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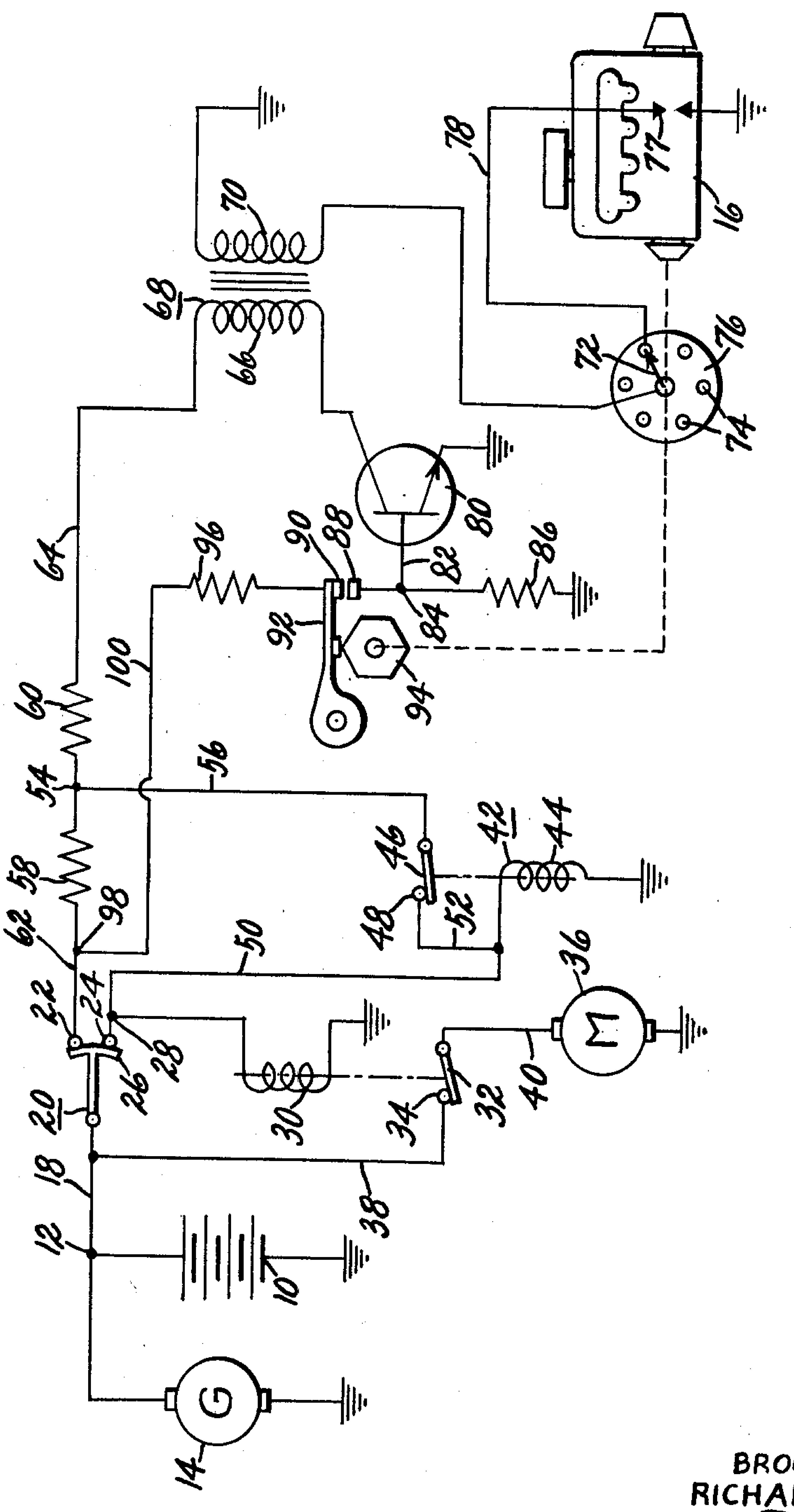

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TRANSISTOR IGNITION SYSTEM HAVING PRIMARY CIRCUIT RESISTANCE CONTROL

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This invention relates to ignition systems for internal combustion engines and more particularly to an ignition system wherein a transistor controls current flow through the primary circuit of the ignition system and wherein the resistance of the primary circuit is controlled as a function of system voltage.

