

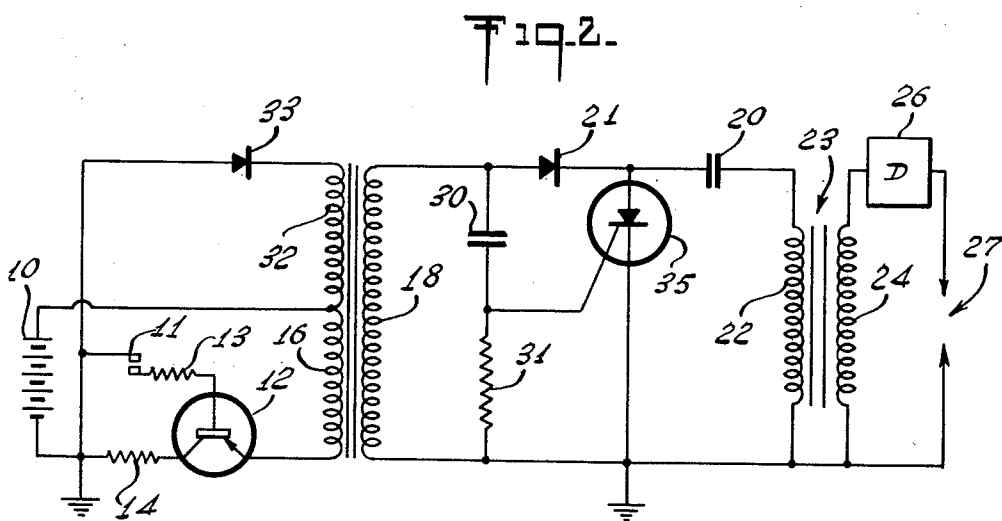
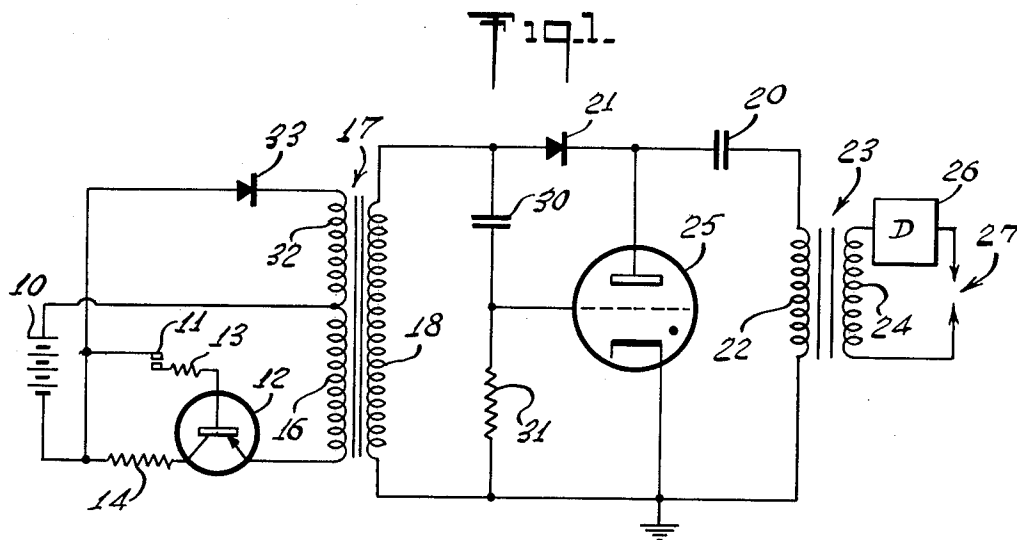
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FIRING CIRCUIT FOR IGNITION SYSTEMS

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## FIRING CIRCUIT FOR IGNITION SYSTEMS

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This invention relates to an ignition circuit for internal combustion engines and has particular reference to a circuit which generates a high voltage pulse without drawing excessive current through the breaker points.

The use of higher compression ratios in the modern automobile and truck engines requires a higher voltage at the discharge points of the spark plugs and greater dependability of the remaining circuit components. Several attempts have been made to achieve the required results by combining transistor amplifiers with gaseous discharge tubes and storage capacitors but these circuits have been generally expensive, bulky, and sometimes refuse to operate when one spark plug is either short-circuited or refuses to fire because the discharge points have too great a gap. The present invention uses only a single controlled discharge device and a single transistor amplifier stage. The circuit is arranged to produce a discharge at any one of the spark plugs regardless of the condition of the other spark plugs.

