Dec. 13, 1966 W. Y. PETERS 3,291,110

HIGH VOLTAGE CIRCUIT FOR AUTOMOBILE ENGINE IGNITION

Filed Sept. 2, 1965 2 Sheets-Sheet 1

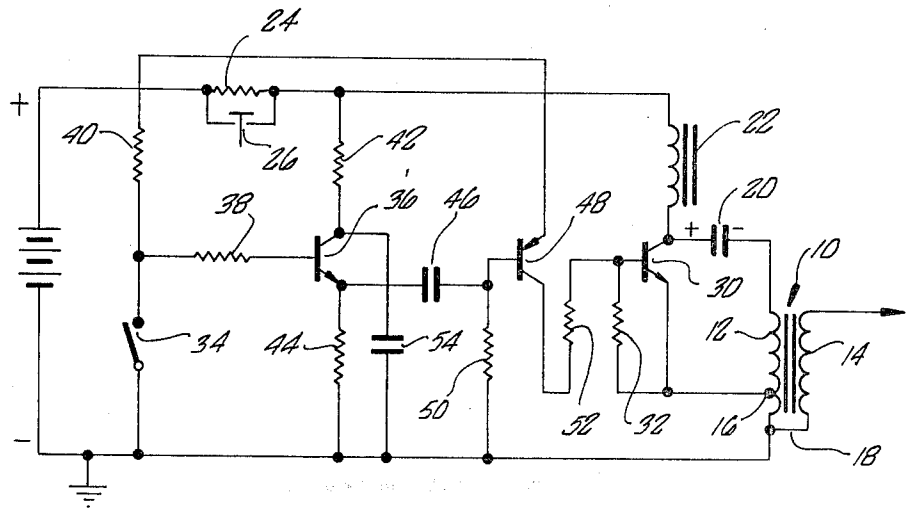


FIG. 1

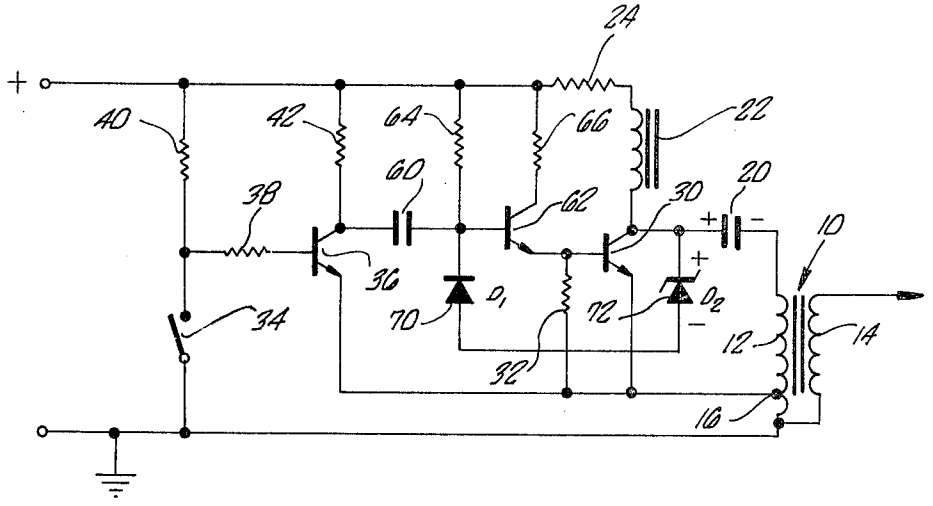


FIG. 2

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FIG. 3.

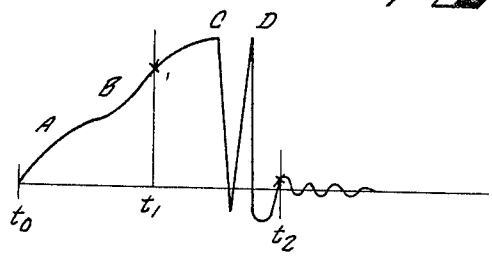


FIG. 4.

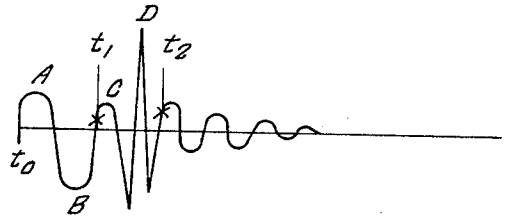
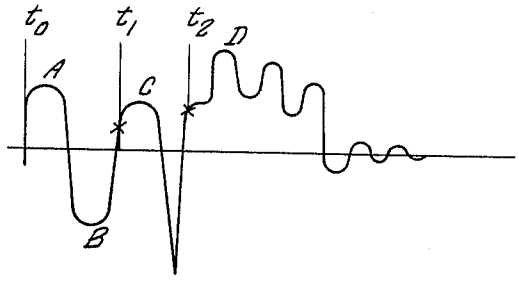


FIG. 5.



