

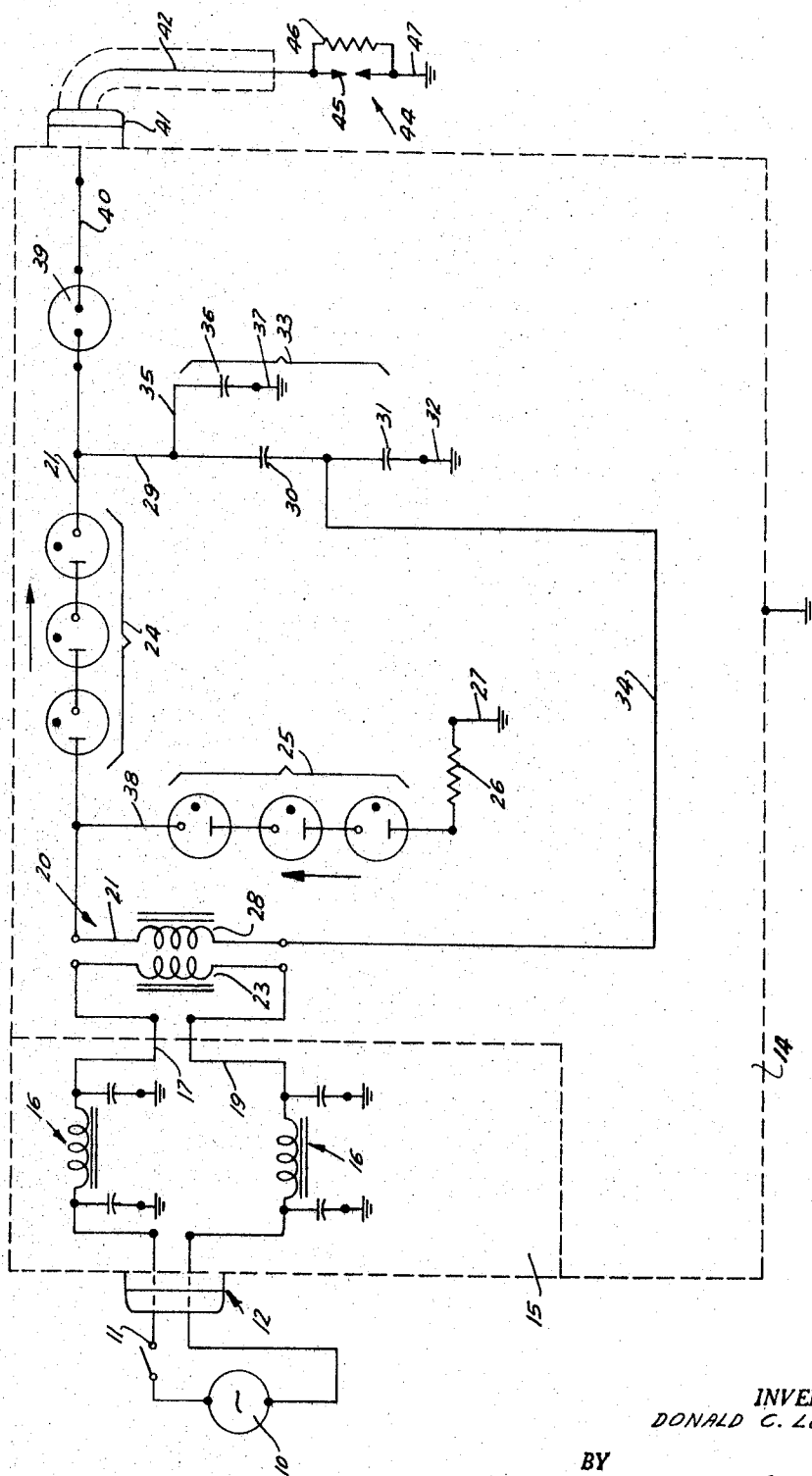
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ELECTRICAL PULSE GENERATING APPARATUS

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1

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ELECTRICAL PULSE GENERATING APPARATUS
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14 Claims. (Cl. 320-1)

This application is a continuation of application Serial No. 665,558 filed June 13, 1957, for "Electrical Apparatus," now abandoned.

This invention relates to electrical apparatus and more particularly to electrical systems adapted for producing electrical impulses for ignition purposes.

One of the objects of the present invention is to provide novel means of simple construction for controlling the charging and discharging of an electrical condenser.

Another object of the invention is to provide electrical apparatus including a novel circuit having a storage condenser and a load device such as a spark discharge gap fed thereby.

A further object is to provide a novel electrical circuit of the above type which is dependable in operation and is adapted for use during long periods without danger of operating failures.

Still another object is to provide novel electrical apparatus for producing sparks or arcs, such as for igniting combustible charges in combustion engines of all types.

