March 28, 1961 B. H. SHORT 2,977,507

IGNITION SYSTEM

Filed Sept. 12, 1958 2 Sheets-Sheet 1

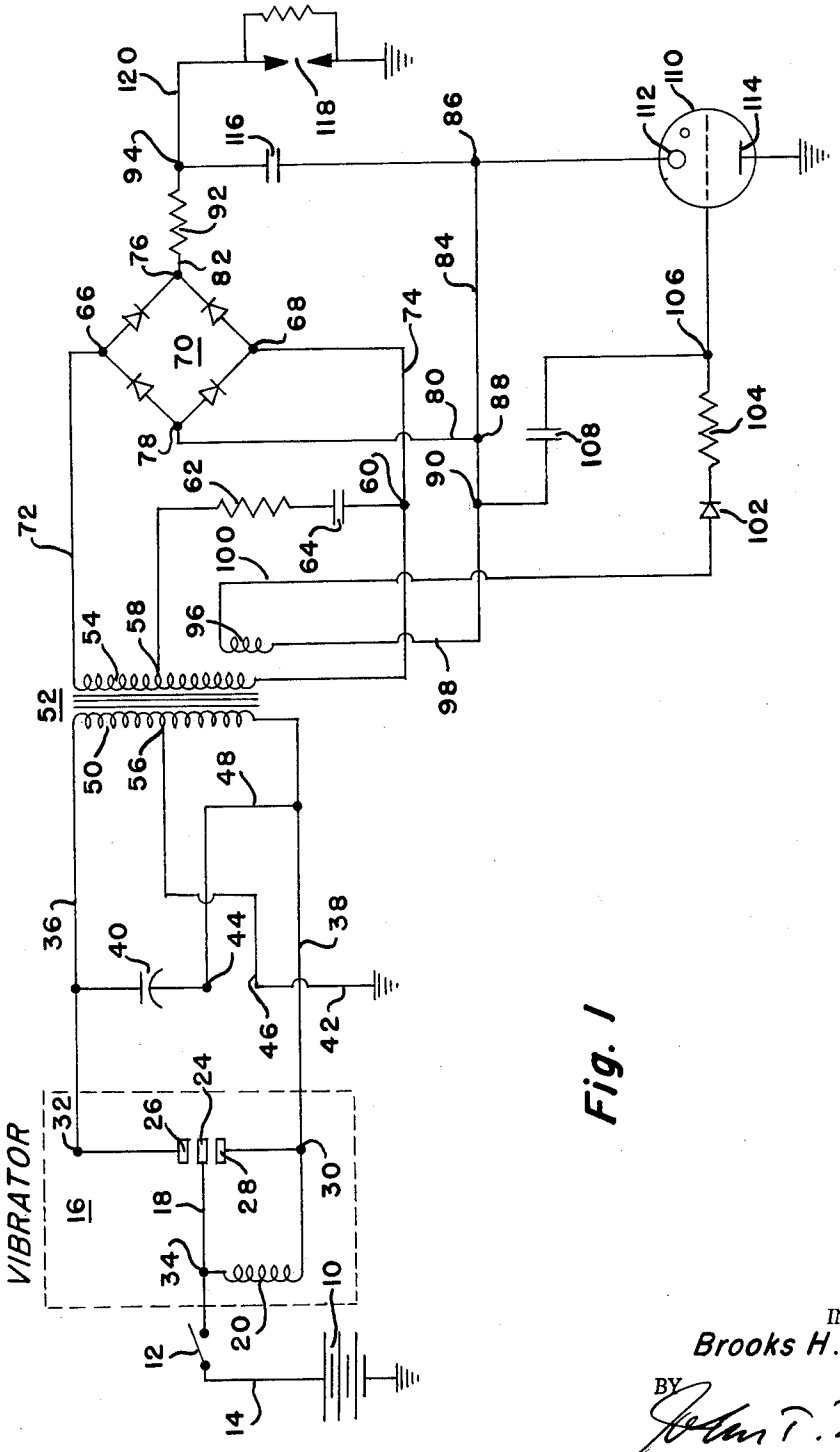


Fig. 1

INVENTOR.
Brooks H. Short

BY

His Attorney

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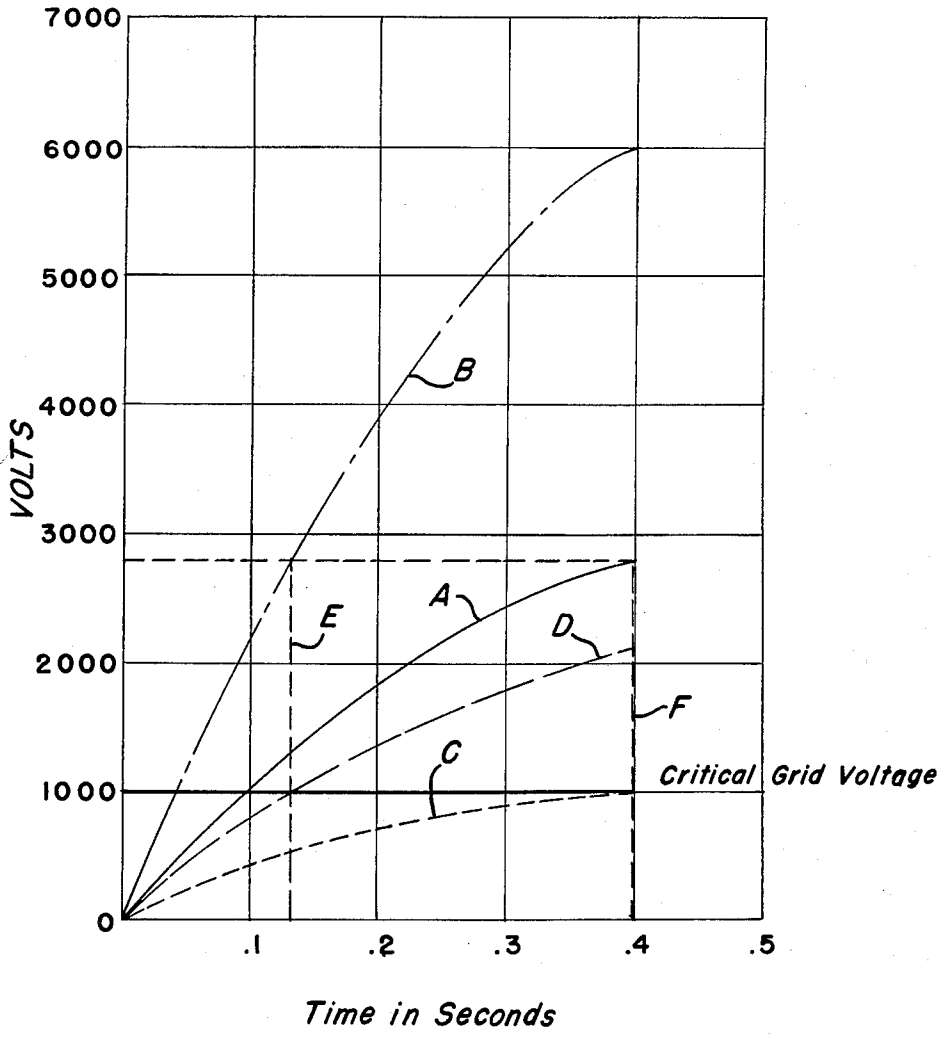


Fig. 2

INVENTOR.
Brooks H. Short
BY
John D. Mannix
His Attorney

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IGNITION SYSTEM

Brooks H. Short, Anderson, Ind., assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

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This invention relates to electronic ignition systems and more particularly to ignition systems of the low voltage type that have particular utility when used for igniting the gaseous mixture of gas turbines and the like.

By low voltage type, it is meant that the spark plug or spark discharge device of the system is of the shunted surface type or creepage gap type which may be fired at relatively low voltage, for example, 2500 to 3000 volts.

This invention contemplates providing an electronic ignition system wherein a relatively low input D.C. voltage is converted to A.C. and wherein this A.C. voltage is then stepped up and converted back to high voltage direct current where it is useful in supplying power to fire a spark discharge device.

In the system just described, it is important that the ignition circuit work effectively over a wide range of input voltages and it is therefore an object of this invention to provide an ignition circuit that provides uniform firing of a spark discharge device over a wide range of D.C. input voltages.

Another object of this invention is to provide an ignition circuit that includes a condenser that is charged from a power source through a resistor and which discharges through a spark discharge device, the discharging of the condenser being controlled by a triode that has a plate circuit and a grid circuit and wherein each circuit is connected with a respective R-C circuit having equal time constants.

Still another object of this invention is to provide an electronic ignition system wherein the firing of a spark discharge device is controlled by a triode that has a grid circuit and a plate circuit and wherein each circuit is connected with an R-C network having equal time constants.

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:

Figure 1 illustrates an electronic ignition system made in accordance with this invention.

