

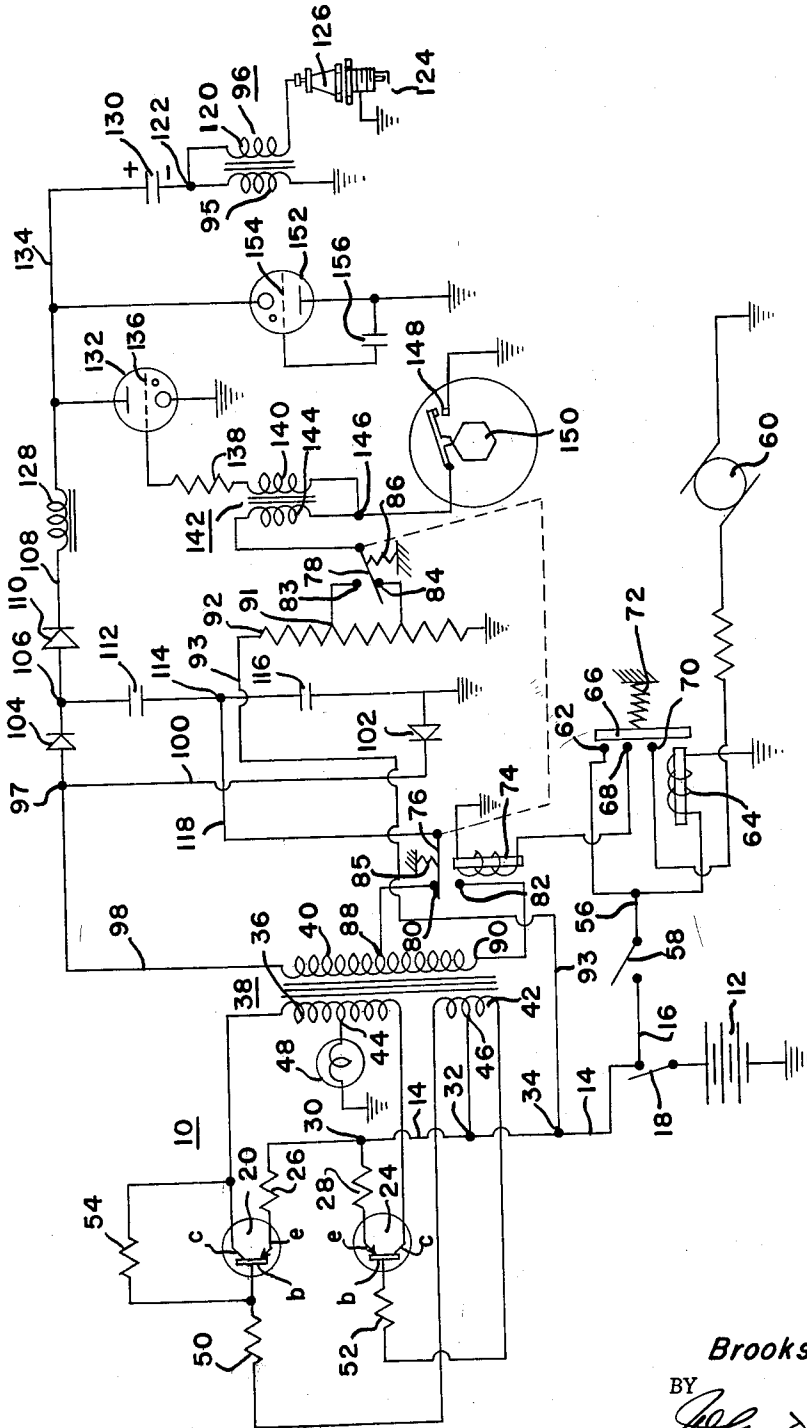
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ELECTRONIC IGNITION

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ELECTRONIC IGNITION

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This invention relates to electronic ignition systems and is an improvement of the circuit disclosed and claimed in application S.N. 561,487, filed January 26, 1956, and now Patent 2,846,992.

In the above-mentioned patent, an electronic ignition system is disclosed and claimed which includes an electronic switch connected in circuit with the primary winding of an ignition coil. The power supply of the system includes a plurality of cold cathode tubes and a vibrator.

Although the circuit of the above-mentioned patent has worked well, it has been found that the expected life of this circuit is limited because of the limited life of the cold cathode tubes and the vibrator. The life of the cold cathode tubes are limited because every time the tube conducts, a pulse of current flows and some of the active material is pulled out of the cathode. The vibrator has a limited life because it usually has at least two sets of moving contacts that are subject to destruction by arcing and mechanical forces.

