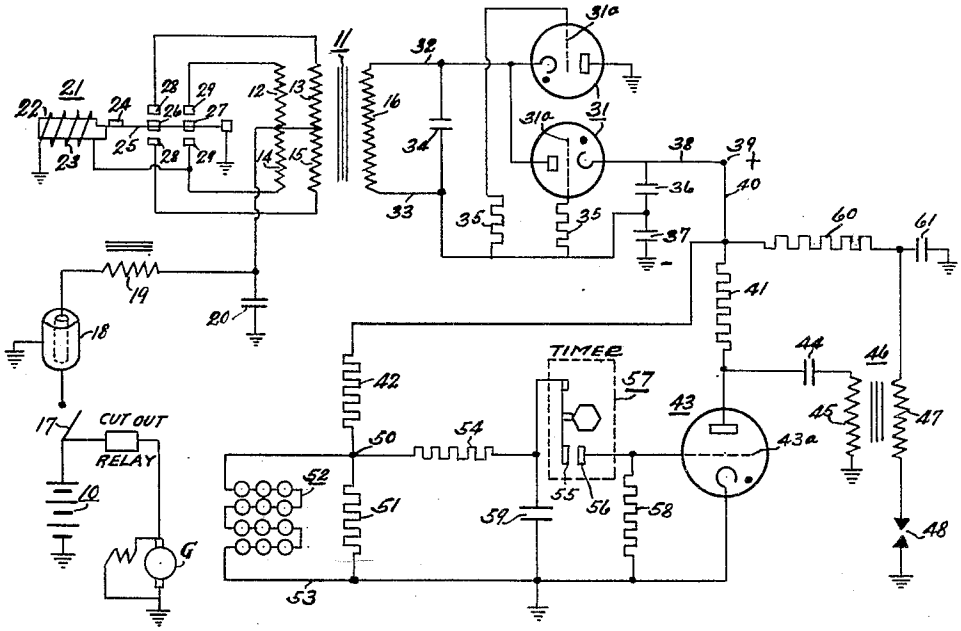
Jan. 2, 1951 B. H. SHORT ET AL 2,536,143

IGNITION SYSTEM

Filed Feb. 16, 1949

Fig. 1



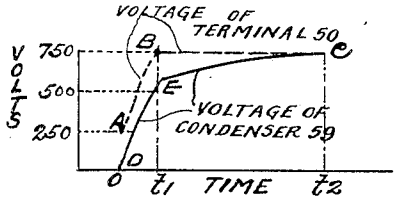


Fig. 2

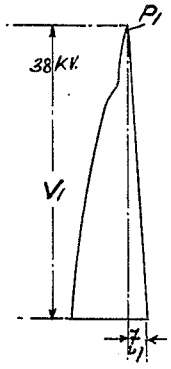


Fig. 3

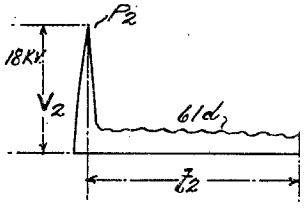


Fig. 4

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IGNITION SYSTEM

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5 Claims. (Cl. 315—209)

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This application is a continuation in part of the copending application of Brooks H. Short and Charles E. Buck, Serial No. 8,768, filed February 17, 1948, now abandoned.

This invention relates to high frequency ignition apparatus having main and auxiliary condensers which are charged while the timer contacts are open. When the timer contacts are closed, the discharge from the auxiliary condenser renders a thyratron conductive whereupon the main condenser discharges through a circuit including the thyratron and the primary of an ignition coil.

An object of the present invention is to provide a system of this type in which cold cathode tubes are employed so that the system is ready for operation the instant the ignition switch is closed.

A further object of the present invention is to increase the duration of the arc at the spark plug so that the fuel mixture will receive heat sufficient to start combustion without requiring a long arc for this purpose. By increasing the duration of the arc, the arc can be made shorter and less potential is required to start the arc.

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.

In the drawings:

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

Figs. 2, 3 and 4 are charts illustrating its operation.

