May 1, 1962 D. C. LOOMIS 3,032,685

IGNITION SYSTEM

Filed Dec. 3, 1959 2 Sheets-Sheet 1

Fig. 1.

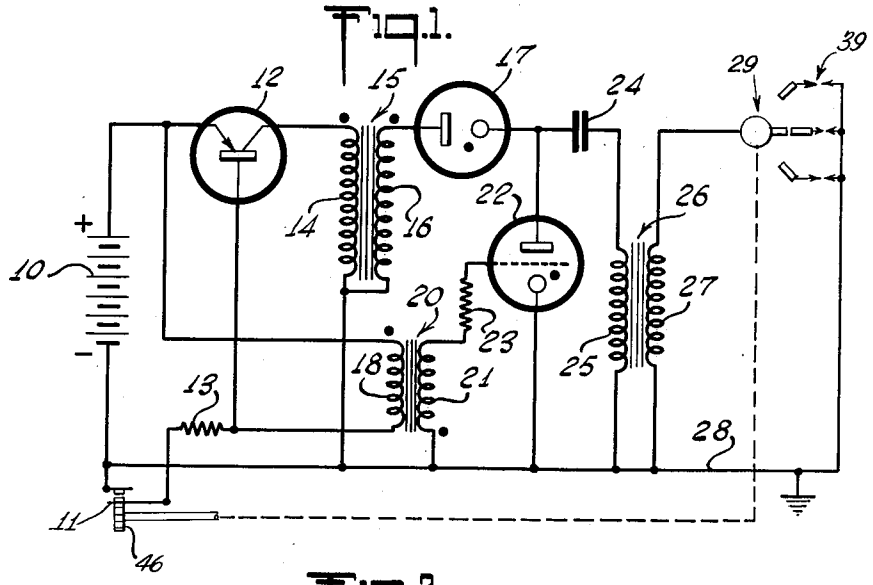
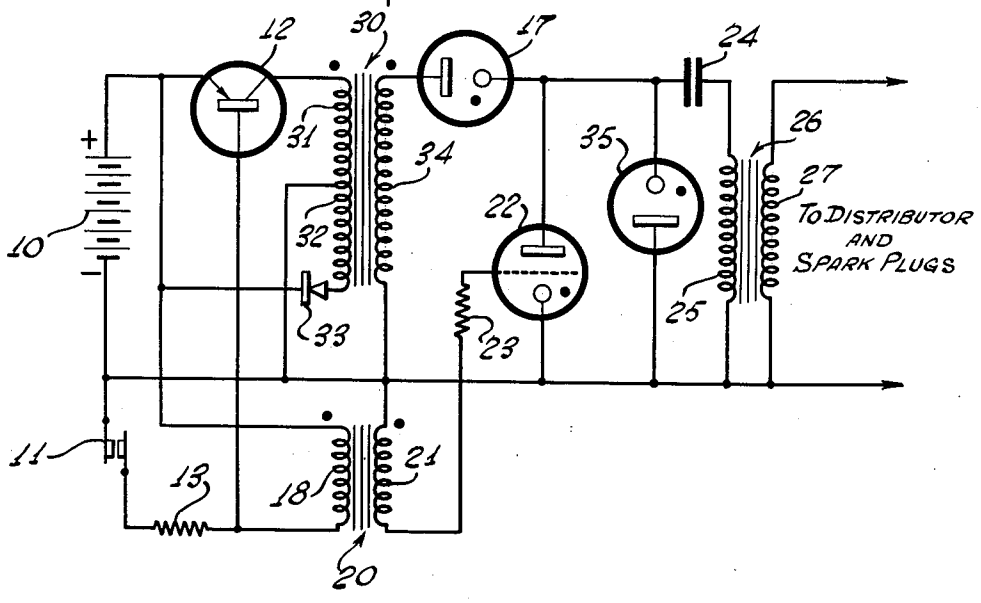


Fig. 2.



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Filed Dec. 3, 1959 2 Sheets-Sheet 2

Fig. 3.

