Aug. 12, 1958 B. H. SHORT ET AL 2,847,489

IGNITION SYSTEM

Filed Jan. 8, 1954 2 Sheets-Sheet 1

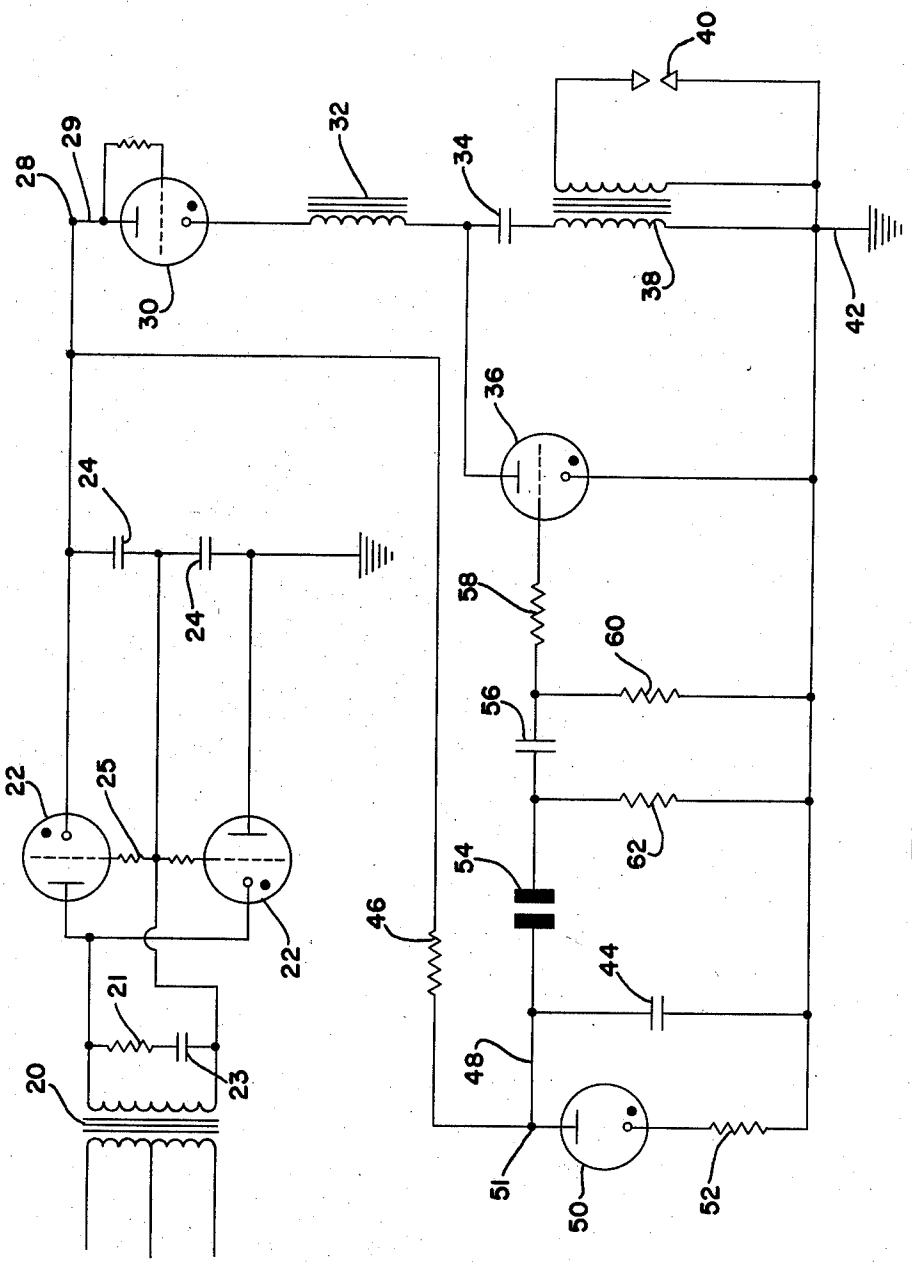

Fig. 1

INVENTOR.
Brooks H. Short
BY Stanley E. Jacke
John T. Mann
Their Attorney

Aug. 12, 1958 B. H. SHORT ET AL 2,847,489

IGNITION SYSTEM

Filed Jan. 8, 1954 2 Sheets-Sheet 2

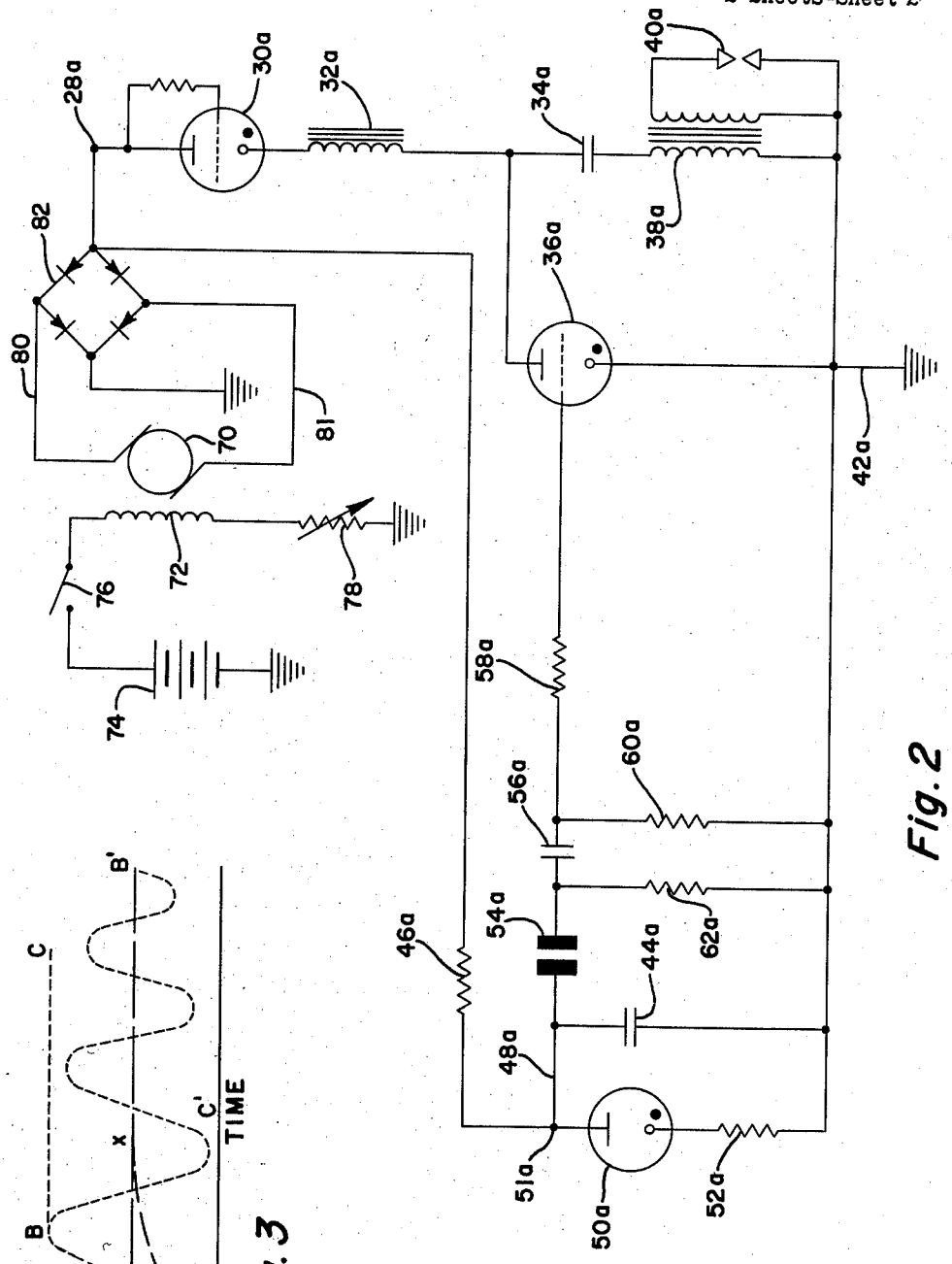

Fig. 2

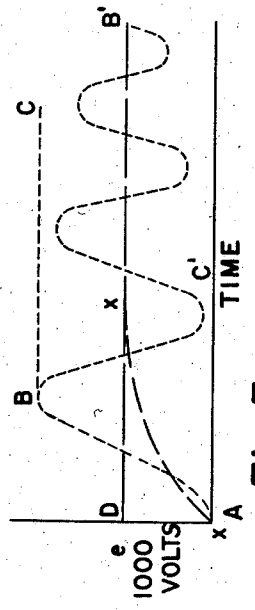

Fig. 3

INVENTOR.
Brooks H. Short
BY Stanley E. Jacke
Their Attorney

United States Patent Office 2,847,489 Patented Aug. 12, 1958

2,847,489

IGNITION SYSTEM

Brooks H. Short, Anderson, Ind., and Stanley E. Jacke, Walled Lake, Mich., assignors to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Application January 8, 1954, Serial No. 402,912

7 Claims. (Cl. 123—148)

This invention relates to an ignition apparatus and system and more particularly to an ignition system adapted for use with an internal combustion engine that has a source of direct current having a fluctuating substantially high voltage.

It is an object of the present invention to impress the highest values of a fluctuating voltage without appreciable loss across the primary windings of a coil so as to provide an efficient ignition system for an internal combustion engine.

It is another object of the present invention to include a cold cathode voltage regulator in an ignition system having a source of fluctuating high voltage direct current so a constant predetermined voltage potential may be impressed on the electrical component parts of a thyratron tube used as a triggering tube in an ignition system.

