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ELECTRICAL APPARATUS

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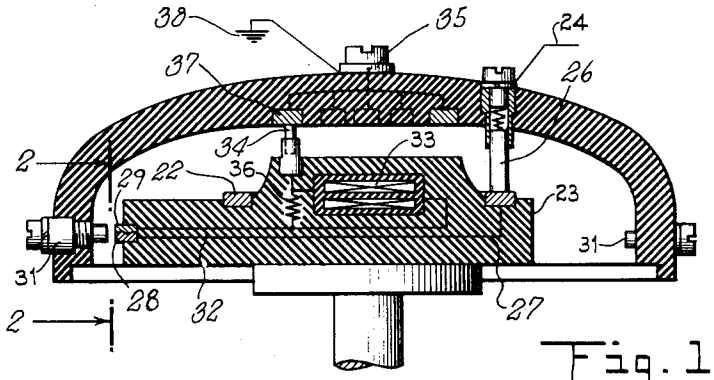



Fig. 1.

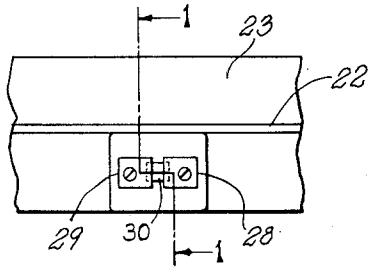



Fig. 2.

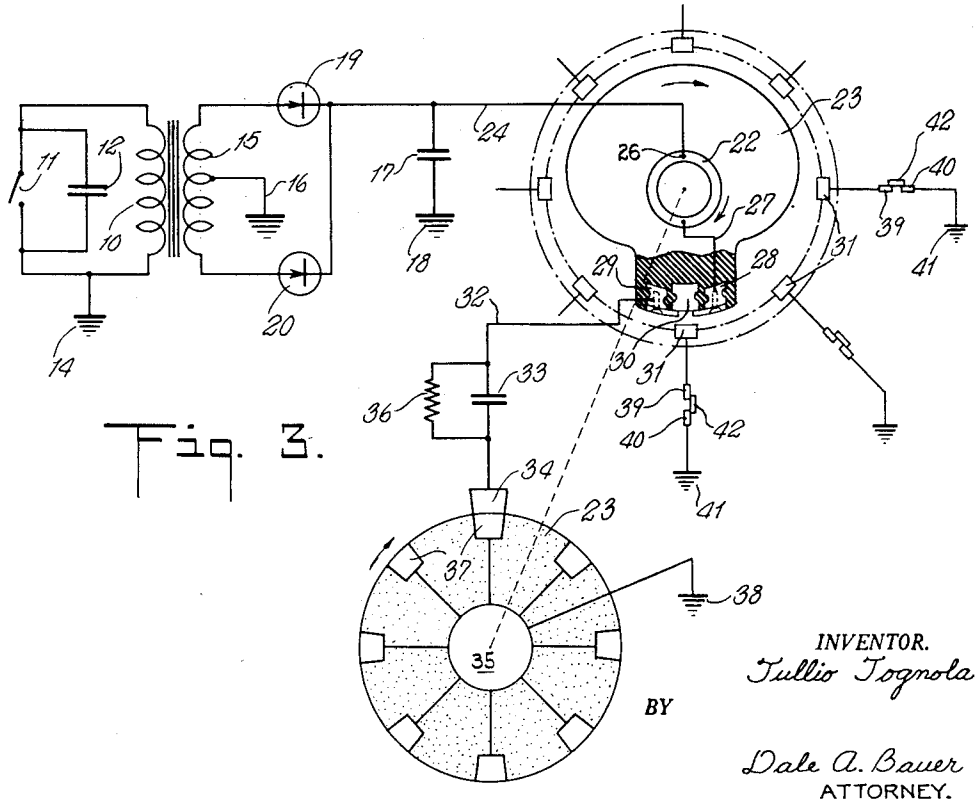



Fig. 3.

INVENTOR.
Tullio Tognola

BY

Dale A. Bauer
ATTORNEY.

