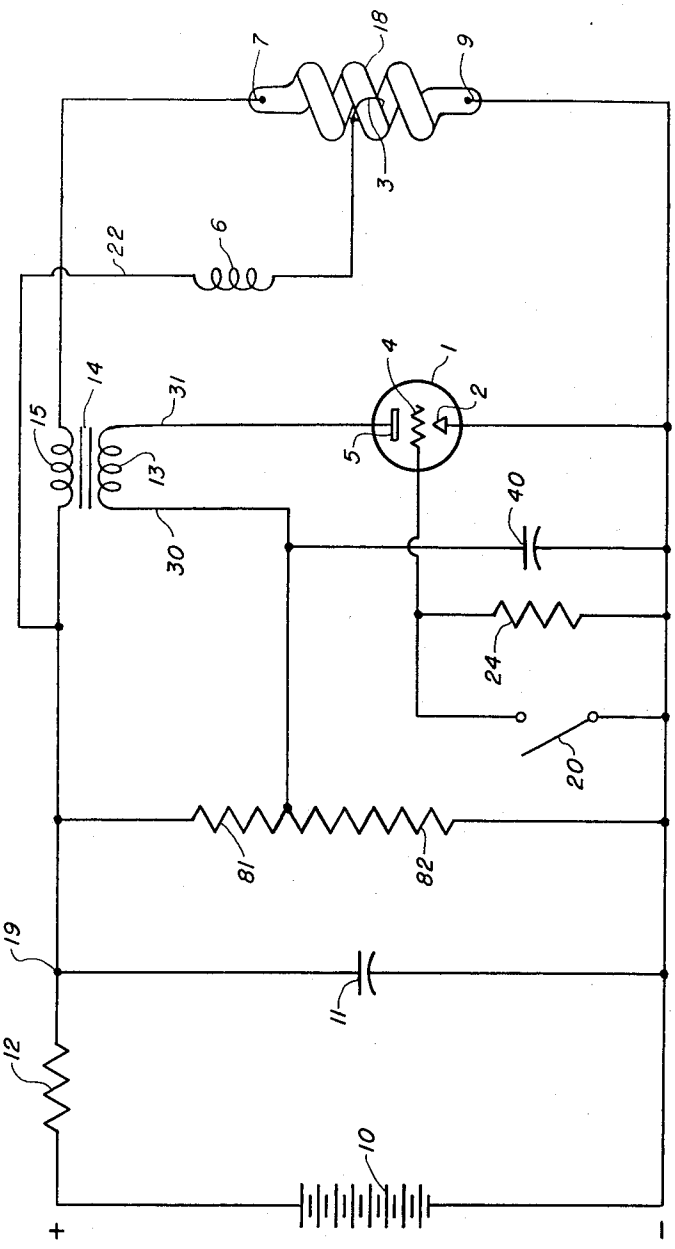
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ELECTRIC SYSTEM

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Inventor
Kenneth J. Germeshausen
by Ruis and Ruis
Attorneys

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ELECTRIC SYSTEM

Kenneth J. Germeshausen, Newton Center, Mass.

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The present invention, though having fields of more general usefulness in electric systems, is particularly related to systems in which a flash condenser is discharged through the gaseous medium of a gaseous-discharge device for such purposes as to produce a single flash or a repetition of flashes in flash-photography and stroboscopic work. The present application is a continuation-in-part of application, Serial No. 679,983, filed June 28, 1946.

In the said application, there is disclosed a very efficient flash-producer comprising a flash lamp, commonly called a flashtube, provided with an anode electrode and a cathode electrode between which to send the flash-producing current through the gaseous medium, and embodying also a series-triggering arrangement for producing the flash through the medium of a voltage provided by a saturable-coil inductor disposed in a specific part of the condenser-discharge circuit. A wire from one end of the gaseous-discharge device, shown as the cathode end, is connected to an intermediate point of the gaseous-discharge device, in order to lower the impulse breakdown voltage of the gaseous-discharge device. The polarity of the voltage impressed upon the saturable-coil inductor is preferably such as to aid the voltage across the flash condenser.

An object of the present invention is to provide a new and improved electric system of the above-described character.

Another object is to provide a new and improved flash-producing system of the above-described character.

