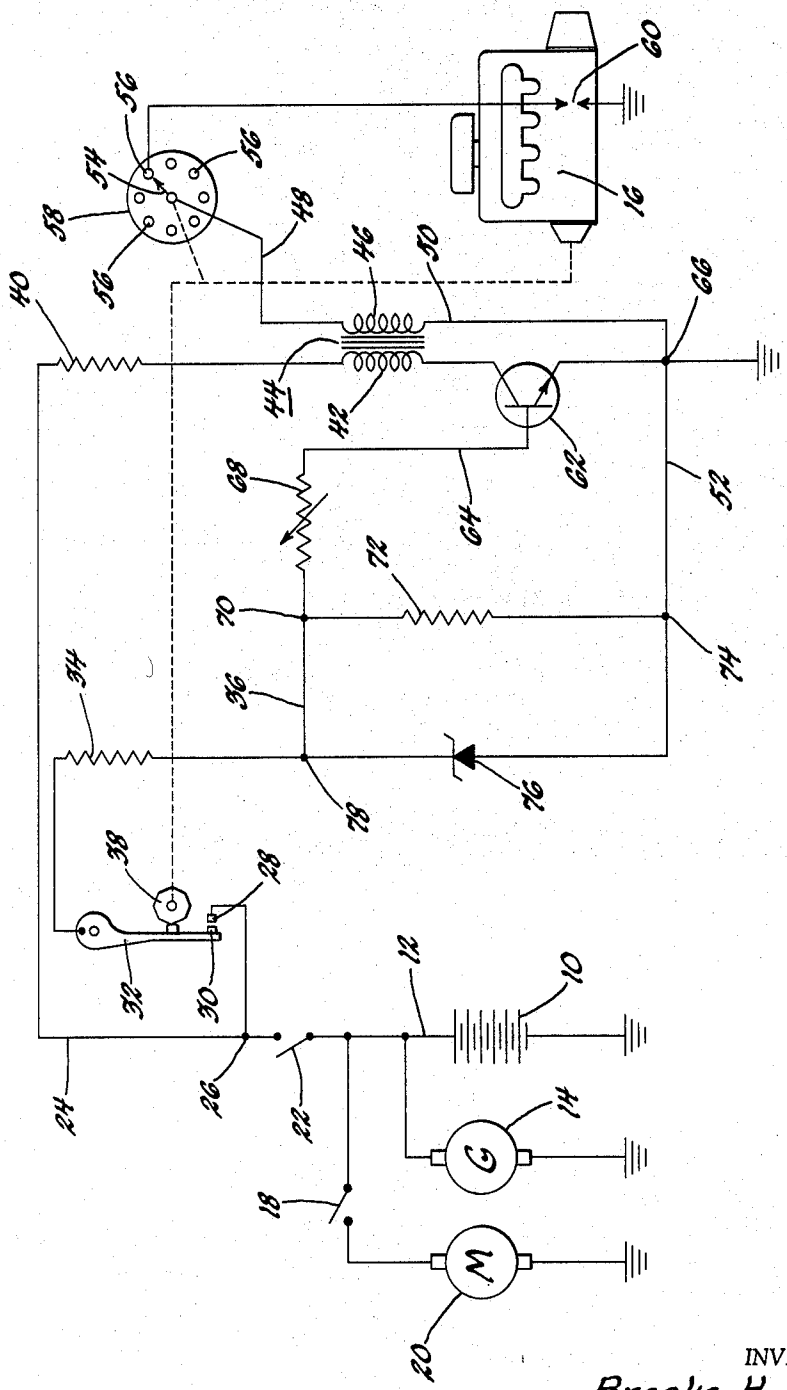
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IGNITION SYSTEM

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IGNITION SYSTEM

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This invention relates to ignition systems for internal combustion engines and more particularly to ignition systems wherein the current flow through the primary winding of an ignition coil is maintained substantially constant.

It is well known that the voltage available to energize the primary circuit of an ignition system on a motor vehicle varies widely under different conditions of operation. Thus, during cranking of the engine, the available voltage drops and this drop is variable depending upon the temperature where cranking occurs. This available voltage, of course, rises upon termination of cranking of the engine and then rises further when the engine begins running and drives the generator. The available voltage, of course, also varies with the condition of charge of the battery on the motor vehicle.

