

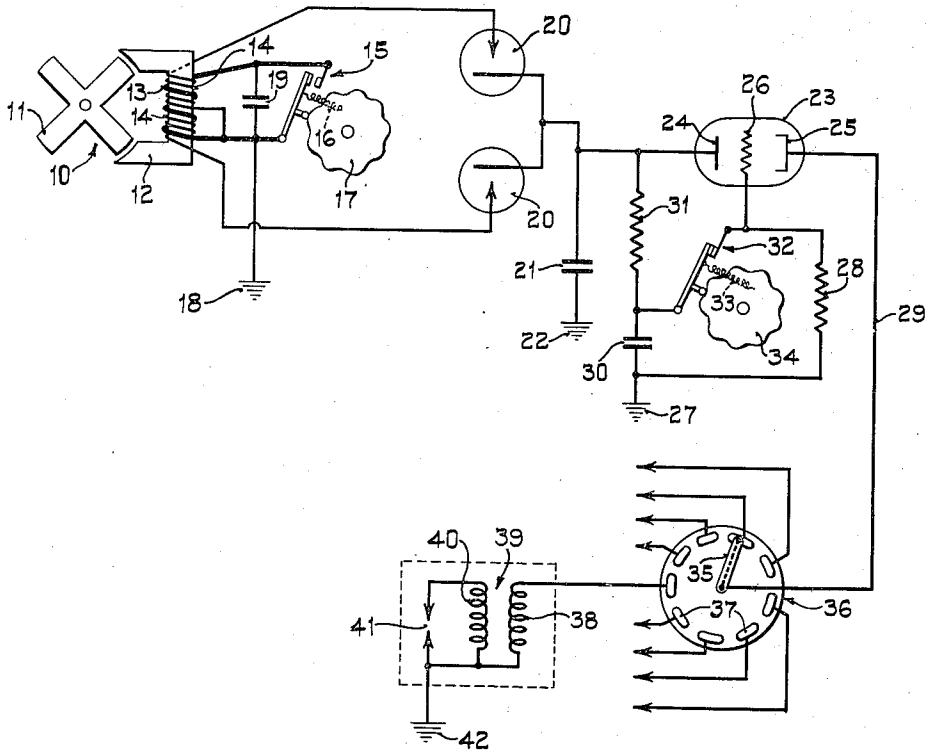
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ELECTRICAL APPARATUS

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ELECTRICAL APPARATUS

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The invention relates to electrical apparatus and more particularly to electrical circuits and means adapted for use in producing electrical arcs or sparks such as those required at the spark plugs in the ignition systems for internal combustion engines or the like.

One of the objects of the present invention is to provide a novel condenser discharge type of electrical circuit for producing high voltage electrical sparks between spaced electrodes.

Another object of the invention is to provide a novel ignition circuit for internal combustion engines or the like wherein the current is distributed to transformer coils adjacent to or mounted in the spark plugs at relatively low voltage and relatively high frequency.

A further object is to provide novel means for controlling the timing or frequency of successive impulses of electrical energy directed to a series of spark gaps, such as the spark plugs in an ignition system of an engine or the like.

Still another object is to provide a circuit of the above character wherein the energy is supplied by a magneto generator and wherein a high sparking rate is attainable across a spark gap or a series of spark gaps.

A still further object is to provide novel means in a condenser discharge type of electrical circuit for effecting a periodic discharge of the storage condenser, said means being efficient and dependable in operation for a long period of time.

Still another object is to provide a novel electrical circuit which is adapted for use in the ignition system of engines and is so constructed that a low distribution voltage may be safely and effectively used, thereby reducing the radio shielding problems and minimizing electrical losses and failures under all operating conditions.

The above and further objects and novel features of the invention will more fully appear from the following detailed description when the same is read in connection with the accompanying drawing. It is to be expressly understood, however, that the drawing is for the purpose of illustration only and is not intended to define the limits of the invention, reference for this latter purpose being had primarily to the appended claims.

In the drawing, the single figure is a schematic diagram illustrating one form of spark generating or ignition circuit which embodies the present invention.

