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SPARK GENERATING SYSTEM

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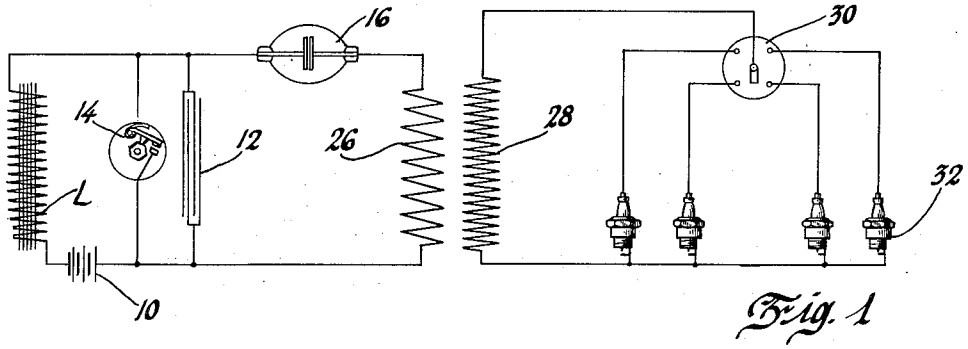


Fig. 1

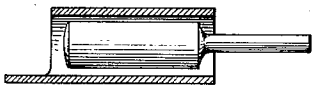


Fig. 2

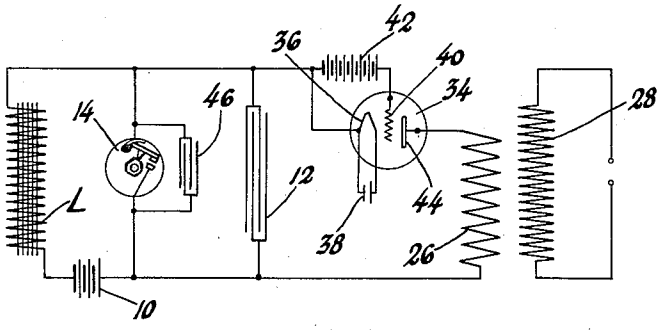


Fig. 3

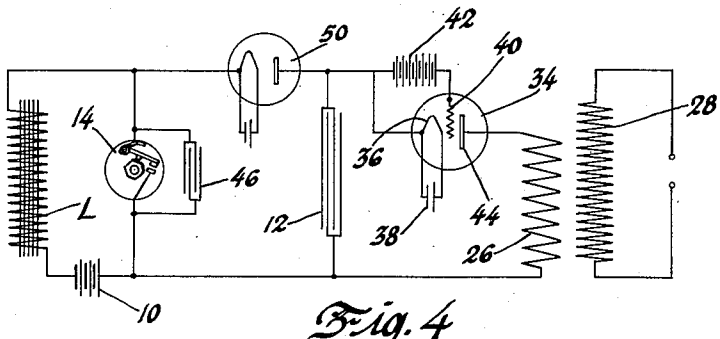


Fig. 4

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SPARK GENERATING SYSTEM

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Application May 1, 1933, Serial No. 668,754

13 Claims. (Cl. 123—148)

This invention relates to an improvement on the type of ignition system disclosed in Patent No. 2,003,466, granted to Donald W. Randolph and Hector Rabezzana on June 4, 1935.

The invention, like that of the prior application, has to do with spark generating systems adapted to provide ignition for internal combustion engines, and is characterized by the fact that the spark is produced by an electrical impulse of very short duration, so short indeed that the system may also be properly termed a high frequency system. This type of discharge is of special advantage in that use because the ignition circuit will continue to produce a spark even when the spark gap is shunted by a large conductance as in the case of a badly fouled plug.

In the prior Randolph and Rabezzana patent there is set forth an ignition system in which the condenser is charged by any suitable means but preferably by a surge of current obtained from a low voltage source such as the usual automobile battery, and the condenser is thereafter discharged through a circuit including a circuit maker and the primary of a transformer, the secondary of which supplies energy to the usual spark gap at the plug electrodes.