A still further object of the present invention is to provide a more efficient ignition system for an internal combustion engine by using a low voltage to control a higher voltage. This object is materialized by providing a source of alternating current, transforming the current to a high voltage, then converting the A. C. current to a high voltage D. C. current in a voltage doubler rectifier system and filtering the rectifier output by a two-section capacitor so the output D. C. voltage may charge a main ignition capacitor through a circuit whereby its voltage is substantially greater in magnitude than the potential of the filter capacitor and when so charged the main ignition condenser discharges through an ignition coil winding when triggered by a thyratron that has the triggering circuit thereof connected to the voltage doubler system so as to receive the average voltage rectified thereby. Thus providing a system whereby the highest values only of voltage are controlled by a circuit using lower voltage.

A further object of the present invention is to control the potential impressed on the grid of a thyratron tube that triggers current passing through the primary windings of an ignition coil so the tube is made conductive on the making and not on the breaking of contact between the points of an ignition timer.

Another object of the present invention is to impress the highest voltage with a minimum electrical energy loss across the primary windings of an ignition coil of an internal combustion engine. This object is accomplished by including a tube that is conductive for one direction of current flow only in a circuit with an inductance and a capacitance so as to charge the capacitance through the inductance to a value greater than the average value of the voltage that is impressed on the circuit.

In carrying out the above object it is another object to charge a main capacitance to a predetermined voltage from a direct current source so the potential of the capacitance when impressed on a grid of a thyratron triggering tube will render the tube conductive on the

