifier appears between conductor 32 and ground. A capacitor 38 is connected between conductor 32 and ground which serves as a filter capacitor.

The ignition system of this invention includes a semiconductor switch means which takes the form of a silicon controlled rectifier generally designated by reference numeral 40. This controlled rectifier has an anode 42, a gate electrode 44 and a cathode 46. The controlled rectifier 40 is of a type which is capable of controlling the conduction of its anode-cathode circuit by varying the voltage of the gate 44 with respect to the cathode 46. In other words, the controlled rectifier 40 is of a type which will be driven to a conductive state whenever the gate electrode 44 is positive with respect to the cathode 46. If the signal is now removed from the gate 44, the controlled rectifier 40 remains conductive in its anode-cathode circuit. The controlled rectifier 40 in contrast to certain types of controlled rectifiers can be switched off in its anode-cathode circuit by applying a voltage to the cathode 46 which is positive with respect

to the gate 44 and even when the anode at this time is positive with respect to the cathode. This differs from the certain other types of controlled rectifiers where it is necessary to drive the cathode 46 positive with respect to the anode 42 in order to switch the controlled rectifier off. In summary, it is apparent that the controlled rectifier 40 is of a type which can be controlled by varying the potential of its gate electrode with respect to its cathode and without regard to the relative potentials of the anode and cathode electrodes.

The ignition system of this invention has another semiconductor switch means which takes the form of a controlled rectifier designated by reference numeral 48. This controlled rectifier has an anode 50, a gate electrode 52 and a cathode 54. The controlled rectifier 48 is of a type that has a relatively high holding current, and any time the current from anode to cathode is less than the holding current, the controlled rectifier will be turned off in its anode-cathode circuit unless the potential of the gate electrode 52 is maintained at a higher value than the potential of the cathode 54. It is seen that a resistor 56 connects the junction 58 with the conductor 14 and is connected in series with the anode-cathode circuit of controlled rectifier 48. The resistance of the resistor 56 is made large enough to limit the current through the anode-cathode circuit of the controlled rectifier 48 to less than its required holding current, and therefore the controlled rectifier 48 will turn off in its anode-cathode circuit whenever an insufficient signal is applied between its gate 52 and cathode 54.

The gate electrode 52 of controlled rectifier 48 is connected to one side of the resistor 60, the opposite side of this resistor being connected with conductor 32. The cathode of controlled rectifier 48 is connected directly to ground as shown.

The anode 42 of controlled rectifier 40 is connected to one side of the primary winding 62 of an ignition transformer designated by reference numeral 64. This ignition transformer has a secondary winding 66. The opposite side of the primary winding 62 is connected to one side of a resistor 68 and the opposite side of this resistor is connected with conductor 14. The gate electrode 44 of controlled electrode 40 is connected with junction 58 through a capacitor 70. The cathode 46 of controlled rectifier 40 is grounded as shown and a capacitor 72 connects the anode and cathode electrodes of the controlled rectifier 40. The capacitor 40 is intended to limit voltage transients appearing across the anode and cathode electrodes of controlled rectifier 40 and in some applications might not be necessary.

One side of the secondary winding 66 of the ignition transformer 64 is grounded. The opposite side of secondary winding 66 is connected with a rotor contact 74 which swings past the electrodes 76 of a distributor cap 78. The electrodes 76 are connected respectively with the spark plugs 80 of the internal combustion engine 28. The opposite side of the spark plugs are grounded in the usual manner and the rotor contact 74 is driven by the engine 28 and distributes electrical energy to the spark plugs via the distributor cap electrodes 76 and the wires connecting these electrodes with the spark plugs. The rotor contact 74 is driven in synchronism with the timing wheel 22 and both of these elements are driven by the engine as has been pointed out above.

When the ignition switch 12 is closed, the high frequency oscillator will be energized and an A.C. voltage will be developed across the primary winding 18. As the timing wheel 22 is rotated by the engine, the voltage induced in the secondary winding 20 will increase and decrease. When the lobes 26 of the timing wheel 22 are in such a position as to reduce the magnetic coupling between primary winding 18 and secondary winding 20, the voltage that is induced in the secondary winding is at its low value. On the other hand, when the notches 24 are in the correct position relative to the magnetic

circuit of the primary and secondary windings, a higher voltage is induced in the secondary winding 20. As a result of this, the voltage induced in the secondary winding 20, increases and decreases as a function of the rotation of the timing wheel 22 which varies the magnetic coupling of the primary and secondary windings 18 and 20.

When the voltage induced in the secondary winding 20 is at its high value, it is rectified to direct current and appears between conductor 32 and ground. This voltage drives the gate electrode 52 of controlled rectifier 48 positive with respect to its cathode 54 and therefore causes the controlled rectifier 48 to switch on in its anode-cathode circuit. With the controlled rectifier 48 switched on in its anode-cathode circuit, current can flow from conductor 14, through resistor 56 and then through the anode-cathode circuit of the controlled rectifier 48 to ground.

When the voltage that is induced in secondary winding 20 is zero or at a relatively low value, the gate electrode 52 of controlled rectifier 48 is not sufficiently positive with respect to its cathode 54 to maintain the controlled rectifier 48 switched on in its anode-cathode circuit and this controlled rectifier therefore switches off. When controlled rectifier 48 switches off in its anode-cathode circuit, current will flow from conductor 14, through resistor 56, through capacitor 70, and through the gate-cathode circuit of controlled rectifier 40 to switch it on in its anode-cathode circuit. With controlled rectifier 40 switched on in its anode-cathode circuit, current can flow from conductor 14, through resistor 68, through primary winding 62 and then through the anode-cathode circuit of controlled rectifier 40 to ground. With controlled rectifier 40 switched on, inductive energy begins to build up in the core of the ignition transformer 64 due to current flow through its primary winding.