The chief improvement consists in employing in the discharge circuit of the condenser a control device in the form of a gaseous discharge tube that does not permit discharge until there has been impressed on the condenser either the approximate maximum voltage of the tube or a critical voltage determined by its characteristics. When that voltage has been attained the control device permits practically unobstructed flow of current. The control device preferably takes the form of a two-element electric discharge tube, preferably filled with gas. The electrodes are either made in whole or in part of material of low work function, or are provided with coatings of such material so as to readily ionize the gas between them when the required voltage is attained and produce an arc. The outstanding characteristic of the tube is the fact that at the lower voltages the gas between the electrodes acts as a very good insulator, and when the critical voltage is attained the gas breaks down and forms a conductor of high current carrying capacity. This characteristic of changing from a good insulator to an excellent conductor upon attaining a critical voltage is of especial importance in ignition systems since the energy available is relatively slight. Thus in one form of the invention disclosed in this application, the amount of energy available at the spark is limited by the amount that can be stored in the magnetic field of the primary inductance by means of a current that can pass the breaker points without undue disintegration of the material of these points, and it is essential that this limited amount of energy be conserved as much as possible. With our voltage control device we have obtained a surge of current which we have found by measurement to reach values as high as 75 amperes with a condenser voltage of approximately 190 volts. This momentary heavy current supplies an ample amount of energy to the secondary circuit containing the spark plug, insuring operation of the plugs under all conditions encountered in service. With tuned circuits we have gotten satisfactory sparking with lower peak currents. We have had satisfactory operation with condenser voltages over a range from 100 to 200 volts.

We believe our invention has overcome the chief disadvantages of prior high frequency ignition systems in that energy is supplied to the secondary circuit in sufficient amount and in so short an interval of time as to produce a satisfactory spark even though atmospheric or other conditions be such as to cause loss in transmission that would otherwise disable the system.

While we have secured best results employing in the discharge circuit a two electrode tube operated cold, it is also possible to employ two electrode tubes in which one or more of the electrodes is heated by means of an auxiliary filament, or to employ a three electrode tube having one electrode heated and the third electrode suitably biased so as to offer resistance to arcing until a certain voltage is attained.

We have likewise simplified the preferred form of circuit used to charge the condenser as disclosed in said prior Patent No. 2,003,466 by eliminating the means employed in the former case to prevent discharging of the condenser through the charging circuit. We have also dispensed with the auxiliary condenser across the breaker points, thereby reducing cost. However, if it should prove desirable for any reason, we may, employ the auxiliary condenser and likewise, if found desirable, we may use any of the devices described in the prior application for preventing undesired discharge of the main condenser.

In the drawing:

Figure 1 is a view showing the preferred form of circuit.

Figure 2 is a view showing slightly modified forms of electrodes.

Figures 3 and 4 show modified forms of circuits.

In Figure 1, 12 indicates the main condenser which may be supplied with energy from the conventional storage battery 10. However, if preferred, we may employ some other source of current such as a motor generator set, or a magneto in which current is generated by rotation of an inductance in a magnetic field.

In series with the battery 10 is an inductance L and a circuit breaker 14 which may be operated mechanically or in any other desired way. The condenser 12 is connected to this circuit so as to receive the energy stored in the magnetic field of the inductance when the circuit is broken at breaker 14. This may be accomplished in a number of ways as by connecting the condenser directly across the terminals of the inductance or across the contact points. In Figure 1 we have employed the last named type of connection.

The discharge circuit includes in series the condenser 12, the control device in the form of a two electrode gas filled tube 16 and the primary 26 of a transformer. The secondary 28 of the transformer supplies current through distributor 30 to the spark plugs 32.

The system operates as follows:

Energy is supplied by the battery 10 to the inductance L when the circuit breaker 14 is closed. In passing current through the inductance a magnetic field is built up in and around the coil and a certain amount of energy is stored in the magnetic field. When this circuit is interrupted by separation of the contacts at 14 the energy in the magnetic field is transferred to the condenser 12, where it remains until discharge takes place between the electrodes in the tube 16, when the energy from the condenser is in part delivered to the spark plugs 32 through the transformer 26—28 and appears in the spark. The purpose of the circuit is to take advantage of the different time intervals and time requirements of the several parts of the circuit. The nature of the ignition system is such as to permit of slow extraction of energy from the battery, relatively slow transfer of energy from the magnetic field of the inductance coil to the condenser 12, and an extremely rapid transfer of energy from the condenser 12 to the inductively coupled spark plug circuit.

One of the great advantages of the circuit is that while starting with a low voltage source, such as the usual six volt storage battery, by the simple means described, a relatively high voltage, in the neighborhood of 150 to 200 volts, is impressed on the condenser, and when the critical voltage is attained, the gap in the tube 16 breaks down, permitting flow of a heavy current through the transformer supplying the spark gap. The small amount of energy provided by the surge of current from the inductance to the condenser is conserved, and a considerable part of it is transferred to the spark plug.

We have had very good success employing at 12 a condenser of one microfarad capacitance, and using an inductance L having an iron core and a value of approximately .006 henry. The tube 16 with which we have had most success is described and claimed in our copending application Serial No. 668,753 filed May 1, 1933, said application being subsequently refiled on March 23, 1934 under S. No. 716,972. It is equipped with electrodes at least one of which, is composed of an alloy of nickel, barium, and copper, or of an alloy of nickel, barium, chromium and copper. One alloy with which we had success contained:

	Percent
Nickel	46
Copper	46
Chromium	4
Barium	4

We have found that, where the impressed voltage is in the neighborhood of 150 to 200 volts, very good results may be obtained by the employment of a gap between electrodes of approximately .3 mm. The gas employed in the tube should be one of the inert gases, preferably neon. We have had success using neon at pressures in the neighborhood of 30 cm. of Hg. We may employ a transformer with either an iron core or an air core, and have successfully used a ratio of terms of 15 to 1500. For best results the primary of the transformer should be of low impedance. We have found it particularly desirable that the resistance be low as well as the inductance.