making of the contact between the points of an ignition timer and not on the breaking thereof. This object is materialized by including a cold cathode voltage regulator tube connected to compensate for changes in the stepped up battery potential and supplying this regulated potential to a main capacitance. Also included are a second capacitance with a pair of current limiting resistances connected therewith to limit the charging and discharging thereof in the discharge circuit of the main capacitance.

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.

In the drawing:

Figure 1 is a wiring diagram of a portion of an ignition system embodying the present invention.

Figure 2 shows a modification of the ignition system as in Figure 1.

Figure 3 is a curve showing characteristics of a condenser charging circuit in Figure 1.

Referring to the wiring diagram, Figure 1, a transformer **20**, rectifier tubes **22** and condensers **24** are connected with other parts of the electrical system, not shown, of an internal combustion engine, and arranged as disclosed in Patent No. 2,536,143, as assigned by the patentees Brooks H. Short and Charles E. Buck to the assignee of the present invention, so a high voltage varying between 600 to 1000 volts will be present at terminal **28** under the various conditions set forth therein.

The present invention is directed to an improvement in the ignition system as disclosed in the cited patent whereby the power consumption is considerably reduced, as for example, from 8 to 3 amperes, so as to provide a highly efficient ignition system which will operate favorably during cranking periods and when the engine is operating.

