April 17, 1934. C. E. VAWTER 1,955,519

IGNITION SYSTEM

Original Filed April 12, 1930 2 Sheets-Sheet 1

Fig. 1.

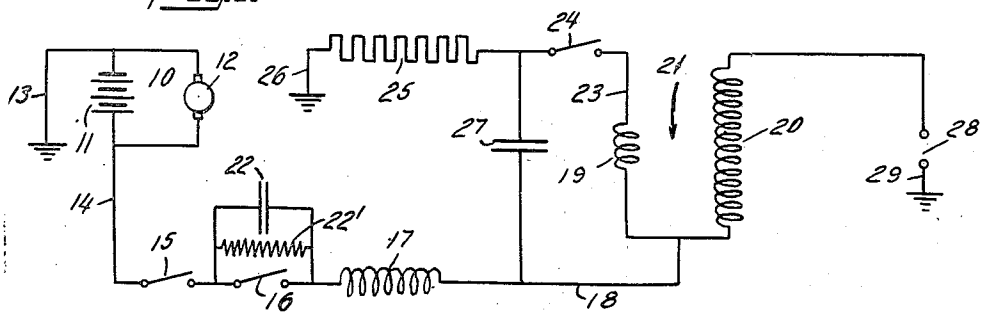


Fig. 2.

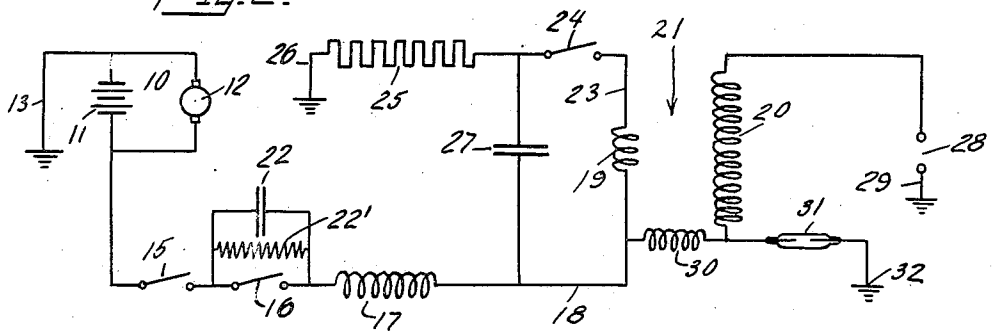


Fig. 3.

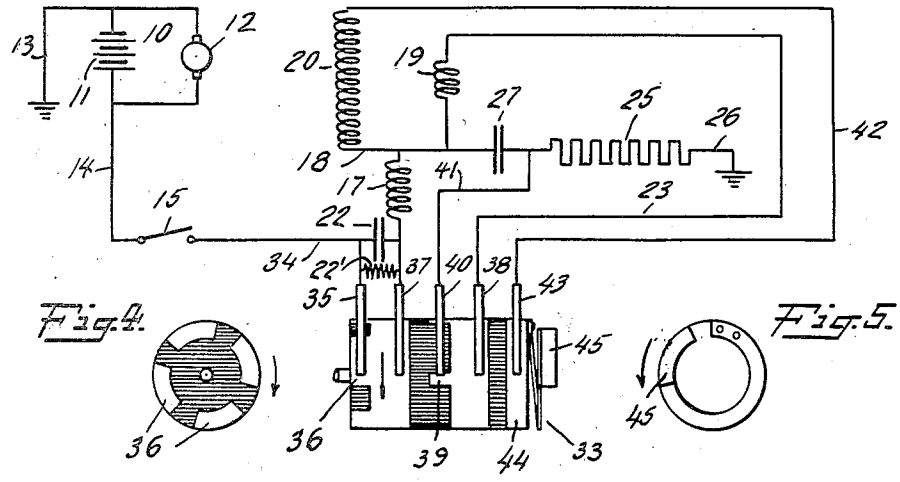
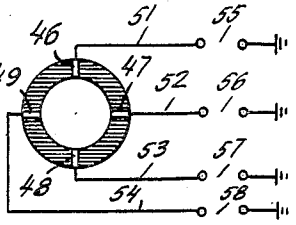


Fig. 4.

Fig. 5.

Fig. 6.



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Fig. 7.

