

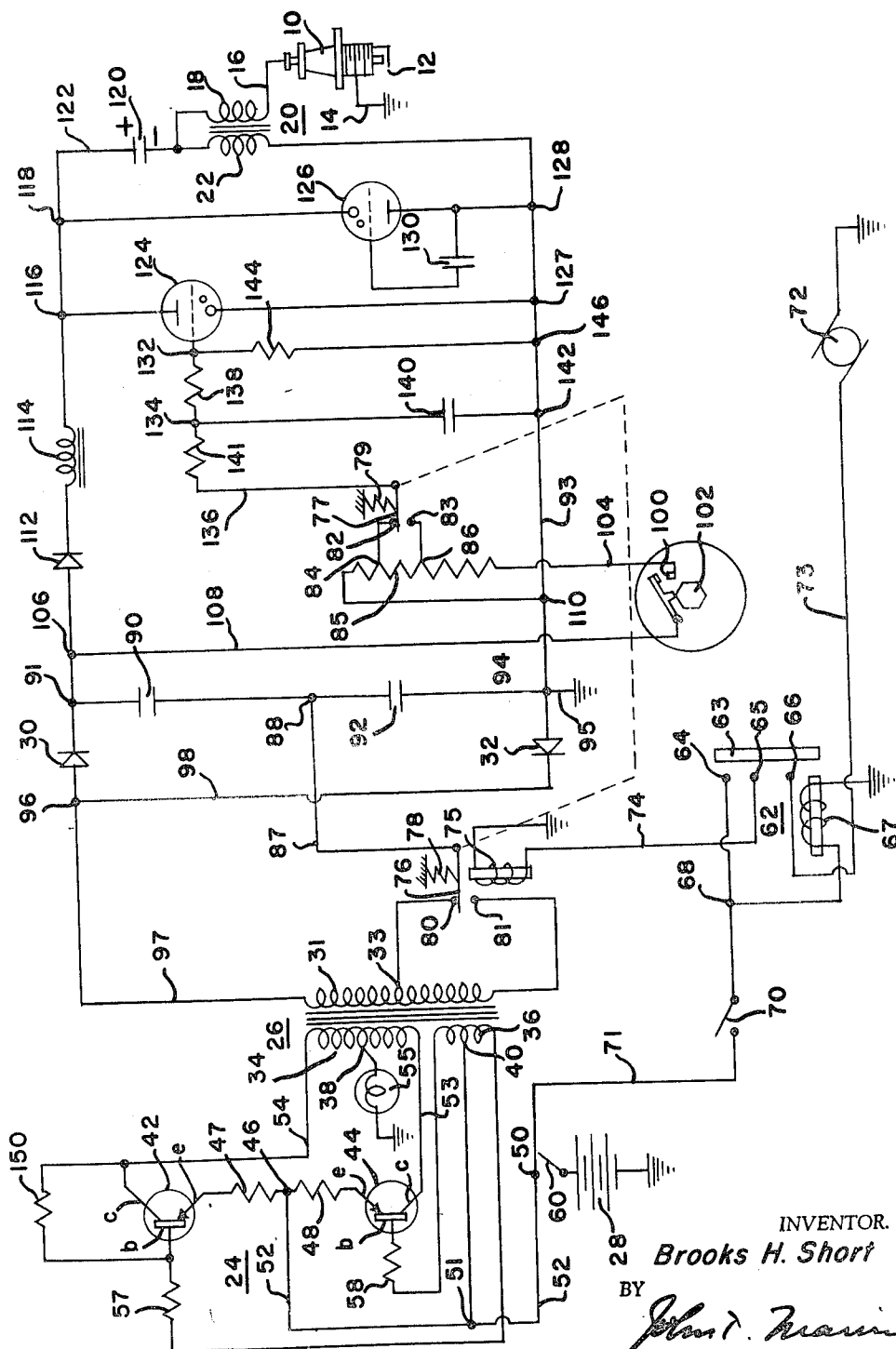
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IGNITION SYSTEM

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1

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IGNITION SYSTEM

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This invention relates to electronic ignition systems and more particularly to electronic systems wherein a shower of sparks is caused to fire the combustible mixture of an internal combustion engine. By a shower of sparks, it is meant that the system supplies power pulses to fire the spark plugs at a periodic rate and for predetermined durations of time.

It is an object of this invention to provide an electronic ignition system wherein a spark plug supplies a shower of sparks and wherein the system includes means for timing the rate and duration of the shower of sparks or periodically varying voltage.

It is another object of this invention to provide an electronic ignition system wherein the firing of a spark plug is controlled by a relaxation oscillator circuit.

Still another object of this invention is to provide an electronic ignition system that has means for supplying power pulses at a rapid rate across the spark gap of a spark plug and wherein the power supply for supplying power to the spark plugs is a transistor oscillator.

