Aug. 8, 1967 H. P. QUINN 3,335,320

IGNITION CIRCUIT WITH VOLTAGE REGULATOR

Filed Feb. 24, 1965

Fig. 1.

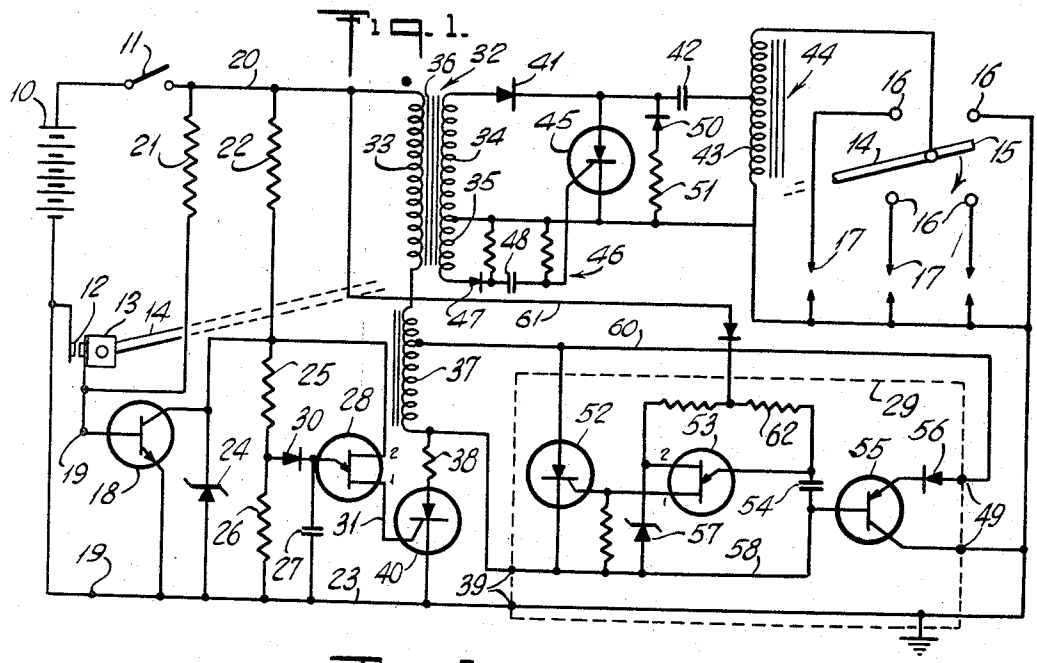


Fig. 2.

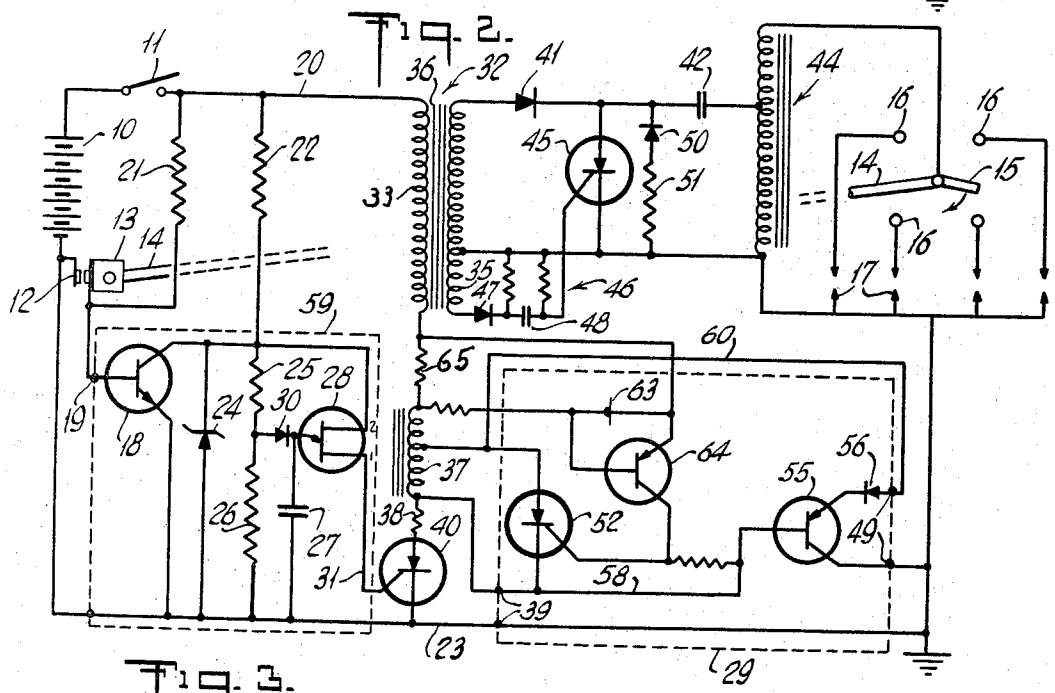
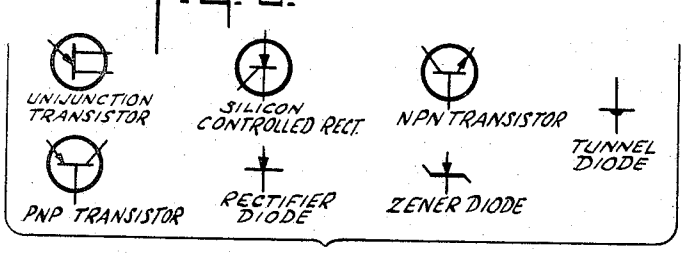