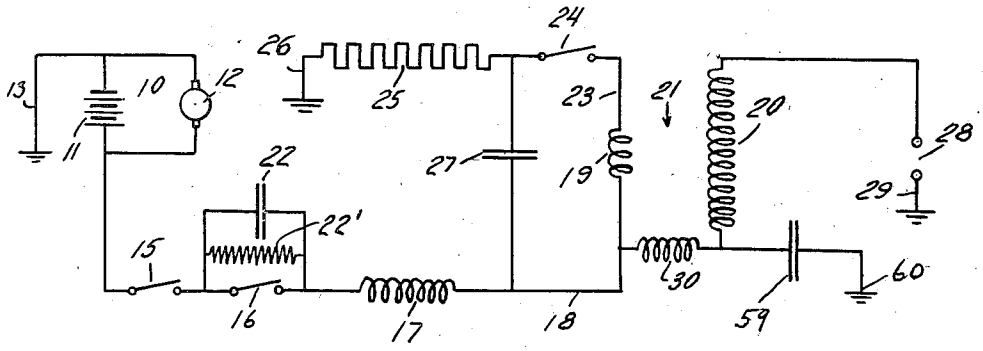
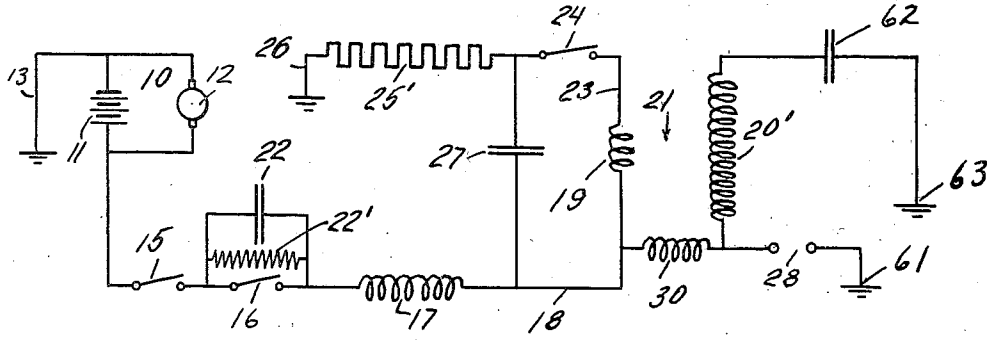


Fig. 8.



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Patented Apr. 17, 1934

1,955,519

UNITED STATES PATENT OFFICE

1,955,519

IGNITION SYSTEM

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Application April 12, 1930, Serial No. 443,730
Renewed January 20, 1934

11 Claims. (Cl. 123—148)

My present invention relates to ignition systems for internal combustion engines.

The ignition systems which are now in common commercial use employ for the ignition or firing of the charge within the engine cylinder a spark from an induction coil or from a high tension magneto, this spark being produced by a comparatively low frequency undulating or alternating current. With these systems the spark gaps between the electrodes of the spark plugs are comparatively easily obstructed by the presence of carbon and lubricating oil.

Also with these ignition systems it is necessary that the fuel mixture be highly explosive in character so that it is comparatively easy to start the explosion or combustion of the mixture. In addition, with the present ignition systems the spark produced is not sufficiently effective to cause even reasonably complete combustion of the fuel charge unless the charge is heated to a fairly high temperature by the time the ignition spark occurs. Hence the ineffectiveness of the present ignition systems is largely responsible for the difficulty experienced in starting internal combustion engines, particularly during cold weather. The tendency in engine design is, moreover, toward higher compression pressures, thus making it still more difficult for the present ignition systems to function properly.

The rate of ignition and the number of explosions per minute in the present ignition systems are limited because of the large inductance in the spark gap circuits. It is necessary to use iron in the magnetic circuits of these ignition systems in order to secure a sufficiently high inductance. The number of explosions per minute is limited by the rate at which the current will build up in these highly inductive circuits. For example, in the designing of aircraft engines, the maximum number of ignitions per second has been less than six hundred. Recently, however, engines with greater speed have been designed and the present ignition systems have failed to operate at this greater speed.

Ignition systems have heretofore been proposed in which a high frequency discharge of the order of frequency produced by an oscillating circuit is employed in association with a source of electricity of comparatively low voltage and capable of supplying a relatively large current. The high frequency discharge ionizes the gap between the electrodes of the spark plug and thereby establishes the current from the low voltage source across the gap converting the spark into an arc. A spark is a disruptive discharge of sufficiently high voltage to break down the gas gap between the electrodes without previous ionization of the gap and consequent reduction of the resistance of the gap. An arc discharge, however, can only take place after the resistance has been diminished by the ionization of the material between the electrodes. For example, it requires in the neighborhood of from five to fifteen thousand volts to produce a disruptive discharge between the electrodes of a spark plug in an ordinary motor vehicle engine under the compression pressures in ordinary use. However, when the gap is once bridged by such a discharge, the resistance of the gap is so reduced by the ionization of the gas that it requires only about forty volts to maintain an arc discharge between the electrodes.