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## ELECTRICAL APPARATUS

Tullio Tognola, Sidney, N. Y., assignor to Bendix Aviation Corporation, New York, N. Y., a corporation of Delaware

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19 Claims. (Cl. 315—217)

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This invention relates to electrical apparatus and more particularly to an electrical circuit and parts thereof adapted for use in the ignition system of a combustion engine.

One of the objects of the present invention is to provide a novel ignition system whereby a high energy spark discharge is assured, although the maximum voltage is very low in comparison to that used in present-day ignition systems.

Another object of the invention is to provide a satisfactory ignition system for combustion engines wherein the electrical energy is distributed at low voltage, thereby minimizing electrical losses, the danger of ignition failures and interference with radio reception.

A further object is to provide novel means for distributing electrical energy to a plurality of circuits from a common source of energy at relatively low potential.

Still another object is to provide a novel ignition circuit and distributor therefor which embody novel means for timing the successive discharges through the output circuits of the distributor.

A still further object is to provide a novel ignition circuit for a multi-cylinder engine whereby the life of the expendable parts is materially increased and the danger of failure due to fouling of the spark gaps in the combustion chambers is substantially eliminated.

Still another obect of the invention is to provide a novel, jump-spark or gap type of ignition distributor for distributing electrical energy at a voltage below the normal spark-over voltage of the gap.

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

In the drawings, wherein like reference characters refer to like parts throughout the several views,

Fig. 1 is a sectional side view, taken substantially on line 1—1 of Fig. 2, of one form of the novel distributor-timer comprehended by the present invention;

Fig. 2 is a detail view of a portion of the rotor shown in Fig. 1, the view being taken substantially on line 2—2; and

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Fig. 3 is a diagram of one form of a complete ignition system embodying the structure of Fig. 1.

A single embodiment of the novel ignition system contemplated by this invention is illustrated in the drawings, by way of example, as comprising a magneto for generating the required electrical energy, but it will be understood that the system can be readily adapted to other types of either direct or alternating current sources. As shown, the magneto is illustrated in a conventional diagrammatic manner as comprising primary winding 10 in series with a circuit breaker 11 which has a condenser 12 connected in shunt therewith, the whole circuit being connected to ground at 14. A suitable magnetic system of any known type may be provided for energizing the primary winding and a cam may be provided for actuating circuit breaker 11, all in a manner well understood in the art.

A secondary winding 15 is inductively coupled with the primary winding and has a center tap 16 to ground. The ends of the secondary winding are connected through any suitable rectifying means to supply uni-directional or uni-polar energy to a storage condenser 17, one side of which is shown as being connected to ground at 18. The rectifying means are illustrated by way of example, as comprising two half-wave rectifiers 19 and 20 of the point-to-plane type. If desired, a single full-wave rectifier or one of any other known type may be employed.

In known systems of the high tension type, it has been the universal practice to distribute the energy at relatively high voltage (12,000 to 15,000 volts) through a so-called jump-spark distributor, i. e., a distributor wherein there is a gap as distinguished from rubbing contact between a rotating input electrode and a plurality of stationary output terminals. In other types, including high frequency condenser discharge systems, it has been the practice to distribute the energy at relatively low voltage (300 to 1000 volts) through a brush type distributor wherein the input electrode makes direct rubbing contact with the output terminals. The present invention contemplates production of a high-energy high-frequency spark discharge with low voltage distribution through a jump-spark type of distributor of novel construction, thereby gaining the advantages while eliminating the chief disadvantages of both prior known systems.