In the circuit illustrated in the drawing, by way of example only, the invention is shown as

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being embodied in an ignition system suitable for use in internal combustion engines, the electrical energy being generated and supplied by a magneto type generator and distributed at relatively low voltage and relatively high frequency. An ignition system embodying the invention will be operable at all altitudes attainable by modern aircraft with a minimum of electrical losses and without appreciable danger of electrical failures. By reason of the low distribution voltages, the radio shielding difficulties and requirements will also be substantially reduced in such a system. It will be understood, of course, that the invention is not limited to use in an ignition system but may be usefully employed in the laboratory or in many other applications where it is desired to produce a series of sparks across spaced electrodes.

In the form shown, the novel electrical circuit comprehended by the present invention comprises a magneto generator 10 as a source of electrical energy. Although the generator may be in the form of any of many known types of magnetos, the particular type illustrated comprises a four-pole magnetic rotor 11 and a two-pole stator 12, the poles of which are connected by a core on which is wound a transformer coil having a primary winding 13 and a secondary winding 14. The construction of these windings may be varied, as is well understood in the art, for obtaining within rather wide limits any desired voltage in the circuit of the secondary winding.

In a manner well understood in the art, primary winding 13 has the opposite ends thereof connected to the points or contacts of a circuit breaker 15. For normally urging said contacts toward closed or engaged position, suitable resilient means such as a spring 16 may be provided, and suitable means such as a rotatable cam 17 may be employed for periodically moving said points to open or disengaged position, as illustrated, for interrupting the flow of current in the circuit containing the primary winding 13. Although a so-called compensated cam commercially used in radial type engines is illustrated, it will be understood that the cam may be of any suitable shape and, as well understood in the art, said cam is preferably driven at a speed proportional to the speed of magneto rotor 11. One side of the primary circuit is connected to ground as at 18 and a condenser 19 is connected across the points of circuit breaker 15 to reduce sparking between said points when the same are moved to open position by the cam.

For the purpose to appear hereafter, secondary winding 14 is tapped at approximately the center thereof and connected to ground, such as at 18. In effect, this divides secondary winding 14 into two windings with respect to the primary winding 13. As shown, the ends or high potential turns of secondary windings 14 are connected to the input terminals of two half-wave rectifiers 20, 20. These rectifiers may be provided in the form of gaseous tubes of the cold cathode point-to-plane type, i. e., of the type wherein one element has a large surface and the other has a relatively small surface. If desired, a single full-wave rectifier of the same type, for example one known commercially as Raytheon No. CK1004, may be used in lieu of said two half-wave rectifiers, as illustrated in my co-pending application Serial No. 567,672. As rotor 11 of magneto 10 is rotated, alternating current is induced in primary winding 13 and the circuit which includes circuit breaker 15. When the primary circuit is interrupted by the opening of the points or contacts of circuit breaker 15, the intervals being determined by cam 17 and the opening usually occurring when the primary current is at about its maximum value, current at a higher voltage is induced in the secondary winding 14, successive impulses being of opposite polarity. With the parts connected in the manner described above, the generated impulses of one polarity in the secondary circuit will flow through one of the rectifiers 20 or by way of one input terminal of a full-wave rectifier and impulses of the other polarity will flow through the other half-wave rectifier 20 or by way of the other input terminal of a full-wave rectifier so that the output from the plate terminals of the rectifiers will be unipolar.

The output or plate terminals of the rectifiers 20, 20 are connected to each other and to one terminal of a storage condenser 21, the other terminal of which is connected to ground as at 22. It is a characteristic of rectifiers of the type illustrated that current will flow therethrough in only one direction, that is, current will flow from point to plane but will not flow in the opposite direction. Accordingly, when the rectifiers are connected in the manner shown, the electrical impulses passing therethrough from the generator will be effective to charge condenser 21 but the latter will be unable to discharge back through the rectifiers or rectifier, as the case may be, through the coil of the magneto or other source. It is another characteristic of these rectifiers that the same will not become conductive below a predetermined voltage which is known as the "on-set" voltage. For most desirable operation, therefore, the maximum voltage generated across the secondary circuit of the magneto at the minimum operating speed thereof must be at least as great as the on-set voltage of the rectifiers and is preferably approximately 100 or more volts higher than the on-set voltage in order to provide a margin or factor of safety. For example, if the on-set voltage of the rectifiers is approximately 500 volts, the voltage across the secondary circuit of the magneto at minimum operating speed should preferably be about 600 volts or more. The voltage of the charge stored on condenser 21 may be varied by varying the capacity of said condenser. After calculating or determining the energy supplied to the condenser from the secondary circuit of the particular magneto employed, it is possible to choose a condenser with a suitable capacity for obtaining the de-

sired voltage across the condenser. These calculations may be made by the use of simple well known electrical formulas.

