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TRANSISTORIZED IGNITION SYSTEM

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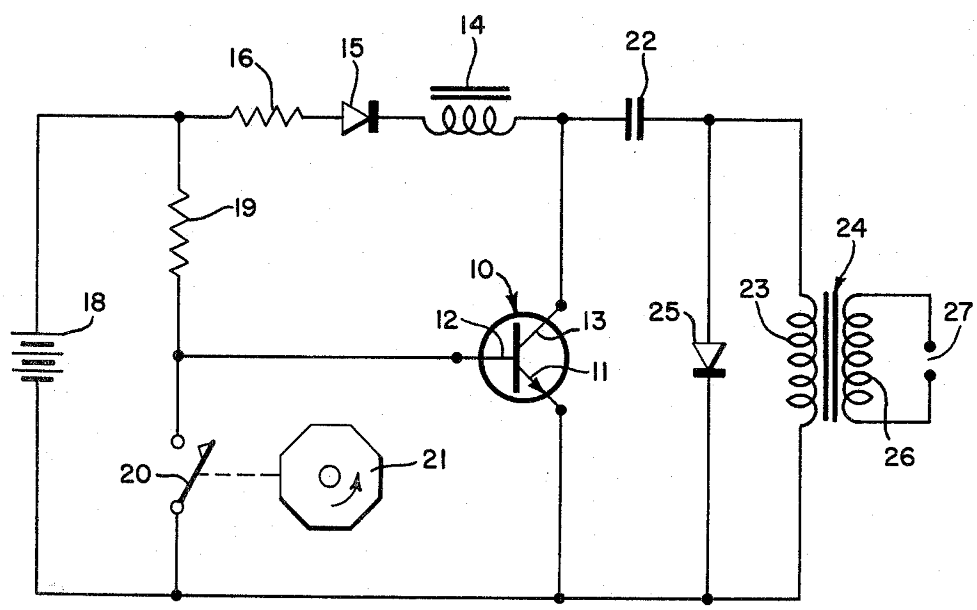

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3,169,212
TRANSISTORIZED IGNITION SYSTEM

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The present invention relates generally to switching circuits and more particularly to switching circuits for rapidly switching currents in inductive load circuits.

Transistorized switching circuits which are particularly constructed for use in automobile ignition systems have heretofore been available in various forms. For example, the copending application of Jearald L. Hutson, Serial No. 60,970, filed October 6, 1960, and assigned to the assignee of the present application, discloses and claims several circuits wherein transistors or controlled rectifiers are utilized to provide current pulses to the primary of an ignition coil. In these and other prior circuits, the breaker points of an automobile ignition system drive an input or control electrode of a semiconductor device, resulting in very small switching current requirements. The problem of arcing across the breaker points is minimized by the small current through the breaker points and the noninductive load which is utilized.

As set forth in the above-mentioned copending application, a circuit particularly adapted for use in ignition systems may advantageously employ an inductor which is connected in series with a voltage supply and a switching device such as a transistor or controlled rectifier. When the controlled device is switched on, current builds up in the inductor to create a magnetic field around the inductor, or charge the inductor. Then, when the controlled device is switched off, the current tends to continue, generating a pulse of current when the inductive field collapses. A capacitor may be arranged in the circuit to be charged by this inductive current pulse. The primary winding of an ignition coil may be placed in the discharge path of this capacitor such that a sharp voltage spike, upon discharge of the capacitor, is generated in the secondary of the ignition coil for driving the spark plugs. Difficulties have arisen, however, when the inductor is in series with the ignition coil primary, since the discharge of the inductor or charging of the capacitor will produce an input to the ignition primary and likewise an output across the spark plugs, producing spurious outputs, possibly resulting in pre-ignition.

Accordingly, it is a principal object of the present invention to provide a switching circuit adapted to produce fast transient current pulses in the primary of a transformer. Another object is to provide a switching arrangement of the type utilizing a controlled semiconductor device adapted to charge an inductor, discharge the inductor into a capacitor, and subsequently discharge the capacitor through the primary of an ignition coil, while at the same time preventing the discharge of the inductor from producing a current pulse in the ignition primary. An additional object is to provide an improved semiconductor switching arrangement for use in ignition circuits.