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HIGH VOLTAGE CIRCUIT FOR AUTOMOBILE ENGINE IGNITION

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8 Claims. (Cl. 123—148)

This invention relates to high voltage pulse generating circuits and, more particularly, is concerned with a circuit for use in the ignition system of automobile engines and the like. This application is a continuation-in-part of application Serial No. 382,149, filed July 13, 1964 and now abandoned.

With the higher speed, higher compression engines being used in automobiles, the problem of generating a sufficiently high voltage for ignition has become more severe. To use the standard breaker point and ignition coil system, it became necessary to convert from a six volt to a twelve volt electrical system. However, even with the higher voltage available, there is still a problem of providing a reliable operation using the conventional ignition coil for generating a high voltage necessary for ignition. The primary of the coil requires substantially large currents which results in pitting and corrosion of the breaker points. As a result, frequent adjustment or replacement of the points is required. Furthermore, any substantial reduction in the voltage on the primary severely affects the energy of the spark. This means that cold weather starting or starting with a battery which is not fully charged may be difficult because of failure of the ignition system to produce an adequate spark.

With the advent of the transistor, there have been a number of transistor circuits proposed for ignition systems. Such circuits have not proved entirely satisfactory because they have suffered from one or more of the drawbacks that they have been too expensive, have not performed well under extremely high temperature operating conditions such as encountered in the warm regions of the country, have been sensitive to drops in voltage of the battery source.

The present invention is directed to an improved high voltage ignition system which provides high energy, high voltage output pulses which can operate at high pulse repetition frequencies. The circuit utilizes silicon transistors to overcome temperature limitations, and operates over a wide range of voltages. In addition, the circuit uses a minimum of components, is inexpensive to manufacture, is rugged and foolproof in operation, and can be made much more compact than the standard ignition coil system.

These and other advantages of the present invention are achieved by utilizing a saturable core transformer having a high voltage secondary. The primary is connected in series with a capacitor and an inductor across the battery source. A normally closed transistor switch connects the series junction point between the capacitor and the inductor to a tap on the primary. The transistor switch is operated from the breaker points through a transistorized control circuit such that on opening of the breaker points, the transistorized switch is momentarily opened for a predetermined time interval causing a pulsing of the primary of the transformer by energy stored in the series resonance circuit. For a more complete understanding of the invention, reference should be made to the accompanying drawings wherein:

FIGURE 1 is a schematic diagram of one embodiment of the present invention;

FIGURE 2 is a schemiatic diagram of an alternative embodiment of the present invention;

FIGURES 3, 4 and 5 show wave forms used in explaining the operation of the circuits of FIGURES 1 and 2.

Referring to FIGURE 1 in detail, the numeral 10 indicates generally a transformer having a primary winding 12 and a secondary winding 14. The primary winding has a tap at 16. Typically, the primary winding has forty-four turns with the tap being at sixteen turns from one end, indicated 18, which end is also connected to one end of the secondary 14. In a typical automobile ignition system, the common end 18 of the primary and secondary windings is connected to ground potential and the other end of the secondary is connected to the distributor. The secondary winding may have in the order of ten thousand to fifteen thousand turns. The primary and secondary windings are wound on a closed loop core made of saturable magnetic material. While square hysteresis loop material such as ferrite may be used, less square loop material such as grain oriented 4 mil Hypersil material has been found suitable.

The ungrounded end of the primary 12 is connected to the positive side of a standard 12 volt automobile battery through a series capacitor 20 and an inductor 22. In addition, a ballast resistor 24 may be provided in the series circuit having a bypass switch 26 which is closed whenever the automobile starter is engaged.

An NPN silicon transistor 30 has its collector connected at the series junction point between the capacitor 20 and inductor 22 and its emitter terminal connected to the tap 16 on the primary of the transformer 10. A bias resistor 32 connects the base electrode of the transistor 30 to the emitter electrode. The transistor 30, which is controlled in the manner hereinafter described by the ignition breaker points, is normally conducting. Thus a low impedance current path is provided from the positive terminal of the battery through the inductor 22, through the sixteen turn portion of the primary winding of the transformer 10 to the grounded negative terminal of the battery. When the transistor 30 is momentarily turned off, providing an open circuit, the capacitor 20 is charged up to a high peak voltage by the collapse of the magnetic field of the inductor 22. As the capacitor 20 continues to charge, the voltage reverses across the primary of the transformer 10 and then begins to go positive again. The transistor switch 30 is then closed again and all the energy stored in the capacitor 20 is discharged through the primary of the transformer 10, producing a negative saturation of the transformer. When the transformer saturates, a flux reversal occurs with the charge on the capacitor being dissipated very rapidly producing a large positive peak. This source of current begins charging the inductor causing a series of small oscillations between the transformer 10 and series capacitor 20. FIGURE 3 shows the voltage wave form across the capacitor 20. The voltage wave form as shown in FIGURE 4 corresponds to the voltages observed across the primary winding of the transformer, while FIGURE 5 shows the corresponding wave form across the secondary winding.