The discharge between the electrodes of the spark plug in the ignition systems in commercial use is of the disruptive or spark type, and on account of the enormous inductance of the apparatus required to generate the voltage necessary to produce this discharge with a low frequency current, the amount of current which flows across the spark gap of the plug is minute. By converting the disruptive discharge into an arc discharge, however, the current passing between the electrodes of the spark plug can be increased enormously. For example, the current flowing across the spark gap in the ordinary motor ignition system is measured in milliamperes, whereas the current in the arc discharge is measured in amperes. The duration of the arc may be much less than the spark and still produce a much higher temperature due to the much greater amperage, yet the total energy may not be any greater and the ill effect upon spark plugs can be made even less destructive.

Moreover, the current increase accompanying the arc discharge takes place with such rapidity as to reach explosive violence. The fact that the impact of the arc that immediately follows the high frequency ionizing discharge has a greater ignition efficiency than an arc established in the same circuit by drawing, that is, by first touching together and then separating the contacts, has long been recognized.

Whenever this principle of ignition has been applied previously, however, it has been accompanied by a number of serious and heretofore insurmountable disadvantages. First the current ionized the gap across the interrupter contacts as well as the gap between the electrodes of the spark plug and these two gaps being in parallel, the arc would sometimes be established across one gap and

sometimes across the other. It could not be made to occur across the spark plug gap only and with certainty. The ignition system was therefore not only rendered inoperative, but the formation of an arc at the interrupter contacts quickly destroyed these contacts. It is an object of the present invention, therefore, to provide an ignition system of the type in which an arc discharge follows a spark discharge, and which is so arranged that the arc is made to occur with certainty across the spark plug electrodes and it is impossible for an arc to be maintained across the interrupter contacts.

A further serious and heretofore insurmountable disadvantage of the arc discharge ignition system has been that the extremely high frequency current employed to produce the disruptive discharge sooner or later caused a breakdown of the condenser or condensers employed in the system. This might not occur immediately but it would always occur after the system had been in use for only a comparatively short time. The only previous remedy for this was to construct the condenser of such expensive materials that the ignition system was rendered commercially impracticable. Hence another object of the present invention is to provide an ignition system in which the circuit is so arranged that breakdown of the condensers is avoided and the use of relatively inexpensive condensers will produce reliable results.

Moreover, in the arc ignition systems as previously proposed, the arcing current which is of comparatively high amperage was passed through the secondary of a high frequency transformer employed to produce the disruptive discharge. This necessitated the use of excessively large wire in the secondary which was undesirable for a number of reasons, among them being the cost and the large distributive capacity of the secondary winding. The greatest difficulty with passing the arcing current through the secondary, however, was that the heating effect of this current in the secondary caused an increase in the dielectric losses of the transformer and thereby reduced the high frequency ionizing or disruptive discharge current. Another object of the present invention is to so arrange the circuit of the ignition system that the arcing current is prevented from passing through the secondary winding of the transformer.

A further object of my present invention is to provide an ignition system of the type in which a disruptive discharge is followed by an arc discharge which is thoroughly practicable so that such an ignition system is made thoroughly reliable.

A still further object of my invention is to provide an ignition system of this type which is practicable not only for use with the present internal combustion engines, but which is also practicable for use with internal combustion engines of desired improved design incorporating for example greater speed of rotation and the use of fuel mixtures incapable of being exploded by the present spark ignition systems.

A still further object of the invention is to provide an ignition system of this type which can be manufactured at about the same, or even less cost than the high inductance magneto or induction coil systems now in use.

My invention will be understood from the following detailed description which is to be read in connection with the accompanying drawings. The disclosure is illustrative only and the details of the system may be changed without departing from the principle of the invention or exceeding the scope of the appended claims.

Referring now to these drawings:

Fig. 1 is a schematic circuit diagram of my improved ignition system;

Fig. 2 is a similar diagram containing certain modifications;

Figs. 3 to 6 illustrate the application of the ignition system to a four cylinder internal combustion engine.

Fig. 7 illustrates a modification of the circuit of Fig. 2; and

Fig. 8 shows a further modification of the ignition system.

Referring first to Fig. 1, the source of electrical energy 10 is such as to supply preferably direct current at a potential of preferably not less than sixty volts. Alternating current may be used as described near the end of this specification. The supply source may consist of either a battery 11 or a generator 12, and it is illustrated as a combination of the two. One terminal of the source 10 is grounded at 13. The other terminal is connected by a lead 14 to the ignition control switch 15 and thence through make and break contacts 16, inductance 17 and conductor 18 to both the primary coil 19 and secondary coil 20 of a transformer 21.

A condenser 22 is connected across make and break contacts 16 to prevent them from arcing, and a discharge resistance 22' is preferably connected across the terminals of condenser 22. This resistance is preferably non-inductive and its value is several thousand ohms. Without this resistance, when the contacts 16 close condenser 22 is discharged, and the repeated arcing which accompanies this discharge results in pitting the contacts. The resistance 22' forms a path by which the charge on condenser 22 may leak off while contacts 16 are open. This resistance is so high in value, however, that the current which flows through it from source 10 is insignificant.