Still another object of this invention is to provide an electronic ignition system wherein power pulses are applied across the spark gap of a spark plug at a rapid rate and wherein the power supply for supplying power to these spark plugs includes an oscillator circuit and one or more p-n junction diodes for converting the A.C. output voltage of the oscillator circuit into direct current.

Still another object of this invention is to provide an electronic ignition system of the type described wherein the power for firing the spark plugs is generated by a transistor oscillator circuit that has its output voltage stepped up by a transformer and wherein the secondary winding of the transformer is connected with one or more p-n junction diodes that convert the A.C. voltage to D.C. voltage.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred embodiment of the present invention is clearly shown.

The single sheet drawing is a circuit diagram of an electronic ignition system made in accordance with this invention. Referring now to the drawing, a spark plug generally designated by reference numeral 10 and having a spark gap 12 is shown connected to be energized by the electronic ignition system of this invention. One of the terminals of the spark plug is connected to ground via lead 14 and the other terminal is connected with a lead 16. The lead 16 is connected to the secondary winding 18 of a high frequency ignition coil designated in its entirety by reference numeral 20 and having a primary winding 22. It will be appreciated that more than one spark plug will be used in most internal combustion engines and that the secondary winding 18 of the ignition coil will be connected to a plurality of spark plugs through a conventional distributor mechanism not shown.

The power supply for the electronic ignition circuit

2

of this invention includes a transistor oscillator circuit generally designated by reference numeral 24, an iron core transformer generally designated by reference numeral 26, a storage battery 28 and a pair of p-n junction diodes designated respectively by reference numerals 30 and 32. The p-n junction diodes 30 and 32 are preferably of the silicon type commonly referred to in the art as silicon diodes and have a very low voltage drop when conducting current in a forward direction. Because of this characteristic, peculiar to this type of diode, it is ideally suited for use with the electronic ignition system as will become more readily apparent hereinafter.

The transformer 26 has a secondary winding 31 which is tapped at 33 and has a primary winding 34 and a tertiary winding 36. The primary winding 34 is center tapped at 38 whereas the tertiary winding is center tapped at 40. The transistor oscillator circuit 24 includes a pair of PNP transistors 42 and 44, each having a base electrode *b*, an emitter electrode *e* and a collector electrode *c*. The emitter electrodes are both connected with junction 46 through resistors 47 and 48. The junction 46 is connected with junctions 50 and 51 via a lead 52. The junction 51 is connected with the center tap 40 of tertiary winding 36 as is clearly shown on the drawing. The collector electrodes of transistors 42 and 44 are connected with opposite ends of primary winding 34 via leads 54 and 53. The center tap 38 of primary winding 34 is connected directly to ground through ballast tube 55. The base electrodes of transistors 42 and 44 are connected to opposite ends of tertiary winding 36 through resistors 57 and 58. The terminal 50 which is connected with lead 52 is connected to one side of storage battery 28 through an ignition switch 60. The opposite side of the storage battery is connected directly to ground as shown.

The present circuit includes means for compensating for the drop in voltage that occurs when the starting motor is energized to crank the engine. To this end, a relay generally designated by reference numeral 62 is provided, which has a movable contactor 63 and fixed contacts 64, 65 and 66. The movable contactor 63 is normally out of engagement with the fixed contacts but shorts these fixed contacts together whenever the actuating coil 67 of the relay is energized. The actuating coil is connected between junction 68 and ground. The junction 68 is connected with junction 50 through a starting switch 70 and lead 71.

The fixed contact 66 of relay 62 is connected to one side of a conventional electrical starting motor 72 through a lead 73. The opposite side of the starting motor is connected directly to ground as shown. The fixed contact 64 of relay 62 is connected to junction 68 whereas the fixed contact 65 of relay 62 is connected with a lead 74.

The lead 74 is connected to one side of an actuating coil 75 that controls the operation of a pair of movable armatures 76 and 77. The armatures 76 and 77 are normally held in the positions shown in the drawing by springs 78 and 79. The armature 76 cooperates with fixed contacts 80 and 81 whereas the armature 77 cooperates with fixed contacts 82 and 83. The contact 80 is connected to the center tap of secondary winding 31 whereas the contact 81 is connected to one side of the secondary winding 31. The contact 82 is connected with a tap point 84 on a voltage dividing resistor 85 whereas the contact 83 is connected with a second tap point 86 on the voltage dividing resistor 85. It thus will be readily apparent that when the actuating coil 75 is energized, the armature 76 is moved to engage switch contact 81 and the armature 77 is moved to engage switch contact 83. When the actuating coil 75 is deenergized, the armatures are held by springs 78 and 79 in their position

3

shown in the drawing. It also will be apparent from an inspection of the drawing that the relay actuating coil 75 is connected between the lead 74 and ground.