In the present system the high potential side of condenser 17 is connected to a conductive ring 22 on the distributor rotor 23, which may be made of any suitable insulating material. This connec-

tion may be effected through lead 24 and a spring pressed brush 26. Ring 22 is in turn connected by a conductor 27 to one element 28 of a novel distributor electrode. The latter comprises a second conductive element 29 separated from but electrically connected to the first element 28 by an electrical resistor or semi-conductive member 30. Each of the electrode elements 28 and 29 may be constituted by a conductive block or terminal embedded in rotor 23 and an electrode plate secured thereto in any suitable manner, such as by a set screw or the like. Said plate portions of the electrode elements extend into surface engagement with the outer face of semi-conductor 30 and into spark gap relation with each other, as best seen in Fig. 3. Element 30 thus provides a high resistance path, the resistance of which is less than the resistance to the flow of current across the gap between elements 28 and 29 in the absence of element 30. The latter is chosen from a variety of suitable materials, such as fused mixtures of suitable conductors like silicon carbide and iron with insulators like aluminum oxide and other ceramics, so that when a circuit is completed, in a manner hereinafter described, the initial surge of current from condenser 17 will flow along the surface or skin of the face of resistor 30 in a low capacity condenser 33. When the current thus flows between electrode elements 28 and 29 across the face of resistor 30 the gaseous medium in the space or gap between the said elements and an output terminal 31 of the distributor will thus be caused to ionize and hence reduce the resistance to current flow through said medium. The resistance of the gap is thus lowered sufficiently to permit the low voltage charge on condenser 17 to partially discharge as a low energy spark across the gap 28–29 and thereby cause further ionization in the space between elements 28, 29 and output electrode 31.

The initial surge of current from the high capacity storage condenser 17, when it is discharged as described above, is effected periodically by a timing mechanism associated in a novel manner with the distributor. In the form shown, electrode element 29 is electrically connected through a lead 32 to a small or low capacity condenser 33 which is in turn connected to a spring pressed brush 34 mounted on rotor 23 (Figs. 1 and 3). A resistance 36 may be connected in shunt with condenser 33. Brush 34 yieldably engages the inner surface of the ditributor cover and makes periodic contact with a plurality of circularly arranged contacts 37, all of which are permanently connected to ground at 38 through a central terminal 35, thereby completing the circuit, referred to above, from condenser 17 across the face of resistor 30. If desired, condenser 33 and resistance 36 may be connected between terminal 35 and ground connection 38.

There are a plurality of distributor output terminals 31 circularly arranged for successive cooperation with rotary electrode 28, 29. Each said terminal is connected with the center or ungrounded electrode 39 of a spark plug or gap in a cylinder or other combustion chamber of the engine. Each spark plug is also provided with an electrode 40 located in spark gap relation to electrode 39 and connected to ground at 41 or to the low potential terminal of condenser 17. Electrodes 39 and 40 are in usual spark gap relation and are bidged by a high resistance or semi-conductive element 42. The resistance of gap 39—40 is such that the voltage across storage condenser 17 is insufficient to create a spark across said gap, but the initial surge of current, when the gap 28—31 is broken down in the manner above described, is believed to flow along the surface or skin of resistor 42 which is in surface engagement with the spark gap electrodes 39 and 40. This flow of current apparently ionizes the gap 39—40, thereby reducing its resistance and permitting the major portion of the energy from condenser 17 to flow across the gap, thus creating a high-energy high-frequency spark discharge which is capable of igniting the combustible charges in the combustion chambers of jet type engines, turbine type engines, internal combustion engines and the like.

As rotor 23 is rotated in timed relation to the engine or other device, electrode 28—29 moves into successive spark gap relation with each of the output terminals 31, each of which is connected to a spark plug or gap 39, 40. Brush 34 is also carried by the rotor and moves into contact with an electrode 37 each time movable electrode 28, 29 is opposite a terminal 31.

Depending upon the other circuit constants, the energy desired, and the operating conditions, the capacity of condenser 17 may be of the order of .5 to 2 microfarads. These values have been found satisfactory for different engine ignition system installations. The capacity of condenser 33, on the other hand, is much less, i. e., of the order of .1 microfarad. The capacity of condenser 33 should be only sufficient to draw the requisite amount of energy from condenser 17 along the face of resistor 30 and across gap 28—29 in the manner and for the purpose above described. When condenser 33 is fully charged the remainder of the energy from condenser 17 is dissipated across gaps 28—31 and 39—40. Likewise, the charge built up on condenser 33 discharges simultaneously with condenser 17 across gaps 29—31 and 39—40. Resistance 36 which may be of the order of 1 megohm is provided to absorb any residual charge on condenser 33 as the rotor moves from one discharging position to the next to thereby insure an adequate initial flow of energy at each station to initiate the operation described.