Transformer 21 is a high frequency transformer and therefore preferably has an air core. Primary coil 19 consists of relatively few turns of heavy wire so that its resistance is practically negligible. Secondary 20 consists of a large number of turns of somewhat smaller wire but still having a comparatively large current carrying capacity sufficient to carry the arc current.

The primary circuit is completed through conductor 23, interrupter contacts 24, and a resistance 25 to ground at 26. Resistance 25 is preferably noninductive and is high in comparison to the ohmic resistance of the secondary coil 20 of the transformer. Thus, for example, resistance 25 may be about 80 ohms and the ohmic resistance of coil 20 about 6 ohms.

A condenser 27 is connected between the interrupter 24 and conductor 18 across the terminals of primary winding 19 forming therewith an oscillating circuit which is controlled by interrupter 24. The capacity and inductive reactances are such that the natural period of the circuit is extremely high and preferably above the radio broadcasting range of frequencies so that the apparatus will not interfere with radio reception. Secondary winding 20 is connected to one of the electrodes of the spark gap plug 28, the other electrode of which is grounded at 29.

Switch 15 is a manually operated switch and remains closed as long as it is desired to operate the ignition system. Make and break contacts 16 and interrupter 24 are mechanically actuated by

the internal combustion engine so as to close and open whenever it is desired to produce a discharge across gap 28. Interrupter 24 is so arranged that it always opens previous to the opening of contacts 16.

The operation of the ignition system is as follows: Control switch 15 is closed by hand. Upon the closing of contacts 16 and interrupter 24 current flows from source 10 through inductance 17, conductor 18, primary winding 19, conductor 23, contacts 24 and resistance 25 to ground at 26. The amount of this current depends upon the voltage of source 10 and the ohmic resistance of inductance 17, primary 19 and resistance 25. Resistance 25 is chosen to give the primary current desired. This resistance, however, will always be comparatively high inasmuch as it is preferable to have the resistance of inductance 17 low as well as that of primary 19, and since it is desired to reduce the primary current to a comparatively small value, and since it is also desired to have resistance 25 high in comparison to the resistance of secondary 20 for a reason which will hereafter appear.

This current causes the storing of considerable amounts of electromagnetic and electrostatic energy in the primary circuit. Interrupter contacts 24 now open and oscillation is thereby set up in the oscillatory circuit comprising primary 19, interrupter contacts 24, condenser 27 and conductor 18. This circuit oscillates at its natural period which, as mentioned above, is very high and the current builds up to a high value.

The high frequency current through coil 19 induces a current of correspondingly high frequency, but of much higher voltage in the secondary 20. The voltage generated is sufficient to break down the gas gap 28 within the engine cylinder and cause a disruptive discharge across this gap. The path of the current can be traced from secondary 20 across gap 28 to ground 29 thence to ground 26, resistance 25, condenser 27, and conductor 18 back to coil 20. This, of course, is assuming that the diagram of Fig. 1 represents all of the possible paths of current flow that might be present in the apparatus. In the device as actually built, on account of the construction and arrangement of the various elements, the high frequency current passing to ground at 29 probably returns to primary 20 largely as displacement current.

The passage of the disruptive discharge ionizes the gas between the electrodes of the gap and this ionization reduces the electrical resistance of the gap to an extremely low value so that the potential from the supply source 10 is sufficient to cause the current from this source to flow through the primary circuit by way of conductor 18 through secondary winding 20 and across the gap 28 to ground. The disruptive discharge which takes place first and bridges the gap 28 is thereby converted into an arc discharge. The resistance of inductance 17 and secondary 20 are such that a comparatively large current is caused to flow through the arc across gap 28.

The minute current produced by the oscillatory discharge which bridges the gap 28 and which has a correspondingly small heating value is suddenly and violently transformed into a current which may be from ten to one hundred times larger and which is sufficient to produce an arc of intense heat, and which will therefore cause extremely rapid and thorough ignition of the charge in the engine cylinder. The intense heat and impact of this violently formed arc are, moreover, sufficient to ignite fuel mixtures which the spark from the ordinary ignition system will not ignite. Tests have shown that it will start a cold motor of extremely high compression using a very lean fuel mixture and without the use of any sort of choking device.

Inductance 17 prevents the high frequency currents from the primary and secondary circuits of transformer 21 from entering supply source 10. The value of this inductance is made as low as possible, however, so as to reduce to the lowest possible extent its retarding action on the building up of the current across gap 28. By making resistance 25 non-inductive, the time required for the current to build up in the primary circuit is kept as short as possible.