Referring to Fig. 1, a generator G driven by the automobile engine supplies current through a cut out relay to a storage battery 10. This relay closes when generator voltage is above battery voltage and opens when the former voltage is below the latter. During cranking current for operating the ignition apparatus is supplied by the battery 10 and during running with the cut out relay closed generator G supplies current for the ignition apparatus. A voltage regulator not shown limits generator voltage to a certain value. These current sources are connected by a switch 17 with a power supply comprising a transformer 11, a vibrator 21 and rectifiers 31 connected in a voltage doubler circuit. Transformer 11 includes two primary windings divided into sections 12 and 14, 13 and 15 and a secondary winding 16. The center taps of the primary windings are connected with battery 10, through an ignition switch 17, a concentric condenser 18 and an impedance choke 19 connected to a

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grounded condenser 20. The elements 18, 19 and 20 provide for elimination of interference with adjacent radio apparatus.

The vibrator 21 comprises a core 22 surrounded by coil 23, an armature 24 carried by reed 25 which is grounded and carries contacts 26 and 27 engageable respectively with side contacts 28 connected with the ends of primary sections 13 and 15 and with side contacts 29 connected with the ends of primary sections 12 and 14. By dividing the primary, the current carried by the contacts of the vibrator is maintained within practical limits.

The ends of the secondary 16 are connected with wires 32 and 33 between which a condenser 34 is connected. Wire 32 is connected with the cathode of upper tube 31 and with the plate of lower tube 31. Wire 33 is connected with resistances 35 connected with elements 31*a* which start electron emission in tubes 31. Wire 33 is connected between condensers 36 and 37, the latter being grounded and the former being connected with a wire 38 leading from the cathode of one of the tubes 31 to the power supply terminal 39 which is maintained at a potential of 1500 volts, for example, when the generator or the battery apply full voltage. If the battery is not fully charged but has enough charge to crank the engine and supply current for the ignition system, the potential at terminal 39 may be as low as 800 volts.

Wire 40 connects positive terminal 39 with resistance 41 which controls charge rate of main condenser 44 connected therewith, with resistance 60 which controls charge rate of spark prolonging condenser 61 connected therewith, and with a voltage absorbing resistance 42 connected with a terminal 59. Resistance 41 is connected with the plate of a thyratron 43. The main condenser 44 is connected with a primary winding 45 of a high frequency ignition coil 46 whose secondary 47 is connected with condenser 61 and with engine spark plugs through a suitable distributor, not shown. One of the spark plugs is indicated at 48.

Resistance 42 is connected with a wire 50 connected through a resistance 51 and a voltage limiting device or regulator 52 with a wire 53. Regulator 52 limits the potential between wires 50 and 53 to a certain value, for example, 750 volts. Wire 50 is connected with auxiliary condenser 59 through a charge rate controlling resistance 54 connected with contact 55 of ignition timer 57. Contact 55 is engageable with timer contact 56 connected with the grid 43*a* of the

thyratron 43. Resistance 58 connects the grid of thyratron 43 with the thyratron cathode through wire 53 connected with the negative or ground terminal of the power supply with which terminals of 52, 51 and 53 are connected.

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

Transformer primaries—each 22 turns of #17 wire;
Transformer secondary 16—3000 turns of #34 wire;
Condenser 34—.003 mfd.;
Grid resistances 33—10 megohms;
Rectifier tubes 31—model CK 1013;
Condensers 36 and 37—1.3 mfd.;
Resistance 41—50,000 ohms, 50 watts;
Resistance 42—220,000 ohms, 2 watts;
Resistance 54—300,000 ohms, 1 watt;
Resistance 51—1 megohm, 1 watt;
Resistance 58—27,000 ohms, 1 watt;
Resistance 60—25,000 ohms;
Condenser 44—.02 mfd.
Condenser 59—.003 mfd.;
Condenser 61—.08 mfd.;
Tube 43—model 2M 324 cold cathode thyratron;
Voltage regulator 52—twelve 60-volt neon bulbs in series.

Condenser 34 is a buffer condenser which absorbs transient voltages when the vibrator contacts open.

The high frequency ignition coil 46 is constructed in the manner disclosed in the patent of Short and Tynan, No. 2,463,123, granted March 1, 1949.