In contrast to the above-described electronic ignition circuit, it is an object of this invention to provide an electronic ignition circuit that has a longer expected life and which is more efficient in operation than the circuit of the above-mentioned patent and any other heretofore known electronic ignition circuits.

A more specific object of this invention is to provide an electronic ignition system that includes an electronic switch for controlling current flow through the primary winding of an ignition coil and wherein the power supplied to the primary winding is derived from a circuit that includes a transistor oscillator and a plurality of p-n junction semi-conductor rectifiers. By employing the transistor oscillator, the subject vibrator contacts are eliminated, thus greatly prolonging the expected life of the circuit. The use of p-n junction diodes such as silicon diodes also greatly prolongs the expected life of the ignition circuit as these diodes have very nearly an unlimited expected life. These diodes also increase the efficiency of the ignition circuit as the voltage drop across this type of diode in the current carrying direction is much less than that of a tube.

Another object of this invention is to provide an electronic ignition circuit that includes a transistor oscillator and a transformer connected therewith for supplying power to the ignition circuit. The transistor oscillator has the great advantage of operating at a high frequency as compared to vibrators thus reducing the size of transformer required.

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

In the drawings:

The single figure drawing illustrates an electronic ignition circuit made in accordance with this invention. Referring now to the drawing, it is seen that the power

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supply for the ignition circuit includes a transistor oscillator circuit generally designated by reference numeral 10 and a storage battery 12. The storage battery in most passenger car systems will be of twelve volts although it is apparent that this voltage will vary with different types of motor vehicle equipment. One side of the battery 12 is connected directly to ground as shown whereas the opposite side thereof is connected with leads 14 and 16 through an ignition switch 18.

The transistor oscillator circuit includes a pair of PNP transistors 20 and 24, each having an emitter electrode *e*, a base electrode *b* and a collector electrode *c*. The emitter electrodes of the transistors are connected respectively with resistors 26 and 28 and the opposite ends of these resistors are connected to a junction 30. The junction 30 is connected to a junction 32. The junction 32 is connected with lead 14 which forms a common connection for junctions 30, 32 and 34. The collector electrodes of transistors 20 and 24 are connected with opposite sides of the primary winding 36 of a transformer that is generally designated by reference numeral 38. It is seen that the transformer has a secondary winding 40 and a tertiary winding 42. The secondary winding has a greater number of turns than the primary to provide a transformer that steps up the voltage from a primary to secondary. The primary winding has a center tap 44 whereas the tertiary winding has a center tap 46. The center tap 44 of primary winding 36 is connected directly to ground through a ballast tube 48, whereas the center tap 46 of tertiary winding 42 is connected with junction 32. It is thus seen that the center tap of tertiary winding 42 is connected with the emitter electrodes of transistors 20 and 24 through resistors 26 and 28. The base electrodes of transistors 20 and 24 are connected with opposite sides of tertiary winding 42 through resistors 50 and 52. A resistor 54 is connected across the base and collector electrodes of transistor 20.

The lead 16 that is connected to one side of ignition switch 18 is connected with a junction 56 through a starter switch 58 that controls energization of a starting motor designated by reference numeral 60. The starting motor, as is well known to those skilled in the art, is used to crank the engine during the time that it is desired to start the engine. The junction 56 is connected with a relay switch terminal 62 and is connected to one side of a relay actuating coil 64. The opposite side of the actuating coil is connected directly to ground as shown. The actuating coil 64 magnetically pulls the switch contactor 66 into engagement with switch contactors 62, 68 and 70 against the bias of spring 72 whenever the actuating coil 64 is energized. The switch contact 70 is connected to one side of starting motor 60 whereas the opposite side of the starting motor is connected directly to ground as shown. The switch contact 68 is connected to one side of a relay actuating coil 74 that magnetically controls the movement of a relay armature designated by reference numeral 76. The opposite side of actuating coil 74 is connected directly to ground and this relay also magnetically operates armature 78 whenever the coil 74 is energized. The armature 78 cooperates with switch contacts 83 and 84. The armature 76 is normally held in contact with switch contact 80 by a spring 85 whereas the armature 78 is normally held in engagement with switch contact 84 by a spring 86. It thus will be apparent that whenever the actuating coil 74 is energized, the armatures 76 and 78 will be moved to engage respectively switch contacts 82 and 83. When a coil winding 74 is not energized, the relay armatures remain in the positions shown in the drawing.

The relay contact 80 is connected to a center tap 88

of secondary winding 40 whereas the relay contact 82 is connected to one side 90 of secondary winding 40. The relay contact 83 is connected to a tap point 91 located intermediate the ends of a resistor 92 that is connected between lead 93 and ground. The relay contact 84 is connected between lead 93 and ground. The relay contact 84 is connected to a second tap point on resistor 92 as shown.

