

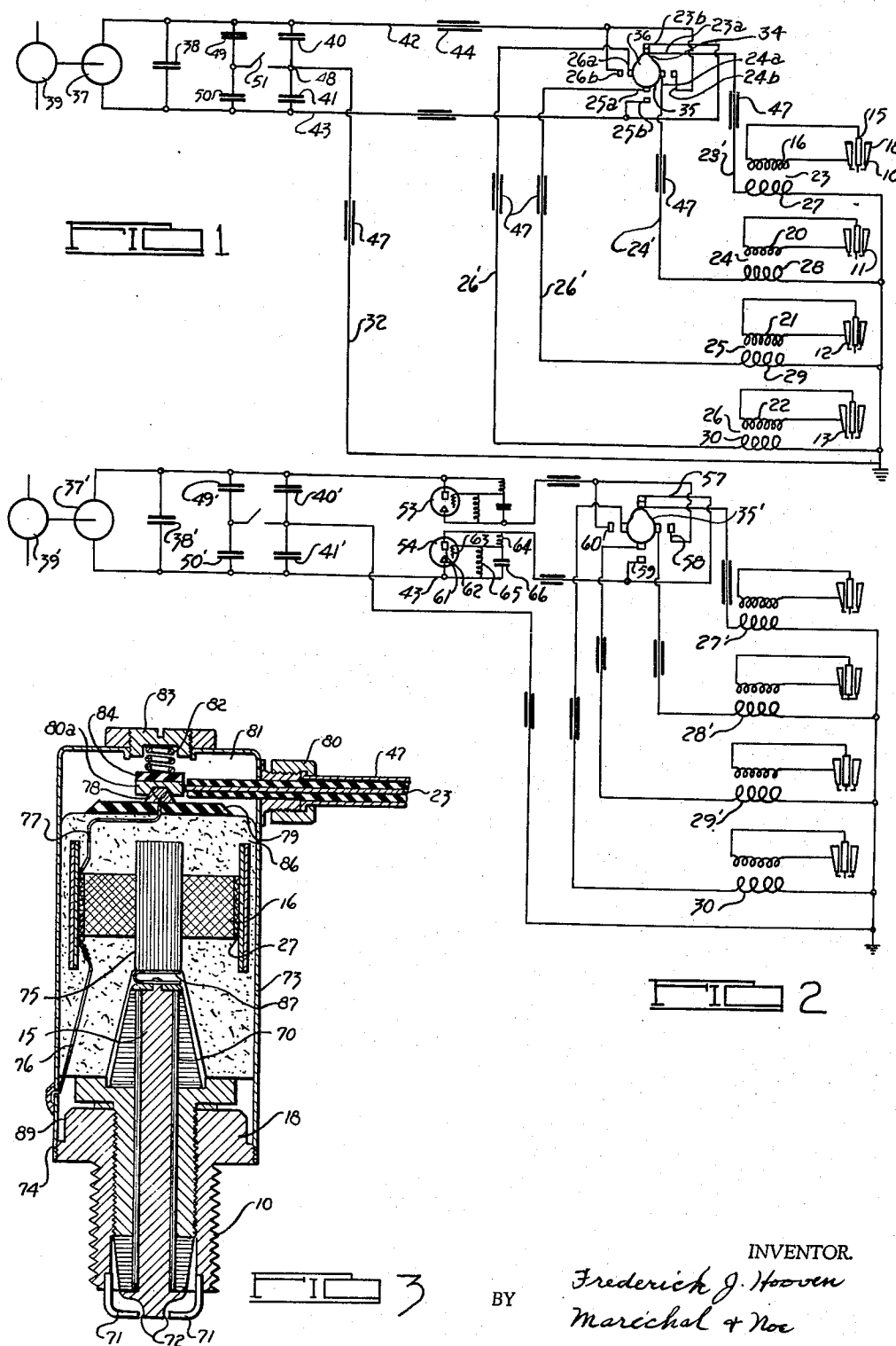
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IGNITION SYSTEM

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IGNITION SYSTEM

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This invention relates to ignition systems such as are used on internal combustion engines.