Tubes 31, 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. The conduction by these tubes is started by elements 31*a* in close proximity to the cathode. Each element 31*a* sets up an electrostatic field which causes electrons to be emitted and causes the tubes 31 to be conducting.

When wire 33 is positive, condenser 37 is charged through the circuit: wire 33, condenser 37, ground and upper tube 31. When wire 32 is positive, condenser 36 is charged through the circuit; wire 32, lower tube 31, condenser 36, wire 33. This circuit arrangement causes the potential of terminal 39 to be twice the potential of each condenser. Hence the condensers 36 and 37 provide a voltage doubler.

Tube 43 requires positive potential on its grid 43*a* in order to become conducting. Having once become conducting, it will continue to conduct so long as the plate voltage is above the ionization voltage, for example 100 volts. Resistance 41 limits the rate of charging condenser 44. When condenser 44 is fully charged, its potential becomes the potential of terminal 39. When tube 43 becomes conducting due to discharge of condenser 59 when timer contacts 55, 56 close, condenser 44 can discharge faster than it can be charged from terminal 39. Hence the potential on the plate of tube 43 will fall below the voltage required to maintain ionization and tube 43 will cease to conduct, the resistance 41 operating to prevent maintenance of a voltage on the plate of tube 43 above the ionization point.

The system is operative with terminal 39 potential in the range of 800 to 1500 volts. As stated before, 800 volts, for example, is that which is obtained when the voltage of a partly charged battery is low but yet sufficient to effect operation of the engine cranking motor and is 1500 volts, for example, when the battery is fully charged when operating the cranking motor or when current is supplied by the generator for ignition and battery charging. In order to provide for adequate charging of condenser 59 when terminal 39 potential is 800 volts and not subject it to excessive voltage when terminal 39 potential is higher than 800 volts, the voltage regulator or voltage limiting device 52 is provided. Device 52 comprises twelve neon tubes in series which do not pass current if the applied voltage is below 750 volts. The difference in potential between voltage of terminal 39 and 750 volts is absorbed in IR drop in resistance 42. So long as the potential of terminal 39 exceeds 750 volts, voltage regulator 52 takes 750 and resistance 42 absorbs the excess. Therefore, the potential of condenser 59, when fully charged, cannot exceed 750 volts.

Resistance 51, which with resistance 42 forms a voltage divider, serves as a bleeder resistance which by-passes current from the voltage regulator and thus lightens the load thereon.

Resistance 54 limits the rate of voltage increase of condenser 59, thereby permitting the timer contacts to be well separated before the condenser can become fully charged to a potential required for triggering. However, because regulator 52 is not conducting until the potential of the terminal 50 reaches 750 volts, no current is diverted by regulator 52 before it becomes conducting. Hence the current flow to the condenser 59 will be greater and it will accumulate its energy in less time than it would if the regulator 52 were conducting at all times. In Fig. 2, horizontal distances denote time and vertical distances denote voltage. Under a condition of low battery voltage when potential of terminal 39 is 800 volts, for example, line D—E—C represents voltage of condenser 59 and line A—B—C represents voltage of terminal 50. At the instant represented by 0 when charging of condenser 59 starts, voltage of terminal 50 is 250 volts, the IR drop in resistance 42 being 550 volts when voltage of terminal 39 is 800 volts. 250 volts less IR drop in resistance 54 is applied to condenser 59 at instant zero. Voltage of condenser 59 rises as represented by line D—E and the current passing to it decreases. As current taken by condenser 59 decreases, the IR drop in resistance 42 decreases and potential of terminal 50 rises as represented by line A—B. When time t_1 has elapsed voltage of terminal 50 has reached 750 volts and can go no higher because regulator 52 then starts to conduct and limits the potential of terminal 50 to 750 volts. Thereafter the rate of voltage rise of condenser 59 takes place less rapidly as represented by line E—C while potential of terminal 50 remains at 750 volts as represented by line B—C. Condenser 59 is charged to 750 volts in time t_2.