The armature 76 is connected with a lead 87 which is in turn connected with junction 88. The junction 88 is connected to one side of condensers 90 and 92, the opposite side of condenser 90 being connected with junction 91 and the opposite side of condenser 92 being connected with lead 93 at junction 94. The lead 93 is connected directly to ground by a lead 95. One side of the secondary winding 31 of transformer 26 is connected with junction 96 via a lead 97 whereas the opposite side of the secondary winding as has been previously described is connected with switch contact 81. The junction 96 is connected to one side of silicon diode 32 via a lead 98.

The ignition system includes a pair of breaker contacts 100 which are opened and closed in synchronism with the operation of the internal combustion engine of a motor vehicle. The breaker contacts are opened and closed by a cam 102 which is driven in synchronism with the engine. One side of the breaker contacts 100 are connected to one side of voltage divider resistor 85 via a lead 104. The opposite side of the breaker contacts 100 are connected with junction 106 via a lead 108. One side of voltage dividing resistor 85 is connected with lead 93 at junction 110.

A p-n junction diode of the silicon type 112 is connected between junction 106 and an inductance 114. The opposite side of inductance 114 is connected with junctions 116 and 118 and is also connected to one side of a condenser 120 via lead 122. The junction 116 is connected to the plate of a cold cathode gas filled thyatron tube 124 whereas the junction 118 is connected with the cathode of cold cathode gas filled thyatron tube 126. The cathode of tube 124 is connected with lead 93 at junction 127 whereas the plate of tube 126 is connected with lead 93 at junction 128. The grid and plate of tube 126 are connected together by a condenser 130. The grid of tube 124 is connected with a junction 132 and is also connected with junction 134 and lead 136. A resistor 138 is connected between junctions 132 and 134 and a second resistor 141 is connected between 134 and lead 136. The lead 136 is connected with the armature 77 that is controlled by actuating coil 75. A condenser 140 is connected between junction 134 and junction 142 and a resistor 144 is connected between junction 132 and junction 146.

In operation, when it is desired to start the internal combustion engine, the switches 60 and 70 are closed. The closure of switch 70 completes a circuit from the battery through relay coil 67 to ground to cause the shorting together of contacts 64, 65 and 66. With the shorting together of these contacts, the starting motor 72 is energized from contact 66 and the actuating coil 75 is energized from contact 65. The starting motor will then crank the engine until it is started and during this time the armature 76 will engage contact 81 whereas the armature 77 will engage contact 83. During cranking, the voltage applied from the storage battery will drop and the movement of armatures 76 and 77 compensates for this drop by placing the entire secondary winding 31 across junctions 91 and 88 and by placing a greater part of the potentiometer 85 across lead 136 and junction 110. The voltage that is lost due to cranking of the starting motor will thus be compensated for in the ignition circuit by energization of relay coil 75 during the time that the engine is being cranked. After the engine starts, the switch 70 will be opened and armatures 76 and 77 will move back to their positions illustrated in the drawing as at this time, compensation is no longer needed.

Both during cranking and running, the ignition switch 60 is, of course, closed and this switch applies power from the battery through the emitter resistor 150 of tran-

4

sistor 42 to the base of this transistor and from the emitter to collector of this transistor. The current in transistor 42 will then flow from emitter to collector and through one half of the primary winding 34 of transformer 26 and thence through ballast tube 55 to ground. This current flowing through one half of the primary winding allows flux to be set up in the core of the transformer. This current grows at a rate determined by the total circuit resistance and the self-inductance of one half of the primary winding. The flux in the core is accompanied by the corresponding voltage in the tertiary winding 36 of the transformer. This voltage causes the transistor 42 that was conducting to be turned off and turns on the transistor 44. When the transistor 44 has been rendered conducting, current is allowed to flow through its half of the primary winding 34. The build up of current and voltage is again a time function of the same circuit parameters, resistance and coil primary inductance. When the current on the second side of primary winding 34 has reached a predetermined value, the tertiary winding shuts off the transistor 44 and brings the transistor 42 into conduction again. In this way, the transistor oscillator circuit operates as a self-excited generator of alternating current which is applied to the primary winding 34 and which is stepped up to a higher value by the transformer 26. The higher value of voltage appears across the secondary winding 31 of the transformer. The oscillator circuit may be termed as a transistor oscillator flip-flop circuit in that the transistors are rendered conducting at different times.

Assuming that the engine is running, the voltage appearing between the center tap 33 of secondary winding and lead 97 is applied to a voltage doubler circuit that includes diodes 30 and 32 and condensers 90 and 92. The p-n junction diodes 30 and 32 rectify the A.C. voltage to D.C. voltage which appears between junction 91 and junction 94. The A.C. voltage generated by the transistor oscillator flip-flop circuit may have a frequency in the neighborhood of 20,000 cycles per second.