In conventional ignition systems, wherein breaker contacts control current flow through the primary circuit of the ignition system, it has sometimes been the practice to provide a resistor in the primary circuit which is shorted out of the primary circuit when cranking occurs. A typical system of this type is shown in the patents to Leece 1,214,555 and to Mallory 1,769,150. Although, systems of this type compensate for the drop in voltage due to cranking of the engine, there is no fine control of primary circuit current, and there is no compensation of primary current under the many conditions other than cranking where system voltage varies.

It accordingly is an object of this invention to provide an ignition system wherein primary circuit current flow is maintained substantially constant with changes in system voltage and without regard to the cause of such changes.

Another object of this invention is to provide an electronic switch means that controls current flow in the primary circuit of an ignition system and wherein means are provided to maintain the current flow through the electronic switch means substantially constant while it is conducting.

A further object of this invention is to provide an ignition system wherein current flow through the primary circuit is controlled by a transistor which is operated conductive or nonconductive and wherein a constant voltage device such as a Zener diode is connected with the transistor to maintain current flow through the transistor substantially constant when it is conductive.

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

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

Referring now to the drawing, the reference numeral **10** designates a storage battery which is connected with the lead wire **12** and which has an opposite side connected directly to ground. The lead wire **12** is connected with a generator **14** and this generator operates to charge the battery **10** and also operates to supply the other D.C. loads of the motor vehicle including the ignition system. The generator **14** is driven by the engine **16** of a motor vehicle and this generator may either

be a D.C. generator or could be an A.C. generator fitted with diodes for rectifying the A.C. output of the generator to direct current.

The lead wire **12** is connected to one side of a switch **18** and this switch controls the current flow to a cranking motor **20**. The cranking motor **20** is operative to crank the engine **16** when it is desired to start the engine.

The lead wire **12** is connected to one side of an ignition switch **22**, the opposite side of this switch being connected with lead wire **24**. The lead wire **24** is connected with junction **26** and this junction is connected to a breaker contact **28** which cooperates with the breaker contact **30** located on a breaker arm **32**. The breaker arm **32** is electrically connected to one side of a resistor **34** and an opposite side of this resistor is connected with a lead wire **36**. The breaker contacts **28** and **30** open and close in synchronism with operation of the engine **16** by virtue of the connection of the engine **16** with a breaker cam **38**. The breaker cam, of course, causes the opening and closing of the breaker contacts **28** and **30** in a manner well known to those skilled in the art.

The lead wire **24** is connected to one side of a resistor **40**, the opposite side of this resistor being connected with the primary winding **42** of an ignition transformer **44**. The secondary winding **46** of the ignition transformer is connected with lead wires **48** and **50**. The lead wire **50** is connected with a lead wire **52** and it is seen that this lead wire is grounded. The lead wire **48** is connected with a rotor contact **54** which rotates in synchronism with the engine **16** and which passes by the electrodes **56** formed in a distributor cap **58**. Each of the electrodes **56** is connected with a separate spark plug on the engine **16** and one of these spark plugs is designated by reference numeral **60**. It is to be understood that there will be as many electrodes **56** as there are spark plugs, and therefore with a six-cylinder engine there will be six equally spaced electrodes **56**.

The ignition system of this invention includes an electronic switch means which in this case takes the form of an NPN transistor **62**. The collector electrode of transistor **62** is connected directly to one side of the primary winding **42** whereas the base electrode of transistor **62** is connected with lead wire **64**. The emitter electrode of transistor **62** is connected with junction **66** and therefore is grounded.

The lead wire **64** is connected to one side of a variable resistor **68**, the opposite side of this resistor being connected with the junction **70**. The junction **70** is connected to one side of a resistor **72**, the opposite side of this resistor being connected to a grounded junction **74**. A constant voltage device which in this case takes the form of a Zener diode **76** is connected between the lead wire **52** and the junction **78**.