As the timing wheel 22 continues to rotate, the voltage induced in secondary winding 20 goes to its high value which turns on the controlled rectifier 48. The capacitor 70 which was previously charged when controlled rectifier 40 was turned on will now discharge through the anode-cathode circuit of controlled rectifier 48 and this discharging of capacitor 70 will drive the cathode 46 of controlled rectifier 40 positive with respect to its gate 44 to turn off the controlled rectifier 40. When controlled rectifier 40 turns off, current flow through the primary winding 62 is terminated and a high voltage is induced in the secondary winding 66 which is applied to one of the spark plugs through rotor contact 74 and one of the distributor electrodes 76.

To review the operation of this system, it is seen that rotation of the timing wheel 22 causes an increase and decrease of the voltage induced in the secondary winding 20 and that this voltage controls the turning on and turning off of controlled rectifier 48. When controlled rectifier 48 is turned on, controlled rectifier 40 will be switched off and when controlled rectifier 48 is switched off, the controlled rectifier 40 will be switched on. By continuous rotation of the timing wheel 22, the circuit for the primary winding 62 is opened and closed by the controlled rectifier 40 to provide the proper spark impulses for the spark plugs 80 of the engine 28.

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 system for an internal combustion engine, comprising, a source of direct current, a semiconductor control means, an ignition coil having a primary winding and a secondary winding, means connecting said primary winding and said semiconductor control means in series with said source of direct current whereby said semiconductor control means controls the current flow through said primary winding, a magnetic device having first and second magnetically coupled windings, a ro-

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tatable means for varying the magnetic coupling between said windings driven by said engine, means connecting one of said windings with said semiconductor control means and operative to cause said semiconductor control means to switch on and off in timed relationship with rotation of said rotatable means and means connecting the other of said windings with a source of pulsating current.

2. The ignition system according to claim 1 wherein the semiconductor control means is a controlled rectifier having its anode-cathode circuit connected in series with said primary winding.

3. An ignition control unit adapted to be connected with a source of direct current and with the primary winding of an ignition coil comprising, a semiconductor switch means adapted to be connected in series with the primary winding of an ignition coil and in series with a source of direct current, a timing means adapted to be driven by an engine, said timing means including first and second magnetically coupled coil windings and a part which is movable to vary the magnetic coupling between said first and second coil windings, means connecting one of said coil windings in controlling relationship with said semiconductor switch means for controlling the switching on and switching off of said semiconductor switch means and means connecting the other of said windings with a source of pulsating current.

4. An ignition system for an internal combustion engine comprising, a source of direct current, an ignition coil having a primary winding and a secondary winding, a semiconductor switch means, means connecting said primary winding and said semiconductor switch means in series with said source of direct current, a timing device having first and second coil windings and a movable member for varying the magnetic coupling of said first and second windings, means connecting one of said windings with a source of alternating current, rectifier means connecting with the other of said windings for converting the voltage induced in the other of said windings to direct current, and means connecting the D.C. output of said rectifier means in controlling relationship with said semiconductor switch means, said movable member of said timing device being driven by said engine.

5. The ignition system according to claim 4 wherein the semiconductor switch means is a controlled rectifier having anode, cathode and gate electrodes.

6. An ignition system for an internal combustion engine comprising, a semiconductor control means, an ignition coil having a primary winding and a secondary winding, a source of direct current, means connecting said source of direct current, said primary winding and said semiconductor control means in a series circuit, a second transformer having primary and secondary windings, means rotatable with respect to said primary and secondary windings of said second transformer for varying the magnetic coupling of said primary and secondary windings, said last-named means being driven by said

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engine, an oscillator circuit having an A.C. output connected with the primary winding of said second transformer and having a D.C. input provided by said source of direct current, rectifier means connected with said secondary winding of said second transformer having D.C. output terminals, and means connecting said D.C. output terminals with said semiconductor control means.

7. The ignition system according to claim 6 wherein the semiconductor control means is a controlled rectifier.

8. The ignition system according to claim 6 wherein the semiconductor control means is a controlled rectifier and wherein said semiconductor control means is connected with the D.C. output terminals of said rectifying means through another controlled rectifier.

9. An electrical control circuit comprising, an electrical load, a source of direct current, first and second controlled rectifiers each having anode, cathode and gate electrodes, means connecting said source of direct current, said electrical load and the anode-cathode circuit of said first controlled rectifier in series, means connecting the anode-cathode circuit of said second controlled rectifier across said source of direct current, a capacitor connecting the anode of said second controlled rectifier with the gate of said first controlled rectifier, a control device having first and second windings, means movable with respect to said first and second windings for varying the magnetic coupling of said first and second windings, a source of pulsating electrical energy for energizing said first winding of said control device and means connecting said second winding of said control device with the gate of said second controlled rectifier.

10. The control circuit according to claim 9 wherein the electrical load is the primary winding of an ignition coil.

11. The control circuit according to claim 9 wherein the source of electrical energy is the output of a high frequency oscillator.

12. The control circuit according to claim 9 wherein the source of electrical energy is a high frequency oscillator connected with one winding of said control device and wherein the output of the other winding of the control device is rectified.

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