It is well known that in motor vehicle electrical systems the system voltage which is available to supply the D.C. loads including the ignition system varies widely under different conditions of operation. Thus, during the time that the cranking motor is energized for cranking the engine, the system voltage drops and the extent of this drop varies in accordance with the temperature in which cranking occurs. In very cold weather the drop in voltage is higher than the drop in voltage that will occur during warm temperatures. As cranking is terminated, the system voltage rises and rises still further when the engine is running to drive the generator which then charges the battery and also supplies the D.C. loads of the motor vehicle including the ignition system.

In the past, it has sometimes been the practice to place a resistor in a primary circuit of the ignition system and this resistor is shorted out whenever the cranking motor is energized to therefore reduce the resistance of the primary circuit at a time when the system voltage is lowered. Typical systems of this type are shown in the patents to Redick 2,807,729, Leece 1,214,555, and Mallory 1,769,-150. Although, the above described system of these patents has been successful in conventional ignition systems it is apparent that they do not compensate for any other condition than the condition that the starting motor is being energized. Thus, the systems do not take into account the varying amount of voltage drop that will occur under different temperature conditions and under different conditions of charge of the battery. Where a transistor is used to control current flow in the primary circuit of an ignition system, the voltage applied to and the current flow through the transistor must be carefully controlled so that the transistor will not be overloaded and burned out.

It accordingly is an object of this invention to provide an ignition system wherein a transistor controls current flow in the primary circuit of the ignition system and wherein the resistance of the primary circuit is controlled as a function of system voltage.

Another object of this invention is to provide a transistor ignition system wherein a resistor is placed in the primary circuit of the ignition system and wherein this resistor is short circuited by a relay, the relay being an accurately calibrated relay which only operates when the system voltage rises above a predetermined value.

A further object of this invention is to provide an ignition system wherein a transistor controls current flow in the primary circuit of the ignition system and wherein means are provided for varying the resistance of the primary circuit in accordance with system voltage and when the cranking motor is being energized.

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.

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The single figure drawing is a schematic circuit illustration of an ignition system made in accordance with this invention.

Referring now to the drawing, the reference numeral **10** designates a storage battery in a motor vehicle electrical system. One side of this storage battery **10** is grounded whereas the opposite side of the battery is connected with a power terminal **12**. The system voltage of the motor vehicle electrical system will appear between junction **12** and ground and this voltage will vary under different conditions of operation. The battery **10** is charged from a generator **14** connected between ground and the power terminal **12**. The generator **14** can be a D.C. generator or could be an alternator fitted with rectifiers. Where a D.C. generator is used, a suitable cutout relay is connected between the junction **12** and one terminal side of the generator **14**. The generator **14** is driven by the internal combustion engine **16** of the motor vehicle.

The power terminal **12** is connected with a lead wire **18** and this lead wire is connected with a switch **20** having fixed contacts **22** and **24**. This switch includes a movable contactor **26** which is operable to connect contacts **22** and **24** with lead wire **18** in one position of the switch. In another position of the switch, the lead wire **18** is connected only with the contact **22** and in still another position of the switch, the lead wire **18** is disconnected from both contacts **22** and **24**. The switch **20** may be a key controlled switch which operates to energize the ignition system from contact **22** and the cranking motor from contact **24**.

The contact **24** is connected with a junction **28** and this junction is connected to relay coil **30** which operates a shiftable contactor **32**. The contactor **32** together with fixed contact **34** forms a switch for controlling the energization of a cranking motor **36**. The cranking motor **36** will crank the engine **16** whenever the contactor **32** engages the fixed contact **34**. The fixed contact **34** is connected with lead wire **18** via lead wire **38** and the contactor **32** is connected to one side of the starting motor **36** by lead wire **40**. In actual practice, the relay coil **30** may be a part of the cranking motor assembly and may also shift a pinion into engagement with the ring gear of the engine **16** in a manner well known to those skilled in the art. It is seen that when the shiftable contactor **26** connects lead wire **18** and junction **28**, the relay coil winding **30** is energized to cause the contactor **32** to shift into engagement with the fixed contact **34**, and therefore causes the starting motor **36** to be energized from lead wire **38**

The ignition system of this invention includes an accurately calibrated relay **42** which has a relay actuating coil **44** and a shiftable contactor **36** that at times engages the fixed contact **48**. The relay **42** is designed such that the contacts **46** and **48** are normally in engagement and will only separate when a voltage is impressed across the actuating coil **44** which is greater than a predetermined voltage. This voltage may be by way of example and not by way of limitation 9 volts in a 12 volt system.