The anode of a rectifier tube **30** is connected through a lead **29** to terminal **28** and the cathode thereof is connected through an inductance **32** to one of the plates of condenser **34**.

The charging characteristics of the condenser 34 circuit which includes tube 30, inductance 32 and condenser 34 are shown in Figure 3 of the drawings wherein the potential *"e"* as impressed on the condenser is plotted against time. It is well known that if a value of the D. C. voltage is 1000 volts and this voltage is impressed on a circuit consisting of inductance, and capacitance, the voltage across the capacitance will vary as indicated by the damped sine curve ABC'B' of Figure 3. Thus, if an average voltage of 1000 volts is present at terminal 28 as shown at point D on the diagram, and the voltage is increasing and as the tube 30 is conductive, in one direction of current flow only, the maximum potential represented by point B will be the final voltage on the condenser **34** as passed through inductance 32 which will be approximately twice the voltage present at terminal 28. In this connection it is to be noted that if a capacitance is charged through a resistance, not shown, then the charging thereof will follow curve AB' of Figure 3 as a capacitance requires time to be fully charged. Further if the resistance is replaced by an inductance as inductance **32** in the drawings, then the charging of the capacitance will follow the sine curve ABC' in Figure 3 as due to the characteristics of the charging circuit. When, however a tube that is conductive in one direction of current flow only is included in the inductance capacitance circuit, then the capacitance will be charged along lines A to B and maintain this charge along line BC instead of losing the charge as represented by the BC' line in Fig. 3. Tube **30** will be conductive only when current is flowing

from point 28 toward the condenser 34. Thus after the voltage as shown at B is established on condenser 34, the tube 30 will be nonconductive until the condenser 34 is triggered to discharge through coil 38.

After condenser 34 is charged and the thyratron trigger tube 36 is caused to become conductive, in a manner to be hereinafter described, current will flow in the primary windings of a high frequency coil 38 to ground 42 and induce a current and voltage in the secondary windings thereof which is distributed through a suitable distributor, not shown, to the engine spark plugs, one of which is indicated at 40 on the drawings.

A main triggering condenser 44 has one of its plates connected to ground 42 and the other to a lead 48 through a junction 51 to the regulated potential across the voltage regulator circuit including regulating tube 50 and resistance 52 which are in series between juncture 51 and ground 42. A regulating resistor 46 bridges the junction 51 with terminal 28. The cold cathode voltage regulator tube 50 has its anode connected to junction 51 and its cathode connected through resistance 52 to ground 42. The tube 50, because of its arrangement in the circuit, acts as a voltage regulator tube and will conduct current and serve as a by-pass whenever the potential at junction 51 exceeds a predetermined value and thus limits the potential of capacitor 44 to a certain value, for example 300 volts.

The breaker points of an ignition timer, diagrammatically shown as contact points 54 on the drawings, are so arranged in the circuit that when the points 54 are closed, a second triggering condenser 56 is charged from the potential of condenser 44. This charge of condenser 56 is impressed on the grid of the thyratron triggering tube 36, through resistance 58, to make tube 36 conductive and causes current to flow in the primary of coil 38 in a manner heretofore set forth.

When the contact points 54 are closed, condenser 56 is charged from condenser 44 through ground 42, tube 36, and resistor 58. The charging of 56 causes the tube 36 to become ionized, or conducting. This ionization causes condenser 34 to be discharged through the primary of coil 38, thereby producing ignition voltages.

Resistance 60, with one end connected between condenser 56 and resistance 58 and the other end connected to ground 42, limits the discharging of condenser 56 when points 54 are opened. When points 54 are opened condenser 56 will discharge through resistors 62 and 60. This circuit during discharge of condenser 56 places a negative voltage on the grid of tube 36. Upon opening the contacts 54, this negative potential removes all possibility of ionizing the tube 36 when the points 54 are opening.

Satisfactory operation has been obtained by using elements having the following model designations or electrical characteristics.