If the potential of terminal 39 were higher than 800, voltage at A would be higher and times t_1 and t_2 would be less. If the potential of terminal 39 is 1500 volts, for example, the system operates so that the potential at terminal 50 is less than 750 volts at 0 time or the instant when the charging of condenser 59 starts. This is desirable since the regulator 52 consumes energy from the power supply and should not be operative any longer than necessary. Time t_2 is sufficient for adequate ignition during cranking when engine speed is low. During running when the generator supplies current to the power sup-

ply and the potential at terminal **39** is 1500 volts the condensers **59** and **44** will be charged adequately even when the engine speed is maximum.

It is intended that the condenser **59** be fully charged when the voltage applied to it is 750 volts. It will receive no more current and the voltage drop across resistance **54** becomes zero. Since the potential between terminal **50** and wire **53** is maintained by the regulator **52** at 750 volts, the current passed by resistance **42** is that which is passed by the regulator **52** and the bleeder resistance **51** which takes some of the load off the regulator **52**. The value of this current passed by resistance **42** is that which causes the IR drop therein to equal potential of terminal **39** minus 750 volts.

Resistance **58** ties the grid **43***a* to the cathode of tube **43** so that its potential equals cathode potential when the timer contacts open. The value of resistance **58** is between a too high value by which control of the grid will be lost and a too low value which would result in the diversion of too much energy from the condenser **59** when discharging.

While the timer contacts **55**, **56** are open, condenser **59** is being charged. When the contacts close, condenser **59** discharges to the grid **43***a*, and tube **43** becomes conducting so that condenser **44** discharges through primary winding **45** of ignition coil **46**. Voltage in secondary winding **47** rises to such value that an arc is established at the gap **48** of the spark plug and a discharge circuit for condenser **61** is established. The arc having been established by attainment of acquired secondary voltage, the duration of the arc is prolonged by discharge of condenser **61**. By prolonging the duration of the arc, the surrounding fuel mixture will receive sufficient heat to start combustion. Therefore, ignition can be effected with a relatively short spark gap. Fig. 4 shows that the secondary voltage V_2 required to start the arc may be, for example, 18 KV. Time t_2 of Fig. 4 represents the time of the decline of voltage peak P_2 plus the time which elapses before the voltage of condenser **61** falls below the value required to maintain the arc. Line **61***d* represents the discharge of condenser **61** to maintain the arc. If no means are provided to maintain the arc after the peak voltage has dropped below the value required to maintain the arc, the duration of the arc is much shorter. Therefore the arc must be longer in order that the surrounding fuel mixture will be heated sufficiently to start combustion. Since the arc must be longer, the peak voltage must be higher. For example, the apparatus with condenser **61** will provide ignition at 18 kv., secondary peak voltage, for a particular engine. Without condenser **61**, satisfactory ignition would not be provided for that engine unless the spark gap is widened to such extent that 38 kv. is required to start the arc as indicated at P_1 in Fig. 3. The duration of the arc is represented by t_1 in Fig. 3 which is considerably smaller than t_2 in Fig. 4. To obtain secondary voltage high enough to start the arc, the condenser **44** must be larger and the coil **46** must have a higher transformation ratio. A larger and more expensive tube **43** would be required to handle the larger amount of current discharged by condenser **44**.

The present system is operative the instant the ignition switch **17** closes since cold cathode rectifier tubes **31** and a cold cathode thyratron tube **43** are used. These tubes require high voltage for their operation without cathode heaters. The

power supply which includes the rectifier tubes and furnishes high plate voltage for the thyratron is one capable of being operated by the automobile storage battery since the latter is the only source of electrical energy provided by the automobile during engine cranking. The ignition apparatus connected with terminal **39** of the power supply is capable of operation when the potential of terminal **39** is low due to low state of battery charge as well as when the potential of terminal **39** is high. The system provides for adequate charging of the main condenser **44** in the range of potential variation of terminal **39** and for adequate charging of condenser **59** when the potential of terminal **39** is at the low limit. To prevent application of excessive voltage to condenser **59**, the system includes a voltage limiting device (regulator **52**) and a voltage absorbing device (resistance **42**). By virtue of the current which condenser **59** takes when its charging begins, resistance **42** absorbs such amount of voltage, that the regulator cannot operate initially and is not normally an energy consuming device. As the charging of condenser **59** increases, its voltage increases and the current received by it decreases and the voltage consumed by resistance **42** decreases and the voltage impressed on the regulator **52** increases. The regulator **52** operates to limit the voltage impressed on the condenser **59** regardless of variation of potential of terminal **39** in the operating range. Therefore the voltage applied to grid **43***a* when condenser **59** discharges never becomes excessive and tube **43** is not damaged although its plate voltage may vary with voltage of terminal **39**.