Novel means are comprehended by the present invention for controlling and timing the successive discharges of storage condenser 21 for the purpose of creating periodic timed sparks across a gap or a series of gaps, said means being of such a nature that the elements thereof will have a long operating life and at the same time permit a high sparking rate. In the form shown, said means comprises a cold cathode gaseous discharge tube 23 which may be of the type known commercially as a strobotron connected between condenser 21 and the load or work portion of the circuit to be hereinafter described. The high potential side of condenser 21 is connected to the plate or anode 24 of tube 23 and the cathode 25 thereof is connected to the load through a lead 29. A grid 26 is provided between plate 24 and cathode 25 of the tube 23, said grid being normally maintained at ground potential or at some minimum potential to act as a block to the passage of electrical current from the anode to the cathode. In the circuit shown, grid 26 is permanently connected to ground, as at 27, through a suitable resistance 28, the function of which will appear hereinafter. Normally, therefore, tube 23 is non-conductive and prevents the discharge of condenser 21.

For the purpose of rendering tube 23 conductive to permit the discharging of condenser 21, novel means are provided for periodically creating a potential between grid 26 and cathode 25. Said means in the form shown comprise a condenser 30, one terminal of which is connected to ground as at 27 and a resistance 31 which is connected between the other terminal of said condenser and the supply line from the source of electrical energy. Condenser 30 and resistance 31 are thus connected in series with each other and in parallel with condenser 21. Any suitable means such as a contactor 32 may be provided for periodically connecting the high potential terminal of condenser 30 to grid 26 at a point between the latter and resistance 28 in order to excite or trigger the tube 23, i. e., to render the tube conductive for the discharge of condenser 21. As illustrated contactor 32 is constructed in the same manner as circuit breaker 15 and the same is operated by a spring 33 and a rotatable cam 34, the latter being driven by the engine at a speed proportional to the speed of the engine crankshaft and, hence proportional to the speeds of rotation of rotor 11 and cam 17.

When the above described circuit is employed for supplying electrical energy to the spark plugs of a multi-cylinder internal combustion engine, the output terminal or cathode 25 of tube 23 may be connected through lead 29 to the rotatable element 35 of an ignition distributor 36. As is well understood in the art, element or arm 35 carries an electrode or brush which moves into successive conductive relationship with a series of circumferentially arranged terminals 37. In one suitable type of distributor, the rotatable arm 35 carries a carbon brush adapted to yieldably and successively engage contacts or terminals 37. Each of the latter is connected to the primary winding 38 of a high frequency step-up transformer coil 39, the secondary winding 40 of which is connected across the electrodes of a spark gap 41 such as the electrodes of a spark plug. One end of each of the windings 38 and 40 and one terminal of spark gap 41 are connected

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to ground in the conventional manner, as at 42. If desired, the coils 39 may be housed within the radio shielding casing of the spark plugs. Since suitable distributors, coils and spark plugs are known and do not, per se, constitute a part of the present invention, it is believed to be unnecessary to illustrate and describe the same in more detail.

In the operation of the illustrated system, upon rotation of magnetic rotor 11 alternating electrical current impulses are generated in primary winding 13, in a manner well known and understood in the art, when the contacts of circuit breaker 15 are in closed or engaged position. The circuit breaker 15 is periodically opened by cam 17, preferably each time the current flow in winding 13 approaches a maximum, thereby breaking the primary circuit and causing a current to be induced in secondary winding 14. This alternating secondary current at a somewhat higher voltage is fed through the rectifiers 20, 20 in the manner fully described above for building up successive unidirectional or unipolar charges on condenser 21. It will be clear that the energy for building up the desired charge on condenser 21 may be supplied by a direct current generator or other suitable direct current source without the use of rectifiers, but this is not suitable in all installations or applications since the voltage developed by such a generator varies substantially with variations in the speed of the rotor. Although the timing of the operation of circuit breaker 15 is not critical, it will be understood that for best results the same should be properly coordinated in a known manner with the operation of magneto rotor 11 and preferably the construction is such that the contacts of circuit breaker 15 will be separated just prior to each closing of the points of contactor 32 which effects the proper timing of the sparks at gap 41.