Transformer 20, primary, each 22 turns of #17 wire.
Transformer 20, secondary, 3000 of #34 wire.
Rectifier tubes, tubes 22, model DT264.
Resistance 21, 5000 ohms.
Condenser 23, .006 mfd.
Grid resistances 25, 10 megohms.
Condensers 24, .68 mfd.
Inductance 32, 70 henrys.
Condenser 34, .025 mfd.
Condenser 44, .25 mfd.
Resistance 46, 47K ohms.
Resistance 52, 51K ohms.
Condenser 56, .0025 mfd.
Resistance 58, 22K ohms.
Resistance 60, 400K ohms.
Resistance 62, 150K ohms.

Tubes 22 and tube 30, known as cold cathode tubes, because they do not have heated cathode filaments, become conducting by an electrostatic field created by the application of relatively high voltage from the transformer secondary and once ionized they are kept ready for conduction by the keep-alive electrode.

Condenser 23 is a buffer condenser which absorbs transient voltages when the vibrator contacts, not shown, open.

Tube 30, known as a rectifier tube as previously set forth is of the type that will conduct increasing values of voltages in one direction of current flow only. Hence until the voltage reaches a maximum for a given direction of current flow, the tube will be conducting during the period as represented by A—B, in Figure 3.

Tube 36, a cold cathode type tube, requires a positive potential on its grid in order to be conducting. Once having become conducting, it will continue to conduct as long as the plate voltage is above the ionization voltage, for example 300 volts.

The inductance 32 because of its arrangement with condenser 34 makes possible the charging of condenser 34 to twice the voltage of terminal 28 so that condenser 34 when fully charged, has a potential twice the maximum potential of terminal 28. When tube 36 becomes conducting, due to charge of condenser 56, condenser 34 is discharged faster than it can be charged from terminal 28. When this happens the potential of the plate of tube 36 falls below the voltage required to maintain ionization and the tube 36 will cease to conduct, as the inductance 32 operates to prevent a rapid increase in voltage on the plate of condenser 34.

Tube 50, of the cold cathode voltage regulator type, becomes conductive when the voltage on the plate exceeds a predetermined value. Thus the condenser 44 will be charged only to that value and the tube will be conductive only when the voltage at junction 51 exceeds that amount.

The high frequency ignition coil 38 is constructed in a manner disclosed in the patent of Short and Tynan, 2,463,123, granted March 1, 1949, as assigned to the assignee of the present invention.

The system is operative when the potential at terminal 28 ranges between 600 to 1000 volts. 600 volts, for example, is that which is obtained when the voltage of the partly charged battery is low but yet sufficient to effect operation of the engine cranking motor and 1000 volts for example, when the battery is fully charged when operating the cranking motor or when current is supplied by the generator for ignition or battery charging. In order to provide for adequate charging of condenser 44 when terminal 28 voltage is 600 volts and not subject the condenser 44 to excessive voltage when terminal 28 potential is higher than 1000 volts, the voltage regulator tube 50 is provided.

The present system is operative the instant the ignition switch, not shown, closes since the cold cathode type rectifier tubes 22 and a cold cathode thyratron tube 36 are used. These tubes require high voltage for their operation which is within the capabilities of the storage battery of an internal combustion engine if a suitable voltage step-up system as a vibrator, transformer and rectifier tubes are employed.

In Figure 2 a modification of the ignition system for an internal combustion engine is shown. In this embodiment an alternator 70 has its field 72 excited by current determined by variable resistance 78 from a storage battery 74 after switch 76 is closed. The leads 80 and 81 conduct the output of the alternator to a rectifier 82 which puts out a relatively high D. C. potential to terminal 28A. It is to be noted that the remainder of the circuit is disclosed in the embodiment previously described.

It is apparent from the foregoing that the device disclosed represents a highly efficient ignition system for an internal combustion engine as the lower loss through the tubes and inductances is small compared to that lost when resistances are used to charge a condenser. This is manifest by the fact that the operating current utilized

in the present system is 3 amperes for an ordinary internal combustion engine compared to 8 amperes when other systems are employed. Another arrangement of the type herein disclosed is contained in application Ser. No. 402,910, concurrently filed herewith and assigned to the assignee of the present invention.