Other and further objects will be explained hereinafter, and will be particularly pointed out in the appended claims.

According to a feature of the present invention, a triggering electrode, for causing the condenser to discharge between the cathode and the anode across which the condenser is connected in series with the saturable-coil winding, may be connected to the anode or the cathode electrode of the gaseous-discharge device through an impedance. The triggering electrode operates to trigger the discharge in response to a voltage pulse induced in the saturable-coil winding in additive polarity with respect to the charge in the condenser.

Another feature of the invention resides in a series-triggering arrangement for producing the flash through the medium of a voltage provided by a saturable-core inductance disposed in a specific part of the condenser-discharge circuit.

The invention will now be more fully explained in connection with the accompanying drawings, the single figure of which is a diagrammatic view of circuits and apparatus arranged and constructed according to a preferred embodiment of the invention.

A D.-C. energy-storing means, shown as a main-discharge electrical flash condenser or capacitor **11**, is intermittently supplied with energy to charge it intermittently from a direct-current voltage source, illustrated as a battery **10**, through a current-limiting charging impedance **12**. The condenser or capacitor **11** is shown series-connected in a condenser-discharge circuit between the two principal or main electrodes, namely, the anode electrode **7** and the cold-cathode electrode **9**, of a normally non-conducting gaseous-discharge device **18**. This device **18** may be constituted of a space-discharge flash-tube or flash-lamp arranged to emit light upon the passage of current therethrough when rendered conductive.

A triggering transformer **14** is provided with at least two windings, a primary winding being shown at **13** and a secondary winding at **15**. The discharge tube **18** is shown connected in the condenser-discharge circuit, from the cathode **9** to the anode **7**, across the condenser **11**, in series with the secondary winding **15**. The series connection of the secondary winding **15** in this circuit, between the anode **7** and the capacitor **11**, is shown provided by connecting it between the upper terminal **19** of the capacitor **11** and the anode **7**.

In addition to the principal or main electrodes **7** and **9**, the gaseous-discharge device **18** is shown provided also with a control-grid triggering electrode **3**, connected by a wire conductor **22** to one end of the flashtube **18**, shown as the end at which the anode electrode **7** is disposed. The connection to the anode electrode **7** is illustrated as effected through the secondary winding **15** from a point intermediate the charging circuit of the condenser **11** and the anode **7**. The connecting-wire means **22** is shown including an impedance **6**, represented as a radio-frequency choke coil. The impedance **6** will prevent sustained arcing between the cathode **9** and the trigger electrode **3** over the exterior surface of the flashtube **18**, if such arcing should happen to be initiated.

If intermittently charged to a D.-C. voltage of, say, from 200 to 2000 volts, the condenser **11** will provide a voltage source sufficient to sustain, though not to initiate, an intermittent flow of current through the discharge circuit and the gaseous medium of the flashtube **18**, between the anode **7** and the cathode **9**. This intermittent flow of current, produced by intermittent discharges of the condenser **11**, will produce intermittent flashes of light.

At a suitable time, a high-voltage transient pulse is designed to be induced momentarily, in the secondary winding **15** by supplying a corresponding voltage pulse for energizing the primary winding **13**. This may be effected in any desired way, as by discharging a small trip condenser or capacitor **40** through the primary winding **13**, in series with a normally non-conducting trigger tube **1**, by way of lead wires **30** and **31**. The capacitor **11** may be referred to as a first capacitor or condenser and the condenser **40** as a second capacitor condenser. The flashtube **18** may similarly be referred to as a first gaseous-discharge device and the tube **1** as a second gaseous-discharge device.

Because of the normally non-conducting character of the trigger tube **1**, it provides a normally open switching device. The condenser **40** may be charged from any desired direct-current source, such as a bleeder resistor. The bleeder resistor is shown comprising two resistor sections **81** and **82** connected in series across the battery **10** to constitute a voltage divider for adjusting the voltage on the condenser **40**. The free terminal of the resistor **81** is connected to one terminal of the condenser **11**, shown as the upper terminal **19**, and the free terminal of the resistor **82** is connected to the other terminal of the condenser **11**, shown as its lower terminal.