One object of the invention is the provision of ignition means which enables the use of a coil small enough to be built integral with the spark plug of an engine or the like, allowing the elimination of radio interference without the use of extended shielded high voltage leads, and especially adapted for high speed engine operation.

Another object of the invention is the provision of ignition means in which the energy of the spark is substantially the same regardless of the speed of engine operation, making it possible to regulate the spark energy to a value which will give efficient operation at all speeds without requiring the provision of an excessive energy at any particular speed, and reducing the deterioration of spark plug electrodes and contact points.

Another object of the invention is the provision of an ignition system for producing successive sparks and including a condenser or condensers which are charged from a source of charging current periodically connected thereto and which are discharged periodically through a transformer winding or windings which are also effective in providing part of the charging circuit for the condenser.

Another object of the invention is the provision of an ignition system in which a pair of condensers are alternately charged from a common source of charging current and periodically discharged alternately through different primary windings of spark coils to thereby energize said primary windings.

Another object of the invention is the provision of an ignition system having a continuous source of charging current connected uninterruptedly to a storage condenser and connected to a coil energizing condenser or condensers by means of a single series of distributor contacts which establish circuits for the charge or discharge of the coil energizing condenser or condensers through the coil windings, the construction being such that the distributor contacts open at a time when no current is flowing through them.

Another object of the invention is the provision of an ignition system having a distributor in a low voltage circuit which periodically establishes connections between condensers and the primary windings of spark coils which are arranged at the spark plug locations where they are effectively shielded against electrical radiation, the distributor also controlling the charging of the condensers.

Another object resides in the method of operation of an ignition system of the character referred to.

Other objects and advantages of the invention will be apparent from the following description, the appended claims, and the accompanying drawing in which:

Fig. 1 is a diagrammatic showing of the various electrical connections of an ignition system embodying the present invention;

Fig. 2 is a diagrammatic showing of a modified construction in which rectifying space discharge tubes are provided in the circuits connected to the distributor; and

Fig. 3 is a vertical sectional view of a spark plug and coil unit.

Referring more particularly to the drawing by reference numerals, Fig. 1 shows an electrical ignition system for producing electric sparks at a number of spark gaps, the system being especially adapted for energizing the spark plugs of an internal combustion engine and particularly engines adapted for aeronautical use. In Fig. 1 the several spark plugs of the engine are designated 10, 11, 12 and 13, it being understood that these plugs may be of any suitable number in accordance with the number of cylinders in the engine.

In the usual ignition system of airplane engines, the distributor is provided in the high voltage part of the system and the high voltage wires leading from the distributor to the several spark plugs of the engines are shielded to prevent radio interference by metal casings which increase the capacity effect of the high voltage part of the system to such an extent as to require the supply of comparatively large amounts of power in the production of the sparks at the spark plugs. In accordance with the preferred arrangement of the present invention, however, the distributor is provided in the lower voltage part of the system and the primary windings of the spark coils are arranged closely adjacent the spark plugs themselves so that the wires leading to the primary windings at the spark plugs are comparatively low voltage wires and their shielding may be effected where they extend from the distributor to the spark plug locations without substantially increasing the capacity effect of the high tension part of the system. Thus the central electrode 15 of the spark plug 10 is connected to one end of the secondary winding 16 associated with that spark plug, the other end of the secondary 16 being connected to the metal body portion 18 of the spark plug as shown dia-

grammatically in Fig. 1. The other spark plugs are similarly connected to the secondary windings 20, 21, and 22 of the transformer or spark coils. The four transformer coils are designated 23, 24, 25 and 26 and include the primary windings 27, 28, 29 and 30 respectively.

The several primary windings of the transformer coils 23 to 26 inclusive are electrically connected to a common lead 32 which is preferably grounded and to the several leads 23', 24', 25', and 26' which extend respectively to contact members 23a, 24a, 25a, and 26a of a distributor. Cooperating with these contact members are additional contact members 23b, 24b, 25b and 26b respectively, the contact members to which the same numbers are applied cooperating with one another and being normally open or disconnected, but being periodically connected together to establish an electric circuit by means of a cam 34 provided on the rotatable distributor member 35. It will be understood that the distributor member 35 is carried by a rotatable shaft 36 which is operated in timed relation with respect to the several engine cylinders so as to close the several circuits periodically and successively to produce sparks at the spark plugs at the required time.

