July 20, 1965 H. P. QUINN 3,196,313

IGNITION CIRCUIT WITH SUSTAINED SPARK

Filed Oct. 18, 1961

Fig. 1.

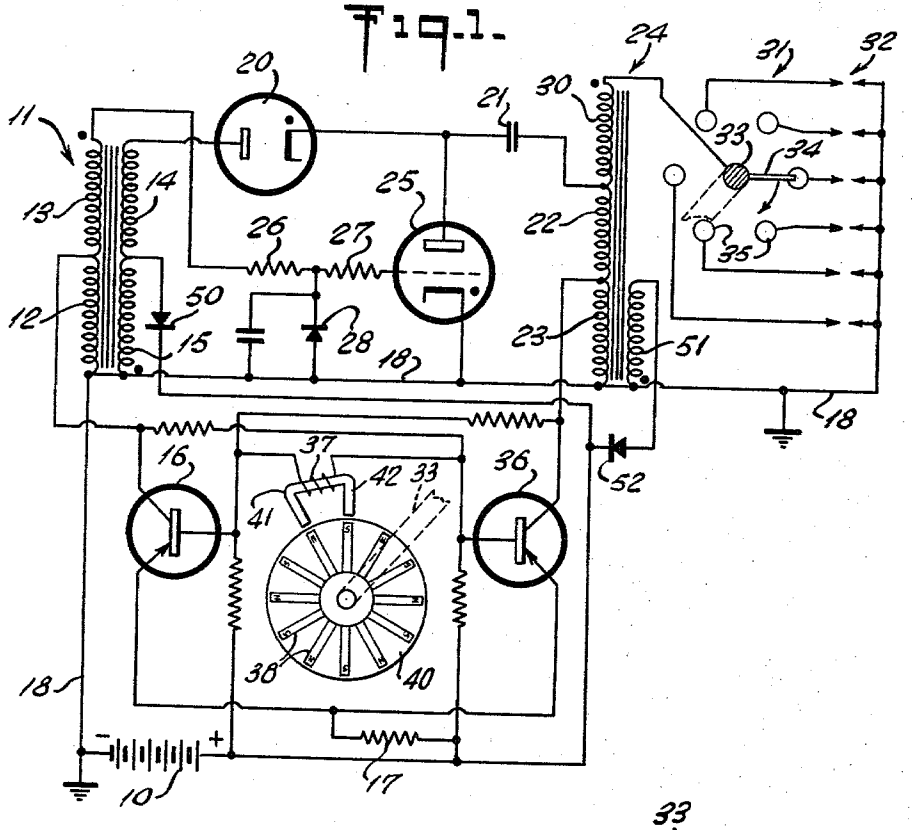


Fig. 2.

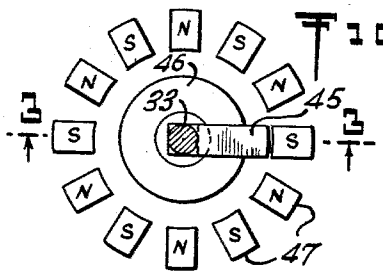


Fig. 3.

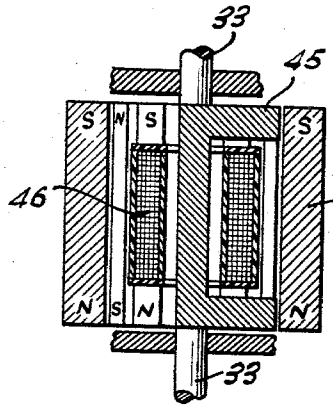
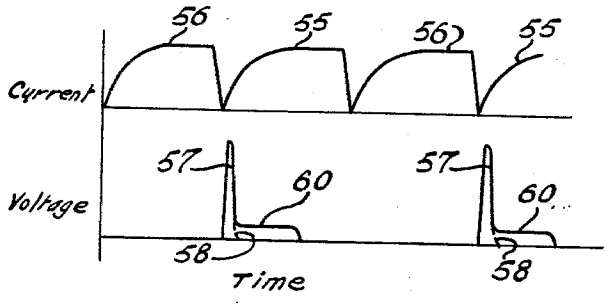


Fig. 4.



INVENTOR
HALSEY P. QUINN
BY
Eyre, Mann & Lucas
ATTORNEYS

United States Patent Office 3,196,313 Patented July 20, 1965

3,196,313

IGNITION CIRCUIT WITH SUSTAINED SPARK

Halsey P. Quinn, Morris Plains, N.J., assignor to Tung-Sol Electric Inc., a corporation of Delaware

Filed Oct. 18, 1961, Ser. No. 145,816
9 Claims. (Cl. 315—209)

This invention relates to an ignition circuit for internal combustion engines having a spark plug in each combustion chamber. It has particular reference to a circuit for generating a prolonged spark having a fast rise time at each of the spark plugs.