It is also to be noted that an ionizing arc is drawn between interrupter contacts 24 whenever a discharge takes place across gap 28. Interrupter contacts 24 and the electrodes of gap 28 are connected in parallel with the supply source 10. Hence if an arc is established across gap 28, it will not be maintained across contacts 24, and if an arc is maintained across contacts 24 it will not be established across gap 28.

By placing resistance 25 in series with interrupter contacts 24, however, and choosing a value of this resistance which is large in comparison with the resistance of secondary 20, the current from source 10 will choose the path of least resistance which includes coil 20 and ionized gap 28 so that the arc is prevented from being maintained across contacts 24 and will always be established across gap 28.

Referring now to Fig. 2 of the accompanying drawings, the modified circuit here shown is identical with the circuit of Fig. 1 except for the insertion of an inductance 30 between one end of transformer secondary 20 and conductor 18, and the presence of a high frequency vacuum discharge device 31, one side of which is connected to the secondary circuit between coil 20 and inductance 30, and the other side of which is connected to ground at 32.

Device 31 is so constructed that it offers a low impedance to very high frequency currents, and a large impedance to low frequency currents, and will prevent entirely the passage of low voltage direct or continuous current. Device 31, therefore, provides a path to ground of low impedance for the high frequency currents from secondary 20 so that these currents will flow through device 31 to ground without flowing through the primary circuit. This device therefore protects condenser 27 against the action of the high frequency high voltage currents from secondary 20, thus prolonging the life of condenser 27 and permitting the use of a condenser constructed of relatively inexpensive material. Device 31, however, prevents the grounding of the supply source, since the current from the supply source is of such a character that it will not pass through the device. I preferably make use of a vacuum discharge device containing a pair of oppositely placed electrodes and having its envelope exhausted to a very high degree so that the high frequency currents will be readily conducted between the electrodes.

Even without employing inductance 30, the greater portion of the high frequency currents across gap 28 to ground 29 will return to secondary 20 by means of ground 32 and device 31 since this is the path of lowest impedance. It is preferable, however, to use inductance 30 so as to positively exclude from the primary circuit all

high voltage high frequency currents from secondary 20. It will be understood that inductance 30 as well as inductance 17 and secondary 20 are wound with sufficiently heavy wire and are otherwise of appropriate construction to carry the arc current from supply source 10 which will vary depending upon the heating properties of the arc discharge desired for any particular purpose.

The ohmic resistance of inductance 30 and also of inductance 17 are as low as possible so as to avoid overheating. Resistance 25, however, is still very high compared to the sum of the ohmic resistance of inductance 30 and secondary 20.

In Figs. 3 to 6 inclusive, are shown the application of the ignition system above described to a four cylinder internal combustion engine. The make and break contacts 16 which correspond to the primary contacts, the interrupter contacts 24, and a distributor are combined in a single commutator and brush device 33 which is driven in any suitable manner by the internal combustion engine and usually rotates at one-half the engine speed.

The switch 15 is connected by a lead 34 with a brush 35, and the current entering this brush passes into one of segments 36 leaving by brush 37 which is connected to inductance 17. Condenser 22 is connected across the terminals of brushes 35 and 37 to prevent arcing between brush 35 and segments 36. Discharge resistance 22' is also connected across the terminals of these brushes.

Inductance 17 is connected to primary 19, secondary 20 and condenser 27 by conductor 18 as before. The other end of primary 19 is connected by conductor 23 to a brush 38 which bears upon the ring portion of the four commutator segments 39. Condenser 27 is connected through non-inductive resistance 25 to ground at 26 and is also connected to brush 40 through conductor 41.

It will be understood that brushes 35 and 37 together with their coacting commutator segments 36 correspond to the make and break contacts 16 of Figs. 1 and 2. Also brushes 38 and 40 together with their coacting commutator segments 39 correspond to interrupter contacts 24 of Figs. 1 and 2. It will be observed that brushes 35 and 40 are adjusted so that their ends make contact with the commutator cylinder at points which are approximately in line with one another parallel with the axis of the commutator.

Commutator device 33 rotates in the direction shown by the arrows. The leading tips of commutator segments 36 and 39 are approximately in axial alignment so that they come beneath brushes 35 and 40 respectively at about the same instant. The four segments 39 are, however, narrower in width than are segments 36 so that each of segments 39 passes from beneath brush 40 before its corresponding segment 36 passes from beneath brush 35. Hence the oscillating circuit of condenser 27 and primary 19 is broken while the ignition system is still connected with the supply source 10 through brush 35 and segments 36.