While we have illustrated the charging of the condenser by surge of current obtained as described, if preferred, we may employ any of the known ways of charging the condenser including those disclosed in said prior Patent No. 2,003,466, as well as those previously referred to in this specification.

An interesting feature of the circuit described is the fact that the tube has proven in use to be sensitive to light. During the operation of the tube the interior of the envelope becomes coated with a mixture of barium, nickel and copper metal and the oxides of nickel and copper. This coating emits photoelectrons upon being exposed to light and these electrons assist in ionization of the gas. This action was sufficiently marked in certain tubes tested that when a non-transparent cover was placed over the tube, the engine stopped, and when it was removed the engine resumed operation. The starting voltage of the tube in the dark may be made sufficiently low so that the engine would not stop even if the tube displayed photoelectric characteristics. Another way to avoid such action is to make one of the electrodes in the form of a hollow cylinder and the other in the form of a solid or hollow cylinder placed within it, as illustrated in Figure 2. Furthermore thorough degassing of the electrodes previous to assembling them in the tube reduces this action to a negligible factor.

In Figure 3 we have illustrated a slightly modified circuit in which the tube 16 is replaced by a three element tube 34. The chief distinction between this and the preceding circuit consists in the use of a three electrode tube 34 in place of the two electrode tube 16. This tube may be of the well known type consisting of a filament 36 heated by means of a battery 38, a grid 40 biased by means of a B battery 42 and a plate 44 connected to primary 26 of the transformer. The grid 40 serves the purpose of preventing flow of current through the tube until the charge on the condenser 12 has attained the desired voltage. The disadvantage of this circuit is the added complication and expense of additional batteries. Another variation shown in this circuit consists in the employment of condenser 46 across the breaker points 14. However, in practice we have found the use of such small condenser to be unnecessary.

In place of the three electrode tube 34 we may employ a two electrode tube having one of its electrodes heated as by means of an auxiliary

filament supplied with current from a separate battery. When a heated tube is employed, it is possible to use for the electrodes, materials having higher work functions that would not emit satisfactorily when used in a cold tube.

In Figure 4 we have shown a slight modification of the circuit of Figure 3 in that a rectifier tube 50 of any preferred design is employed in the connections from the charging circuit to the main condenser 12 to prevent undesired discharge of the condenser.

Any of the circuits described, such as the charging circuit, or the condenser discharge circuit, may be designed for resonance if desired, but this is not essential.

While in each case we have illustrated the distributor in the secondary circuit we may, if desired, employ it in the primary circuit, but this leads to the necessity of employing separate transformers for each of the plugs.

One of the advantages of our circuit consists in the fact that very slight arcing takes place at the breaker points 14 owing to the large size of the condenser 12, consequently it will seldom be necessary to renew these points. The simplicity of the preferred form of circuit likewise renders it easy and cheap to manufacture. It has been found that there is little interference with radio reception. The higher frequency discharge not only renders the system practically immune to trouble from fouling of plugs, but also makes it possible to use plugs with covered electrodes as described and claimed in the copending application of Duffendack, Wolfe, Headrick and Randolph, Serial No. 672,136 filed May 22, 1933.

It is obvious that the circuit herein disclosed, without the secondary circuit containing the gaps of the spark plugs, may be used to produce intermittent flashes in the discharge tube or to produce oscillations of current in the primary circuit, these phenomena being employed for any of the purposes known in the art.

We claim:

1. In an ignition system the combination of a condenser, means for applying a charge to the condenser, a discharge circuit including the condenser and a gaseous discharge tube having electrodes between which current passes when the charge on the condenser reaches the desired voltage, and a circuit including an igniting device inductively coupled to the discharge circuit.

2. In an ignition system the combination of a condenser, means for applying a charge to the condenser, a discharge circuit including the condenser and in series therewith the primary of a step-up transformer and a gaseous discharge tube having a plurality of electrodes between which current passes when the charge on the condenser reaches the desired voltage, an igniting device, the secondary of the transformer being connected to supply current to the igniting device.

3. In an ignition system the combination of a device for receiving a charge of electrical energy and rapidly releasing the same, a charging circuit including a source of electrical energy, an inductance, and an interrupter through which the inductance is connected to the source to receive energy therefrom, means connecting the device to the charging circuit to receive a charge from the inductance when the circuit is broken at the interrupter, a discharge circuit including the device and a gaseous discharge tube having electrodes between which current passes when the charge on the device reaches the desired voltage, and an ignition circuit coupled to said discharge circuit.