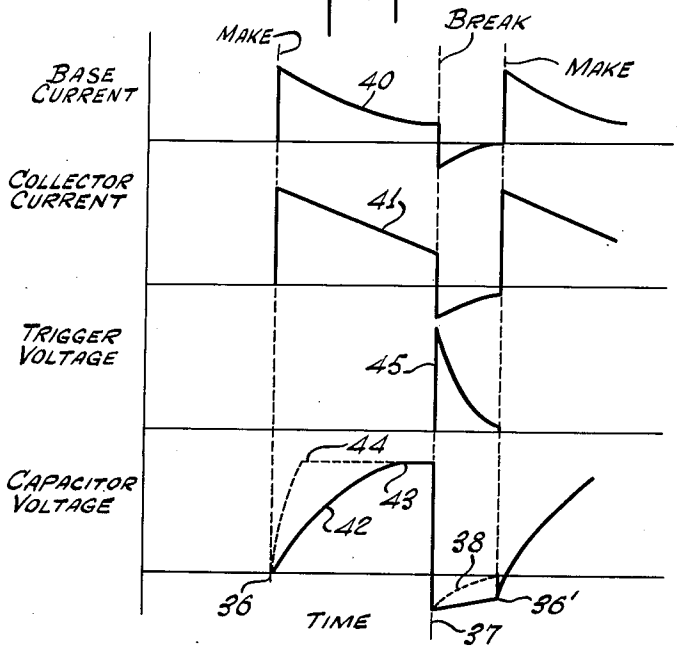
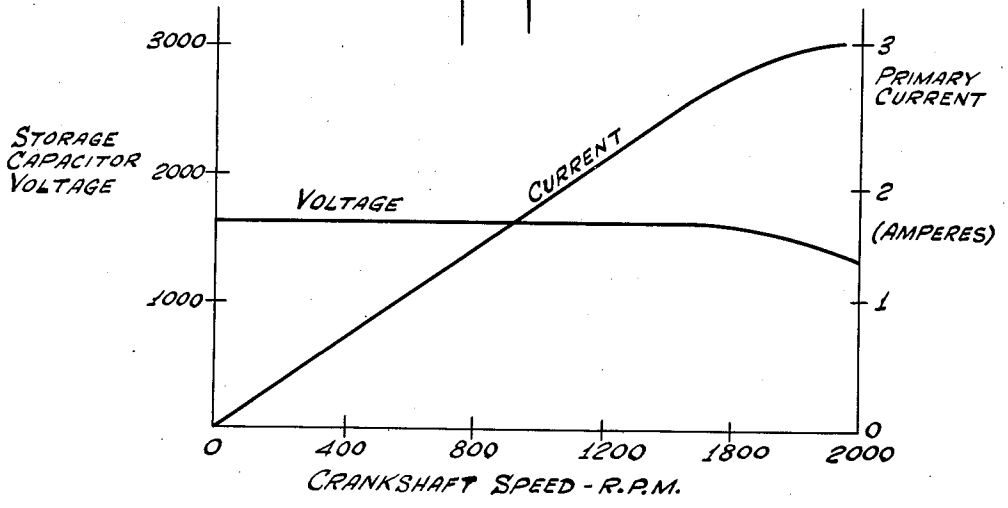


Fig. 4.



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IGNITION SYSTEM

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This invention relates to an ignition system for internal combustion engines and has particular reference to an electronic circuit using rectifiers and cold cathode electron discharge devices.

Ignition systems now used on automobiles include a primary circuit comprising a storage battery and breaker contacts which are run in synchronism with the distributor shaft. A secondary or high voltage circuit includes the secondary of a transformer, distributor points, and spark plugs. At medium speeds and a moderate compression ratio this system works well and has provided good service in automobiles for many years.

The use of higher engine speeds and higher compression ratios places a greater strain on the breaker contacts which must break larger currents at a greater frequency. The higher compression ratios create greater pressures in the cylinder and require a higher voltage at the spark plugs. Several attempts have been made to increase the voltage at the spark plugs but these circuits have generally drawn more current through the breaker contacts and reduced their useful life.

The useful life of spark plugs is generally determined by the amount of carbon deposited on the insulation between the discharge points. This deposit forms a shunt resistance which absorbs considerable power in the ignition systems in use today. The present invention provides a fast voltage rise at the discharge points so that the shunt resistance acts as a power absorber for a much shorter time and the power efficiency is increased considerably.

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

Another object of the invention is to provide a circuit which passes less current through the breaker contacts and thereby prolongs the life of the breaker points.

Another object of the invention is to produce a larger and hotter spark at the spark plug terminals.

Another object of the invention is to produce an output voltage wave having a steeper wave front.

Another object of the invention is to prolong the useful life of spark plugs by providing a fast rising voltage pulse which reduces the power absorbed by the shunt resistance in fouled spark plugs.

Another object of the invention is to provide a primary battery circuit having less inductance than prior art circuits. This circuit reduces the sparking at the breaker contacts when they open.

The present invention comprises an ignition system for internal combustion engines and includes a first primary circuit having a pair of breaker contacts connected in series with a source of direct current and the input circuit of a current amplifier. A second primary circuit includes the breaker contacts and the source of potential in series with the primary winding of a first transformer whose secondary winding is coupled to a gaseous discharge device which is made conductive each time the breaker contacts open. The output circuit of the amplifier is connected to the primary winding of a second transformer whose secondary winding is connected in series with a rectifier, a storage capacitor, and the primary winding of an output transformer whose secondary winding is connected to a distributor and spark plugs. The discharge

device is connected across the storage capacitor and the primary of the output transformer and discharges the capacitor through the transformer winding to produce the single high voltage ignition spark at the selected spark plug.