As will now be apparent from the drawing, the electrical energy from the source will be divided between the parallel connected branches of the circuit which include condensers 21 and 30. Thus, both of these condensers will be charged simultaneously upon each opening of circuit breaker 15, at which times the points of contactor 32 will be in open position. The presence of resistance 31 reduces the voltage of the charge stored on condenser 30 and prevents grid 26 from dissipating an appreciable portion of the energy of the charge stored on condenser 21 when contactor 32 is closed. When the contacts of contactor 32 are closed or permitted to close after the condensers 21 and 30 have been charged, condenser 30 will discharge and apply a sufficient voltage potential between grid 26 and cathode 25 to cause tube 23 to break down, i. e., become conductive to the flow of current from anode 24 to cathode 25 and, hence, permit the discharging of condenser 21. The resistance 28 is inserted in the ground connection for grid 26 in order to allow a potential to be built up between the grid and cathode 25 when the contactor 32 closes. The connection through resistance 28 also ties the grid 26 down electrostatically as hertofore pointed out and stabilizes the gap between anode 24 and cathode 25, thereby insuring against any discharging of condenser 21 before the closing of contactor 32. Accordingly, upon closure of contactor or circuit maker 32, the charge on condenser 21 is discharged through tube 23 and distributor 35 to the primary winding 38 of one of the coils 39. As is known, the discharge of condenser 21 is a high frequency or oscillating dis-

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charge so that a similar high frequency current is induced in secondary winding 40 of the coil 39 at a considerably higher voltage, the step-up in voltage being determined by the construction of coil 39. A spark and usually a shower or series of sparks are thus created across gap 41. The foregoing cycle of operation may be repeated at high speed for producing periodic sparks across gap 41 or across a series of gaps connected in the same manner with terminals 37 of the distributor.

In one suitable embodiment of the invention in the form illustrated in the drawing and heretofore specifically described, a standard magneto generator of the type currently used on modern aircraft engines was employed, the same being adapted to generate a voltage of from 250 to 300 volts across the primary circuit thereof. This voltage was stepped up to about 600 volts in the secondary circuit of the magneto when rectifiers having an on-set voltage of approximately 500 volts were used. Condenser 21 had a capacity of approximately .5 microfarad so that the voltage across the same when charged was approximately 350 volts. Resistor 31 had a resistance of approximately 100,000 ohms and the capacity of condenser 30 was only .005 microfarad so that the voltage across the same when charged was approximately 150 volts. The current flow through contactor 32 was on the order of a milli-ampere, thereby eliminating detrimental sparking at and consequent deterioration of the contactor points. This also eliminates the erratic timing which is normally experienced with contactors which are required to carry large currents at high voltages. The resistor 28 may have a resistance on the order of 500,000 ohms. It will be understood, of course, that the foregoing examples are illustrative only and that the electrical values of the various elements of the circuit may be varied between rather wide limits.

There is thus provided a novel electrical circuit and novel control means therefor for producing electrical sparks which circuit, by way of example but not by way of limitation, is adapted for use in the ignition systems of internal combustion engines or the like. Said circuit embodies novel simplified means for controlling the discharge of a condenser and, hence, for timing the occurrence of sparks at one or a plurality of spark gaps. The circuit or system comprehended is reliable and efficient in operation at all altitudes and permits the production of sparks at a high rate while using a single source of electrical energy and a single control means. Other attributes of said circuit are long life and low cost of manufacture, installation and upkeep.

Although only a single embodiment of the invention is schematically illustrated in the drawings and described in detail in the foregoing specification, it is to be expressly understood that the same is not limited thereto. For example, other well known types of circuit breakers may be substituted for those illustrated and suitable sources of electrical energy other than that illustrated may be employed. If accurate timing is not essential the contactor 32 may be eliminated. Various other changes may also be made, particularly in the design and arrangement of the parts illustrated without departing from the spirit and scope of the invention, as will now be understood by those skilled in the art. For a definition of the limits of the invention, reference is had primarily to the appended claims.