The saturable-core inductance device **14** is therefore connected in series between the plurality of discharge devices **1** and **18**, on the one hand, and the condenser **11**, on the other hand, which therefore serves as a common direct-current voltage source for both these gaseous-discharge devices **1** and **18**.

The trigger tube 1 should be of a type capable of passing high-peak currents. It may, for example, be thermionic or of the normally non-conducting cold-cathode gaseous-discharge type illustrated and described in Letters Patent 2,185,189, 2,201,166 and 2,201,167, issued to Kenneth J. Germeshausen on January 2, and May 21, 1940. It may comprise an evacuated glass envelope filled with a suitable gas, such as neon, or any of the other noble gases, such as argon or helium. The space-discharge tube 1 is shown possessing two principal or main electrodes, namely, a solid cathode 2, shown connected to the negative end of the battery 10, and an anode or plate 5, and one of more control-grid electrodes 4. The two capacitors 11 and 40, the primary winding 13 and the principal or main electrodes 2 and 5 of the tube 1 are shown series-connected in a closed-circuit loop.

As explained in the said Letters Patent, the source of the electrons is a bright cathode spot on the surface of the cathode 2. The moment of discharge of the condenser 40 through the primary winding 13 is controlled by actuating the normally open trigger-tube switching means 1 to closed condition. A unidirectional voltage becomes thus supplied across the main electrodes 2 and 5.

An impedance 24, shown as a resistor, is connected in parallel with the capacitor 40, between the cathode 2 and the grid 4, to constitute a means for establishing the potential of the control-grid electrode 4. It is shown connected in parallel also with a mechanism 20 for triggering the flashes of the flash tube 18. The mechanism 20 may, for example, be in the form of terminals, not shown, but illustrated in the said application. It is shown herein as in the form of a switch or contactor device.

The circuit for triggering the flashes of light may be called a first circuit means. It is shown connecting the primary winding 13 and the switch tube 1 in series across the resistor 82 and, therefore, across the condenser 11, as well. The tube 1 becomes triggered in this first circuit to impress at least part of the voltage of the condenser 11 across the inductance device 14, as determined by the resistance of the resistor 82 relative to that of the resistor 81.

When it is desired to trigger the flashes, a trigger voltage impulse is applied, through the switch terminals or other mechanism 20, to the control-grid electrode 4, The grid electrode 4 thereupon becomes controlled to actuate the normally open switching device 1 to closed condition. This results in suddenly connecting the primary winding 13 across the resistor 82 and, therefore, across the capacitor 11 also. The triggering tube 1 is thereupon rendered suddenly conducting, thus enabling the trip condenser 40 suddenly to discharge therethrough. A direct-current voltage thereupon becomes suddenly applied across the primary winding 13. A short current pulse then becomes switched to the series-connected inductance device 14 comprising the primary winding 13 to produce a transient impulse voltage in the secondary winding 15, and the flash-tube 18 is thus triggered or rendered suddenly conducting. Current flow through the flashtube 18 becomes then initiated from the condenser voltage source 11. The voltage and the power necessary to effect this result depend upon the design of the particular switching tube 1 employed.

The polarity of the transient voltage pulse impressed upon the primary winding 13 and, therefore, the voltage induced in the secondary winding 15 also, is preferably in the same sense as the sense of the voltage across the condenser 11. The relative polarities of the transformer primary and secondary windings 13 and 15 are therefore such that, upon the actuation of the switching means 1, a voltage is induced in the secondary winding 15 having a polarity that is additive to that of the voltage charge on the condenser 11. It will therefore aid the voltage across this condenser 11. This will reduce the magnitude

of the voltage required to be supplied by the transformer 14 to fire the flashtube 18.

The transient high-voltage pulse impressed upon the secondary winding 15 is therefore utilized to trigger the space-discharge tube 18 by connecting this space-discharge tube 18 in the before-described condenser-discharge circuit, which may be called a second circuit means. The discharge of the condenser 11 becomes initiated through the condenser-discharge circuit and the flash-tube 18 connected therein when the flash-tube 18 becomes rendered momentarily conducting by ionization. This happens when the high-voltage pulse in the secondary winding 15, when it becomes communicated to the condenser-discharge circuit, added to the voltage of the condenser 11, exceeds the breakdown voltage between the anode 7 and the cathode 9. For a typical tube, this voltage may be on the order of twice the voltage at which the tube is designed to operate; say, 5,000 volts.