In accordance with one embodiment of the invention an inductor and a controlled semiconductor switching device are connected in series across a power supply. The controlled switching device is driven alternately conductive and non-conductive by a mechanical switch such as is normally used as the breaker points in an ignition system. A capacitor and a diode in series shunt the switching device such that after the device is cut off, the collapse of the field about the inductor will charge

the capacitor. When the switching device is subsequently cut on, the capacitor will discharge through the device and through the primary of an ignition coil which is connected across the diode. It is noted that the charging current of the capacitor does not flow in the ignition primary, but instead flows through the diode which shorts the primary in one direction.

The novel features which are believed characteristic of this invention are set forth in the appended claims. The invention itself, as well as additional objects and advantages thereof, will best be understood from the following description of one illustrative embodiment, when read in conjunction with the accompanying drawing, in which:

The single figure is a schematic diagram of an ignition circuit incorporating the principal features of the present invention.

With reference to the figure of the drawing, there is shown a transistor **10** having an emitter electrode **11**, a base electrode **12** and a collector electrode **13**. The collector electrode is serially connected with an inductor **14**, a diode **15**, a current-limiting resistor **16**, and to the positive terminal of a voltage source **18**. A resistor **19** is connected between the positive terminal of the voltage source **18** and the base electrode **12** of the transistor while a switch **20**, corresponding to the breaker points in an ignition system of an automobile engine, is coupled between the base electrode and the negative terminal of battery **18′**. The switch **20** is mechanically coupled to a distributor rotor **21** which, of course, rotates in synchronism with the engine crankshaft. The emitter **11** of the transistor is connected to ground, as is the negative terminal of the source **18**. A capacitor **22** is connected to the junction of the inductor **14** and the collector **13**, and is also connected to a primary winding **23** of an ignition transformer **24**. The other terminal of the primary **23** is connected to ground, while a diode **25** shunts the primary. A secondary winding **26** of the transformer **24**, having a high turns ratio to produce a high ignition voltage, is connected across a spark gap **27**. In an automobile ignition system, the secondary would be sequentially connected to the spark plugs of the engine through a distributor system.

The operation of the circuit set forth above will now be described, starting at a time when the switch **20** is open and the voltage source **18** has just been applied. Under these conditions, the capacitor **22** has no charge thereon and the transistor **10** is biased to full conduction by base current through the resistor **19**. Accordingly, current will flow from the source **18** through the resistor **16**, the diode **15**, the inductor **14** and the collector-emitter circuit of the transistor **10**. This current will result in a magnetic field being set up around the inductor **14**. Subsequently, when the rotor **21** has closed the switch **20**, the transistor **10** will be cut off and current can no longer flow through the collector-emitter circuit thereof. However, as the magnetic field which had been set up around the inductor **14** collapses, there will be a tendency for current to flow in the same direction through the inductor **14**, and therefore, a transient current will flow through the only alternative path which includes the capacitor **22** and the diode **25**. This transient current after cut-off of the transistor **10** has the effect of charging the capacitor **22**. When the rotor **21** has again opened the switch **20**, the transistor **10** will conduct, thus providing a shorted path for discharge of the capacitor **22**. The polarity of the diode **25** will prevent capacitor discharge current from flowing therethrough, and so the discharge circuit of the capacitor **22** will include the primary **23** of the transformer **24**. This will result in a sharp current pulse or spike in the secondary circuit of the transformer, providing an arc across the spark plugs or the spark gap **27**. Meanwhile, of course, the conduction of the transistor **10** will result in a magnetic field being created around the inductor **14** as before, so that the cycle will repeat each time the switch is opened and closed by the rotor **21**.