It will be understood that condenser 17 is being continuously charged by magneto 10—15 or any other suitable source of electrical energy. When using a spark gap 39—40 of practical dimensions, for example about .020 inch in an annular gap, satisfactory operation may be attained by providing a source voltage of about 800 to 1000 volts across condenser 17. This voltage is insufficient to cause a spark discharge across any of the gaps 28—29, 28—31 and 39—40 in the absence of resistors 30 and 42. Preferably, the latter should be so constituted that the initial discharge applied thereto will create a flow of energy along the surface or skin thereof adjacent the associated spark gap. The dissipation of energy within the resistor should be kept to a minimum and to this end the actual conductive portion of members 30 and 42 adjacent the gap may be relatively thin. Consideration must be given, however, to the life of this conductive layer or film under continuous sparking operation at high temperatures in the presence of combustible gases.

There is thus provided a novel electrical circuit wherein energy from a single relatively low voltage source may be dissipated as successive high-energy spark discharges across spark gaps in a plurality of branched circuits whereby the same is adapted for use as an improved ignition

system for multi-cylinder reciprocating engines as well as for jet and turbo-jet engines. This novel system also eliminates many of the hazards of high voltage ignition systems now in common use, such as, for example, the hazards of flash-overs in the distributor and other parts of the circuit, especially at high altitudes, and of fouled spark plugs, both of which result in a reduction of available power and possible engine failure. Additionally, the circuit provided operates in accordance with a novel method for creating spark discharges and embodies novel means for timing the occurrence of successive spark discharges in relation to the operation of an engine or the like. The circuit comprehended is also highly efficient and has a wide range of adaptability. The source of voltage for the present circuit, the width of the spark gaps and the energy in the sparks may be varied between wide limits, depending upon the results desired and the operating conditions.

Although only a single embodiment of the invention is illustrated in the drawing and described in the foregoing specification, it is to be expressly understood that the invention is not limited thereto. The circuit shown and described is a high-frequency high-energy system with the spark being created by discharging condensers, but suitable low-frequency sources of energy may be substituted and the energy in the sparks created may be very materially varied. In some installations the resistance **30** may be dispensed with depending upon the voltage employed and other circuit constants and dimensions. Various changes may also be made in the design and arrangement of the parts illustrated, as well as in the materials, electrical values, and circuit constants herein suggested as suitable without departing from the spirit and scope of the invention as it 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. Apparatus of the class described comprising a source of electrical energy, a storage condenser connected to be charged by said source, a second condenser of less capacity than said storage condenser, means for electrically connecting said condensers, said means including a pair of electrodes in spark gap relation and a resistor connecting said electrodes, and means for intermittently completing a circuit through said condensers whereby said storage condenser discharges through said resistor and across the gap between said electrodes into said second condenser.

2. Apparatus as defined in claim 1 wherein a resistance is connected in shunt with said second condenser for absorbing the residual charge thereon when the circuit is open.

3. In apparatus of the class described, a source of electrical energy including a storage condenser, a second condenser, and means connecting said source and said second condenser including a pair of electrodes in spark gap relation and a resistor connecting said electrodes in proximity to the gap therebetween.

4. In apparatus of the class described, a storage condenser, means for charging said condenser, a spark gap comprising three spaced electrodes, a resistor connecting two said electrodes, means for connecting said two electrodes to opposite terminals of said condenser, and an electrical load connected to the other of said electrodes.



5. In apparatus of the class described, a source of electrical energy, a pair of electrodes forming a spark gap, a resistor connecting said electrodes in proximity to said gap, means connecting one of said electrodes to one terminal of said source, and means for connecting the other electrode to the other terminal of said source, said last-named means including a condenser.

6. Apparatus as defined in claim 5 wherein a resistance is connected in shunt with said condenser and the last-named connecting means is intermittently operable.