Fig. 3.



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

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IGNITION CIRCUIT WITH VOLTAGE REGULATOR

Halsey P. Quinn, Morris Plains, N.J., assignor to Wagner Electric Corporation, a corporation of Delaware

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ABSTRACT OF THE DISCLOSURE

An ignition circuit is described having a voltage regulator which permits operation with a battery voltage within the range of 4.5 volts to 36 volts. The usual combination of a charging transformer, storage capacitor, output transformer, the semiconductor switch provide the coupling means between a battery and the spark plugs. A first control circuit provides a synchronized pulse for the charging transformer. A second control circuit cuts off the current through the primary winding of the charging transformer after it has reached a predetermined value.

This invention relates to an ignition circuit employing semiconductor components for the generation and application of a series of high voltage pulses to an array of spark plugs in an internal combustion engine. The invention has particular reference to a voltage regulator circuit wherein the spark intensity is independent of the battery voltage over a wide range of voltage values.

Many ignition circuits have been devised for creating a higher voltage spark, a more rapid spark frequency and a means for eliminating the spark at the breaker contacts. The present invention has all these features and, in addition, contains a built-in voltage regulator circuit which provides an adequate spark at the spark plugs even though the battery voltage may vary between 4.5 volts to 36 volts. Because of this wide variation, the ignition circuit may be used with 6 volt, 12 volt, or 24 volt batteries. It is obvious that other power systems employing alternators and rectifiers may be used.

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 regulate the output voltage so that it is constant within a small range of values even though the supply voltage may vary over a wide range of values.

Another object of the invention is to employ semiconductor components in the ignition circuits so that the frequency range can be raised and so that the life of the circuit can be lengthened.

Another object of the invention is to reduce the current through the breaker contacts so that arcing, pitting and corrosion are greatly reduced.

The invention comprises an ignition circuit for internal combustion engines having spark plugs in piston chambers. The circuit includes a pair of breaker contacts connected in series between a source of direct current power, which may be a battery, and a limiting resistor. The contacts are operated by a distributor shaft which is coupled to the engine's pistons. A charging transformer is coupled to the source of power and includes a ferromagnetic core which holds a primary winding and a secondary winding. The charging transformer charges a storage capacitor before each spark and then, later, the capacitor discharges through a switching component and delivers a spark at one of the spark plugs. The source of power supplies current to a series circuit which includes the primary winding of the charging transformer, an inductor, and a power transistor. A first control circuit is coupled between the breaker contacts and a silicon controlled rectifier. A second control circuit is coupled between the primary winding and a transistor. The transistor is adapted to short circuit a portion of the control circuit when the second control circuit is activated by a positive control pulse having more than a minimum voltage.