The engine with which the spark plugs are associated is provided with an electrical generator 37 which may be driven from a separate battery-operated motor 39 or which may be connected mechanically to the engine shaft as desired. This generator, which is preferably adapted to supply direct current of a voltage preferably of the order of 250 volts, is connected across a condenser 38 which may have a capacity of about 4 microfarads and which acts as an electrical storage or reservoir member. Connected across the storage condenser 38 there are two coil energizing condensers 40 and 41, one side of each of these condensers being connected to opposite sides of the storage condenser 38 to which an uninterrupted supply of direct current is furnished from the generator 37. The two condensers 40 and 41, each of which may have a capacity of about 3 microfarad, are connected to the common wire 32 which leads to the several primary windings of the transformers. The wires 42 and 43 which extend from those sides of the condensers 40 and 41 that are connected to the source of charging current extend to alternate contact members of the distributor as shown, the wire 42 being connected to the contact members 24b and 25b while the wire 43 is connected to the contact members 23b and 26b. These wires 42 and 43 are preferably enclosed in metal shielding tubes 44 and 46, and shielding tubes 47 are provided to enclose the wires 23', 24', 25' and 26' and 32 throughout their extent to the transformer windings at the spark plug locations.

The operation of the described arrangement is such that the condensers 40 and 41 are periodically and successively connected to the uninterrupted source of charging current furnished from a suitable D. C. supply source such as generator 37 and storage condenser 38, and are charged thereby; and are periodically connected to the transformer coils and discharged or charged through the transformer coils which are thus energized to produce a sufficiently high voltage across the ends of the secondary windings to cause sparking at the spark plugs. With the two condensers 40 and 41 connected as shown through the distributor contacts, one of these condensers will be discharged through a primary winding of

a coil at the same time the other one of these condensers is charged through that same primary winding, both condensers having an additive effect in producing a current flow through the primary winding.

Consider the parts in the particular position shown in Fig. 1 in which a connection has just been established between the contact members 23a and 23b so as to close a circuit from wire 43 to primary winding 27, the return circuit being through wire 32 to the point 48. This places the primary winding 27 across the condenser 41 so that the charge on that condenser is dissipated through the winding 27 and a spark is thus produced between the electrodes 15 and 16 of the spark plug 10. And since the primary winding 27 is placed across the condenser 41 that winding 27 will form a conductive path through which the condenser 40 will be charged from the storage condenser 38. The charging current of condenser 40 and the discharging current from condenser 41 act together, one adding to the effect of the other, to produce a current flow through the winding 27.

As the distributor cam 34 continues to rotate in a clockwise direction it will open the circuit to the winding 27, and since the two condensers 40 and 41 are connected in series across the charging condenser 38, the charge of the condenser 40 will be maintained and the condenser 41 will remain in a discharged state until the contacts 24a and 24b are connected together by cam 34. The closing of these contacts connects the primary winding 28 of transformer coil 24 to the wire 42 and the return wire 32, thus placing the winding 28 across the condenser 40, and therefore placing it in series with the condenser 41 across the charging source 37, 38 so that the condenser 40 will now be discharged through the winding 28, and the condenser 41 will be charged from the charging source through the winding 28. The distributor then opens the circuit to the winding 28 and closes the circuit to the winding 29 as the distributor cam continues its rotational movements, the winding 29 thus being connected across the condenser 41, which discharges again, and connected in series with the condenser 40 which charges again. These operations are repeated in timed succession so that each condenser is periodically charged and discharged at successive sparking times, first one of the condensers and then one of the others being connected through a primary winding to the storage generator 37 and condenser 38 which are sufficiently large in capacity, as compared with the size of the condensers 40 and 41, to supply a charge to those condensers between the time elapsing from the opening of a pair of contacts of the distributor to the closure of the next succeeding pair. The storage or reservoir condenser 38 is itself maintained substantially charged as it is connected continuously to the generator 37. The generator itself may be of comparatively small size.