The junction **28** is connected to one side of relay actuating coil **44** by a lead wire **50**. The fixed contact **48** of relay **42** is connected with lead wire **50** by the lead wire **52**. The movable contactor **46** of relay **42** is connected with junction **54** by a lead wire **56**. It is seen that the relay actuating coil **44** will be energized whenever the switch contactor **26** connects lead wire **18** and junction **28**. If the voltage appearing between junction **12** and ground is greater than 9 volts, the contacts **46** and **48** will then be separated. If this voltage is less than 9 volts, the contacts **46** and **48** remain engaged.

The junction **54** is connected between resistors **58** and **60**. The resistor **58** is connected with lead wire **62** whereas the resistor 60 is connected with lead wire 64. The lead wire 64 is connected with the primary winding 66 of an ignition transformer 68. The secondary winding 70 of the ignition transformer is connected with a rotor contact 72 that distributes current to fixed electrodes or contacts 74 in the distributor cap 76. The electrodes 74 feed the spark plug 77 of the engine 16 by means of lead wires 78. Only one lead wire 78 and one spark plug 77 is illustrated in the drawing but it will be apparent to those skilled in the art that there will be as many lead wires 78 as there are spark plugs 77 and that there will also be as many electrodes 74 as there are spark plugs. The rotor contact 72 is driven by the engine 16.

The ignition system includes an NPN transistor 80. The collector electrode of transistor 80 is connected with the primary winding 66 of ignition transformer 68. The emitter electrode of transistor 80 is grounded as shown. The base electrode of transistor 80 is connected with lead wire 82 which is in turn connected with junction 84. A resistor 86 is connected between junction 84 and ground.

The junction 84 is connected with a breaker contact 88 which becomes engaged and disengaged with the other breaker contact 90. The breaker contact 90 is carried by a breaker arm 92 which is moved by a breaker cam 94 driven in synchronism with the engine 16. As the breaker cam 94 rotates, the contacts 88 and 90 are opened and closed in a manner well known to those skilled in the art. The breaker contact 90 is connected with resistor 96 and the opposite side of this resistor is connected with junction 98 via the lead wire 100.

When the operator of a motor vehicle desires to start the engine 16, the switch contactor 26 is shifted to a position wherein it contacts both fixed contacts 22 and 24. In this position of the switch contactor 26, the coil 30 will be energized to cause the closure of contacts 32 and 34. With contacts 32 and 34 closed, the starting motor 36 is energized and cranking of the engine 16 will begin. As the engine 16 is being cranked, the breaker cam 94 causes the contacts 88 and 90 to open and close and also causes the rotor contact 72 to sweep by the fixed electrodes 74.

When contactor 26 engages the contact 24, a circuit is now completed for the relay actuating coil 44. If the voltage appearing between junction 12 and ground is greater than 9 volts, the contacts 46 and 48 will separate. Assuming however that this voltage has dropped below 9 volts, the relay contacts 46 and 48 remain engaged. The resistor 58 is therefore shorted out of the circuit by a circuit that may be traced from lead wire 18, through closed contacts 26 and 24, through lead wire 50, through lead wire 52, through closed contacts 46 and 48 and then through lead wire 56 to junction 54.

The primary circuit of the ignition system extends from junction 98 to ground and includes resistor 58, junction 54, resistor 60, primary winding 66 and the emitter-collector circuit of transistor 80. Since the system voltage has dropped below 9 volts, the resistor 58 is short circuited so the primary circuit is actually from junction 54, through resistor 60, through primary winding 66 and through the emitter-collector circuit of transistor 80. If it is assumed that breaker contacts 88 and 90 are closed, the transistor 80 will be conductive between its collector and emitter electrodes because at this time there is a path for base current that may be traced from junction 98, through lead wire 100, through resistor 96, through closed contacts 90 and 88, through lead wire 82 and then through the base to emitter junction of transistor 80. With transistor 80 now conductive between its collector and emitter electrodes, current flows through the primary winding 66 and flux is built up in the ignition transformer 68.

When breaker contacts 88 and 90 separate, there no longer is a base current path for transistor 80 and the emitter and base electrodes of transistor 80 are connected by resistor 86. This substantially equalizes the potential of the emitter and base electrodes of transistor 80 and causes the transistor 80 to be driven to a substantially fully nonconductive state between its collector and emitter electrodes. When this occurs, the primary current is interrupted and a large voltage is induced in the secondary winding 70 which is applied to the spark plug 77 via rotor 72, a fixed electrode 74 and the lead wire 78. The opening and closing of the contacts 90 and 88 cause the transistor 80 to switch on and off and cause ignition pulses to be applied to the spark plugs of the engine 16.

