

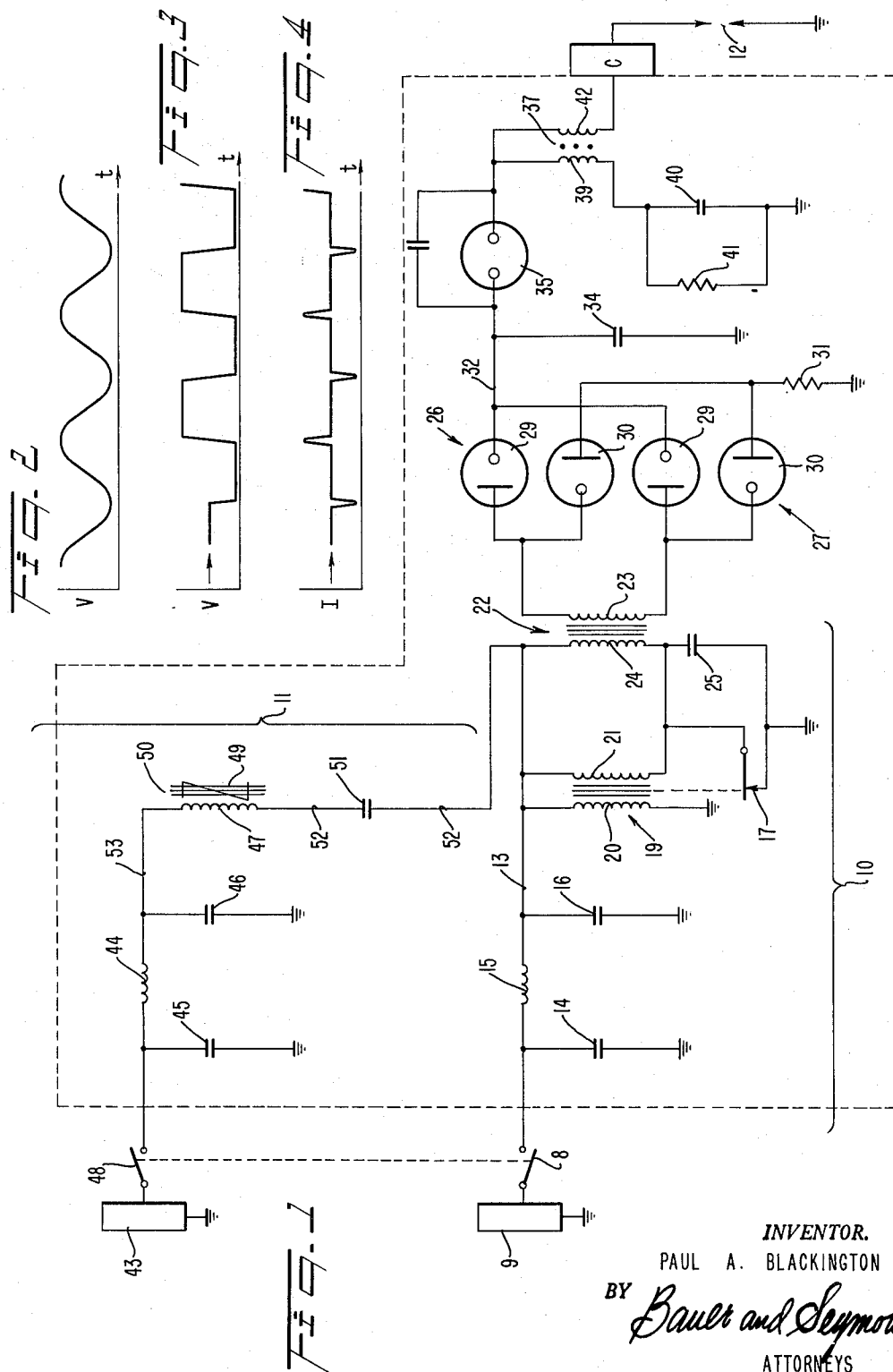
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IGNITION SYSTEM ENERGIZED BY EITHER A.C. OR D.C. SOURCE

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IGNITION SYSTEM ENERGIZED BY EITHER A.C. OR D.C. SOURCE

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16 Claims. (Cl. 315-175)

This invention relates to a novel ignition system which provides a succession of spark gap discharging pulses to a spark gap. The ignition system of the invention may be used to advantage, for example, in internal combustion engines of the jet or ram jet type.

This application is a continuation of application Serial No. 17,932, filed March 28, 1961 now abandoned.

The invention has among its objects the provision of a novel ignition system which may be continuously operated without damage to a spark discharge device supplied thereby or to parts of the ignition system.

A further object of the invention lies in the provision of an ignition system of the type indicated wherein there are provided two power sources, one of which may be employed at certain critical times in the operation of an engine and the other of which may be employed as a continuously operating stand-by source of ignition spark discharges.