Ignition circuits used at the present time do not provide a fast rise time and for this reason worn out plugs with some leakage resistance fail to produce a spark sufficient to ignite the mixture. Other ignition circuits which have been proposed have a fast rise time but the discharge lasts for a very short time, of the order of one microsecond, and this spark although it may be intense, does not always ignite the mixture. The present invention produces a spark which has a fast rise time and also a sustained sparking interval which exists long enough to ignite the mixture even under adverse conditions.

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 eliminate the breaker points.

Another object of the invention is to prolong the electrical discharge at the spark plugs in order to insure ignition of the mixture.

Another object of the invention is to provide a discharge at the spark plugs having a fast rise time.

Another object of the invention is to reduce the maintenance required to keep the ignition circuit in efficient running order.

The invention comprises an ignition circuit for internal combustion engines having a spark plug in each combustion chamber and includes a source of direct current, a first electronic switching means, and a charging transformer having a primary winding connected in series with a source of potential and the switching means. The secondary winding of the charging transformer is connected in series with a rectifier, a charging capacitor, and the primary winding of an output transformer. An electronic discharge device is connected across the storage capacitor and the primary winding of the output transformer. The discharge device is normally non-conductive and is made conductive by a control electrode which is coupled to the primary winding of the charging transformer. A secondary winding of the output transformer is connected in series with a distributor arm and contacts which are connected respectively to each spark plug in the engine. A second electronic switching means is connected across a portion of the primary winding of the output transformer for producing a current in the winding and then cutting off the current when the discharge is started, thereby prolonging the discharge due to the collapse of the magnetic field in the output transformer core. Both electronic switching devices are controlled by means of a plurality of permanent magnets which are rotatable with respect to a core having a winding connected to the control electrode of each of the switching means.

For a better understanding of the present invention, together with various embodiments thereof, reference is made to the following description taken in connection with the accompanying drawing.

FIG. 1 is a schematic diagram of connections showing the ignition circuit together with one form of inductive means which includes a plurality of rotating permanent magnets.

FIG. 2 is a top view of an alternate form of the permanent magnet inductive arrangement in which the permanent magnets are stationary and the inductive core is rotated.

FIG. 3 is a cross sectional view of the inductive arrangement shown in FIG. 2 and is taken along line 3—3 of that figure.

FIG. 4 is a graph showing the current and voltage relationships in parts of the circuit.

Referring now to FIG. 1, the circuit includes the usual storage battery 10 which produces the electric power for the spark plug discharge. A charging transformer 11 includes a single primary winding 12 and three secondary windings 13, 14 and 15. The primary winding 12 is connected in series with the collector-emitter electrodes of a first switching transistor 16, a small current limiting resistor 17, and the battery 10. The combined secondary windings 14 and 15 of the charging transformer 11 are connected in series between a ground conductor 18 and the anode of a diode rectifier 20. In FIG. 1 rectifier 20 is illustrated as a gaseous discharge device having an anode and a cathode within an envelope containing gas at a reduced pressure. However, it is understood that solid state rectifiers may be substituted for this component.

The cathode of discharge device 20 is connected to a storage capacitor 21 and two primary windings 22 and 23 of an output transformer 24. One end of winding 23 is connected to the ground wire 18 thereby completing a series charging circuit. In order to discharge capacitor 21, an electron discharge device 25 is provided with its anode connected to the cathode of diode 20 and its cathode connected to the ground conductor 18. Discharge device 25 is normally non-conductive with its control electrode maintained at the same potential as the cathode. However, at a predetermined time, a positive potential is applied to the control electrode from secondary winding 13 connected in series with two limiting resistors 26 and 27 and the charge on capacitor 21 is discharged through windings 22 and 23. A diode rectifier 28 is connected between the ground conductor 18 and the junction point between resistors 26 and 27 in order to maintain the voltage of the control electrode at ground potential when a negative potential is applied to the control electrode from winding 13.

The output transformer 24 is partially connected as an autotransformer having windings 22, 23 and 30 connected in series to generate the output voltage which is applied to distributor 31 and spark plugs 32. The distributor 31 is the usual collection of components having a rotating shaft 33, a rotating arm 34, and stationary contact points 35. Each contact point 35 is connected respectively to one of the spark plugs 32 in the usual manner.