Once the engine 16 has been started, the operator shifts the contactor 26 so that it no longer engages fixed contact 24 but remains engaged with fixed contact 22. In this position of the switch contactor 26, the relay coil 44 can no longer be energized and there is no short circuiting of the resistor 58 since the circuit to lead wire 50 has now been opened. The engine then continues to operate with the breaker contacts 88 and 90 opening and closing to control the conductivity of the transistor 80.

If the system voltage between junction 12 and ground should remain above 9 volts when cranking of the engine 16 occurs, the relay coil 44 will cause the contacts 46 and 48 to be separated. The resistor 58 will then be in the primary circuit of the ignition system during cranking of the engine. It thus is seen that whether or not the resistor 58 is in the primary circuit depends on whether or not the system voltage is above or below 9 volts and also depends on whether or not the contactor 26 is in engagement with fixed contact 24. Under running conditions where the contactor 26 engages the fixed contact 22, the resistor 58 will always be in the primary circuit of the ignition system.

In the particular embodiment of FIGURE 1, the transistor 80 is shown controlled by breaker contacts 88 and 90. It is apparent to those skilled in the art that other means operated in synchronism with engine 16 might be used to control the conductivity of transistor 80 such as a device that generates pulses of voltage in synchronism with operation of the engine.

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 system for an internal combustion engine comprising, a source of direct current voltage, an ignition coil having a primary winding and a secondary winding, a resistor, a transistor having emitter, collector and base electrodes, a primary circuit for said ignition system energized from said voltage source including said resistor, said primary winding and the emitter-collector circuit of said transistor, means for causing the conductivity of said transistor to vary in its emitter-collector circuit in timed relationship with operation of said engine, a relay having an actuating coil and a pair of normally closed contacts, said contacts remaining closed when a voltage is impressed across said actuating coil which is below a predetermined value and opening when said voltage is above said predetermined value, a circuit for bypassing said resistor including the switch contacts of said relay, and means connecting said relay actuating coil across said source of direct current voltage.

2. In combination, a source of direct current voltage, an ignition coil having a primary winding and a secondary winding, a transistor having emitter, collector and base electrodes, a resistor, a primary circuit energized from said source of voltage including said resistor, said primary winding and the emitter-collector circuit of said transistor, means operating in timed relationship with said engine for controlling the conductivity of said transistor in its emitter-collector circuit, an electric cranking motor, a switch for controlling the energization of said cranking motor from said voltage source, an accurately calibrated relay including an actuating coil and a pair

of normally closed switch contacts, said actuating coil causing said contacts to separate only when a voltage is impressed across said actuating coil that is greater than a predetermined value, said contacts remaining continuously closed when the voltage impressed across said actuating coil of said relay is less than said predetermined value, a circuit bypassing said resistor including said relay switch contacts, and means connecting one side of said relay contacts and one side of said actuating coil with one side of said switch.

3. In combination, a source of direct current voltage, switch means operable to connect one side of said source of direct current voltage with first and second conductor means and operable to connect said one side of said voltage source with only one of said first or second conductor means, an ignition coil having a primary winding and a secondary winding, a resistor, a transistor having emitter, collector and base electrodes, a primary circuit including said resistor, said primary winding and the emitter-collector circuit of said transistor, means connecting one side of said primary circuit with said first conductor means, an electric cranking motor, said electric cranking motor being energized when said switch means connects one side of said source of voltage with said second conductor means, a relay having an actuating coil and a pair of normally closed contacts, said relay maintaining said contacts closed when the voltage impressed across the relay actuating coil is less than a predetermined value and opening said contacts only when a voltage is impressed across the relay actuating coil which is greater than said predetermined value, a bypassing circuit connected across said resistor including said relay switch contacts, and conductor means connecting one side of said relay actuating coil with said second conductor means.

4. An ignition system for an internal combustion engine comprising, a source of direct current voltage, an ignition coil having a primary winding and a secondary winding, a transistor having emitter, collector and base electrodes, a primary circuit for said ignition system energized across said source of direct current voltage including said primary winding and the emitter-collector circuit of said transistor, means operating in timed relationship with said engine for controlling the conductivity of said transistor in its emitter-collector circuit, and a voltage responsive control means responsive to at least two different voltage magnitudes having sensing terminals connected with said source of direct current, said voltage responsive control means including means connected in said primary circuit for varying the resistance of said primary circuit, said voltage responsive control means being operative to provide a primary circuit resistance which has a predetermined value when said voltage responsive control means senses a source voltage which is below a predetermined value and increasing said primary circuit resistance when said voltage responsive control means is sensing a source voltage which is above said predetermined value.