Immediately after the production of the flash, the normally open trigger-tube switching means 1 becomes automatically returned to its normally open condition, to render it non-conducting once more, by automatic resetting means responsive to integrated current flow through the said switching means. The automatic resetting is effected by the discharge of the condenser 11 through the secondary winding 15 and the flash tube 18, and also through the trigger tube 1.

It is desirable to have the lamp dimensions and the gas pressure such that the breakdown voltage of the flashtube 18 shall be appreciably greater than the voltage to which the discharge condenser 11 is charged, say, several times as great. It has been found that the lamp 18 then converts a greater proportion of the energy in the condenser 11 into useful light.

Since the secondary winding 15 of the transformer 14 is series-connected in the condenser-discharge circuit, it is desirable, in order to attain high efficiency and a discharge time that shall not be too long, that its impedance be low with respect to the impedance of the lamp 18 at the time of discharge of the condenser 11. For a reasonable discharge current in the tube 1, on the other hand, it is desirable that the impedance of the primary winding 13 be reasonably high at the time that the triggering impulse is applied to the primary winding 13 and prior to the discharge of the condenser 11.

With a primary winding the effective impedance of which is high at the time of the discharge of the condenser 40, moreover, it is possible to arrange that the impedance of the lead wires 30 and 31 to the transformer primary winding 13, which may be fairly long, shall not be too great compared to the impedance of this primary winding 13. The required low impedance of the secondary winding 15, at the time of the discharge of the condenser 11, and the required high impedance of the primary winding 13, at the time that the triggering impulse is applied to the primary winding 13, prior to the discharge of the condenser 11, may be attained by providing the transformer 14 with an iron core that saturates at the time when the main condenser 11 discharges through the transformer in response to the production of the triggering voltage across the secondary winding 15. It is because of the saturable character of the core of the transformer 14 that a low impedance is offered to the discharge of the condenser 11 through the discharge circuit including the gaseous-discharge device 18. The iron core of the transformer 14 may be made to saturate abruptly a short time after the break-down between the anode 7 and the cathode 9 by the trigger voltage. The sudden voltage change across the inductance device 14 will therefore occur before the saturation thereof.

A saturable-core inductance device is thus provided for presenting a very low impedance to a very large discharge current at the time when the transformer core is saturated, the induction current of the flashtube 18 saturating the

core of the inductance-device transformer **14** and the tube **1**. Substantially the full voltage of the capacitor **11** becomes therefore applied to the flashtube **18** to maintain conduction therein. The permissible saturated inductance of the secondary winding **15** of the transformer **14** may be computed from the well-known equations governing the transient behavior of a series-discharge circuit of resistance, inductance and capacitance.

The impedance of a typical flashlamp **18**, for example, 30 centimeters long and 4 millimeters inside diameter, and filled with xenon at 10 centimeters pressure of mercury, may be 3 or 4 ohms. A typical condenser **11** may be of 10 microfarads capacity. The transient in the series-condenser discharge circuit comprising the condenser **11**, the secondary winding **15** and the lamp **18** will depend on the relative proportions of the resistance, the inductance and the capacitance.

The saturated inductance of the secondary winding **15** of the transformer **14** may be as great as 40 microhenries without seriously affecting the duration of the flash or the peak current in the condenser-discharge circuit. If the resistive component of the impedance of the secondary winding **15** is low compared to 4 ohms, the efficiency will still be good, and the operation will be comparable to the operation that takes place without the transformer **14**. Under the above conditions, the operation will be satisfactory, so long as

$$L=\frac{R^2C}{4}$$

where L is the inductance of the condenser-discharge circuit, R is its resistance, and C is its capacitance. In most practical cases, it is permissible to tolerate even the relation

$$L=R^2C$$

A typical transformer **14** may have a closed core of 0.094 square inch cross section and 4 inches effective length, and may be constituted of a good grade of thin silicon-steel laminations. On this core may be wound a secondary winding **15** of 50 turns and a primary winding **13** of 5 turns. When the iron core is saturated, the inductance of the primary winding **13** is of the order of 0.20 microhenry, and that of the secondary winding **15** is of the order of 20 microhenries. The saturated inductance of 20 microhenries for the secondary winding **15** is well below the value 40 microhenries before referred to. When the iron core is not saturated, the inductance may be 100 times as great, corresponding to a primary-winding inductance of 20 microhenries. Since ordinary cable has an inductance on the order of 0.2 microhenry per foot, this value is large enough so as not to introduce troubles due to the impedance of the lead wires **30** and **31**.