In order to prolong the spark for a predetermined time interval and thereby insure the ignition of the explosive mixture, an auxiliary circuit is connected in series with winding 23. This circuit includes an electronic switching means 36 which in FIG. 1 is shown as a transistor having the usual collector and emitter electrodes connected in series with the limiting resistor 17 and the positive terminal of storage battery 10. Transistor 36 is normally non-conductive but at a predetermined time the transistor is made conductive so that current flows from the battery 10 through the winding 23 and resistor 17. When this current is cut off, the collapse of the field in the core of transformer 24 generates sufficient voltage in windings 22 and 30 to prolong the spark for a definite period.

Conduction of transistors 16 and 36 is controlled by an inductive winding 37 connected between the two tran-

sistor bases. Voltage pulses are generated in winding 37 by means of a plurality of permanent magnets 38 which are secured to a non-magnetic disc 40 and connected to shaft 33 which controls the movement of distributor arm 34. Winding 37 encloses a core 41 having pole pieces 42 mounted adjacent to the periphery of disc 40 and the ends of permanent magnets 38. The voltage pulses generated in winding 37 are applied to the bases of transistor 16 and 36 (interconnected as a bistable multivibrator) and cause the sequential transfer of conductance between the emitter-collector electrodes of the two transistors.

FIGS. 2 and 3 show an alternate arrangement of magnets and inductive winding which can be used to produce the same result as the arrangement shown in FIG. 1. In the alternate arrangement, shaft 33 is connected to a soft iron core 45 which includes a central portion enclosed within winding 46 and two pole pieces which rotate adjacent to the pole pieces of an array of permanent magnets 47. Magnets 47 are arranged with their polarities in alternate sequence as shown in FIG. 2. There are twice as many permanent magnets in this arrangement as there are spark plugs.

It will be obvious from the figures that both embodiments produce voltage pulses in winding 37 which alternate in polarity. When one arrangement of permanent magnet poles pass pole pieces 42, a negative pulse is applied to the base of transistor 16 thereby producing conductance and permitting current to flow from the battery 10 through winding 12. During the next one-twelfth revolution of disc 40 another pulse is generated which applies a negative potential to the base of transistor 36 thereby permitting conductance and permitting current to flow from the battery through winding 23 in the output transformer.

There may be times during the operation of the ignition circuit when the discharge device is not made conductive. This may be due to the fact that the pulses generated by winding 37 are not strong enough to trigger the multivibrator circuit or for any other reason. In this case protective circuits are provided which absorb the unused energy. One of these protective circuits includes winding 15 and diode 50. The other circuit includes winding 51 and diode 52. Each winding 15 and 51 is arranged to generate somewhat less than the battery voltage during normal operation and, for this reason, no current normally flows through diodes 50 and 52. When capacitor 21 is not discharged, the next charging sequence develops a high voltage in windings 14 and 15 because there is no load on the secondary winding to absorb the energy. This high voltage can cause injury to several components, including transistors 16 and 36. With diodes 50 and 52 connected as shown, a portion of the current is sent to battery 10 to charge it and these circuits then produce sufficient load to prevent high voltage surges.

The operation of the circuit shown in FIG. 1 is as follows:

Let it be assumed that due to a previous sequence of events capacitor 21 has been charged. Then when permanent magnet 38 passes pole pieces 42, a pulse is generated in winding 37 and this is applied to the base electrode of transistor 16 thereby causing it to conduct, sending current through winding 12 and generating a positive potential at the upper end of winding 13. This pulse is applied to the control electrode of discharge device 25 and capacitor 21 is discharged through device 25 and windings 22 and 23. This discharge generates a high voltage at the upper end of winding 30 and sends a high voltage pulse through the distributor and its arm 34 to the spark plug 32 which is connected at that time.

At the same time that transistor 16 is made conductive, transistor 36 is made non-conductive and the current which was flowing through winding 23 is cut off, thereby causing the collapse of the magnetic field in the core of output transformer 24. This collapse generates sufficient current in windings 30 and 22 to prolong the discharge through the spark plugs for an additional time interval.

Transistors 16 and 32 are interconnected with each other to form a bistable multivibrator circuit. The emitters of the transistors are connected to each other and each transistor collector is connected through a resistance to the base of the other transistor. Because of this circuit, one transistor remains in a conductive condition as long as the other transistor is non-conductive. The pulses generated by winding 37 are used only for triggering this circuit and the pulses may be of very short duration.