5. An ignition system for an internal combustion engine comprising, a source of direct current voltage, a transistor having emitter, base and collector electrodes, an ignition coil having a primary winding and a secondary winding, a resistor, a primary circuit for said ignition system including in a series connection, said resistor, said primary winding and the emitter and collector electrodes of said transistor, means for varying the conductivity of said transistor in timed relationship with said engine, and voltage responsive control means having voltage sensing terminals connected with said source of direct current voltage and operative to short circuit said resistor from said primary circuit when the voltage that said voltage responsive means is sensing drops below a predetermined value, said resistor remaining continuously in said primary circuit when the voltage that said voltage responsive control means is sensing is above said predetermined value.

6. An ignition system for an internal combustion engine comprising, a source of direct current voltage, an ignition coil having a primary winding and a secondary winding, a three terminal semiconductor having a pair of current carrying terminals and a control terminal, a primary circuit for said ignition system including in a series connection, the control terminals of said semiconductor and said primary winding energized across said source of direct current voltage, means connected with the control terminal of said semiconductor for controlling its conductivity in timed relationship with said engine, a voltage responsive control means having voltage sensing terminals connected across said source of voltage and including means connected in said primary circuit to vary the resistance of said primary circuit, said voltage responsive control means being operative to provide a primary circuit resistance which has a predetermined value when said voltage responsive means is sensing a voltage which has a predetermined value and being operative to increase said primary circuit resistance when said voltage responsive means is sensing a voltage which is above said predetermined value said primary circuit resistance remaining at its increased value as long as the voltage responsive means is sensing a voltage which is above said predetermined value.

7. The ignition system according to claim 6 wherein the three terminal semiconductor is a transistor.

8. An ignition system for an internal combustion engine comprising, a battery, an ignition coil having a primary winding and a secondary winding, a three terminal semiconductor having a pair of current carrying terminals and a control terminal, a primary circuit for said ignition system including the control terminals of said semiconductor and said primary winding, means connected with the control terminal of said semiconductor for controlling the conductivity of said semiconductor in timed relationship with said engine, a voltage responsive control means connected in said primary circuit which includes means that is operative to vary the resistance of said primary circuit, said voltage responsive control means having a pair of voltage sensing terminals, an electric cranking motor for cranking said engine, a switch means operative to simultaneously connect said primary circuit across said battery and to connect the voltage sensing terminals of said voltage responsive means across said battery, said voltage responsive control means being operative to provide a primary circuit resistance which has a predetermined value when said voltage responsive means is sensing a battery voltage which is a predetermined value and being operative to increase said primary circuit resistance when said voltage responsive means is sensing a battery voltage which is above said predetermined value.

9. An ignition system for an internal combustion engine comprising, an ignition coil having a primary winding and a secondary winding, a semiconductor, a resistor, a primary circuit for said ignition system including in a series connection said semiconductor, said primary winding and said resistor, a source of direct current voltage, a voltage responsive means having switching terminals and voltage sensing terminals, said switching terminals being connected across said resistor whereby said resistor is shorted when said switching terminals are connected, an electric starting motor for cranking said engine, a switching means for simultaneously energizing said electric cranking motor and for connecting said primary circuit across said source of voltage, said switching means connecting the voltage sensing terminals of said voltage responsive means across said source of direct current voltage when said starting motor is energized, said voltage responsive means opening the circuit between its switching terminals when said source of direct current voltage is above a predetermined value and maintaining a

complete circuit between said switching terminals when said source of direct current voltage is below said predetermined value.

10. An ignition system for an internal combustion engine comprising, an ignition coil having a primary winding and a secondary winding, a semiconductor, a resistor, a primary circuit for said ignition system including in a series connection said semiconductor, said primary winding and said resistor, a battery, a relay having an actuating coil and normally closed switch contacts, said contacts of said relay being connected across said resistor whereby said resistor is bypassed when said contacts are closed, an electric starting motor for cranking said engine, means for energizing said relay actuating coil, said primary circuit and said electric cranking motor from said battery when said engine is being cranked including manually operable switch means, said relay being calibrated such that said relay contacts remain continuously

closed when the terminal voltage of the battery is below a predetermined value and open said relay contacts when the terminal voltage of the battery is higher than said predetermined value.

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