Yet another object of the invention lies in the provision of an ignition system which selectively supplies the ignition needs of an engine or the like from a direct current power source, and which provides continuously operating stand-by ignition powered from an alternating current source.

A still further object of the invention lies in the provision of an ignition system of the type indicated in which most of the elements are employed with either of the said two power sources, whereby the provision of the stand-by ignition feature adds relatively little to the weight and bulk of the system as a whole.

The above and further objects and novel features of the invention will more fully appear from the following 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.

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

FIG. 1 is a circuit diagram for a preferred embodiment of ignition system in accordance with the invention;

FIG. 2 is a diagram showing the relationship between voltage and time of the alternating current source of the ignition system;

FIG. 3 is a diagram in which the voltage of the charge on the current-limiting condenser of the alternating current power source is plotted against time; and

FIG. 4 is a diagram in which the current flowing through the primary of the transformer of the system when supplied by the alternating current power source is plotted against time.

Engines of the jet or ram jet type are customarily ignited by an ignition system which supplies a succession of spark gap discharging pulses to a spark gap device positioned within the engine. Although a jet engine will normally continue to operate when once ignited, even though the ignition system is then shut off, it is much safer to operate a jet aircraft with the ignition system thereof in continuous operation, since this guards against flame-out of the engine which may be dangerous at any time.

The present invention provides an ignition system in which electrical spark discharges are generated when desired, as during take off and landing of an aircraft, and which further provides continuous stand-by spark discharges of appreciably lower intensity at all other times. If, therefore, flame-out should accidentally occur, the engine will readily be started again almost immediately by the stand-by ignition discharges. In the specific embodiment shown, the spark discharges for initial operation of the engine are provided from a direct current source such as a battery, and the stand-by spark discharges are provided by an alternating current source, such as an alternating current generator which may be either air driven or driven by the jet engine once it has started.

Turning now to the drawings, there is shown in FIG. 1 a direct current source 9, such as a battery, which is selectively connected to a first power circuit generally designated 10 through a switch 8. A second power circuit, generally designated 11, to be described hereinafter, is powered by an alternating current source. The ignition circuit of the invention, powered either by circuit 10 or 11, generates a succession of high voltage electrical pulses which are discharged through an electrical spark discharge device such as an igniter plug shown schematically at 12.

Power supply circuit 10 includes a radio filter sub-circuit of conventional design and incorporating an inductance 15 and two capacitors 14 and 16 having one side of each connected to ground, as shown. The main ungrounded lead wire 13 of circuit 10 is connected to a vibrator having alternately opened and closed contacts 17 and a vibrator coil 19 having a bias winding 20 and a coil 21. One end of the bias winding 20 and of coil 21 is connected to the lead wire 13, the other end of the bias winding being connected to ground. The other end of coil 21 is connected to ground through contacts 17. One end of the primary 24 of a power transformer 22 is also connected to ground through contacts 17, the other end of the primary being connected to lead 13. A condenser 25 is connected in shunt with the contacts 17, to minimize sparking at the contacts.

Alternate opening and closing of contacts 17 produce current surges through the primary 24 of transformer 22, and thus produce current surges through the secondary 23 of the transformer. One lead wire from secondary 23 of the transformer is led to a first rectifier bank 26 having two reversely connected rectifier tubes 29 and 30, and the other lead from the secondary 23 is led to a similar rectifier bank 27 having reversely connected rectifier tubes 29 and 30. The cathodes of rectifier tubes 30 are connected in parallel and thence through a current-limiting resistor 31 to ground. The anodes of tubes 29 are connected in parallel and to a lead wire 32 which is connected to one electrode of a control gap 35. Connected to wire 32 in advance of the control gap is a storage condenser 34 which has one side thereof connected to ground. A further condenser 36 is connected in shunt with the electrodes of control gap 35.

When switch 8 is closed, the ignition circuit thus far described produces a series of unidirectional pulses in wire 32 whereby to charge the storage condenser 34 to a voltage equal to the break-down voltage of control gap 35. When the charge on condenser 34 exceeds such predetermined value, a discharge takes place across the gap between the electrodes of control gap 35. The output of the control gap is led to one end of the primary 39 and the secondary 42 of a high frequency step-up transformer 37. The other end of primary 39 is connected to ground through a condenser 40, there being a resistor 41 con-

nected in shunt with such condenser. The other end of secondary 42 of the transformer 37 is connected to the spark gap 12 as through a lead including a conventional separable connector, as shown.