Another object is to provide electrical apparatus of the condenser discharge type which embodies a novel condenser system and novel means for charging the same, the weight and volume of the condenser and of the charging means being thereby markedly decreased.

A still further object is to provide an electrical circuit having a control gap interposed between a storage condenser and an electrical loading device, said circuit incorporating novel means for protecting the circuit upon the short circuiting thereof, for reducing the magnitude of the peak current through the rectifiers and for increasing the conduction time through the rectifiers.

Another object is to provide a novel ignition circuit which may be advantageously incorporated in fuel igniting apparatus which is subjected to high temperatures during use.

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

The single figure of the drawing is a diagram illustrating one form of electrical circuit embodying the invention.

The embodiment of the invention illustrated in the accompanying drawing is, by way of example, shown in the form of a circuit for apparatus adapted for use as an ignition system in combustion engines and so-called jet and gas turbine engines. A particular use in which such apparatus and circuit have been found advantageous is in an ignition system for a ramjet engine wherein the weight and volume of the ignition system are desirably held to a minimum. The ignition system for a ramjet engine should also be rugged and free from tendencies to become short-circuited at high temperatures since usually the ignition system of such engine is subjected to elevated temperatures during use. As above pointed out, however, the invention is not limited to such use, since it is capable of use in various other applications.

As shown in the drawing, one suitable embodiment of the invention comprises, as a source of electrical energy, an alternating current generator 10 which may be con-

2

nected to the remainder of the circuit by means of a switch 11 interposed in one of the supply leads to the circuit. Generator 10 is connected by means, such as a plug 12, to the input of the electrical impulse generating device of the invention, which is conveniently supplied as a unit designated 14. Preferably such unit is contained in a metallic casing which may be grounded as indicated.

Unit 14 includes a suitable filtering means 16 in each side of the supply circuit, means 16 being useful, for example, when the generator 10 supplies other circuits, so as to prevent radio frequencies from feeding back from unit 14 into other circuits powered by the generator. In the particular embodiment shown, the filter means comprises by-pass condensers connected between ground (which may be the shielded case of unit 14) and each power supply line, there being an inductance interposed in each such power supply line and between the by-pass condensers. The filters are conveniently contained in a sub-housing designated 15. Such filters, which are conventional, form no part of the present invention. The power supply lines beyond filters 16, 16 are designated 17 and 19.

The wires 17 and 19 are connected to the opposite ends of the primary 23 of voltage step-up power transformer 20. The secondary 28 of transformer 20 charges a condenser system or bank 33 in a step-by-step manner until the condenser bank reaches the potential at which control gap 39 discharges. The control gap then feeds its output through lead 40 to wire 42 connected to unit 14 by plug 41, and thence to a load which in this instance is a spark discharge device 44. In the embodiment shown, device 44 has a spark gap 45 which is shunted by a resistance 46 which may be in the form of a semi-conductive surface at the spark gap. The other side of device 44 is connected to ground through lead 47.

Transformer 20 is preferably of the so-called reactance-type having high secondary leakage inductance characteristics, or, in other words, wherein the primary and secondary are loosely coupled and there is a large leakage flux, the degree of which is governed by the secondary load conditions. In such transformer, as the secondary load current increases the secondary terminal voltage drops. In the embodiment shown a first lead 21 from secondary 28 of transformer 20 has a first set 24 of serially connected rectifiers interposed therein in advance of the control gap 39. A second set of rectifiers, designated 25, which are connected reversely from rectifiers 24, are connected to wire 21 between the secondary 28 of the transformer and rectifier set 24 by a wire 38. The other end of rectifier set 25 is connected to ground through a serially connected resistance 26 and a wire 27. A wire 29, connected to wire 21 between rectifier bank 24 and control gap 39 has two serially connected condensers 30 and 31 interposed therein. A wire 32 connects condenser 31 to ground. A wire 35, connected to wire 29 between wire 21 and condenser 30, has a condenser 36 interposed therein. The condenser 36 is connected to ground by wire 37. The second lead 34 from secondary 28 of transformer 20 is connected to wire 29 between condensers 30 and 31.

Condensers 30 and 31 are preferably of small, equal capacity. Condenser 36 is preferably of much larger capacity than that of each of condensers 30 and 31. Preferably condenser 36 has a capacity on the order of 100 times that of either condensers 30 or 31. The described first, second and third condensers 30, 31, and 36, respectively, function together as a tank condenser which is alternately charged during the two half-cycles through rectifiers 24 and 25, respectively. When rectifier 24 charges the condenser bank 33, the condensers 31 and 36 are in effect connected in series, and such series-connected condensers are connected in parallel with con-

denser 30. When condenser bank 33 is charged by rectifier 25, condensers 30 and 36 are in effect connected in series, such serially-connected condensers being connected in parallel with condenser 31. Such operation of the system results from the facts that wires 27, 32, 5 and 37 are in effect connected together, since they are all connected to ground, and that the resulting circuit is alternately fed with charging current through wires 29 and 27. After the condensers 30, 31, and 36 have been charged step-by-step in the manner described to a predetermined voltage, which may be relatively low, e.g. 10 on the order of 3000 volts, the discharge gap of device 39 breaks down and the condensers discharge as a unit through gap 39 into spark gap 44 to discharge the latter, following which the charging of condenser system 33 is 15 repeated.