Even though the two condensers 40 and 41 are not the same in capacity effect, the charging current of one added to the discharging current of the other is substantially constant, so that the several primary windings associated with the several spark plugs are supplied with the same amounts of current, and sparks of substantially uniform intensity are successively produced at the several spark plugs. Even if one of the condensers 40 and 41 is entirely omitted, if the capacity of the remaining condenser is sufficient, it will supply sufficient current first by charging

through and then by discharging across the successive primary windings.

To provide a hotter spark under starting conditions or for emergency, a pair of auxiliary condensers 49 and 50 are connected in series across the reservoir condenser 38 and a manually operable switch 51 is provided so that it may be closed to connect these two condensers 40 and 41 so that the condensers 49 and 40 operate together and the condensers 50 and 41 operate together, increasing the flow of current through the primary windings to increase the power of the several spark coils. Under normal conditions, however, the switch 51 is open, and the condensers 49 and 50 remain connected across the reservoir condenser 38 and thus they themselves act as reservoir condensers and serve to increase the capacity of the storage or reservoir part of the system. Under normal conditions of operation, after the engine has been started, a hot spark is not required, and a spark that is hotter than necessary is even a disadvantage as it increases the wear or deterioration of the spark plug electrodes.

It will be understood that the time required for the discharge of a condenser 40 or 41 and the charging of the other one of these condensers through a primary winding is exceedingly small, so that a flow of current takes place across the contacts 23a and 23b for example as those contacts approach one another and even a little before they close, it having been found that the time during which current flows across contacts 23a and 23b is so exceedingly small that the flow probably ceases before the contacts actually touch one another. When these contacts 23a and 23b open, the flow of current through the winding which they connect in circuit has stopped so that no flow of current is interrupted as these contacts separate. This entirely eliminates sparking across the contacts of the distributor at the time of opening of the contacts, and any spark produced as the contacts close does not adversely affect the operation because the voltage is sufficiently high when the contact is made to insure instantaneous flow of current even if the contacts are pitted. The contacts may therefore remain in service for very extended periods of time even though they are made of ordinary cheap material, for example tungsten.

It will also be apparent that in the form of construction described, a single series of distributor contacts are provided in the low voltage part of the system which requires no supplemental circuit breaking or interrupting devices, since the opposite sides of the condensers 40 and 41, arranged in series, are connected continuously across an uninterrupted supply of charging current. The arrangement is such that no interval of time is required, as is customarily necessary between sparking impulses, for the recharge of an energy reservoir, such as building up a current in a coil or the recharging of a condenser preparatory to the production of a succeeding spark. This greatly reduces the minimum time between successive sparks and allows the sparks to be created as often as desired, thus removing the limitations on the speed of operation even in an engine having many cylinders.

In accordance with the present invention the natural frequency of oscillation of the ignition system is extremely high. The higher the natural effect of oscillation of the system, the less it is affected by leakage resistance across the

spark gap such as may be occasioned by a leaky or foul plug. The described arrangement is one in which the sparking ability is scarcely affected by a leakage resistance of 25,000 ohms across the gap, whereas a high grade magneto of conventional construction is unable to perform satisfactorily with a leakage resistance less than about 200,000 ohms. This factor is very important because, in addition to serving as an increased safety factor, it allows the use of a much colder running spark plug. With a cold running spark plug, an important obstacle to the development of high output engines is removed, for as is well known, the limitation in the increased cooling of spark plugs is the tendency for them to foul up with deposits of carbon or other material while idling or running at part load, and with conventional ignition systems it is necessary to operate the plug so that it becomes hot enough to burn off such carbon deposits in order to prevent electrical leakage such as would cause misfiring.