It is disadvantageous to maintain the direct current supply for the ignition system in continuous operation because of the consequent wear of the vibrator and because the transformer would become unduly heated if it were continuously operated from a direct current source. The present invention overcomes such difficulties, while still providing a continuous, stand-by source of electrical discharges, by providing a further power source which is powered by alternating current, so that the vibrator need not be operated when the ignition circuit is powered by such alternative source. Such alternative, alternating current source also is advantageous since the heating of the transformer when thus powered during continuous operation of the circuit does not exceed feasible limits.

The stand-by power source includes an alternating current source 43, such as an alternating generator, which is selectively connected to circuit 11 through a switch 48. As indicated, switches 8 and 48 may, if desired, be interconnected so that when one is closed the other is open. It is to be understood, however, that switches 8 and 48 may also be made so as to be independently operable. Circuit 11 includes a radio filter sub-circuit, including an inductance 44 and two condensers 45 and 46, one end of each of the latter being connected to ground. The main lead wire 53 of circuit 11 is connected to one end of the coil 47 of a switching inductance 50. The other end of coil 47 is connected to one side of a current limiting condenser 51, the other side of such condenser being connected by a wire 52 to the primary 24 of the transformer 22.

The switching inductance 50 is of such design that when a sine wave alternating current is impressed thereon, it transmits a signal having generally a square wave shape. Thus the condenser 51 is alternately charged to opposite polarities, the rate of change of polarity of the condenser being very rapid. The current surge thus produced by condenser 51 through the primary 24 of transformer 22 closely approximates in amplitude the current surges therethrough produced by the opening and closing of contacts 17 of the vibrator when the latter is used with the direct current source, but such variations take place in much shorter times. As a result, the heating of the transformer is markedly decreased. Consequently, the ignition system operates efficiently both when it is powered by the direct current supply circuit 10 and when it is powered by the alternating supply circuit 11.

The operation of the alternating current supply circuit will perhaps be better understood by reference to FIGS. 2, 3, and 4 of the drawing. In FIG. 3 there is shown the voltage wave form appearing across condenser 51. Because of the "switching" characteristics of inductance 50, it transforms the impressed signal shown in FIG. 2 to the generally square wave signal shown in FIG. 3. Such square wave pulses, fed from condenser 51 through wire 52, produce current pulses of short duration and opposite polarity in the primary 24 of transformer 22, as shown in FIG. 4.

Simply by way of illustration, the following further description of elements 50 and 51, which have proved satisfactory in operation, are given. Switching inductance 50 was provided with a core 49 of "square loop" magnetic material such as "Deltamax 5320-B1." Coil 47 had 360 turns of #21 wire. Condenser 51 was a 3 mfd. $\pm 10\%$ 250 W.V. (working volts) condenser. The D.C. source 9 was a 24 volt battery; the A.C. source 43 was a 115 volt 400 cycle alternating current generator.

The number of turns of the winding on the switching inductance 50 was calculated from the formula

$$NA = \frac{10^8}{B} \int e dt$$

where

N =number of turns

A =core area in cm^2

B =peak to peak flux limits of core

With the present invention, a single power transformer 22 can be employed in the circuit, to be supplied by either vibrator-interrupted direct current or from an alternating current source. If it is attempted to impress 400 cycle alternating current directly upon the primary 24 of transformer 22, it will be found that the impedance of such primary is too low, so that the current flow through it is too high. The condenser 51 of the circuit of the invention regulates the power fed to the primary 24 of the transformer, so that the current through such primary is held to a desirable value. Condenser 51 also functions to prevent the feeding of direct current into inductance 47 when the circuit is powered by the direct current source.

Although only one embodiment of the invention has been illustrated in the accompanying drawing and described in the foregoing specification, it is to be especially understood that various changes, such as in the relative dimensions of the parts, materials used, and the like, as well as the suggested manner of use of the apparatus of the invention, may be made therein without departing from the spirit and scope of the invention as will now be apparent to those skilled in the art.

What is claimed is:

1. In electrical apparatus a power transformer comprising a primary winding and a secondary winding, a first source of direct current, means connecting said primary winding to be energized by said source, means for periodically interrupting the current flow from said source through said primary winding to induce a voltage across said secondary winding, a second source of alternating current, circuit means for connecting said primary winding to be energized by said second source, said circuit means including means for converting the sine wave output of said second source into periodic current impulses through said primary winding, and switch means for selectively connecting said sources to energize said primary winding.

2. Electrical apparatus as defined in claim 1 wherein said means for periodically interrupting the current flow from the first source through said primary winding comprises a vibrator connected to said first source.

3. Electrical apparatus as defined in claim 2 wherein said vibrator comprises separable normally closed contacts, a core, a bias winding on said core connected across said first source and a running winding on said core connected across said first source in series with said contacts.

4. Electrical apparatus as defined in claim 1 wherein said circuit means includes a switching inductance and a condenser connected in series with said primary winding.

5. Electrical apparatus as defined in claim 4 wherein said switching inductance comprises a coil winding on a core of "square loop" magnetic material.