One feature of the ignition circuit includes a zener diode in the first control circuit which insures that a positive voltage pulse, having a predetermined value, is applied to the silicon controlled rectifier to make it conductive each time the breaker contacts are opened.

Another feature of the invention includes a unijunction transistor in the second control circuit adapted to fire only when the current through the primary winding of the charging transformer has created enough magnetic flux in the transformer core to transfer a regulated voltage pulse to the charging transformer secondary.

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 invention.

FIG. 2 is also a schematic diagram of connections but showing an alternate form of the invention.

FIG. 3 is a collection of legends showing the various symbols used for the semiconductor components.

Referring now to FIG. 1, the ignition circuit comprises a source of direct current power **10**, which may be a battery or an alternator connected through a rectifier circuit. An ignition switch **11** is generally connected in series with the battery so that no current can flow when the switch is open. The usual breaker contacts **12** are controlled to open and close by a cam **13** at one end of a shaft **14**. The other end of the shaft **14** is connected to a rotating distributor arm **15** which moves in close proximity to terminals **16** and transfers high voltage pulses to spark plugs **17**.

Contacts **12** are connected to the base electrode of an NPN transistor **18** and to the positive conductor **20** through a limiting resistor **21**. When the contacts are closed, no current flows through the transistor because the base is grounded. When the contacts are opened, the base is given a positive potential and then current flows from conductor **20**, through resistor **22**, then through the collector-emitter electrodes of transistor **18** to ground conductor **23**.

The base and emitter electrodes of transistor **18** are the input terminals **19** of a first control circuit which also includes a zener diode **24**, a voltage divider circuit including resistors **25** and **26**, a capacitor **27**, and a unijunction transistor **28**. The emitter of unijunction transistor **28** is connected to the junction of resistors **25** and **26** in series with a rectifier diode **30**. The output of this first control circuit is applied to conductors **31** and **23** and transmits a positive pulse through base **1** of the unijunction transistor every time it is fired.

The spark transfer circuit which transfers power from the direct current source to the spark plugs is conventional and similar circuits have been described in prior patents such as 3,150,286, issued to H. P. Quinn, Sept. 22, 1964. This circuit includes a charging transformer **32**, having a primary winding **33**, two secondary windings **34** and **35**, all of these windings on a ferromagnetic core **36**. The primary winding is connected in series with the source of direct current power **10**, an inductor **37**, a resistor **38**, and the anode-cathode electrodes of a silicon controlled rectifier **40**. The latter portion of this circuit will be discussed later. The secondary winding **34** is connected to a series circuit comprising a rectifier diode **41**, a charging capacitor **42**, and a primary winding **43** of an output transformer **44**. A switching device **45**, which may be either a gas filled thyratron or a silicon controlled recti-

fier, has its anode connected to the junction point of rectifier 41 and storage capacitor 42 while its cathode is connected to the other side of winding 34.

The second secondary winding 35 is connected to the cathode of switching device 45 and to its firing or control electrode through a filter circuit 46. The filter circuit includes a series rectifier diode 47, a series capacitor 48, and two shunt resistors. This circuit applies a positive pulse to the switching device 45 to fire it and to discharge the storage capacitor through primary winding 43 and thereby generate a high voltage pulse which is applied to the spark plugs through distributor 15, 16. A rectifier diode 50 in series with a resistor 51 is bridged across the anode-cathode electrodes of the switching device to eliminate any negative-going oscillatory waves which may result from the distributed capacity in the transformer 44 and the distributor. Secondary winding 34 charges capacitor 42 during one part of the cycle, while secondary winding 35 triggers the switching device 45 to discharge capacitor 42 and provide a spark at one of the spark plugs during a second part of the cycle.

A second control circuit (shown within dotted lines 29) has its input terminals 39 connected to conductor 23 and to the junction of inductor 37 and resistor 38. The control circuit includes a second controlled rectifier 52, a unijunction transistor 53, a second storage capacitor 54, and a PNP transistor 55. A rectifier diode 56 is connected in series with the emitter electrode of transistor 55 to limit leakage at high temperatures. Also, a zener diode 57 is connected between base 2 of unijunction transistor 53 and common conductor 58 to limit the voltage applied to this electrode. The output terminals 49 of this second control circuit are connected to conductors 60 and 23.