Figure 2 is a graphical representation of certain of the voltages in the circuit of Figure 1.

Referring now more particularly to Figure 1, the ignition system of this invention is shown connected with a suitable source of direct current voltage 10 which, in this case, takes the form of a storage battery. The battery may have any required voltage, and in the system to be described, could have a voltage anywhere between fourteen and thirty volts. One side of the battery 10 is connected directly to ground as shown, whereas the opposite side of the battery is connected with an ignition switch 12 by means of lead 14.

The battery 10 energizes a well-known vibrator generally designated by reference numeral 16 and including the usual movable armature 18 and a coil 20. The armature 18 carries a contact 24 which vibrates between

contacts 26 and 28 in a conventional manner. The contact 28 is connected with junction 30, whereas the contact 26 is connected with junction 32. The coil 20 is connected between junctions 30 and 34 and is also connected to one side of ignition switch 12 as is clearly illustrated in the drawings.

The junctions 30 and 32 are connected respectively with leads 36 and 38 which form the output circuit of the vibrator 16. A condenser 40 is connected between lead 36 and a junction 44, and this junction is connected with lead 38 via lead 48. A lead 42 connects lead 46 to ground and thus connects the tap point 56 to ground. The condenser 40, as is well known to those skilled in the art, prevents contact arcing. The transformer is generally designated by reference numeral 52. The transformer has a secondary winding 54 of a greater number of turns than the primary winding so that a predetermined voltage step-up is achieved between the primary and secondary windings. The primary winding 50 is center-tapped at 56 and this tap point is connected with the lead 46. It will be appreciated that the vibrator 16 and its associated circuit convert the direct current voltage of the storage battery 10 to an A.C. voltage that appears across the primary winding 50 of transformer 52. This A.C. voltage may have a frequency of four hundred cycles per second and is stepped up by the transformer 52 so that a much higher voltage appears across the secondary winding 54 of the transformer.

The secondary winding 54 of the transformer is center-tapped at 58 and this center tap is connected with junction 60 through resistor 62 and condenser 64. The ends of secondary winding 54 are connected to the input terminals 66 and 68 of a single-phase, full wave bridge rectifier network generally designated by reference numeral 70. The input terminal 66 is connected to secondary winding 54 by lead 72, whereas the input terminal 68 of the bridge rectifier network is connected to the opposite side of the secondary winding by a lead 74. The lead 74 is also connected with junction 60 as is clearly apparent from Figure 1.

The output terminals 76 and 78 of the bridge rectifier network 70 are connected respectively with leads 80 and 82. The lead 80 is connected with a lead 84 which forms a common connection for junctions 86, 88, and 90. The output terminal 76 of bridge rectifier network 70 is connected to one side of a resistor 92, the opposite side of the resistor being connected with a junction 94.

The secondary winding 54 of transformer 52 is inductively coupled with a coil winding 96 which is connected with leads 98 and 100. The lead 98 is connected with junction 90, whereas the lead 100 is connected to one side of a rectifier 102. The rectifier 102 is connected to one side of a resistor 104 while the opposite side of the resistor is connected with junction 106. A condenser 108 is connected between junctions 90 and 106. The coil winding 96, as will become more readily apparent hereinafter, is adapted to supply grid triggering voltage for an electronic switch.

The electronic switch 110 takes the form of a cold cathode thyratron tube 110 having a cathode 112 connected with junction 86 and having a plate 114 connected directly to ground as shown. The grid of the thyratron tube is connected with junction 106. The thyratron tube, as is well known to those skilled in the art, will fire whenever a predetermined voltage is applied between cathode and grid which may be termed as control terminals.

A condenser 116 is connected between junctions 86 and 94 and is operative to discharge through a spark discharge device 118 which, in this case, is a shunted surface gap or creepage gap type of spark plug that will

break down when a relatively low voltage is applied thereacross, for example, a voltage of 2500 to 3000 volts. One side of the shunted surface gap plug **118** is connected directly to ground whereas the opposite side thereof is connected with junction **94** via lead **120**. The spark plug **118** will, of course, be associated with a gas turbine or other type of engine in the usual manner for igniting the gaseous mixture of the engine when it is desired to start the engine. The spark plug **118** will continue firing as long as the ignition switch **12** is closed as will become more readily apparent hereinafter.