By reason of the described connection of condensers 30, 31, and 36, there is obtained both a doubling of the voltage impressed upon condenser system 33 and a marked saving in weight and space required to yield a given desired capacity. This effects a marked saving in the weight and volume of the capacitor required for the operation of the device. Such saving will be appreciated upon the consideration of the following example setting forth typical values of the condensers in the condenser bank or system 33. In such example, condensers 30 and 31 each has a capacity of .02 mfd., and condenser 36 has a capacity of 2 mfd. The total capacity of series-connected condensers is, of course, given by the formula $1/C = 1/c_2 + 1/c_3 = 1/c_3$, etc. The total capacity of 30 condensers connected in parallel is given by the formula $C = c_1 + c_2 + c_3$, etc. The total effective capacity on discharge of condenser system 33 may thus be calculated to be 2.01 mfd. If the same voltage and total capacity were to be obtained from the two condensers 30, 31, without condenser 36, each of condensers 30, 31 would necessarily have a capacity of about 4 mfd.

The transformer 20 functions as a choke coil to determine to a material extent the rate of flow of current from the discharge electrode of device 39. The loosely coupled reactance-type transformer 20 delivers only a limited amount of power due to its high secondary leakage inductance. Consequently, it effectively controls the charging rate of the condenser system and regulates the spark-producing rate of the apparatus, as well as reducing the magnitude of the peak current through the rectifiers and increasing the conduction time of such rectifiers. It has been found that, when such reactance-type transformer is used, no other regulating elements need be employed in the circuit. The resistance 26, which is preferably used in the circuit, limits the current which flows through rectifier sets 24 and 25 in series should condenser 36 attain a negative potential during discharge. Thus, such resistance protects the rectifiers from overload.

The circuit of the invention makes possible the production of high energy sparks at discharge device 44 with a substantial decrease in the total capacity of the condensers employed. Such saving in total capacitance required, and thus in the weight and volume of the ignition unit, is particularly marked when the described reactance-type power transformer is employed in the circuit. The circuit of the invention is simple and easily maintained. It eliminates the necessity for current control devices other than the reactance-type power transformer. It also allows the use of much smaller condensers in the circuit than if a conventional "close coupled" power transformer were used. Thus, with such latter type of transformer, condensers 30 and 31 must each be of 4 mfd. capacity in order that the circuit may operate in a manner comparable to that of the circuit of the invention. 70

Although only one embodiment of the invention has been illustrated in the accompanying drawing and described in the foregoing specification, it is to be expressly understood that the invention is not limited thereto but 75

that it may be embodied in other specifically defined circuits. For example, other well known sources of pulsating or alternating current may be provided in lieu of the generator-transformer combination illustrated. Wires 27, 32, and 37 may be actually physically connected together by a wire, rather than all being connected to ground. Additionally, the various parts of the circuit may be rearranged with respect to each other without appreciably affecting the operation of the circuit. Various other changes may also be made, such as the electrical values suggested herein, by way of example, without departing from the spirit and scope of the invention, as the latter will now be understood by those skilled in the art.

What is claimed is:

1. In electrical apparatus having a storage condenser, a load circuit connected to be fed by the storage condenser, and a control gap interposed between the storage condenser and the load circuit, the improvement which comprises a multiple condenser system forming said storage condenser, said system having a first and a second condenser connected in series and a third condenser connected in parallel with said series-connected first and second condensers, said first and second condensers being of substantially equal capacity and said third condenser having a capacity which is relatively large compared to that of either the first or second condenser, a source of current producing pulses of alternating polarity, means to establish a first charging circuit electrically connecting a first side of said source to the condenser system between the first and second condensers and the other side of said source between the first and third condensers at each positive pulse of the current source, and means to establish a second charging circuit electrically connecting said first side of the current source to the condenser system between the first and second condensers and the other side of said source between the second and third condensers at each negative pulse of the current source.

2. In electrical apparatus having a storage condenser, a load circuit connected to be fed by the storage condenser, and a control gap interposed between the storage condenser and the load circuit, the improvement which comprises a multiple condenser system forming said storage condenser, said system having a circuit with a first and a second condenser connected in series and a third condenser connected in parallel with said series-connected first and second condensers, a source of alternating current comprising a loosely coupled transformer having a large leakage flux, one side of said source being connected to the condenser system between, and to the first sides of, the first and second condensers, additional circuits connecting the other side of the source to the condenser system at the second sides of the first and second condensers, and reversely connected half-wave rectifiers interposed in each of said additional circuits.