The output of the energizing circuit for energizing the primary winding 95 of the ignition coil 96 is fed from the secondary winding 40 of the transformer. Thus, one side of the transformer secondary 40 is connected with a junction 97 through a lead 98. The junction 97 is connected with a lead 100 which is, in turn, connected to one side of a p-n junction semiconductor diode 102 which is, in this case, a silicon diode. The silicon diode is, as is well known to those skilled in the art, formed primarily of silicon material and has a junction formed of p and n type material. This diode is sometimes termed as a p-n junction diode or as a silicon junction diode. This type of diode has a very low voltage drop when conducting current in the forward direction and this voltage drop remains substantially constant with changes in current flow therethrough. The junction 97 is connected with a second silicon diode 104 and the opposite side of this diode is connected with a junction 106. The junction 106 is connected with lead 108 through a third silicon diode 110 poled in such a direction as to prevent current flow toward junction 106. The junction 106 is also connected with a condenser 112, the opposite side of which is connected with junction 114. A condenser 116 is connected between junction 114 and ground as shown and this condenser is also connected to one side of silicon diode 102. The junction 114 is connected with the relay armature 76 by means of a lead 118. It will be appreciated that the silicon diodes 104 and 102, together with the condensers 112 and 116 form a rectifying voltage doubler circuit which is connected between one side of transformer secondary 40 and center tap 88 whenever the relay armature 76 is in the position contacting switch contact 80. It will also be apparent that the voltage developed by this voltage doubler circuit from the transistor oscillator 10 appears between lead 108 and ground and thus is available for supplying current to the primary winding 95 of ignition coil 96. The ignition coil 96 has a secondary winding 120 which is connected between junction 122 and spark gap 124 of spark plug 126.

The circuit for controlling the application of current to the primary winding 95 of ignition coil 96 includes and inductance 128 and a condenser 130. It is seen that the inductance 128 and condenser 130 are connected in series between lead 108 and ignition coil 95. Since one side of the ignition coil 95 is grounded as shown, the inductance, condenser and primary winding of the ignition coil are connected in series between lead 108 and ground. A gas filled thyatron tube designated by reference numeral 132 is connected between lead 134 and ground. The grid 136 of thyatron tube 132 is connected with a resistor 138 and with the secondary winding 140 of a transformer generally designated by reference numeral 142. The primary winding 144 of the transformer is connected with junction 146 and with the relay armature 78. The junction 146 is connected to ground through a set of breaker contacts 148 which are opened and closed by a cam 150 that is driven in synchronism with the engine of the motor vehicle as is well known to those skilled in the art. A second gas filled thyatron tube 152 having a grid 154 is connected between lead 134 and ground. A condenser 156 is connected between the grid of tube 152 and ground.

In operation, when it is desired to start the motor vehicle engine, the switches 18 and 58 are closed to energize both the ignition circuit and the starting motor circuit. The closure of switch 58 completes a circuit to ground for relay coil 64, thus shorting together contacts

62, 68 and 70 by the movement of switch contactor 66. With these contacts shorted, a circuit is complete for the starting motor 60 to ground through switch contacts 62 and 70. In addition, the relay coil 74 is energized through switch contacts 62 and 68 to move the armatures 76 and 78 to positions contacting respectively switch contacts 82 and 83. The movement of relay armatures 76 and 78 from their normal positions applies a greater potential developed across a portion of resistor 92 to the primary winding of transformer 142, and also applies the voltage developed by the entire secondary winding 40 to the ignition circuit. This arrangement is desirable since the output voltage of storage battery 12 will drop when the starting motor load is connected thereto and the movement of armatures 76 and 78 thus compensate for this drop in voltage by applying greater voltages to the ignition circuit.

The closure of ignition switch 18 connects one side of battery 12 with the emitter electrodes of transistors 20 and 24 through resistors 26 and 28. When this occurs, the transistor 20 will begin to conduct current from emitter to collector. This current will pass from battery 12 through lead 14, through the emitter to collector circuit of transistor 20, through a portion of the primary winding 36 and thence through ballast tube 48 to ground. The current flowing through one half of the primary winding allows flux to be built up into the core of transformer 38. This current grows at a rate determined by the total circuit resistance and self-inductance of one half of the primary winding. The flux in the core of transformer 38 is accompanied by a corresponding voltage in the tertiary winding 42 of the transformer. This voltage causes the transistor 20 that was conducting to be turned off and turns on the transistor 24. When the transistor 24 has been rendered conducting, current is allowed to flow through its half of primary winding 36. 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 the primary winding 36 has reached a predetermined value, the tertiary winding shuts off the transistor 24 and brings the transistor 20 into conduction again. In this way, the transistor oscillator operates as a self-excited generator of alternating current which may have a frequency in a neighborhood of 20,000 cycles per second.