The secondary 20 is connected through high tension lead 42 with brush 43 of the distributor mechanism. This brush bears upon rotating ring 44 from the side of which a single spring segment 45 projects. This segment contacts successively with stationary contacts 46, 47, 48 and 49 which are mounted in the distributor cap 50. This cap fits over the right hand end of the device 33 for this purpose. The high tension leads 51, 52, 53 and 54 connect contacts 46 to 49 inclusive with their respective spark plugs which are indicated by the gaps 55, 56, 57 and 58, one side of each of these gaps being grounded as indicated.

The leading edge of the distributor segment 45 is arranged approximately in line with commutator segments 36 and 39. The width of segment 45 is, however, slightly greater than segment 36 so that the arcing current across the spark plugs will be broken by segment 36 rather than by distributor segment 45. The passing of commutator segment 39 from beneath brush 40 causes the ignition discharges to take place. These contacts hence correspond to the timer contacts of the ordinary ignition system.

It will be understood that the commutator device 33 causes the same sequence of connections as described above in connection with Fig. 1 which are as follows: First commutator segments 36 and 39 and distributor segment 45 move approximately simultaneously into contact with their respective brushes 35 and 40, and one of the distributor contacts. This establishes the current through the primary circuit. Second segment 39 breaks contact with brush 40 causing the oscillatory discharge across the electrodes of one of the spark plugs which is followed instantly by the arc discharge. Third segment 36 breaks contact with brush 35 cutting off the arc discharge current.

Brush 40 and segments 39 which form the interrupter contacts should preferably be made of tungsten or some similar metal which will withstand the sparking which occurs at the opening of the primary currents through these contacts. The insulation of device 33 should preferably be Pyrex glass. Somewhat improved operation may be obtained by designing the timer and interrupter contacts so that they are immersed in insulating oil. It will be understood that the ignition system can be adapted for any number of engine cylinders by increasing the number of segments 36, 39 and distributor contacts 46 to 49 inclusive.

In Fig. 7 there is shown a modification of the circuit illustrated in Fig. 2. The difference between the two circuits lies in the substitution of a condenser 59 in place of vacuum discharge device 31, this condenser being connected to ground at 60. Condenser 59 is preferably of the right capacity to tune the secondary circuit comprising secondary winding 20, gap 28, ground 29, ground 60 and condenser 59 to the same frequency as the natural period of the primary circuit comprising primary winding 19, conductor 23, interrupter contacts 24, condenser 27 and conductor 18. By tuning the secondary circuit in this manner a maximum of current across gap 28 during the ionizing discharge will be produced. This gives a short and easily tuned secondary circuit and makes it possible to provide a system that will not interfere with radio reception and transmission.

In the circuit just described, the high frequency high voltage currents of the secondary circuit are prevented from entering the primary circuit by means of the inductance or choke coil 30, and also because of the fact that condenser 59 tunes the secondary circuit with the primary circuit. A further modification in the circuit of Figs. 2 and 7 may be made by making condenser 59 of relatively large capacity so that it will operate as a by-pass condenser. This will afford a return path of low impedance for the high frequency currents from ground 29 back to second-

ary 20 and the operation of the ignition system will be about the same as when vacuum discharge device 31, as shown in Fig. 2, is used. This has the advantage of giving a larger drop across the spark gap as the voltage drop across condenser 59 will diminish as its capacity is increased, thus allowing a condenser of lower voltage rating to be used.

Referring now to Fig. 8 of the accompanying drawings, there is here illustrated a further modification of the circuits shown in Figs. 1, 2 and 7. In Fig. 8 the connections of the primary circuit are the same as described in connection with the previous figures, but the connections of the secondary circuit differ widely and greatly improve the operation of the ignition system.

In Fig. 8 conductor 18 which is a part of the primary circuit connects the supply source 10 through inductance 17 to the inductance 30 and directly to the gap 28, the other side of which is grounded at 61. The same terminal of secondary winding 20' that is connected to inductance 30 is also connected to gap 28. The other terminal of secondary 20' is connected to a condenser 62 which is grounded at 63. As described in connection with Fig. 7, the capacity of condenser 62 is preferably such as to tune the secondary circuit comprising secondary winding 20', condenser 62, ground 63, ground 61 and gap 28 to the same frequency as the natural period of the primary circuit. Condenser 62 may, however, be of larger capacity and operate as a by-pass condenser if desired.

The ignition system shown in Fig. 8 operates in substantially the same manner as the systems shown in the previous figures of the drawings, that is, the ionizing charge is first made to take place across gap 28 by opening interrupter contacts 24 in the primary circuit, and this discharge is instantly followed by an arc discharge passing from supply source 10 through switch 15, contacts 16, inductance 17, conductor 18, inductance 30, gap 28 to ground at 61.