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. In an ignition system for an internal combustion engine having a source of substantially high voltage direct current, the combination comprising; a primary circuit including; an electronic switch connected to said source adapted to pass current therethrough in one direction of current flow only, an inductance, and a capacitance connected between the electronic switch and the primary winding of a coil for inducing an electrical current in a secondary winding of said coil, a triggering means including an electronic switch for regulating a flow of current in said primary circuit, and a voltage regulating means for providing a current having a substantial constant voltage to said triggering means.

2. In an ignition system for an internal combustion engine having a source of substantially high voltage direct current, the combination comprising; a primary circuit, a secondary circuit, a means for triggering the passage of current in the primary circuit, and a means for regulating the fluctuations of the high voltage current to provide a current of substantially constant voltage to the triggering means, said regulating means including; a resistance of predetermined value in series with said triggering means, and a single cold cathode type voltage regulating tube that is conductive only when the voltage impressed thereon exceeds a predetermined value and connected in parallel with said triggering means for supplying a current of constant voltage thereto.

3. In an ignition system for an internal combustion engine, the combination comprising; a primary circuit, a secondary circuit, means for triggering the passage of current in said primary circuit, and means for providing a substantially constant potential to said triggering means, said second mentioned means including a single cold cathode type electronic switch that is adapted to be conductive when the potential exceeds a predetermined value, said switch being connected in circuit with a condenser for regulating the potential impressed thereon.

4. In the primary circuit of an ignition system for an internal combustion engine, the combination comprising; an electronic switch connected to a source of direct current and adapted to pass current from said source therethrough in one direction of current flow only, triggering means for controlling the flow of current in said primary circuit, an inductance connected in circuit with said switch to said current source, and a capacitance having one terminal connected to the primary winding of an ignition coil and the other terminal connected through the inductance and electronic switch to said current source.

5. In an ignition system for an internal combustion engine the combination comprising; a source of fluctuating substantially high voltage direct current, a primary

circuit, a secondary circuit inductively coupled to said primary circuit, means including an electronic switch having a control member for triggering current flow in said primary circuit from said source, a main condenser adapted to be charged from the source to a predetermined potential, an auxiliary condenser adapted to be charged by said main condenser, a timer for opening and closing a circuit between said condensers, a circuit connecting the auxiliary condenser with the control member whereby a charge of one polarity is impressed on said control member from the main condenser when the timer closes the circuit between said condensers, and a pair of current limiting resistances connected in circuit to discharge the auxiliary condenser to provide a pulse of the opposite polarity on said control member when said timer points open the circuit between said condensers.

6. In an ignition system for an internal combustion engine having a primary and secondary circuit, the combination comprising; means for triggering the passage of current in said primary circuit, and means for periodically supplying a positive potential to said triggering means for causing said current flow in the primary circuit, said second mentioned means including; a main condenser, an electronic voltage regulator in circuit with said main condenser for regulating the potential impressed thereon, an ignition timer, an auxiliary condenser adapted to be charged by said main condenser when a circuit therebetween is closed by the timer and connected in circuit with said triggering means for delivering said positive potential to said triggering means when said circuit is closed, and a means for discharging said auxiliary condenser and causing a negative potential to be impressed on the triggering means when said timer opens the circuit.

7. In an ignition system for an internal combustion engine having a primary and a secondary circuit, the combination comprising; means including an electronic switch having a grid arranged to control the passage of current in said primary circuit, and means for controlling the polarity of said grid, said second mentioned means including; a main condenser, an electronic voltage regulator in circuit with said main condenser for regulating the potential impressed thereon, an auxiliary condenser in circuit with said main condenser and adapted to be charged thereby when the circuit therebetween is closed by points of a timer, said auxiliary condenser being connected through a resistance in circuit with said grid for impressing a positive potential thereon when points of the timer are closed, and a pair of current limiting resistances connected on opposite sides of the auxiliary condenser for discharging said auxiliary condenser when said points open whereby a negative pulse is impressed on said grid when said points open.

References Cited in the file of this patent

UNITED STATES PATENTS

2,169,818	Scott	Aug. 15, 1939
2,463,123	Short	Mar. 1, 1949
2,536,143	Short	Jan. 2, 1951
2,552,989	Mayer	May 15, 1951
2,590,168	Felici	Mar. 25, 1952