In accordance with the modified arrangement shown in Fig. 2, there is a similar arrangement of a motor 38' operating a generator 37' which is connected to a storage condenser 38', to auxiliary starting condensers 49' and 50' and to the coil energizing condensers 40' and 41'. The spark coils including the primary windings 21', 28', 29' and 30' are similarly associated with the secondary windings and with the spark plug electrodes and are similarly connected to the contact members of the distributor 35'. However in this construction rectifying space discharge tubes 53 and 54 are connected to the wires 42' and 43' between the condensers 40' and 41' and the contact members 57, 59 and 58, 60 of the distributor. The space discharge tube 54 comprises spaced elements 61 and 62 and an energizing or grid element 63, the latter being connected to impedances 64 and 65 and a small condenser 66 as shown so that when the contact 57 closes current flows through the winding 21', through the impedance 64 to the grid 63 and then through the gas contained within the tube to the element 61, this flow of current between the elements 63 and 61 rendering the gas which separates elements 61 and 62 conductive so that the flow of current then takes place across those elements. The impedance of part 64 may be sufficient to slightly delay the time at which the main current flow starts across elements 61 and 62 so that the contact 54 will be closed before this current flow starts. The sparking effect across the contacts at the time the contacts close is thus eliminated. And as the glow tube provides for flow of current in one direction only between the electrodes 61 and 62, any surging or oscillation tendency that might otherwise be produced is completely damped out instantaneously. The glow tube 53 is similarly connected to the wire 42'. The glow tubes are also effective in enabling a greater charge to be applied to the condensers than would otherwise be obtained. This may take place because the inductance of the primary winding of the spark coil and the capacity of the condenser 40' or 41' when connected to that winding and charging can produce a voltage across the condenser in excess of the voltage across the storage condenser due to the oscillatory currents that arise in the circuit and the inductive action which builds up the voltage through the unidirectional path pro-

vided by the glow tube, even above the voltage of the charging source.

Fig. 3 shows the mechanical arrangement of the primary and secondary windings of a spark coil or transformer on the spark plug itself. The central electrode 15 is separated from the metal body 18 by suitable insulation 70, the lower ends of the body 18 having fingers 71 providing a plurality of spark gaps 72 to the central electrode. Detachably secured to the body 18 of the spark plug is a metal casing shield 73, of cylindrical form, having its lower end 74 threaded so it may be readily engaged in a detachable manner with threads provided on the body member 18. Within the casing 73 is a metal contact member 75 which may form a magnetic core for the secondary winding 16 which is preferably arranged in honeycomb formation and which is electrically connected directly to the contact member 75 at one end of the secondary winding. The other end of the secondary winding is electrically connected by wire 76 to the metal casing and therefore to the body member of the plug. The wire 76 is also connected to one end of the primary winding 12, the other end of the primary winding being connected as indicated at 77 to a metal contact member 78 which is provided above the insulation washer 79. The wire 23', having a shielding conduit 47, extends through the coupling member 80 and into the space 81 at the top of the casing where it may rest on the contact member 78, being held down against that contact member by a spring 82 engaged by an adjustable holding screw 83 which is threaded in the top of the casing. An insulating disk 80a is provided on the lug 84 at the end of wire 23' and between that lug and the spring. When the screw 83 is loosened and removed, the lug 84 may be lifted from the contact member 78 and pulled out through the opening which the coupling member provides.

The windings 27 and 16 are preferably surrounded and enclosed in a homogenous body 86 of heat-resistant insulating material such as a suitable ceramic or plastic. The electrical connection between the secondary winding of the coil and the central electrode of the spark plug is effected by a spring blade 87 connected to the top of the plug electrode and bearing yieldingly against the contact member 75, against which it is held by means of the spring 82 which holds the entire coil structure downwardly in a yielding manner in the casing 73. The primary and secondary windings together with their enclosing shield which prevents radio disturbance may thus be readily removed from the spark plug itself and may be readily attached to the lead wire. The plug may be connected to the engine by using a wrench on the usual hexagonal nut portion 89, and the coil and casing then added, after which the wire 23' is connected.

The primary winding 27 of the coil may consist of about 25 turns applied to a honeycomb secondary winding having about 800 turns, the latter being capable of generating current at sufficiently high voltage of the order of several thousand volts to break down the gap across the plug terminals. There are no long shielding wires to greatly increase the capacity of the high voltage part of the system, and the shielding of the comparatively low voltage wires of the system is a simple matter and can be accomplished without materially increasing the power required by the high voltage system. Condensers may therefore be used to energize the primary windings of the

transformers and to produce a sufficiently hot spark for effective operation. And since the time required for charging and discharging the condensers is almost infinitesimal, the system is especially useful for high speed aeronautical engines and especially engines in which the elimination of radio interference is a very desirable factor.