The advantage of the circuit shown in Fig. 8 is that the current of the arc discharge across gap 28 is removed from secondary 20', being shunted to ground at 61. In fact it is impossible for the arc current to pass through secondary 20' because of the presence of condenser 62. The operation of the high frequency transformer 21 in establishing the high frequency disruptive ionizing discharge across gap 28 is, moreover, facilitated. It will be remembered that the arc current is of comparatively high value, being measured in amperes whereas the disruptive discharge current is of very minute value being measured in milliamperes. Therefore by arranging the circuit as shown in Fig. 8 so that the secondary 20' is relieved of the burden of carrying the arc current, this secondary coil can be wound of very much finer wire and without having to take into consideration the heating of this coil by the arc current.

The secondary coil 20' is wound solely for carrying the high frequency current. It is smaller, has less distributed capacity, and is more efficient for carrying high frequency currents. It is free from the heating effect of the arc current and the consequent increase in dielectric losses. Because of its lower distributed capacity it can be tuned more sharply with the primary. It can also be tuned to a frequency which is out of the range of frequencies commonly employed for the transmission of radio signals, thus avoiding interference therewith.

The extremely hot electrical discharge produced by the ignition system of the present invention, makes the system suitable for use in connection with internal combustion engines which burn a low grade of fuel, that is, a fuel which requires an unusually high temperature to ignite it. This ignition system therefore, makes it practicable to design internal combustion engines for the burning of the cheaper grades of fuel, such for example as the heavy fuels such as used in engines of the Diesel type. These engines, however, can be designed for much lower compression pressures than is required in Diesel engine construction to raise the temperature of the gas within the engine cylinder sufficiently high to cause combustion of the fuel. By designing such engines for moderate compression pressures instead of the extraordinarily high pressures required in Diesel engines, the weight of the engine per horse power output is enormously reduced, and both the first cost and maintenance cost are materially lowered.

The ignition system of the invention also improves the operation of ordinary internal combustion engines designed for electric ignition since the discharge across the spark plug points is of such a character that it will ignite cold, lean fuel mixtures and the collection of lubricating oil and carbon deposits upon the terminals of the spark plug do not interfere with formation of a hot electric arc. The spark plug electrodes can literally be covered with lubricating oil without causing the ignition system to cease functioning properly even when this oil contains carbon in quantities sufficient to short circuit the present ignition systems.

It is well known that carbon deposits form upon the insulating material separating the electrodes of the ordinary spark plug. A thin film of such carbon will not materially affect the operation of the present spark ignition systems. However as this film of carbon increases in thickness, its conductivity for the low frequency currents of the present ignition systems increases, and ultimately is lowered to a point where the spark gap between the electrodes is short circuited thereby. Its conductivity for the high frequency ionizing current employed in the system of the present invention, however, does not increase since such high frequency current travels on the surface, and the area of the surface of the carbon deposit is not appreciably increased as the film grows into a cake. Hence the conductivity for these high frequency currents will not be sufficiently reduced to short circuit the spark gap between the electrodes nor to interfere with the establishing and maintaining of the low voltage arc.

It was stated above that the source 10 supplies direct current. A source of alternating current, however, may be employed if desired. For example a magneto capable of supplying a comparatively large alternating current at a relatively low voltage, that is, in the neighborhood of 60 volts, may be used provided that the driving mechanism of the magneto is interconnected with the driving mechanism which rotates the commutator device 33. This driving mechanism must be so arranged that each segment 36 will pass underneath brush 35 while the armature coil of the magneto is passing through the maximum magnetic flux, and that segments 39 pass from beneath the end of brush 40 at the point of maximum voltage generated by the magneto.

I claim:

1. An ignition system comprising a primary circuit containing a transformer primary and a circuit interrupter, a secondary circuit containing a transformer secondary and a gap, means for establishing the primary current across said gap when the same has been bridged by the secondary voltage, and resistance means for preventing the primary current from maintaining an arc discharge across the interrupter contacts.

2. An ignition system comprising a primary circuit, containing a transformer primary and a circuit interrupter, an oscillating circuit consisting of a condenser said transformer primary and said interrupter, a secondary circuit containing a transformer secondary and a gap, means whereby the primary current is established across the gap when the same has been bridged by the secondary voltage, and resistance means for preventing the primary current from maintaining an arc discharge across the interrupter contacts.

3. An ignition system comprising a primary circuit containing a transformer primary and a circuit interrupter, an oscillating circuit consisting of a condenser said transformer primary and said interrupter, a secondary circuit containing a transformer secondary and a gap, a common supply circuit for said primary and secondary circuits whereby current is established across the gap when the same has been bridged by the secondary voltage, and resistance means for preventing the supply circuit current from maintaining an arc discharge across the interrupter contacts.