It is seen that the charging current for the inductor **14** is provided directly from the source **18**, whereas the charging current for the capacitor **22** results from the discharge of the inductor **14**. Of course, the capacitor **22** could be charged directly from the source **18**, but a much higher charging voltage and a sharper output spike are obtained by use of the inductor **14**. The transformer primary **23** is seen to appear in the circuit only during the discharge of the capacitor **22**. It is especially important that the charging current of the inductor **14** does not flow through the transformer primary. Such current flow in the inductor would cause an inductive voltage spike to appear across the primary after cut-off of the transistor and would result in a spurious output on the secondary in addition to the sharp spike desired at the time of ignition of the fuel and air charges in the cylinders.

While the invention has been described with reference to a specific embodiment, it is not intended that this description be construed in a limiting sense. Various modifications of the circuit described above will appear obvious to persons skilled in the art. For example, a controlled rectifier or any other suitable switching device might be substituted for the illustrated transistor, and many alternative arrangements may be provided for driving the control electrode of the switch. Accordingly, it is contemplated that the invention be limited only by the scope of the appended claims, interpreted in view of the prior art.

What is claimed is:

1. An electrical circuit comprising an inductor and a semiconductor switching means connected in series across a source, control means for periodically cycling said switching means between conductive and non-conductive conditions, a capacitor and a unidirectional device connected in series across said source and across said switching means, and output means shunting said unidirectional device.

2. An electrical circuit comprising an inductor and a semiconductor switching means connected in series across a source of potential control means connected to said switching means and adapted to cycle said switching means between conductive and non-conductive states, a capacitor and a unidirectional device connected in series across said switching means to provide a discharge path for said inductor, said unidirectional element having its anode connected to said capacitor, a charging path for said capacitor effective when said switching means is cycled from conductive to non-conductive states, and output means shunting said device to provide a discharge path for said capacitor when said switching means is conductive.

3. An ignition circuit comprising a first closed series circuit including an inductor and a semiconductor switching means along with a voltage source, control means connected to said switching means and adapted to cycle said switching means between conductive and non-conductive states, said first closed series circuit defining a charging path for said inductor when said switching means is conductive, a second closed series circuit including a capacitor and a unidirectional device along with said inductor and said source, said second closed series circuit defining a charging path for said capacitor when said switching means is non-conductive, a third closed series circuit including output means along with said capacitor and said switching means, said third closed series circuit defining a discharge path for said capacitor when said switching means is conductive.

4. A circuit comprising an inductive element, means for producing a current in said inductive element, thereby to store energy in said inductive element when said current is flowing therethrough, said circuit comprising a transformer, a capacitive element connected between said inductive element and said transformer, said means including means responsive to a first predetermined condition for causing said capacitive element to be charged, said last mentioned means being responsive to a second predetermined condition for causing said capacitive element to be discharged, and means including a unidirectional element in shunt with said transformer for placing an effective short circuit across said transformer upon said first predetermined condition thereby providing a charge path effective when said capacitive element is charging.

5. A circuit comprising an inductive element, means for producing a current in said inductive element, thereby to store energy in said inductive element when said current is flowing therethrough, a transformer having a primary and a secondary winding, a capacitive element connected between said inductive element and the primary winding of said transformer, means responsive to a first predetermined condition for causing said capacitive device to be charged, said last mentioned means being responsive to a second predetermined condition causing said capacitive element to be discharged, and a unidirectional element in shunt with the primary winding of said transformer for placing an effective short circuit across a primary winding upon occurrence of said first predetermined condition when said capacitive element is charging through said unidirectional element.

6. A circuit comprising an inductive element, means for producing a current in said inductive element, thereby to store energy in said inductive element when said current is flowing therethrough, a transformer having a primary and a secondary winding, a capacitive element connected between said inductive element and the primary of said transformer, a semiconductor device having a control electrode, an electron emitting electrode and an electron collecting electrode, said electron emitting and electron collecting electrodes forming a shunt circuit in shunt with said capacitor and said primary winding, means responsive to a predetermined condition for varying the bias on said control electrode, and a unidirectional element having its anode connected to said capacitor and being in shunt with said primary winding for placing an effective short circuit across the transformer when said capacitive element is charging through said unidirectional device.

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