In the operation of the ignition system which has been described, and when it is desired to start the engine **16**, the ignition switch **22** is closed and the switch **18** is closed to energize the cranking motor **20**. As the engine is cranked, the breaker contacts **28** and **30** will be opened and closed by rotation of the breaker cam **38**. When the contacts **28** and **30** close, current will flow from one side of the battery **10**, through junction **26**, through breaker contacts **28** and **30**, through the dropping resistor **34**, through variable resistor **68**, and then through the base to emitter junction of transistor **62** to ground. Current will now flow from one side of battery **10** through ignition switch **22**, through lead wire **24**, through resistor **40**, through the primary winding **42** of ignition transformer **44**, and thence through the collector to emitter circuit of transistor **62** to ground. As the current flows through the

primary winding 42, flux is built up in the ignition transformer. As the breaker contacts 28 and 30 open, there is no longer a circuit between junction 78 and the battery 10, and the base and emitter electrodes of transistor 62 are connected through resistors 68 and 72. This will cause an abrupt turning off of the transistor 62 in its emitter-collector circuit and will therefore cause a high voltage to be induced in the secondary winding 46 of the ignition coil 44. This high voltage is impressed across a spark plug 60 through a circuit that includes lead wire 48, rotor contact 54, one of the contacts 56 of distributor cap 58 and the lead wire connecting one of the electrodes 56 wtih the spark plug. After the engine starts switch 18 is opened and the ignition system continues to operate in a manner just described.

It is pointed out that the Zener diode 76 performs a very important function in the ignition system of this invention in that it maintains a constant current through the primary circuit of the ignition system even though the system voltage may vary. Since a Zener diode is a constant voltage device, it is apparent that the junction 78 will be maintained at some voltage which is constant with respect to the voltage of lead wire 52 as long as the system voltage is higher than the Zener rating of the Zener diode. The circuit constants are such that the system voltage will not go below the Zener rating of the Zener diode under normal operating conditions. Since the junction 78 is maintained at a constant voltage with respect to lead wire 52 when system voltage exceeds the voltage rating of the Zener diode, the voltage applied between the base and emitter electrodes of transistor 62 is maintained constant. Thus, with this arrangement the collector to emitter current of transistor 62 will build up to a constant value and the current flow through the primary winding 42 of the ignition coil is therefore maintained constant.

It can be seen from the foregoing that changes in voltage within limits between junction 26 and ground will not operate to change the primary current flowing through the primary winding of the ignition coil and this current will be maintained constant as long as system voltage exceeds the voltage rating of the Zener diode. In addition, a very fine control of primary current is achieved which will compensate for small changes in system voltage.

The resistor 68 is made variable so that differences in individual transistors may be compensated. This resistor will also compensate for the change in gain characteristic of the transistor due to temperature changes.

The resistor 40 is optional and when used performs the function of limiting current through primary winding of the ignition coil to a desired value at the lowest expected system voltage.

In the system as disclosed, a pair of breaker contacts 28 and 30 have been shown for varying the base voltage of the transistor 62 in synchronism with operation of the engine 16. It will be apparent to those skilled in the art that any other device might be used to control the conductivity of the transistor 62 in timed relationship with operation of the engine without departing from the spirit and scope of this invention.

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

What is claimed is as follows:

1. An ignition system for controlling the firing of a spark plug of an internal combustion engine comprising, an ignition transformer having a primary winding and a secondary winding, means connecting said secondary winding with said spark plug, a source of direct current voltage which may fluctuate under different conditions of operation, a series circuit connected across said source of voltage including the primary winding of said ignition transformer and a first switching means, a second switching means operating in synchronism with said engine controlling said first switching means, and means connected in series with said second switching means for maintaining a constant current flow through the primary winding of said ignition coil and through said first switching means when said first switching means is conductive and regardless of changes in voltage of said voltage source within a predetermined range.

2. An ignition system for an internal combustion engine comprising, an ignition coil having a primary winding, a source of direct current voltage which may fluctuate under different conditions of operation, a circuit for energizing said primary winding from said voltage source including in a series connection said primary winding and the emitter-collector circuit of a transistor, means for causing a varying voltage to be applied across the emitter-base circuit of said transistor in timed relationship with operation of said engine, said voltage varying substantially between zero and a higher value, and means for maintaining said voltage substantially constant when it is at its higher value and within a range of voltages of said voltage source.

3. An ignition system for an internal combustion engine comprising, an ignition coil having a primary winding, a source of direct current voltage which may vary under different conditions of operation, a circuit for energizing said primary winding including said voltage source and the emitter-collector circuit of a transistor, said transistor having a base electrode, means for applying a voltage to said base electrode of said transistor which varies between two values in timed relationship with operation of said engine, and means for maintaining one of said values substantially constant regardless of changes in voltage of said voltage source within a predetermined range.