The operation of this circuit (FIG. 1) is as follows: With the ignition switch 11 open and contacts 12 closed, no current flows in the circuit and all the semiconductor components, except the rectifier diodes, are biased for non-conduction. When switch 11 is closed (breaker contacts still closed) the only current flowing is the small current through resistors 22, 25 and 26. Resistors 25 and 26 are so chosen that, at the potentials available, unijunction 28 does not fire even though capacitor 27 may be fully charged to the potential existing across resistor 26. No current flows through the transformer primary winding 33 because both the silicon controlled rectifier 40 and PNP transistor 55 are biased for non-conduction.

Now, let it be assumed that the breaker contacts 12 are opened for the first time. The NPN transistor 18 is made conductive (because its base voltage is raised) and current flows through resistor 22 and transistor 18 to ground. This current reduces the voltage of base 2 of the unijunction transistor 28 while the voltage of the emitter is maintained by the charge on capacitor 27. The transistor 28 "fires" and sends a positive voltage pulse over conductor 31 to the control electrode of silicon controlled rectifier 40 causing it to conduct and permitting a small current to flow through the primary winding 33 of transformer 32. This current reduces the potential of conductor 58 and makes PNP transistor 55 conductive permitting a much larger current to flow through the primary winding 33 and setting up a substantial magnetic flux in the core 36. Also at this time silicon controlled rectifier 40 is short circuited and made non-conductive.

Prior to the firing of the first controlled rectifier 40, conductor 58 is maintained at the same positive potential as the positive terminal of battery 10. Conductor 61 and resistor 62 are also at this same potential and capacitor 54 has no charge. As soon as the first controlled rectifier 40 is made conductive, the potential of conductor 58 is reduced by a substantial amount and capacitor 54 charges through resistor 62. The circuit for unijunction transistor 53 is now set up. Base 1 of this transistor is at the same potential as conductor 58 while base 2 is maintained at a predetermined potential above the conductor potential by zener diode 57. When the voltage on capacitor 54 reaches 0.6 of the voltage on base 2, transistor 53 fires and sends a positive pulse to the control electrode of the second controlled rectifier 52, making it conductive.

The current through rectifier 52 shorts the lower portion of inductor 37 and also shorts the emitter and base electrodes of PNP transistor 55, thereby making it non-conductive again. This action cuts off all current through the primary winding 33 and the magnetic flux collapses, generating a high voltage in the secondary windings 34 and 35. Winding 34 charges the storage capacitor 42. Winding 35 does nothing at this time because the pulse generated cannot pass through rectifier diode 47. During the next cycle when transistor 55 is made conductive, the initial current through winding 33 generates a pulse which passes through a diode 47, fires the controlled rectifier 45, and discharges capacitor 42 through the rectifier 45 and the primary winding 43 of the output transformer 44. This current generates the high voltage pulse which passes through the distributor and through one of the spark plugs.

It is obvious from the above description that the intensity of the spark at the spark plugs is proportional to the peak current in winding 33 at the time conduction is cut off and the magnetic field collapses. If this peak current can be maintained at a constant value, the output voltage will always be the same regardless of the voltage supplied by battery 10.

In the circuit shown in FIG. 1, the voltage on the zener diode 57 is fixed and the capacitor 54 is charged from the input power source (battery 10) which may vary over a wide range of values. When the voltage is high, the capacitor is charged quickly and the unijunction transistor 53 is fired a short time after PNP transistor 55 is made conductive. During this time interval, the current in winding 33 rises to a desired peak value. When the battery voltage is low, the capacitor is charged slowly and the unijunction transistor 53 is fired a longer time after transistor 55 is made conductive. During this longer time interval, the current in winding 33 rises to the same desired peak value.

The circuit shown in FIG. 2 is similar to the circuit shown in FIG. 1 and performs the same functions. The power transfer circuit is the same and the first control circuit (shown within dotted lines 59) is the same. The second control circuit 29 employs a tunnel diode 63 and an additional transistor 64 instead of the combination of unijunction transistor 53 and capacitor 54. The operation is generally the same. After transistor 55 is made conductive, the current through winding 33 rises until the voltage across resistor 65 triggers diode 63 into its higher voltage state making transistor 64 conductive. This action fires the second controlled rectifier 52, making transistor 55 non-conducting and stopping the rise in current in winding 33 at the desired peak value.