4. An ignition system comprising a primary circuit containing a transformer primary of low inductance, and a circuit interrupter, a secondary circuit containing a transformer secondary of low inductance and a gap, a common supply circuit connected to said primary and secondary circuits, an oscillating circuit comprising a condenser said transformer primary and said interrupter, whereby when the gap is bridged by the secondary voltage the current from the supply circuit is established across said gap, resistance means for preventing the supply circuit current from maintaining an arc discharge across the interrupter contacts, and an inductance in said supply circuit having a value sufficient to prevent the high frequency currents of said primary and secondary from flowing into said supply circuit but insufficient to appreciably retard the establishment of the supply circuit current across said gap.

5. An ignition system comprising a primary circuit containing a transformer primary and a circuit interrupter, a secondary circuit containing a transformer secondary and a gap, a common supply circuit connected to said primary and secondary circuits and an oscillating circuit comprising a condenser said transformer primary and said interrupter, whereby when the gap is bridged by the secondary voltage the current from the supply circuit is established across said gap, resistance means for preventing the supply circuit current from maintaining an arc discharge across the interrupter contacts, and means forming a path of low impedance for the return to said transformer secondary of the high frequency current flowing across said gap.

6. An ignition system comprising a primary circuit containing a transformer primary and a circuit interrupter, a secondary circuit containing a transformer secondary and a gap, a common supply circuit connected to said primary and secondary circuits and an oscillating circuit comprising a condenser said transformer primary and said interrupter, whereby when the gap is bridged by the secondary voltage the current from the supply circuit is established across said gap, resistance means for preventing the supply circuit current from maintaining an arc discharge across the interrupter contacts, and a highly evacuated vacuum discharge device in said secondary circuit and forming a path of low impedance for the return to said transformer secondary of the high frequency current flowing across said gap.

7. An ignition system comprising a primary circuit containing a transformer primary and a circuit interrupter, a secondary circuit containing a transformer secondary and a gap, a common supply circuit connected to said primary and secondary circuits and an oscillating circuit comprising a condenser said transformer primary and said interrupter, whereby when the gap is bridged by the secondary voltage the current from the supply circuit is established across said gap, resistance means for preventing the supply circuit current from maintaining an arc discharge across the interrupter contacts, means forming a path of low impedance for the return to said transformer secondary of the high frequency current flowing across said gap, and an inductance connecting said primary and secondary circuits, said inductance having a value sufficient to prevent the passage therethrough of the high frequency currents of the secondary circuit but insufficient to appreciably retard the establishment of the current from the supply circuit across said gap.

8. An ignition system comprising a primary circuit containing a transformer primary and a circuit interrupter, a secondary circuit containing a transformer secondary and a gap, a common supply circuit connected to said primary and secondary circuits, and an oscillating circuit comprising a condenser said transformer primary, and said interrupter, and mechanically actuated means for closing substantially simultaneously said common supply circuit said interrupter and said secondary circuit, mechanically actuated means for opening said interrupter thereby setting said oscillating circuit in oscillation and causing the secondary voltage to bridge said gap and establish the current from the supply source across the same, means for thereafter opening said supply circuit and means for subsequently opening said secondary circuit.

9. An ignition system comprising a primary circuit containing a transformer primary and a circuit interrupter, a secondary circuit containing a transformer secondary and a gap, a common supply circuit connected to said primary and secondary circuits and an oscillating circuit comprising a condenser said transformer primary and said interrupter whereby when the gap is bridged by the secondary voltage the current from the supply circuit is established across said gap, resistance means for preventing the supply circuit current from maintaining an arc discharge across the interrupter contacts after they open, and a condenser connected in said secondary circuit to form a path for the return to said transformer secondary of the high frequency current flowing across said gap, said condenser being of such value as to tune said secondary circuit to the same frequency as the natural period of said oscillating circuit.

10. An ignition system comprising a gap, a primary circuit containing a transformer primary

and a circuit interrupter, a secondary circuit containing a transformer secondary and said gap, a common supply circuit connected to said primary circuit, said gap and said secondary circuit, and an oscillating circuit comprising a condenser said transformer primary and said interrupter, whereby when the gap is bridged by the secondary voltage the current from the supply circuit is established across said gap, resistance means for preventing the supply circuit current from maintaining an arc discharge across the interrupter contacts when they are opened, an inductance connecting said primary and secondary circuits for preventing the secondary currents from passing into said primary circuit, and means in said secondary circuit for permitting the passage therethrough of the high frequency currents from said transformer secondary but preventing the passage through said secondary of the supply circuit current.

11. An ignition system comprising a primary circuit containing a transformer primary and a circuit interrupter, an oscillating circuit consisting of a condenser said transformer primary and said interrupter, a secondary circuit containing a transformer secondary and a gap, a common supply circuit for said primary and secondary circuits whereby current is established across the gap when the same has been bridged by the secondary voltage, and resistance means in said primary circuit for limiting the current passing therethrough from said common supply circuit to a value below that necessary to maintain an arc across the interrupter contacts when they open.

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