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 showing one form of the circuit.

FIG. 2 is a schematic diagram of connections showing an alternate form of the circuit using an additional rectifier.

FIG. 3 is a graph showing some of the more important currents and voltages that occur in the circuit during normal operation.

FIG. 4 is a graph showing the variation of voltage across the storage capacitor and the current in the primary circuit as the crank shaft speed is varied.

Referring now to FIG. 1, the circuit includes a battery 10, a pair of breaker contacts 11, and a current amplifier 12 which may be a transistor or other semiconductor amplifying device. A small current limiting resistor 13 is connected in series with the breaker contacts 11 and the base electrode of the transistor. The input circuit to the transistor includes the emitter and the base electrodes. The output circuit of the transistor 12 includes the collector and the emitter, the collector being connected to the primary winding 14 of a transformer 15 whose secondary winding is connected between the negative terminal of battery 10 and the anode of a rectifier component 17, which in this case is a diode gaseous discharge device. The charging circuit includes rectifier 17, a storage capacitor 24, and the primary winding 25 of an output transformer 26 whose secondary winding 27 is connected to the distributor 29 and spark plugs 39.

Another primary circuit includes the battery 10 and breaker contacts 11, resistor 13 and the primary winding 18 of a transformer 20 whose secondary winding 21 is connected between the negative terminal of the battery and the firing electrode of a gaseous discharge device 22. A current limiting resistor 23 is connected in series between the firing electrode and the transformer winding 21.

The operation of this circuit is as follows: When the breaker points 11 are closed, a current pulse is sent from the positive battery terminal through transistor 12 in series with resistor 13. This current pulse produces a larger current pulse from the collector electrode of transistor 12, through primary winding 14, and back to the negative terminal of battery 10. The current pulse through winding 14 produces a high voltage pulse in winding 16 which is applied to rectifier 17, capacitor 24, and winding 25, thereby charging capacitor 24 to a high voltage.

When breaker points 11 are closed, another circuit is completed and the battery 10 is connected across the primary winding 18 in series with resistor 13. Because of the inductance, the current takes a measurable time interval to reach its maximum value and, before this occurs, transistor 12 is biased to amplify the current through winding 14. When the current through winding 18 reaches its maximum value to which it is limited only by the resistances in the circuit, the voltage drop across resistor 13 creates a new bias voltage for the base of transistor 12 and the current through winding 14 is reduced.

A short time interval later, breaker contacts 11 are opened and the reduction of current in winding 18 produces a voltage pulse in secondary winding 21 which raises the potential of the firing electrode in discharge device 22 thereby providing conduction between its anode and cathode and discharging the accumulated charge on capacitor 24 through winding 25 of the output trans-

former 26. This single discharge provides a high voltage pulse in winding 27 which is carried to the distributor 29 and to that one of the spark plugs 39 which at that instant is connected between the distributor and the common grounded conductor 28. A single intense spark is thereby produced across the spark plug gap and the compressed mixture in the cylinder is ignited. The breaker contacts are operated by a cam wheel 46 which is mechanically coupled to the distributor 29.

When breaker contacts 11 are first closed current is sent from the battery 10 through winding 18 and this produces a voltage pulse in the secondary winding 21, but the polarity of this voltage makes the firing electrode in device 22 more negative than the cathode and for this reason the device remains in its nonconductive condition. Discharge device 22 is made conductive only when contacts 11 are broken and the firing electrode is made more positive than the cathode. It should be pointed out that the additional transformer 20 produces its voltage pulse for firing discharge device 22 independently of transformer 15 which has no other purpose than to charge capacitor 24.

Referring now to the circuit shown in FIG. 2, the ignition system includes the same battery 10, breaker contacts 11, transistor 12, and limiting resistor 13. Also, transformer 20 is the same as transformer in FIG. 1, having a primary winding 18 and a secondary winding 21. The charging transformer 30 in this circuit includes a first primary winding 31 which is connected between the collector of transistor 12 and the negative terminal of battery 10. Transformer 30 also includes a second primary winding 32 which is connected between the negative terminal of battery 10 and the positive terminal of the battery in series with a rectifier component 33. The secondary winding 34 of transformer 30 is similar to secondary winding 16 and is part of a charging circuit which includes rectifier 17, storage capacitor 24, and primary winding 25 of output transformer 26.