One of the objects of this invention is to provide an improved ignition circuit which avoids one or more of the disadvantages and limitations of prior art circuits.

Another object of the invention is to reduce the cost of ignition circuits for high compression engines.

Another object of the invention is to provide a simplified firing circuit for the gaseous discharge device.

The invention comprises an ignition circuit for supplying high voltage pulses to the spark plugs in internal combustion engines. The usual pair of breaker contacts is connected in series with a storage battery and the base electrode of a transistor amplifier. The output of this amplifier stage is coupled through a transformer to a discharge device. The breaker contacts are controlled to open and close in synchronism with the movements of the engine's pistons. The primary winding of the coupling transformer stores the energy of the current pulses in the core of the transformer. The stored magnetic energy in the core is transferred to a storage capacitor by means of a secondary winding connected in series with the storage capacitor and a rectifier. Voltage for the spark plugs is obtained by discharging the capacitor through a discharge device connected in series with the capacitor and the primary winding of an output transformer. The secondary winding of the output transformer is connected to the spark plugs through the usual rotatable distributor head.

One of the features of this invention is the firing circuit of the discharge device. This circuit comprises only a capacitor and a resistor connected across the output circuit of the first transformer with the junction between the capacitor and resistor connected to the firing electrode in the discharge device. By means of this circuit, the storage capacitor may be charged and discharged during a single operating pulse received from the transistor stage.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings.

FIG. 1 is a schematic diagram of connections of one form of the ignition circuit.

FIG. 2 is a schematic diagram of connections of the preferred circuit, similar to FIG. 1, but employing a silicon controlled rectifier or similar triggered semiconductor device instead of a gaseous discharge device.

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Referring now to FIG. 1, the circuit includes the usual storage battery 10 and breaker contacts 11 which are operated by a portion of the mechanical gearing coupled to the engine drive shaft. A transistor amplifier 12 includes a single PNP transistor with its base connected to one of the contacts 11 through a limiting resistor 13, and its collector connected to the negative battery terminal through another limiting resistor 14. The emitter of the transistor is connected through a primary winding 16 of a transformer 17 to the positive terminal of battery 10, this latter connection representing the output circuit of the transistor amplifier. Transformer 17 has a single secondary winding 18. Winding 18 transfers the energy stored by winding 16 to a capacitor 20, this secondary winding 18 being connected in series with a rectifier 21, capacitor 20 and the primary winding 22 of an output transformer 23 having a secondary winding 24. When capacitor 20 is being charged, the charging current includes secondary winding 18, rectifier 21, capacitor 20, and the primary winding 22. When the storage capacitor 20 is discharged, the circuit includes the capacitor 20, the anode-cathode circuit of a discharge device 25, and the primary winding 22 of the output transformer.

Transformer 23 is a step-up transformer and its secondary winding 24, which produces a high voltage, is connected in series with the distributor contacts 26 and the spark plug points 27. The operation and details of the distributor and the spark plugs are well known and need not be described here in detail.

The firing circuit for initiating a discharge in the gaseous discharge device 25 includes a capacitor 30 and a resistor 31, these components being connected in series across the output of transformer winding 18. The junction between capacitor 30 and resistor 31 is connected directly to the firing electrode in discharge device 25.

The operation of this circuit is as follows: When contact points 11 are open, no current flows through the transistor 12 because the base is disconnected from other parts of the circuit. When contacts 11 close, current is drawn from the battery 10, through winding 16, and the transistor electrodes to the negative terminal of the battery. This current is made possible by the change in potential of the base of the transistor and it should be noted that the current through the contact points 11 is a minimum value, only enough to alter the potential of the base. During the time that the contacts remain closed, the direct current battery 10 establishes a current in winding 16 and sets up a reservoir of magnetism in the ferro-magnetic core of the transformer 17.

When contacts 11 open, the current through winding 16 is cut off abruptly and the collapse of the magnetic field in the core of transformer 17 sets up an inductive voltage in secondary winding 18 which results in a charging current. The circuit can be traced from the upper end of winding 18, through rectifier 21, capacitor 20, winding 22, and back to the other side of winding 18. This current charges capacitor 20 to a potential of approximately 2000 volts. During the above described action, a charging current is also charging capacitor 30 through resistor 31. Since the time constant of this second charging circuit is considerably shorter than the first described circuit, the potential of the firing electrode in discharge device 25 is not raised to the firing voltage by the relatively slow rising voltage charging capacitor 20.