4. An ignition system for an internal combustion engine comprising, an ignition coil having a primary winding, a source of direct current voltage which may fluctuate under different conditions of operation, a transistor having emitter, base and collector electrodes, means connecting said primary winding and the emitter-collector circuit of said transistor across said voltage source, means operating in timed relationship with said engine for applying a varying voltage across the emitter and base electrodes of said transistor, said voltage varying substantially between zero and a higher value, and a voltage limiting device connected across said emitter and base electrodes whereby the emitter to base voltage, when at its higher vxalue, has a substantially fixed value.

5. An ignition system for an internal combustion engine comprising, an ignition coil having a primary winding, a transistor having emitter, base and collector electrodes, a source of direct current voltage which may fluctuate under different conditions of operation, a first circuit connected across said source of voltage including said primary winding and the emitter-collector circuit of said transistor, a pair of breaker contacts opened and closed in timed relationship with operation of said engine, a second circuit connected across said voltage source including said breaker contacts and the emitter-base circuit of said transistor, and a constant voltage device connected across the emitter and base electrodes of said transistor in series with said breaker contacts.

6. The system according to claim 5, wherein the constant voltage device is a Zener diode.

7. An electrical system comprising, a source of direct current voltage which may vary, an electrical load, a transistor having emitter, collector and base electrodes, a circuit for energizing said electrical load including said voltage source, and the emitter-collector circuit of said transistor, means for varying the voltage applied to the base electrode of said transistor between two values, one of said values causing a conductivity of said transistor in its emitter-collector circuit and the other voltage value causing said transistor to be substantially nonconductive in its emitter-collector circuit, and means connected with the emitter and base electrodes of said transistor for causing the current flow through said transistor to be substantially constant within a range of voltages of said voltage source

when said transistor base electrode has a voltage value to cause it to be conductive.

8. An electrical system comprising, a source of direct current voltage which may vary, an electrical load, a transistor having emitter, base and collector electrodes, an electrical circuit connecting said voltage source and said load including the emitter-collector circuit of said transistor, means connected between the base electrode of said transistor and said voltage source for varying the potential applied to the base electrode of said transistor between two values, one of said voltage values causing said transistor to be substantially fully nonconductive and the other voltage value causing said transistor to be conductive, and a constant voltage device connected with said base electrode for causing the voltage applied to said base electrode to be substantially constant at one of said voltage values within a predetermined range of voltages of said voltage source.

9. An electrical system comprising, a source of direct voltage, an electrical load, a transistor having emitter, base and collector electrodes, a circuit for energizing said electrical load from said voltage source including the emitter-collector circuit of said transistor, switch means, means connecting said switch means between the base electrode of said transistor and said voltage source, means permanently connecting the emitter and base electrodes of said transistor, and a Zener diode connecting the emitter and base electrodes of said transistor, said Zener diode being connected in series with said switch means.

10. An electrical system comprising, a pair of terminals adapted to be connected across a source of direct current voltage, an electrical load, a first series circuit connecting said terminals including said electrical load and the emitter-collector circuit of a transistor, switch means, a second electrical circuit connecting said terminals including said switch means and the emitter-base circuit of said transistor, a resistive circuit permanently connecting said emitter and base electrodes of said transistor, and a Zener diode connected across the emitter and base electrodes of said transistor in series with said switch means.

11. A transistor switching circuit comprising, a source of direct current, an electrical load, a transistor having emitter, base and collector electrodes, a circuit for energizing said electrical load from said source of direct current including the emitter and collector electrodes of said transistor, means connected across the emitter and base electrodes of said transistor for applying a variable D.C. voltage across said emitter and base electrodes, said D.C. voltage varying between first and second values which are capable of driving said transistor substantially conductive and nonconductive between its emitter and collector electrodes, and means for maintaining said voltage substantially constant when it is at said first value.

12. A transistor switching circuit comprising, a source of direct current, an electrical load, a transistor having emitter, collector and base electrodes, a circuit for energizing said electrical load from said source of direct current including the emitter and collector electrodes of said transistor, a resistor connected across the emitter and base electrodes of said transistor, a control means connected in series with said resistor for causing a variation in current flow through said resistor, said variation in current flow causing a voltage to be developed across said resistor which has at least two values one of which is capable of biasing said transistor to its conductive state, and means connected in parallel with said resistor for maintaining said voltage substantially constant when it biases said transistor to its conductive state.

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