Control of the transistor switch 30 in the arrangement of FIGURE 1 is from the breaker points indicated generally as a switch 34. The switch 34 controls an NPN transistor 36 having its base normally connected to the positive side of the battery through a pair of resistors 38 and 40. The breaker point 34, when closed, connects the junction between the resistor 38 and the resistor 40 to the grounded terminal of the battery. The collector of the transistor 36 is connected through a load resistor 42 to the positive terminal of the battery through the ballast resistor 24. The emitter of the transistor 36 is connected to ground potential through a bias resistor 44. Thus when the breaker points are closed, the transistor 36 is rendered nonconductive, and when the breaker points 34 open, the transistor 36 becomes conductive.

The emitter of the transistor **36** is connected through a coupling capacitor **46** to the base of a PNP transistor **48**. The base of the transistor **48** is also connected to ground potential through a bias resistor **50**. The emitter of the transistor **47** is connected to the positive terminal of the battery while the collector is connected through a resistor **52** to the base of the transistor **30**.

In operation, when the breaker points open, the transistor **36** is turned on. This produces a positive going signal at the emitter of the transistor **36** which, in turn, provides a positive going pulse across the differentiating circuit formed by the capacitor **46** and resistor **50**. This pulse occurring on the base of the transistor **48** momentarily turns off the transistor **48**. When the transistor **48** is on, the transistor **30** is biased on, but when the transistor **48** is turned off by the positive going pulse applied to the base thereof, the transistor switch **30** is momentarily turned off. Both the transistor **48** and resistor **30** turn back on again after an interval determined by the time constant of the capacitor **46** and resistor **50**.

A capacitor **54** connects the collector electrode of the transistor **36** to ground potential. The capacitor **54** in combination with the resistor **42** provides a relatively constant voltage source for the transistor **36** so that the timing pulse for the transistor **48** is more uniform under changing voltage conditions, such as occur in starting or due to a weak battery.

The circuit arrangement of FIGURE 2 is a modification of the above-described circuit of FIGURE 1 and differs only in the pulsing circuit for the transistor switch **30**. The same reference characters are used in FIGURE 2 to identify circuit components which are the same as in FIGURE 1. The circuit arrangement of FIGURE 2 has the advantage that it utilizes NPN transistors for all three stages.

In the arrangement of FIGURE 2, the collector of the transistor **36** is coupled through a capacitor **60** to the base of an NPN transistor **62**. The base of the transistor **62** is also connected through a biasing resistor **64** to the positive terminal of the battery. The collector of the transistor **62** is connected through a load resistor **66** to the positive terminal of the battery. Both the emitter of the transistor **36** and the emitter of the transistor **30** are directly connected to the tap **16** on the primary of the transformer **10**. The base of the transistor **62** is connected to the collector of the transistor **30** through a diode **70** and the zener diode **72**.

In operation, when the circuit breaker points **34** open, the transistor **36** is turned on producing a negative pulse at the base of the transistor **62**. This pulse momentarily turns off the transistor **62** and turns off the switching transistor **30**.

As pointed out above, as the capacitor **20** charges, the tap **16** on the primary of the transformer **10** goes below ground. Although the voltage on the base of the transistor **62** tends to rise as the capacitor **60** discharges through the resistor **64**, the fact that the emitter of the transistor **36** is dropping below ground results in the transistor **62** being held nonconductive for a period of time that ensures that the transistor **30** is not prematurely turned on before the pulsing circuit can completely cycle. The zener diode limits the voltage to which the capacitor **20** charges regardless of changes in the supply voltage. When the potential at the collector rises in relation to the potential at the base of transistor **62** to the breakdown potential of the zener diode, the transistor **62** is turned on sooner and the charging action interrupted. The diode **70** blocks reverse current flow from the base of the transistor **62** through the zener diode in the forward direction.

The zener diode is important in that it permits effective operation of the circuit over a wide range of supply voltage, e.g., six volts when starting to as high as 15 volts when the car generator is charging at a high rate. It eliminates the need for the bypass switch starting arrangement described in connection with FIGURE 1 and at the same time protects against an over voltage condition.