While the method and forms of apparatus herein described constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to this precise method and these forms of apparatus, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:

1. The method of successively energizing the primary windings of spark coils to create sparks at successive spark plugs comprising periodically charging a condenser through a primary winding from a source of charging current while discharging a second condenser through the same primary winding to thereby energize said primary winding, and then discharging the first condenser through a second winding while charging the second condenser through the second winding to thereby energize the second winding.

2. An ignition system of the character described comprising a direct current generator, a storage condenser connected across said generator, a coil energizing condenser connected electrically at one side to one side of said storage condenser, a series of primary windings, a secondary winding for each primary winding, a series of spark gaps connected to said secondary windings, and a series of contact means for alternately placing the coil energizing condenser across a primary winding and subsequently connecting the coil energizing condenser to the storage condenser through another primary winding, and means for operating said contact means in timed succession.

3. An ignition system of the character described comprising a power source of charging current, a pair of condensers, a series of transformer coils, a spark plug associated with each transformer coil, and contact means for placing one of said condensers across a transformer coil while connecting the other condenser to the power source through the same transformer coil.

4. An ignition system of the character described comprising a power source of continuous charging current, storage means connected across said source, a pair of condensers connected across said storage means, a series of primary windings, a secondary winding and a spark plug associated with each primary winding, and a distributor for successively connecting the primary windings one at a time across one of said condensers and at the same time in series with the other condenser across said storage means.

5. An ignition system of the character described comprising a power source of uninterrupted charging current, a pair of condensers, a series of transformer coils, a spark plug associated with each transformer coil, the transformer coils for the respective spark plugs being located at the spark plug locations, a distributor having circuit closing means for each transformer coil, and connections between said source, condensers, coils and distributor for placing one of said condensers across a transformer coil while connecting the other condenser to the power source through the same transformer coil.

6. An ignition system of the character described comprising a power source of continuous charging current, storage means connected across said source, a pair of condensers connected across said storage means, a series of primary windings, a secondary winding and a spark plug associated with each primary winding, a distributor for successively connecting the primary windings one at a time across one of said condensers and at the same time in series with the other condenser across said storage means, a supplemental condenser, and means operable to connect said supplemental condenser across one of said pair of condensers.

7. An ignition system of the character described comprising a power source of continuous charging current, a pair of condensers connected in series across said storage means, a series of primary windings, a secondary winding and a spark plug associated with each primary winding, a distributor for successively connecting the primary windings one at a time across a condenser and in series with the other condenser across said power source, and a rectifying space discharge tube connected between each of said condensers and said distributor.

8. The method of energizing a transformer means to create sparks at the spark plugs of an ignition system comprising periodically charging a pair of condensers alternately from a common source of charging current, and periodically discharging the condensers alternately through the transformer means so that the charging current of one condenser and the discharging current of the other condenser flow simultaneously through the transformer means to energize the same.

9. The method of energizing the primary part of a spark coil system to create sparks at the spark plugs comprising periodically charging a winding energizing condenser mainly from a storage condenser and to a comparatively small extent from a direct current generator and passing the charging current through a primary winding of the system to energize the same, and

then discharging the energizing condenser through a primary winding of the system to energize the same, and continuously charging the storage condenser from the direct current generator.

10. The method of energizing the primary part of a spark plug system to create sparks at the spark plugs comprising periodically charging a condenser through a primary winding of the system from a source of charging current while simultaneously discharging a second condenser through the same winding to thereby energize the winding, and then discharging the first condenser through a primary winding of the system while simultaneously charging the second condenser from the same source.

11. An ignition system of the character described comprising a direct current generator, a storage condenser connected across said generator continuously, a coil-energizing condenser connected electrically to one side of said storage condenser, transformer means, a series of spark plugs energized by said transformer means, and contact means for alternately connecting said coil-energizing condenser across the transformer means and connecting said condenser to said storage condenser through said transformer means to discharge and charge the energizing condenser alternately at successive spark intervals.

12. An ignition system of the character described comprising a direct current generator, a storage condenser connected across said generator continuously, a pair of energizing condensers connected in series across said storage condenser, transformer means, spark plugs associated with said transformer means, and contact means for placing one of said energizing condensers across the transformer means while simultaneously connecting the other energizing condenser to the storage condenser through the transformer means.

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