The charging circuit of FIG. 2 is similar to the charging circuit shown in FIG. 1 except that an additional rectifier 35 has been connected across the terminals of discharge device 22 and a second primary winding has been added to transformer 30. It will be noted that the cathode of rectifier 35 is connected to the anode of discharge device 22 while the anode of rectifier 35 is connected to the cathode of device 22. This means that rectifier 35 will conduct only when the normally positive side of capacitor 24 is more negative than the other terminal. This condition occurs only after contacts 11 are broken. Rectifier 35 adds to the efficiency of the circuit but may be omitted if desired.

The operation of the circuit shown in FIG. 2 is similar to that of FIG. 1, the only difference being that winding 32 in conjunction with rectifier 33 reduces the reverse voltage generated in the primary windings 31 and 32 when the current through transistor 12 and the primary windings is reduced quickly. The voltage pulse generated by this action is short-circuited by rectifier 33 to the positive side of battery 10.

In order to explain the action of rectifier 35 reference is made to the graph shown in FIG. 3. In this graph the time of the closing of contacts 11 is indicated by line 36. When contacts 11 are closed the base current and the collector current rise sharply and then decrease slowly as shown by curves 40 and 41. During this time interval capacitor 24 is charged by a current which produces a voltage which varies with time as indicated by curve 42. If the crank shaft speed is high, of the order of 1500 revolutions per minute, the capacitor 24 will receive its maximum voltage only a short time interval before the opening of contacts 11. This value is indicated by point 43. If the crank shaft speed is slow, of the order of 200 revolutions per minute, the capacitor 24 will receive its charge a longer time before the opening of contacts 11, this point being indicated by 44.

When contacts 11 are opened a trigger voltage 45 is applied to discharge device 22, the capacitor voltage drops very fast and the collector and base currents also drop. Because of the inductance and capacity in the discharge circuit the residual voltage across capacitor 24 will be somewhat negative with respect to ground potential. If rectifier 35 is not used in the circuit the voltage across capacitor 24 will not change much during the time contacts 11 are open, therefore when these contacts are closed capacitor 24 will still have a negative charge as indicated by point 36' in FIG. 3 and the charging current from secondary winding 16 must overcome this negative charge before providing a positive one. If rectifier 35 is used in the circuit as shown in FIG. 2 the negative charge on capacitor 24 will leak-off through rectifier 35 as indicated by the dotted line 38 in FIG. 4 thereby providing a more efficient circuit.

The graph shown in FIG. 4 indicates the results produced by the circuit described. It will be noted that the storage capacitor voltage is constant for all values of crank shaft speed from zero to 1800 revolutions per minute and the primary current from the battery 10 increases in a linear manner over the same range of speeds.

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 appended claims.

What I claim is:

1. An ignition circuit for internal combustion engines comprising; a first primary circuit which includes a pair of breaker contacts in series with a source of direct current and the input circuit of a current amplifier; a second primary circuit which includes the primary winding of a first transformer in series with said source of potential and said breaker contacts; a second transformer whose primary winding is connected to the output circuit of said amplifier and whose secondary winding is connected in series with a rectifier, a storage capacitor, and the primary winding of an output transformer; the secondary winding of said output transformer being connected to a distributor and spark plugs; and a gaseous discharge device having an anode, a cold cathode, and firing electrode with its anode connected to one side of said capacitor, its cathode connected to one side of said primary of the output transformer, and its firing electrode connected to one terminal of the secondary winding of said first transformer, the other terminal of the said secondary winding being connected to said cold cathode.

2. The ignition circuit according to claim 1 wherein said breaker contacts are mechanically coupled to the distributor.

3. The ignition circuit according to claim 2 wherein said current amplifier is a transistor and wherein a resistor is connected between the base of the transistor and one of the breaker contacts.

4. The ignition circuit according to claim 2 wherein said rectifier cathode is connected to the anode of said gaseous discharge device.

5. The ignition circuit according to claim 2 wherein said primary of the second transformer includes a second winding connected to said source of potential in series with a rectifier for reducing reverse transient pulses produced in the primary winding.

6. The ignition circuit according to claim 2 wherein said gaseous discharge device is shunted by a rectifier which permits the flow of current in a direction reverse to the current in said device, thereby neutralizing any reverse charge on said capacitor which may have collected due to oscillatory currents.

7. An ignition circuit for internal combustion engines comprising; a first primary circuit which includes a pair of breaker contacts in series with a source of direct current and the input circuit of a current amplifier; a second primary circuit which includes the primary winding of a first transformer in series with said source of potential

and said breaker contacts; a resistor in series with said breaker contacts and common to both said first and second primary circuits for lowering the voltage on the amplifier input circuit when the primary winding of the first transformer draws current from the source of current; a second transformer whose primary winding is connected to the output circuit of said amplifier and whose secondary winding is connected in series with a rectifier and a storage circuit; and a gaseous discharge device for discharging said storage circuit, said discharge device having a

cathode and a firing electrode connected across the secondary winding of the first transformer.

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