By rendering regulator **52** operative only when needed, electrical energy is conserved and a less expensive power pack can be used. Furthermore, electrical energy is conserved through the use of the arc maintaining condenser **61** since satisfactory ignition is provided when the spark plug gaps are relatively short thereby requiring less energy to start the arc.

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. An ignition system for automotive vehicles comprising a storage battery, a power supply having an output terminal and receiving current from the battery and furnishing relatively high voltage direct current to the output terminal, an induction coil, a main condenser connected with the output terminal and with the primary winding of the induction coil, a discharge circuit for the main condenser including a cold cathode thyratron which conducts when a certain positive potential is impressed on its grid, a circuit for periodically supplying the required positive potential to the grid of the thyratron and including an auxiliary condenser and contacts of the engine operated ignition timer which, when closed, cause the auxiliary condenser to discharge through the thyratron grid, and means connected with the output terminal and operating independently of the state of battery charge, within certain limits, and consequent change in power supply output voltage for controlling application upon the auxiliary condenser to charge it of a voltage which is limited to a predetermined value, said means comprising a device which passes current only when voltage of said predetermined value is applied to it and a resistance which absorbs the potential in excess of

said value, said device and the auxiliary condenser being connected in parallel and together in series with the resistance.

2. The system according to claim 1 in which the device is a bank of a plurality of neon tubes in series.

3. The system according to claim 1 in which the device is a bank of a plurality of neon tubes in series and in which there is a bleeder resistance in parallel with the bank of neon tubes to lighten the load thereon.

4. An ignition system comprising a current source, an ignition coil having primary and secondary windings, a spark gap connected with the secondary winding, a main condenser charged by the source, a main condenser discharge circuit including the primary winding and a thyratron, an auxiliary condenser charged by the source, an auxiliary condenser discharge circuit including ignition timer contacts and the grid of the thyratron, the closing of the contacts causing the thyratron to establish the main condenser discharge circuit whereby secondary voltage increases to a value to produce an arc at the spark gap and a third condenser charged by the source and connected in series with the secondary winding and spark gap and discharging through the circuit established by the arc and operating to maintain the arc until the discharge voltage of said third condenser falls below arc-maintaining voltage.

5. An ignition system for use on an automotive vehicle having a storage battery and battery charging generator operated by the vehicle propeller engine, a power supply which receives relatively low voltage direct current from the battery or from the generator when it charges the battery and which produces relatively high voltage at its terminals, one of which is positive, the other or negative terminal being grounded, an ignition coil having a primary and secondary winding, a spark gap and an arc-prolonging condenser in series with the secondary windings, a charge-rate controlling resistance connecting the arc-prolonging condenser with the positive terminal of the power supply, a main condenser and a second charge-rate controlling resistance connected in series with the primary winding and said positive terminal, a main condenser discharge circuit including the primary windings and a code cathode thyratron, an auxiliary condenser, means connected with said power supply and auxiliary condenser and operating independently of the state of battery charge, within certain limits, and consequent change in power supply output voltage to control the application upon the auxiliary condenser to charge it of a voltage which is limited to a predetermined value, said means comprising a device which passes current only when voltage of said predetermined value is applied to it and a resistance which absorbs the potential in excess of said value, said device and the auxiliary condenser being connected in parallel and together in series with the resistance, there being a charge-rate controlling resistance connecting a terminal of the auxiliary condenser with the device and the potential-absorbing resistance, and an auxiliary condenser discharge circuit which includes engine controlled timer contacts, when closed, the grid and the cathode of the thyratron.

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