The impedance across which the excess voltage to the lamp **18** is delivered need not be constituted, however, of the secondary winding **15** of the transformer **14**. As explained in the said application, it may be in the form of an iron saturable-coil inductor of other type connected in series between the direct-current source **11** and the flash-tube **18**.

Further modifications will occur to persons skilled in the art, and all such are considered to fall within the spirit and scope of the invention, as defined in the appended claims.

What is claimed is:

1. In combination, a condenser, means for charging said condenser, a space-discharge tube possessing an anode, cathode and triggering electrode, a winding possessing a saturable core, means connecting said discharge tube from cathode to anode across said condenser in series with said winding, means for inducing a voltage pulse in said winding in additive polarity with respect to the charge on said condenser for triggering said discharge tube, and means including an impedance connecting said triggering electrode intermediate said charging means and said anode.

2. In combination, a condenser, means for charging said condenser, a space-discharge tube possessing two principal electrodes, namely, an anode and a cathode, and a triggering electrode, a winding possessing a saturable core, means connecting said discharge tube from cathode to anode across said condenser in series with said winding, means for inducing a voltage pulse in said winding in additive polarity with respect to the charge on said condenser for triggering said discharge tube, and means including an impedance connecting said triggering electrode intermediate said charging means and one of the principal electrodes.

3. An electric system having, in combination, a gaseous-discharge device comprising an envelope provided with two principal electrodes, namely, an anode and a cathode, and a triggering electrode, a condenser, means for charging the condenser, means connecting the anode and the cathode to provide a discharge circuit for the condenser, means for impressing a voltage pulse upon the discharge circuit in additive polarity with respect to the charge on the condenser to cause the condenser to discharge through the discharge circuit and the gaseous-discharge device between the anode and the cathode, and means comprising an impedance connecting the triggering electrode intermediate said charging means and one of the principal electrodes.

4. A flash-producing system having, in combination, a gaseous-discharge flash device comprising an envelope provided with two principal electrodes, namely, an anode and a cathode and a triggering electrode, a condenser, means for charging the condenser, means connecting the condenser to the anode and the cathode to provide a discharge circuit for the condenser, means for impressing a voltage pulse upon the discharge circuit in additive polarity with respect to the charge on the condenser to cause the condenser to discharge through the discharge circuit and the gaseous-discharge flash device between the anode and the cathode in order to produce a flash, and means comprising an impedance connecting the triggering electrode intermediate said charging means and one of the principal electrodes.

5. An electric system having, in combination, a gaseous-discharge device comprising an envelope provided with two principal electrodes, namely, an anode and a cathode, and a triggering electrode, a condenser, means for charging the condenser, means connecting the anode and the cathode to provide a discharge circuit for the condenser, a saturable inductor connected in the discharge circuit, means for impressing a voltage pulse upon the inductor in additive polarity with respect to the charge on the condenser to cause the condenser to discharge through the discharge circuit and the gaseous-discharge device between the anode and the cathode, and means comprising an impedance connecting the triggering electrode intermediate said charging means and one of the principal electrodes.

6. A flash-producing system having, in combination, a gaseous-discharge flash device comprising an envelope provided with two principal electrodes, namely, an anode and a cathode, and a triggering electrode, a condenser, means for charging the condenser, means connecting the anode and the cathode to provide a discharge circuit for the condenser, a saturable inductor connected in the discharge circuit, means for impressing a voltage pulse upon the inductor in additive polarity with respect to the charge on the condenser to cause the condenser to discharge through the discharge circuit and the gaseous-discharge flash device between the anode and the cathode in order to produce a flash, and means comprising an impedance connecting the triggering electrode intermediate said charging means and one of the principal electrodes.

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