Capacitor 20 retains its charge until points 11 are opened again. At this time there is a fast rising voltage pulse produced across the terminals of winding 18 because capacitor 20 is charged and no current can flow in this charging circuit. This voltage pulse is applied to circuit 30, 31, and the firing electrode of discharge device 25, causing it to conduct and discharge capacitor 20 through the primary winding 22 of transformer 23.

This discharge is quite rapid and leaves a small negative charge on capacitor 20 due to the inductive nature of the load. At this time rectifier 21 again becomes conductive and charges capacitor 20 from the pulse furnished by winding 18. The discharge pulse through winding 22 generates a very high voltage across spark gap 27 and producing a spark which ignites the mixture in the cylinder. From the above description it is obvious that the storage capacitor 20 is both discharged and charged shortly after the opening of contacts 11.

If, for any reason, the discharge device 25 does not conduct such as under contact bounce conditions, capacitor 20 will retain its charge. During the next cycle, when the energy in inductor winding 16 would normally be transferred to capacitor 20, there is a high voltage developed across winding 16 and also across transistor 12. This voltage may cause serious injury to the transistor and for this reason a second primary winding 32 is wound on the core of transformer 17 and connected across battery 10 in series with a rectifier 33. If the voltage across winding 32 is greater than the battery voltage, current is sent through rectifier 33 and absorbs the inductor energy by charging battery 10.

The circuit shown in FIG. 2 is the same as that shown in FIG. 1 except that the discharge device 25 has been replaced by a silicon controlled rectifier (or other triggered semiconductor device) 35 which acts in a similar manner to the gaseous discharge device in FIG. 1. The operation of this circuit is the same as the circuit of FIG. 1 except that the second circuit is more dependable since there is no deionization time interval for the silicon rectifier and as soon as capacitor 20 has been discharged through rectifier 35, the circuit is ready to accept another charging pulse from transformer winding 18. The fact that discharge device 35 deionizes immediately means that very high speeds are possible with this modified circuit.

The following circuit constants may be used in the circuit shown in FIG. 1 and are illustrative of the specific application of the invention.

|                    |                       |      |
|--------------------|-----------------------|------|
| Battery            | -----volts-----       | 12   |
| Resistor 13        | -----ohms-----        | 15   |
| Resistor 14        | -----do-----          | 1    |
| Transistor 12      | -----2N443-----       |      |
| Windings 16 and 32 | -----turns-----       | 22   |
| Winding 18         | -----do-----          | 2950 |
| Capacitor 20       | -----microfarads----- | .03  |
| Capacitor 30       | -----do-----          | .001 |
| Resistor 31        | -----ohms-----        | 2700 |

The foregoing disclosure and drawings are merely illustrative of the principles of this invention and are not to be interpreted in a limiting sense. The only limitations are to be determined from the scope of the appended claims.

I claim:

1. In an ignition system for internal combustion engines which includes a pair of breaker contacts connected in series with a source of direct current and controlled to open and close in synchronism with the movements of the engine's pistons; an inductive winding on a ferromagnetic core coupled to said contacts for storing magnetic energy in the winding's field; a storage capacitor coupled to said inductive winding for storing a charge received from the winding and core when the contacts open; and a discharge circuit which includes the storage capacitor, a controllable discharge device, and the primary winding of an output transformer; the improvement comprising a firing circuit which includes a firing capacitor and a resistor connected in series across a secondary winding coupled to said inductive winding, and a connection between the firing circuit and the discharge device for making said device conductive, said firing circuit having a time constant which is less than the time constant of said discharge circuit.

2. In an ignition system for internal combustion engines which includes a pair of breaker contacts connected in series with a source of direct current and controlled to open and close in synchronism with the movements of the engine's pistons; an inductive winding on a ferromagnetic core coupled to said contacts for storing magnetic energy in the core each time the contacts close; a storage capacitor coupled to said inductive winding for storing a charge received from the winding and core each time the contacts open; and a discharge circuit which includes the storage capacitor, a controllable discharge device, and the primary winding of an output transformer; the improvement comprising a firing circuit which includes a firing capacitor and a resistor connected in series across a secondary winding coupled to said inductive winding, and a connection between the firing circuit and the discharge device for making said device conductive, said firing circuit arranged to control the discharge device to conduct before the storage capacitor is charged during each firing cycle started by the opening of the contacts.

3. The improvement as claimed in claim 2 wherein said discharge device is a thyatron containing an anode, a cold cathode, and a firing electrode; and said firing electrode is connected to the junction of said firing capacitor and said resistor.

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