4. In an ignition system the combination of a device for receiving a charge of electrical energy and rapidly releasing the same, a charging circuit including a source of electrical energy, and inductance, and an interrupter through which the inductance is connected to the source to receive energy therefrom, means connecting the device to the charging circuit to receive a charge from the inductance when the circuit is broken at the interrupter, a discharge circuit including the device and in series therewith the primary of a step-up transformer and a gaseous discharge tube having a plurality of electrodes between which current passes when the charge on the condenser reaches the desired voltage, an igniting device, the secondary of the transformer being connected to supply current to the igniting device.

5. A circuit for use in ignition systems and the like comprising a condenser, a charging circuit therefor including a source of electrical energy, an inductance, and an interrupter through which the inductance is connected to the source to receive energy therefrom, means connecting the condenser to the charging circuit to receive a charge from the inductance when the circuit is broken at the interrupter, a discharge circuit including in series said condenser and an arc discharge tube for preventing discharge of the condenser until the desired high voltage has been attained, and a circuit including a spark gap electrically connected to the condenser circuit by means of an inductive coupling only.

6. A circuit for use in ignition systems and the like comprising a condenser, a charging circuit therefor including a source of electrical energy, an inductance, and an interrupter through which the inductance is connected to the source to receive energy therefrom, means connecting the condenser to the charging circuit to receive a charge from the inductance when the circuit is broken at the interrupter, a discharge circuit including in series said condenser and an arc discharge tube for preventing discharge of the condenser until the desired high voltage has been attained, and the primary of a step-up transformer, a spark gap, the secondary of said transformer supplying current to said spark gap, said transformer constituting the sole coupling between the discharge circuit and the circuit including the spark gap.

7. A circuit for use in ignition systems and the like comprising a condenser, a charging circuit therefor including an electrical generator comprising an inductance, and an interrupter in series with the generator, means connecting the condenser to the charging circuit to receive a charge from the inductance when the circuit is broken at the interrupter, and a discharge circuit including in series said condenser, an arc discharge tube for preventing discharge of the condenser until the desired high voltage has been attained, and a work circuit coupled to the discharge circuit by an inductive coupling only.

8. In an ignition system the combination of a condenser, means for applying a charge to the condenser, a discharge circuit including the condenser, the primary of a step-up transformer, and a gaseous discharge tube having electrodes between which current passes when the charge on the condenser attains a sufficient voltage, and a work circuit including the secondary of said transformer, a plurality of ignition devices, and

a distributor adapted to successively connect the ignition devices to the secondary.

9. In a high frequency ignition system, the combination of a condenser, means for intermittently applying a charge to the condenser, a discharge circuit for the condenser including the primary of a step-up transformer and a discharge tube containing inert gas at sufficient pressure to permit substantial flow of current, said tube having electrodes between which the current passes when the charge on the condenser reaches the break-down voltage of the tube, one of said electrodes containing material of low work function to reduce the breakdown voltage, and a work circuit including the secondary of said transformer and an igniting device, said transformer constituting the sole coupling between said circuits.

10. In a high frequency ignition system the combination of a condenser, means for intermittently applying charges thereto, a discharge circuit including the condenser and an arc discharge tube having electrodes between which current passes in the form of an arc when the charge on the condenser reaches a predetermined voltage and a circuit including an igniting device inductively coupled to the discharge circuit.

11. In a high frequency ignition system the combination of a condenser, means in constant, unrestricted current conducting relation with said condenser for intermittently applying charges thereto, a discharge circuit including the condenser, and in series therewith, the primary of a step-up transformer and an arc discharge tube having a plurality of electrodes between which current passes in the form of an arc when the charge on the condenser reaches the desired voltage, an igniting device, the secondary of the transformer being connected to supply current to the igniting device.

12. In a high frequency ignition system the combination of a condenser, means at all times in unrestricted current conducting relation with said condenser for intermittently applying charges thereto, a discharge circuit for the condenser comprising in series the primary of a step-up transformer and a tube containing spaced electrodes between which a heavy surge of current is adapted to pass upon application of a predetermined voltage thereto and a plurality of igniting devices arranged in parallel with each other and in series with the secondary of said transformer, and a distributor adapted to successively connect the igniting devices to the secondary.

13. In a high frequency ignition system the combination of a condenser, means at all times in unrestricted current conducting relation with said condenser for intermittently applying charges thereto, a discharge circuit including the condenser and an arc discharge tube having electrodes between which current passes in the form of an arc when the charge on the condenser reaches a predetermined voltage and a circuit including an igniting device coupled to the discharge circuit.

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