In operation, when it is desired to ignite the combustible mixture of a gas turbine engine or the like, the ignition switch **12** is closed. The closure of ignition switch **12** sets the vibrator **16** into operation to provide alternating current across the primary winding **50** of transformer **52**. The A.C. voltage appearing across the primary winding of the transformer is stepped up and appears as a higher voltage across the secondary winding **54** of the transformer. Contact arcing, as has been noted before, is minimized by condenser **40** and also by the series combination of resistor **62** and condenser **64**.

The A.C. voltage appearing across secondary winding **54** is rectified by bridge rectifier circuit **70** and is then supplied to charge condenser **116** through resistor **92**. This R-C network, formed of resistor **92** and condenser **116**, has a predetermined time constant or R-C product which is equal to the time constant of the R-C network of resistor **104** and condenser **108**. The condenser **116** will thus build up a charge along an exponential curve as will be readily apparent from an inspection of Figure 2. If the voltage of battery **10** is fourteen volts, the voltage across condenser **116** will build up along curve A of Figure 2. On the other hand, if the voltage of a storage battery is thirty volts, the voltage across condenser **116** will build up along the curve B of Figure 2. The particular values of voltage are only cited by way of example and not by way of limitation.

During the time that the condenser **116** is being charged toward the voltage appearing across the output terminals **76** and **78** of bridge rectifier **70**, the condenser **108** is being charged through an R-C network that includes resistor **104** and condenser **108**. The voltage for charging the condenser **108** is obtained from coil winding **96** and this voltage is rectified by rectifier **102** so that direct current voltage is applied to the R-C combination of resistor **104** and condenser **108**. If the battery voltage is fourteen volts, the voltage developed across condenser **108** will follow an exponential curve designated by the letter C in Figure 2. If the voltage of the storage battery is thirty volts, the voltage will build up across condenser **108** according to curve D of Figure 2. It will be appreciated that the voltage developed across condenser **108** is available for biasing the thyratron tube **110** into conduction as it is connected directly across the cathode to grid circuit of the thyratron.

If it is assumed that the spark plug **118** will fire at approximately 2800 volts, and that the critical grid voltage for causing firing of the tube **110** is approximately 1000 volts, it is desirable that these two voltages be attained at the same time so that the condenser **116** will discharge through the spark plug **118** at the correct time. This is accomplished in the circuit of Figure 2 by making the time constants of R-C network **92** and **116** equal to the time constant of the R-C network **104** and **108**. Thus, when the storage battery **10** is at thirty volts, the tube **110** will be caused to conduct at the point of time indicated by line E on the curves of Figure 2. At this point of time, the voltage across condenser **116** has reached 2800 volts so that the condenser will now discharge through the tube **110** and through the spark plug **118** at the instant that the grid voltage reaches 1000 volts.

As has been noted hereinbefore, the present invention operates to provide a uniform amount of energy across the spark plug **118** irrespective of the battery voltage **10**. This becomes readily apparent from an inspection of Figure 2 where it is seen that, when the battery voltage is fourteen volts, the voltage across condenser **116** reaches 2800 volts at the same time that the voltage across condenser **108** reaches 1000 volts. This point in time is designated by letter F on the curves of Figure 2 and corresponds to approximately .4 of a second.

It will be readily apparent from the foregoing that, by providing R-C networks of equal time constants, the discharging of condenser **116** through the spark plug **118** will always occur at a predetermined voltage which, in the graphical representation, is 2800 volts. Thus, the circuit just described insures that the voltage appearing across the spark plug **118** will always reach the same value at the time that the grid voltage of tube **110** is of a sufficient value to fire the tube. This circuit then provides for uniform discharge of energy across the spark gap **118** irrespective of the value of voltage applied to the ignition circuit.

It will be appreciated that, after the condensers **108** and **116** have discharged respectively through the grid and plate circuits of the thyratron tube **110**, the condensers once more build up a charge to cause a second firing of the spark discharge device **118**. This operation is repetitive and, thus, the condensers **108** and **116** continue to charge and discharge and, upon each discharge of **116**, an arc is produced across the spark plug **118**. It thus is clearly apparent that the spark plug **118** will continue to be periodically fired as long as the switch **12** is closed.

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 electronic ignition system, comprising; a source of relatively low direct current voltage, means for converting said source of direct current voltage into a source of A.C. voltage, a transformer having a primary winding connected with said converting means and having a secondary winding, a first rectifier connected with said secondary winding, a condenser, a spark discharge device, an electronic switch, a second rectifier energized from the secondary winding of said transformer, means connecting said first rectifier and said condenser in circuit with each other to provide a charging circuit for said condenser, a discharging circuit for said condenser including said electronic switch and said spark discharge device, and means for controlling the conduction of said electronic switch including said second rectifier.