The voltage applied to the ignition circuit will either be the voltage appearing across the entire secondary winding 40 which occurs during starting of the engine or will be the voltage appearing across the tap point 88 and one side of the secondary winding 40 during the time that the engine is running and when the starting motor is not energized. In either case, the A.C. voltage is rectified by silicon diodes 104 and 102 and thus appears as direct current voltage between lead 108 and ground.

The D.C. voltage appearing between lead 108 and ground is operative to force current through inductance 128, condenser 130 and through primary winding 95 of the ignition coil to ground. The condenser 130 will thus build up a charge of the polarity indicated in the drawing. During the time that the breaker contacts 148 were closed, current is permitted to flow through the primary winding 144 of the transformer 142 via a circuit that may be traced from junction 34 through lead 93 through all or a part of resistor 92, through armature 78 and thence through the primary winding 144 to ground, through breaker contacts 148.

When the breaker contacts 148 open, a high voltage is induced in the secondary winding 140 of transformer 142 and this voltage is applied to the grid of tube 132 through resistor 138. This voltage is of such a polarity as to cause conduction of tube 132. With tube 132 conducting, the condenser 130 discharges through a circuit that includes tube 132 and primary winding 95. The discharging of condenser 130 through primary winding 95 causes a high voltage to be developed in secondary

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winding 120 which is applied across spark gap 124 to cause the firing of spark plug 126. The discharging circuit for the spark plug includes both the primary and secondary windings of the ignition coil 96. It will be appreciated, of course, that the secondary winding 120 will be connected with a plurality of spark plugs through a distributor mechanism not shown.

The tube 152 is used to drain off the residual charge that appears across condenser 130 after it discharges. Thus, after the condenser discharges, it builds up a small charge that is opposite in polarity to that indicated in the drawing and this charge is drained off by tube 152. It is noted that the tubes 132 and 152 conduct current in opposite directions between lead 134 and ground and, thus, the tube 152 is effective to drain off this residual charge but will not permit discharging of condenser 130 during the time that it has the polarity shown in the drawing.

While the embodiments of the present invention as herein disclosed constitute preferred forms, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. An ignition circuit for an internal combustion engine, comprising: a source of direct current voltage, an oscillator circuit including at least one transistor, means connecting said oscillator circuit with said voltage source to be energized thereby, a p-n junction semiconductor rectifier, means connecting the output terminals of said oscillator circuit with an ignition coil energizing circuit through said rectifier, an ignition coil having a primary winding and a secondary winding, means connecting the primary winding of said ignition coil in circuit with said energizing circuit, and means including an electronic switch for controlling the energization of the primary winding of said ignition coil from said energizing circuit.

2. An ignition circuit for an internal combustion engine, comprising: a source of direct current voltage, an oscillator circuit including a pair of transistors having output terminals and connected to be energized by said source of direct current voltage, an ignition coil energizing circuit, a voltage doubler circuit including a pair of condensers and a pair of p-n junction semiconductor diodes, means connecting the output terminals of said oscillator circuit with said energizing circuit through said

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voltage doubler circuit, an ignition coil having a primary winding and a secondary winding, a set of breaker contacts, electronic switch means, means connecting the primary winding of said ignition coil in circuit with said energizing circuit through a third p-n junction semiconductor diode, and means including said breaker contacts and electronic switch means for controlling the energization of the primary winding of said ignition coil from said energizing circuit.

3. An ignition circuit for an internal combustion engine, comprising: a source of direct current voltage, an oscillator circuit including at least one transistor, means connecting said oscillator circuit to be energized from said source of direct current voltage, an ignition coil energizing circuit, a p-n junction semiconductor rectifier, means connecting said energizing circuit with said oscillator circuit through said rectifier, an ignition coil having a primary winding and a secondary winding, means connecting the primary winding of said ignition coil to be energized by said ignition coil energizing circuit, and means for controlling the application of power to said primary winding from said ignition coil energizing circuit.

4. An ignition circuit for an internal combustion engine, comprising: a source of direct current voltage, an oscillator circuit including at least one transistor, means connecting said oscillator circuit to be energized from said source of direct current voltage, an ignition coil energizing circuit, a rectifier, means connecting said energizing circuit with said oscillator circuit through said rectifier, an ignition coil having a primary winding and a secondary winding, means connecting the primary winding of said ignition coil to be energized by said ignition coil energizing circuit, and means including a condenser and electronic switch means for controlling the application of power to said primary winding from said ignition coil energizing circuit.

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