Both the circuits shown in FIGS. 1 and 2 include a reference voltage component which controls the charging current in the primary winding 33 to increase to a desired value, then the current is shut off. This type of peak current regulator insures the stability of the output power applied to the spark plugs.

In one example of the circuit shown in FIG. 2, the following component values were used:

Tunnel diode	IN 2720	
Resistor 65	.04 ohms	
Transistor 64	PNP	400 milliwatt.
SCR 52	1 ampere	25 volts.
SCR 45	8 amperes	200 volts.

From the above description it will be evident that the circuit provides a constant output voltage which can be used in any load requiring a train of sequential electrical pulses.

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 comprising; a source of direct current power; a pair of breaker contacts connected in series between said source of power and a resistor, said contacts operated by a distributor shaft which is coupled to pistons in the engine, a charging transformer including a ferromagnetic core holding a primary winding and a secondary winding, said secondary winding connected to a utilization circuit including a storage capacitor, an output transformer, a distributor, a plurality of spark plugs, and a switching device for discharging the storage capacitor through a primary winding of the output transformer; a first controlled rectifier having an anode, a cathode, and a control electrode adapted to make the anode-cathode circuit of the rectifier conductive when activated by a positive pulse; an inductor including a winding on a ferromagnetic core connected in series with the primary winding on the charging transformer and the first controlled rectifier; said series circuit connected across the source of power; a first control circuit having input terminals connected across the breaker contacts and an output circuit connected across the control electrode and the cathode of the first controlled rectifier, said first control circuit adapted to generate a positive voltage pulse when the breaker contacts are opened; a second control circuit for controlling the time intervals of the current pulses in the primary winding of the charging transformer, said control circuit including a pair of input terminals connected in series with said primary winding and said inductor, a second controlled rectifier having its anode and cathode connected across a portion of said inductor, a unijunction transistor having its base 2 coupled to the source of potential, its base 1 connected to the firing electrode of the second controlled rectifier, and its emitter electrode coupled to a second storage capacitor; and a PNP transistor for switching current on and off through the primary winding of the charging transformer, said PNP transistor having its emitter and collector electrodes connected in series between the primary winding of the charging transformer and negative terminal of the source of potential; said PNP transistor having its base electrode connected to the second charging capacitor.

2. An ignition circuit as claimed in claim 1 wherein said second control circuit includes a zener diode as a voltage reference component, said diode connected between base 2 of the unijunction transistor and one side of said inductor and adapted to limit the voltage applied to the base 2.

3. An ignition circuit as claimed in claim 1 wherein said second control circuit includes a transistor 64 which is normally biased for non-conduction and wherein a tunnel diode is connected in parallel with the base and emitter electrodes of said transistor for holding the transistor non-conductive until a predetermined current flows in the primary of the charging transformer.

4. An ignition circuit as claimed in claim 1 wherein a unijunction transistor is included in said first control circuit, the emitter of the unijunction transistor being connected to a mid-point of a voltage divider which is connected across the source of power, and the base 1 connected to the firing electrode of the first controlled rectifier for starting current flow through the primary winding of the charging transformer.

5. An ignition circuit as claimed in claim 4 wherein said first control circuit includes an NPN transistor having a base, a collector, and an emitter; said base connected to one of the breaker contacts, the emitter connected to the other contact, and the collector coupled to one of the terminals of the source of potential.

6. An ignition circuit as claimed in claim 5 wherein a zener diode is connected across the emitter and collector electrodes of said NPN transistor, for limiting the voltage applied to the emitter of the unijunction transistor.

References Cited

UNITED STATES PATENTS

3,045,148	7/1962	McNulty et al.	315—183
3,150,286	9/1964	Quinn	315—209
3,240,198	3/1966	Loudon et al.	123—148
3,242,420	3/1966	Ulrey	323—58
3,260,251	7/1966	Lange	123—148

JOHN W. HUCKERT, *Primary Examiner.*

D. O. KRAFT, R. SANDLER, *Assistant Examiners.*