7. Apparatus of the class described comprising a source of electrical energy including a storage condenser, a second condenser of less capacity than said storage condenser, means for intermittently electrically connecting said condensers including spaced electrodes, a resistor connecting said electrodes and intermittently operable contact means, and means such as a resistance in shunt with said second condenser for dissipating residual energy in the latter when the circuit is open.

8. The combination with apparatus as defined in claim 7 of a third electrode in spark gap relation with at least one of said spaced electrodes, a spark gap in circuit with said third electrode, and a resistor connecting the electrodes of said spark gap.

9. Apparatus of the class described comprising a source of electrical energy including a storage condenser and means for distributing electrical energy stored in said condenser to a plurality of branch circuits comprising a pair of revolving electrodes in spark gap relation, a resistor connecting said electrodes, means connecting one of said electrodes to a terminal of said condenser, a plurality of circularly arranged terminal electrodes with which said first-named electrodes move successively into spark gap relation, and means for connecting the other of said first-named electrodes to the other terminal of said condenser whenever said first-named electrodes move into spark gap relation with one of said terminal electrodes, said last-named connecting means including a condenser.

10. The method of producing an electrical spark discharge which comprises the steps of charging a storage condenser, partially discharging said condenser into a second condenser to ionize a spark gap and render the latter conductive to the charge on said storage condenser, and thereafter discharging said storage condenser across said gap.

11. The method of producing an electrical spark discharge which comprises the steps of charging a storage condenser, partially discharging said storage condenser into a second condenser through a high resistance adjacent a spark gap to ionize the latter, continuing the discharge of said storage condenser across said gap into said second condenser, and thereafter discharging said condensers simultaneously across a second spark gap ionized by the discharge across said first spark gap.

12. The method of creating an electrical spark discharge which comprises ironizing a first spark gap by passing electrical current through a high resistor adjacent said gap and connecting the electrodes thereof, ionizing a second spark gap with the electrical discharge across said first gap, and thereafter creating an electrical discharge across said second gap.

13. The method of ionizing a spark gap which comprises charging a storage condenser, and dis-

charging said storage condenser into a second condenser through a resistor connecting a pair of spaced electrodes and across the spark gap between said electrodes whereby a spark gap between one of said electrodes and a third electrode is ionized.

14. Electrical apparatus of the class described comprising a plurality of circularly disposed terminal electrodes, a rotatable member, a pair of spaced electrodes forming a spark gap and carried by said member into successive spark gap relation with said terminal electrodes during rotation of said member, a resistor element connecting said spaced electrodes and bridging the gap therebetween, and means for connecting said spaced electrodes across the terminals of a source of electrical energy.

15. Electrical apparatus of the class described comprising a plurality of terminal electrodes, rotatable means, a pair of spaced electrodes forming a spark gap carried by said means into successive spark gap relation with said terminal electrodes, means for connecting one of said spaced electrodes to one terminal of a source of electrical energy, and means including a condenser for connecting the other of said spaced electrodes to the other terminal of said source.

16. Apparatus of the class described comprising rotatable means, a pair of spaced electrodes forming a spark gap carried by said means, and means for periodically connecting said spaced electrodes across the terminals of a source of electrical energy.

17. An ignition distributor comprising a plurality of circularly disposed terminal electrodes, a rotatable member, a pair of spaced electrodes forming a spark gap and carried by said member into successive spark gap relation with said terminal electrodes, a resistor connecting said spaced electrodes and bridging the gap therebetween, means including a brush contact for connecting one of said spaced electrodes to a source of electrical energy, and means including a brush contact for periodically connecting the other of said spaced electrodes to the other terminal of said source.

18. In electrical apparatus of the class described, a pair of spaced electrically conductive elements, an electrical resistor mounted between said elements, and an electrode removably secured to each of said elements and extending into spark gap relation with each other in contact with said resistor, and the latter being otherwise insulated from said elements.

19. In electrical apparatus of the class described, a pair of spaced electrically conductive elements, an electrical resistor between said elements, and an electrode removably secured to each of said elements and contacting said resistor, the adjacent ends of said electrodes forming a spark gap bridged by said resistor, and the latter being otherwise insulated from said elements.

TULLIO TOGNOLA.

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