2. An electronic ignition system, comprising; a source of voltage, a thyratron tube having cathode, grid and plate electrodes, a first resistor and a first condenser connected in series with each other to form a first R-C network, a second resistor and a second condenser connected in series with each other to form a second R-C network, a first rectifier connected between said source of voltage and said first R-C network for charging said first condenser, a second rectifier connected to be energized by said source of voltage and connected in circuit with said second R-C network for charging said second condenser, a spark discharge device, means connecting said first condenser, said spark discharge device and the cathode-plate circuit of said thyratron tube in series with each other, and means for conecting the condenser of said second R-C network across the cathode and grid of said thyratron tube, said R-C networks having time constants that are equal to one another.

3. An electronic ignition system, comprising; a spark discharge device having a predetermined firing potential, a source of voltage, a first condenser, a charging circuit for said first condenser connected with said voltage source through a first resistor, an electronic switch, a discharging circuit for said first condenser including said electronic switch and said spark discharge device, a

second resistor and a second condenser connected in series with one another and connected with said voltage source, said second resistor and said second condenser having an R-C time constant that is equal to the R-C time constant of said first resistor and said first condenser, and means for controlling the conduction of said electronic switch including said second resistor and said second condenser.

4. An electronic ignition system, comprising; a spark discharge device having a predetermined firing potential, a source of voltage, a condenser, a charging circuit for said condenser connected with said source of voltage, an electronic switch having control terminals that are adapted to be connected with a triggering voltage for causing conduction of the switch at a predetermined triggering voltage, a discharging circuit for said condenser including said electronic switch and said spark discharge device, means connected with said voltage source for charging said condenser to said firing potential, means for deriving a variable triggering voltage from said source and for applying said triggering voltage to said control terminals, said means causing said firing potential and said predetermined triggering voltage to be attained substantially simultaneously irrespective of changes in source voltage.

5. An electronic ignition system, comprising; a direct current power source, a vibrator connected with said power source for converting the D.C. voltage of said power source to A.C. voltage, a transformer having a primary winding connected with the output terminals of said vibrator and having a secondary winding, first and second rectifiers connected to be energized from said secondary winding, a first R-C network including a first resistor and a first condenser, a second R-C network including a second resistor and a second condenser, a triode tube, a charging circuit for said first condenser including said first rectifier and said first resistor, a spark discharge device, a discharging circuit for said first condenser including said spark discharge device and the cathode-plate circuit of said tube, and a grid circuit for said tube including said second R-C network, said second rectifier and the cathode-grid circuit of said tube, the R-C time constants of said first and second R-C networks being substantially equal.

6. An electronic ignition system comprising; an electronic switch having a pair of control terminals and a pair of current carrying terminals, a source of voltage, a spark discharge device, a first R-C network including a first resistor and a first condenser, a second R-C network including a second resistor and a second condenser, a charging circuit for said first condenser including said voltage source and said first resistor, a discharging circuit for said condenser including the current carrying terminals of said electronic switch and said spark discharge device, and means connecting said control terminals, said second R-C network and said voltage source in circuit with each other, said R-C networks having substantially equal time constants.

7. An electronic ignition system, comprising; a spark discharge device having a predetermined firing potential, a source of voltage, a first condenser, a charging circuit for said condenser connected with said source of voltage, an electronic switch having control terminals that are adapted to be connected with a triggering voltage for causing conduction of the switch at a predetermined triggering voltage, a discharging circuit for said condenser including said electronic switch and said spark discharge device, a second condenser connected with said voltage source and the control terminals of said electronic switch, and means for causing said first condenser to be charged to said firing potential and said second condenser to said triggering voltage substantially simultaneously.

8. An electronic ignition system comprising; a spark discharge device having a predetermined firing potential, a source of voltage, a condenser, a charging circuit for said condenser connected with said source of voltage, an electronic switch, a discharging circuit for said condenser including said electronic switch and said spark discharge device, and means including an R-C network connected between said voltage source and said electronic switch for causing said switch to become conductive when said condenser has been charged to said firing potential.

9. An electronic ignition system comprising; a spark discharge device having a predetermined firing potential, a source of voltage, a condenser, a charging circuit for said condenser connected with said source of voltage, an electronic switch, a discharging circuit for said condenser including said electronic switch and said spark discharge device, and means including means for deriving variable voltage from said voltage source connected with said voltage source and electronic switch for applying a sufficient voltage to said electronic switch to cause it to conduct only when said condenser has been charged to said firing potential.

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