What is claimed is:

1. In an ignition system or the like, a storage

condenser, a second condenser, means for charging said condensers, a spark gap, a normally non-conductive electronic discharge device connected between said storage condenser and said gap, and means including a periodically and mechanically operable circuit maker for operably connecting said second condenser to said device for rendering said device conductive to the discharge of said storage condenser.

2. Spark producing apparatus comprising a storage condenser, a source of electrical energy for charging said condenser, a second condenser connected to said source in parallel with said storage condenser, a discharge device having an anode connected to said storage condenser, a cathode and a grid, a spark gap connected to said cathode, and mechanically controlled means for periodically connecting said second condenser to said grid for rendering said device conductive to the discharge of said storage condenser.

3. In apparatus of the class described, a storage condenser, means for charging said condenser to a predetermined voltage, a spark gap, a discharge device connected between said condenser and said gap, said device being normally non-conductive at said voltage, and means including a contact maker and a second condenser connected with said charging means for periodically rendering said device sufficiently conductive to permit said first-named condenser to discharge through said device.

4. In apparatus of the class described, a first condenser, a second condenser and a resistance connected in series with each other and in parallel with said first condenser, an electronic discharge device having an element connected to said first condenser and being normally non-conductive to a charge thereon, mechanically operated means for periodically connecting another element of said device to said second condenser to thereby render said device capable of conducting the discharge of said first condenser.

5. In apparatus of the class described, a first and a second condenser connected in parallel branches of a circuit, an electronic discharge device having an anode, a cathode and a grid, means connecting said first condenser to said anode, means permanently connecting said grid to a point of low potential such as to ground through a resistance, and means for periodically connecting said grid to the high potential side of said second condenser to render said device conductive to the discharge of said first condenser.

6. In apparatus of the class described, a source of unidirectional electrical current, circuit means connected to said source including three branches connected in parallel with each other, one of said branches including a condenser adapted to be charged by said source, another of said branches including a condenser and a resistance connected between said second-named condenser and said source, another of said branches including an electronic discharge device having the anode thereof connected to said first-named condenser, means for connecting the grid of said device to the high potential side of said second-named condenser, means for periodically opening and closing said last-named connecting means, means including a resistance for permanently connecting said grid to a point of low potential such as ground, and a spark gap adapted to be connected to the cathode of said device.

7. In apparatus of the class described, a condenser, a source of unidirectional current for

charging said condenser, a transformer, normally non-conductive electronic means connected between said condenser and said transformer, and means including a second condenser connected with said source and mechanically controlled means for periodically connecting said second condenser with said electronic means for rendering the latter conductive to permit said first condenser to discharge across said transformer.

8. In apparatus of the class described, a source of alternating current, means for rectifying the same, condenser means supplied from said rectifying means, electronic valve means connected to the output of said condenser means, an induction coil also connected to the condenser means and the valve means whereby the latter controls the energization of the coil from said source, and means for periodically triggering said valve means including a second condenser means and a mechanically operable timing means for periodically connecting said second condenser means to the control element of said valve means for rendering the latter conductive to the charge on said first-named condenser means.

9. In apparatus of the class described, a source of electrical energy, condenser means chargeable by said source, electrical valve means and an energy-consuming load, such as the primary winding of a transformer, connected in circuit with said condenser means, and means for periodically triggering said valve means to permit said condenser means to discharge therethrough and across said load, said triggering means comprising a condenser chargeable by said source and a cam operated circuit maker for periodically connecting the high potential side of said condenser to the control element of said valve means to render the latter conductive to the charge on said condenser means.

10. In apparatus of the class described, a source of electrical energy, condenser means chargeable by said source, electrical valve means and an energy-consuming load, such as the primary winding of a transformer, connected in circuit with said condenser means, and means for periodically triggering said valve means to permit said condenser means to discharge therethrough and across said load, said triggering means comprising a condenser chargeable by said source, means including a contact maker for periodically connecting the high potential side of said condenser to the control element of said valve means to render the latter conductive to the charge on said condenser means, and means including a resistor for permanently connecting said control element to a point of low potential, such as to ground.

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