After the disc 40 has turned one-twelfth of a revolution, a positive pulse is applied by winding 37 to the base of transistor 36 causing it to conduct and, by means of the multivibrator coupling, cutting off transistor 16. When transistor 16 is made non-conductive, the magnetic flux in winding 12 collapses and a positive pulse is generated in windings 14 and 15 which sends current through diode 20 to charge capacitor 21. At the same time, transistor 36 conducts and current is sent through winding 23 to produce flux in the core of output transformer 24. After the disc 40 has turned another twelfth of a revolution the above described operation is repeated.

FIG. 4 shows the current and voltage relationships in some of the circuit components. When transistor 16 is made conductive, current flows in winding 12 in series with resistor 17, this current build up being represented by curve 55. When this transistor is cut off, transistor 36 is made conductive and this current build up is illustrated by curve 56. When transistor 16 is made conductive, the storage capacitor 21 discharges as described above and sends a high voltage pulse 57 to the distributor and spark plugs. Under ordinary circumstances this pulse would terminate almost immediately as indicated by dotted line 58. Because of the sustaining circuit and the collapse of the field due to winding 23, the discharge is prolonged by an amount indicated by curve 60.

From the above description it will be evident that the ignition circuit described above produces a discharge which has a fast time rise and which lasts for any predetermined time interval.

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. An ignition circuit for internal combustion engines having a spark plug in each combustion chamber comprising: a source of direct current; a first electronic switching means connected to said source of potential and adapted to conduct current when biased by an applied pulse; a charging transformer having a primary winding connected in series with the source of potential and said switching means; a charging circuit including in series connection, a secondary winding of the charging transformer, a rectifier, and a storage capacitor for storing an electrical charge; an output transformer having a primary winding in series with said charging circuit and a secondary winding connected through a distributor to said spark plugs; a controlled discharge device connected across said storage capacitor and the primary winding of the output transformer for discharging the capacitor through the primary winding at a predetermined time; a second electronic switch connected in series with said source of potential and a portion of the primary winding of the output transformer and adapted to conduct current when biased by an applied pulse; and pulsing means controlled by said distributor for sequentially transferring conductance between said first and second switching means.

2. An ignition circuit for internal combustion engines having a spark plug in each combustion chamber com-

prising: a source of direct current; a first electronic switching means connected to said source of potential and adapted to conduct current when biased by an applied pulse; a charging transformer having a primary winding connected in series with the source of potential and said switching means; a charging circuit including in series connection, a secondary winding of the charging transformer, a rectifier, and a storage capacitor for storing an electrical charge; an output transformer having a primary winding in series with said charging circuit and a secondary winding connected through a distributor to said spark plugs; a controlled discharge device connected across said storage capacitor and the primary winding of the output transformer for discharging the capacitor through the primary winding at a predetermined time; a second electronic switch connected in series with a said source of potential and a portion of the primary winding of the output transformer and adapted to conduct current when biased by an applied pulse; said first and second electronic switches coupled together by means of a bistable multivibrator circuit; and pulsing means controlled by said distributor for sequentially transferring conductance between said first and second switching means.

3. An ignition circuit as claimed in claim 2 wherein said first and second electronic switches are transistors.

4. An ignition circuit as claimed in claim 2 wherein said pulsing means includes a winding on a core and rotatable means for applying magnetic flux to said core in sequentially alternate polarity.

5. An ignition circuit for internal combustion engines having a spark plug in each combustion chamber comprising: means for charging a storage capacitor to a predetermined voltage; an output transformer having a primary winding coupled to said storage capacitor and a secondary winding connected through a rotatable distributor to the spark plugs; an electronic discharge means connected across said capacitor and said primary winding

for discharging said capacitor through the discharge means at predetermined intervals whereby the capacitor charge creates a current in said primary winding; a switching circuit which includes an electronic switch, a portion of the primary winding, and a source of direct current in series connection; said switch coupled to control means for sending current through said portion prior to the discharge of the storage capacitor and for cutting off said current at the same time the storage capacitor is discharged.

6. An ignition circuit as claimed in claim 5 wherein said control means includes a rotatable magnetic core mechanically coupled to said distributor for rotation therewith.

7. An ignition circuit as claimed in claim 5 wherein said electronic switch is a transistor having its emitter-collector terminals connected in series with said source of potential and said portion of the primary winding.

8. An ignition circuit as claimed in claim 7 wherein said magnetic control means includes a stationary ferromagnetic core having a winding connected to the base of the transistor.

9. An ignition circuit as claimed in claim 8 wherein said rotary magnetic means comprises a rotatable base on which is secured a plurality of permanent magnets with alternate north and south magnetic poles moving adjacent to ends of said ferromagnetic core.

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DAVID J. GALVIN, *Primary Examiner.*

ARTHUR GAUSS, *Examiner.*