6. Electrical apparatus comprising a source of unidirectional current, a pair of separable contacts biased toward normally engaged position, a transformer having a primary winding connected in series with said contacts across said source, and means for periodically disengaging said contacts comprising a first coil winding connected in series with said contacts across said source and a second coil winding connected across said source and inductively coupled with said first coil winding, said coil windings, when simultaneously energized by said source, being effective to generate a magnetic field to disengage said contacts.

7. Electrical apparatus comprising a source of direct current, a transformer having a primary winding, a run-

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ning winding, a bias winding coupled across said source and inductively coupled with said running winding, said running and primary windings being normally connected to said source in parallel circuits, and means including said running and bias windings for periodically opening and closing the circuits containing said primary and running windings, said bias winding and said running winding being effective to generate a magnetic field to open said circuits when said bias and running windings are simultaneously energized by said source.

8. Electrical apparatus comprising a source of direct current, a pair of normally engaged separable contacts, a transformer having a winding connected in series with said contacts across said source, and electromagnetic means for periodically disengaging said separable contacts and releasing the same for re-engagement, said last-named means including core means, a running winding on said core connected in series with said contacts across said source and a bias winding on said core connected across said source, the disengagement of said contacts being effected by the magnetic field generated when said running winding and said bias winding are simultaneously energized by said source.

9. An ignition system for supplying a spark discharge gap with a continuous succession of pulses of gap discharging voltage, an intermittently operable first source of power for the discharge gap comprising a source of direct current, a first circuit connected to said direct current source, and a vibrator for periodically interrupting the current flow in the first circuit, a transformer having a primary and a secondary, the primary being connected in said first circuit, a second circuit connected to the secondary of the transformer, current rectifying means, a storage condenser, a control gap, a voltage step-up coil and the spark discharge gap being so connected in said second circuit that current delivered from the secondary of the transformer is rectified, stored in the condenser, then fed to the control gap, the step-up coil, and the spark discharge gap, in that order, and a second source of power for the discharge gap, said second source being adapted for continuous operation and comprising a source of alternating current, means fed by the alternating current source for converting each half cycle of the sine wave output of said alternating current source into a sharp current pulse of short duration and a further circuit connecting the last-named means to the primary of the transformer for energizing said second circuit.

10. An ignition system as claimed in claim 9, comprising means selectively to energize the first circuit by the first source of power and means selectively to energize said converting means by the second source of power.

11. An ignition system as claimed in claim 9, comprising means for blocking current flow from said first power source into said means for producing the current pulses.

12. An ignition system for supplying a spark discharge gap with a continuous succession of pulses of gap discharging voltage, an intermittently operable first source of power for the discharge gap comprising a source of direct current, a first circuit connected to said direct current source, and a vibrator for periodically interrupting the current flow in the first circuit, a transformer having a primary and a secondary, the primary being connected in said first circuit, a second circuit connected to the

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secondary of the transformer, current rectifying means, a storage condenser, a control gap, a voltage step-up coil and the spark discharge gap being so connected in said second circuit that current delivered from the secondary of the transformer is rectified, stored in the condenser, then fed to the control gap, the step-up coil, and the spark discharge gap, in that order, and a second source of power for the discharge gap, said second source being adapted for continuous operation and comprising a source of alternating current, means comprising an inductance fed by the alternating current source for producing a succession of current pulses and a further circuit connecting the last-named means to the primary of the transformer.

13. An ignition system as claimed in claim 12, comprising means for preventing current flow from said first power source into said means for producing the current pulses.

14. An ignition system as claimed in claim 13, wherein the said means for preventing current flow from said first power source into said means for producing the current pulses comprises a condenser.

15. An ignition system comprising an igniter plug, a storage condenser, means for controlling the discharge of said condenser across said igniter plug when the charge thereon attains a predetermined voltage, means for charging said condenser to said predetermined voltage comprising a transformer having a primary winding and a secondary winding connected to said condenser through rectifier means, a source of alternating current and circuit means connecting said source and said primary winding including a switching inductance and a condenser in series, whereby a succession of current impulses of short duration are supplied to said primary winding, a source of uni-directional current and means including a vibrator connected to said source of uni-directional current for supplying interrupted direct current to said primary winding, and switching means for selectively connecting said sources to energize said primary winding.

16. Electrical apparatus comprising a source of uni-directional current, a pair of normally engaged separable contacts, a transformer having a primary winding connected in series with said contacts across said source, and means for periodically disengaging and engaging said contacts comprising a first coil winding connected in series with said contacts across said source and a second coil winding connected across said source and inductively coupled with said first coil winding, a source of alternating current and circuit means connecting said source of alternating current to said primary winding to supply a succession of sharp current impulses thereto including a switching inductance and a condenser connected in series.

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