From the above description, it will be recognized that a high voltage ignition circuit is provided in which a comparatively low current flows through the transformer more or less constantly and is interrupted only momentarily to charge the storage capacitor **20**. This circuit is designed to provide an interruption period of approximately two hundred microseconds. When the current begins to flow again with the turning on of the transistor **30**, a new charging cycle for the inductance **22** commences. This short interruption makes possible the use of a charging choke drawing substantially less current than that required for the conventional ignition coil. By having a separate inductance, an optimum charging choke design can be achieved without the necessity of compromise in favor of high voltage considerations, as is required where the inductance is part of the high voltage coil.

It is also important that when the transistor **30** again turns on and pulses the transformer, the resulting high voltage pulse is concurrent with the beginning of the recharging cycle of the inductance **22**. Thus the charging cycle for the inductance does not have to be suspended until the high voltage output oscillations have subsided as in the conventional type of ignition system.

In recent developments of coils for transistorized systems, it has been found necessary to use high current drain primary coils as a measure to reduce working voltages and still retain good high speed characteristics. This is not necessary with the present invention because of the substantially greater "on" time available to charge the inductance **22**. As a result, a lower charging current is required than in conventional ignition systems.

The fact that the present circuit requires a comparatively small primary and no cooling for the coil makes possible the design of a very compact transformer unit which may be connected directly to the center lead of a conventional distributor cap. The result is a more compact design than it is now possible to achieve with conventional high voltage coils.

What is claimed is:

1. An internal combustion ignition circuit controlled in response to the opening and closing of a switch for generating a high voltage pulse from a standard battery source, said circuit comprising a transformer having a saturable core and primary and secondarly windings, the secondary having a large number of turns in relation to the primary, the primary having an intermediate tap, one end of the primary and secondary windings being connected to one side of the battery source, a capacitor and inductor connected in series between the other end of the primary and the other side of the battery source with the capacitor being connected between said other end of the primary winding and the inductor, normally closed switch means connecting the series connection point between the inductor and capacitor to said tap, and means for momentarily opening the switch means to start the generation of a high voltage on the secondary.

2. An ignition circuit for generating a high voltage from a low voltage direct current source comprising a transformer having a primary winding and a secondary winding having a large number of turns in relation to the primary, means including an inductance and capacitance connecting the primary across said source, the inductance and capacitance being in series circuit with the primary across the source, and a normally closed switch connecting the junction between the inductance and capacitance to an intermediate tap on the primary, the switch being opened momentarily to initiate the generation of high voltage oscillations at the output of the secondary.

3. An ignition circuit for generating high voltage oscillations from a low voltage direct current source in response to the opening of a switch, comprising an output transformer having a primary and a high voltage

secondary, a capacitor and inductor connecting in series between one end of the primary and one end of the source, the other end of the primary being connected to the other end of the source, a first transistor having its emitter-collector circuit connected between a tap on the transformer primary and the common connection between the inductor and capacitor, a resistor connecting the base of the first transistor to the emitter, a second transistor having its emitter-collector circuit connected between the base and one terminal of the source so as to form a biasing current through said resistor when the second transistor is conducting in a direction to turn on the first transistor, and means including a third transistor responsive to the opening of said switch for turning off the second transistor for a predetermined time interval.

4. Apparatus as defined in claim 3 wherein said last-named means further includes a resistance-capacitance differentiating circuit coupled to the base of the second transistor to control said time interval.

5. Apparatus as defined in claim 3 wherein all three transistors are of the same conductive type and the emitter of the first and third transistors are connected to the tap on the transformer primary.

6. Apparatus as defined in claim 5 further including a zener diode connected between the collector of the first transistor and the base of the second transistor.

7. An ignition circuit for generating a high voltage signal from a low voltage direct current source comprising first, second and third transistors of the same conductive type, each transistor having a base, an emitter and a collector electrode, an output transformer having a tapped primary and high voltage secondary, a storage capacitor connected in series with one end of the primary, an inductor connected between the capacitor and one

side of the source, the other side of the source being connected to the opposite end of the primary, the emitters of the first and third transistors being connected to the tap on the primary, the collector of the third transistor being connected to the common junction between the capacitor and inductor, a bias resistor connecting between the base and emitter of the third transistor, a first load resistor connects between the collector of the first transistor and said one side of the source, a second load resistor connected between the collector of the second transistor and said one side of the source, a capacitor connected between the collector of the first transistor and the base of the second transistor, a bias resistor connected between the base of the second transistor and said one side of the source, the emitter of the second transistor being connected to the base of the third transistor, and means coupled to the base of the first transistor for turning the first transistor off and on.

8. Apparatus as defined in claim 7 further including a zener diode connected between the collector of the first transistor and the base of the second transistor and a diode in series with the zener diode connected to block current flow through the zener diode in the forward direction.

References Cited by the Examiner

UNITED STATES PATENTS

2,898,392	8/1959	Jaeschke.	
3,078,391	2/1963	Bunodiere et al.	
3,131,327	4/1964	Quinn	123—148 X
3,169,212	2/1965	Walters.	

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