3. In electrical apparatus having a storage condenser, a load circuit connected to be fed by the storage condenser, and a control gap interposed between the storage condenser and the load circuit, the improvement which comprises a multiple condenser system forming said storage condenser, said system having a circuit with a first and a second condenser connected in series and a third condenser connected in parallel with said series-connected first and second condensers, said first and second condensers being of substantially equal capacity and said third condenser having a capacity which is relatively large compared to that of either the first or second condenser, a source of alternating current, one side of said source being connected to the condenser system between, and to the first sides of, the first and second condensers, additional circuits connecting the other side of the source to the condenser system at the second sides of the first and second condensers, and reversely connected half-wave rectifiers interposed in each of said additional circuits.

4. In electrical apparatus having a storage condenser,

5

a load circuit including a spark gap connected to be fed by the storage condenser, and a control gap interposed between the storage condenser and the load circuit, the improvement which comprises a multiple condenser system forming said storage condenser, said system having a circuit with a first and a second condenser of substantially the same small capacity connected in series and a third condenser of markedly larger capacity connected in parallel with said series-connected first and second condensers, a source of alternating current, one side of said source being connected to the condenser system between and to the first sides of the first and second condensers, additional circuits connecting the other side of the source to the condenser system at the second sides of the first and second condensers, and reversely connected half-wave rectifiers interposed in each of said additional circuits.

5. Electrical apparatus as defined in claim 4, wherein the source of alternating current is a reactance-type transformer.

6. In electrical apparatus having a storage condenser, a load circuit connected to be fed by the storage condenser, and means interposed between the storage condenser and the load circuit for controlling the discharge of the condenser, the improvement which comprises a multiple condenser system forming said storage condenser, said system having a first and a second condenser connected in series and a third condenser connected in parallel with said series-connected first and second condensers, said third condenser having a capacity which is relatively large compared to the capacity of either the first or second condenser, a source of current producing pulses of alternating polarity, means to establish a first charging circuit electrically connecting a first side of said source to the condenser system between the first and second condensers and the other side of said source between the first and third condensers at each positive pulse of the current source, and means to establish a second charging circuit electrically connecting said first side of the current source to the condenser system between the first and second condensers and the other side of said source between the second and third condensers at each negative pulse of the current source.

7. Electrical apparatus as defined in claim 6, wherein the first and second condensers are of substantially equal capacity.

8. Electrical apparatus as defined in claim 6, comprising rectifier means in each charging circuit to prevent reverse flow of current therethrough.

9. Electrical apparatus as defined in claim 8, comprising electrical resistance interposed in said charging circuits, said resistance being of sufficient value to protect said rectifiers from overload during the discharging of said condensers.

10. In electrical apparatus having a storage condenser, a load circuit connected to be fed by the storage condenser, and means interposed between the storage con-

6

denser and the load circuit for controlling the discharge of the condenser, the improvement which comprises a multiple condenser system forming said storage condenser, said system having a circuit with a first and a second condenser connected in series and a third condenser connected in parallel with said series-connected first and second condensers, said third condenser having a capacity which is relatively large compared to that of either the first or second condenser, a source of alternating current, one side of said source being connected to the condenser system between, and to the first sides of, the first and second condensers, and additional circuits connecting the other side of the source to the condenser system at the second sides of the first and second condensers, and reversely connected half-wave rectifiers interposed in each of said additional circuits.

11. Electrical apparatus as defined in claim 10, wherein the source of alternating current comprises a loosely coupled transformer having a large leakage flux and a secondary winding to which said condenser system is connected.

12. Electrical apparatus as defined in claim 10, wherein the first and second condensers are of substantially equal capacity.

13. Electrical apparatus as defined in claim 10, comprising a resistance interposed in said additional circuits, said resistance being of sufficient value to protect said rectifiers from overload during the discharging of said condensers.

14. Electrical apparatus comprising in combination a storage condenser, a load circuit connected to be fed by the storage condenser, means interposed between the storage condenser and the load circuit for controlling the discharge of the storage condenser, the latter being in the form of a multiple condenser system, said system having a first and a second condenser connected to the load circuit in series and a third condenser connected in parallel with said series connected first and second condensers, a source of alternating current including a loosely coupled transformer having a large leakage flux, one side of said source being connected to the condenser system between and to the first sides of the first and second condensers, additional circuits connecting the other side of the source to the condenser system at the second sides of the first and second condensers, and reversely connected half-wave rectifiers interposed in each of said additional circuits.

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