The D.C. voltage appearing between junctions 91 and 94 is used to fire the spark plug 10. When the breaker points 100 are closed, the condenser 120 is charged to the polarity indicated on the drawing through silicon diode 112 and inductance 114. At the same time, the condenser 140 is charged through the resistor 141. The voltage on the capacitor 140 will grow according to an exponential curve as is well known to those skilled in the art. It is apparent that the time will come when the voltage on the capacitor 140 will be great enough to ionize the tube 124. This ionization is accompanied by a flow of current from capacitor 140 through resistor 138 from the grid of the tube 124 to the cathode and back to the other side of condenser 140. Ionization of the tube in this manner causes the main condenser 120 to discharge from the plate of the thyatron tube 124, to the cathode, to ground and back through the primary 22 of the high frequency transformer 20 to the negative end of condenser 120. When all of the energy of condenser 140 has been used up, the ionization potential on the grid of the tube 124 disappears and the thyatron tube becomes non-conducting. At this time, condenser 140 proceeds to become charged again from the power source of the voltage divider 85 through its charging resistor 141. In this way, the resistor 141, the condenser 140 and the grid cathode elements of the thyatron tube 124 constitute a relaxation oscillator circuit whose frequency is determined by the resistor 141 and the capacitance of condenser 140. These timed pulses of grid excitation continue as long as the breaker contacts 100 are closed. When the distributor contacts are open, no voltage is supplied and so no relaxation can occur. It will be apparent from the foregoing that the spark plug 10 will be fired at a periodic rate as long as the breaker contacts 100 are closed and for a time duration equal to the time that the breaker contacts are closed.

The tube 126 may be considered a reverse tube as it drains off the residual charge that is accumulated by the condenser 120 when it discharges. Thus, as condenser 120 discharges, a charge is built up on the condenser with such a polarity that is opposite to that shown in the drawing. This charge is drained off by the tube 126 which prevents current flow therethrough when the condenser is charged to the polarity shown in the drawing but which permits current flow therethrough when the condenser is charged to an opposite polarity.

The electronic ignition circuit just described has several advantages over circuits heretofore known. One of these advantages is derived from the use of p-n junction diodes as part of the voltage doubler circuit. These diodes have a very low voltage drop when conducting current in a forward direction and greatly increase the efficiency of the electronic ignition circuit. The transistor oscillator circuit has a great advantage over other power supplies heretofore known in that it may be directly energized from the relative low voltage of the storage battery which is 12 volts in most motor vehicle systems and has the further advantage that no vibrating contacts are present which deteriorate quite rapidly. By employing a transistor oscillator with this ignition system, both the efficiency and the expected life of the circuit is thus greatly increased. An additional advantage realized by the use of the transistor oscillator circuit is that comparatively high frequencies may be generated which greatly reduce the size of the transformer 26.

While the embodiment of the present invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. An electronic ignition system for firing the combustible mixture of an internal combustion engine comprising, a source of direct current power, an ignition coil having a primary winding and a secondary winding, a spark plug connected with said secondary winding, a first condenser, a charging circuit for said first condenser connected across said direct current power source and including the primary winding of said ignition coil, a three terminal electronic switch having a control terminal and a pair of current carrying terminals, a discharging circuit for said first condenser including the current carrying terminals of said electronic switch and the primary winding of said ignition coil, a third circuit including a second condenser, breaker contacts opened and closed in synchronism with operation of said engine, means connecting said breaker contacts with said power source and with said third circuit for controlling application of power to said third circuit, and means connecting said third circuit with the control terminal and one of the current carrying terminals of said electronic switch whereby said

second condenser charges from said source and discharges through said electronic switch at a repetitive rate as long as said breaker contacts are closed, said first condenser charging from said source and discharging through the primary winding of said ignition coil during the closure of the breaker contacts.

2. An electronic ignition system for firing the combustible mixture of an internal combustion engine comprising, a source of direct current power, a spark plug, a first condenser, means connecting said first condenser and said power source whereby said first condenser is charged by said power source, a three terminal electronic switch having a control terminal and a pair of current carrying terminals, a discharging circuit for said first condenser energizing said spark plug including the current carrying terminals of said electronic switch, a further circuit including a second condenser, breaker contacts opened and closed in synchronism with operation of said engine, means connecting said breaker contacts with said power source and with said further circuit for controlling application of power to said further circuit, and means connecting said further circuit with the control terminal and one of the current carrying terminals of said electronic switch whereby said second condenser charges from said source and discharges through said electronic switch at a repetitive rate as long as said breaker contacts are closed, said first condenser being charged by said source and discharged when said electronic switch is conducting.

3. The system according to claim 2 wherein the power source is comprised of a transistor oscillator circuit fed from a battery.

4. The system according to claim 2 wherein the power source is comprised of a transistor oscillator connected with a PN junction semiconductor rectifier and wherein the oscillator is fed from a battery.

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