

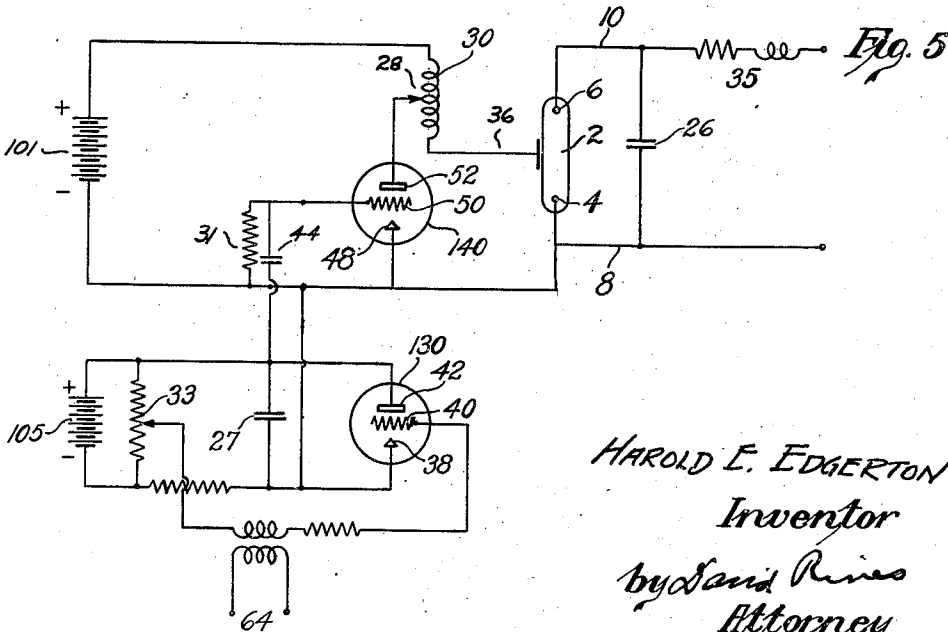
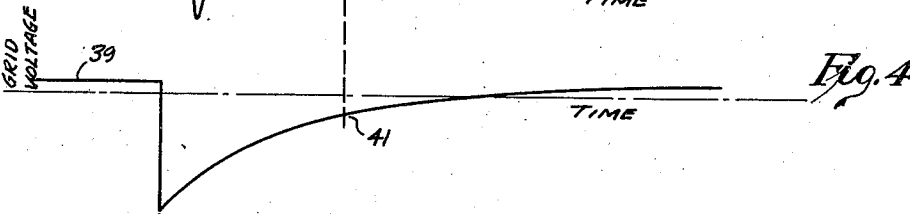
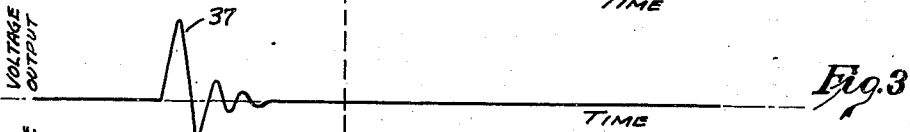
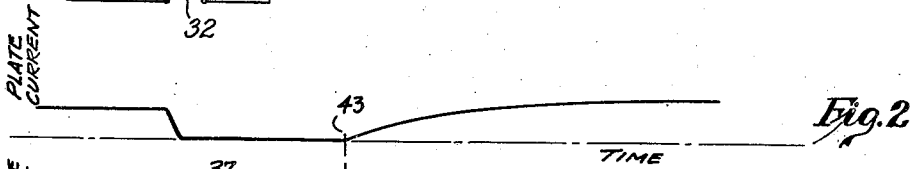
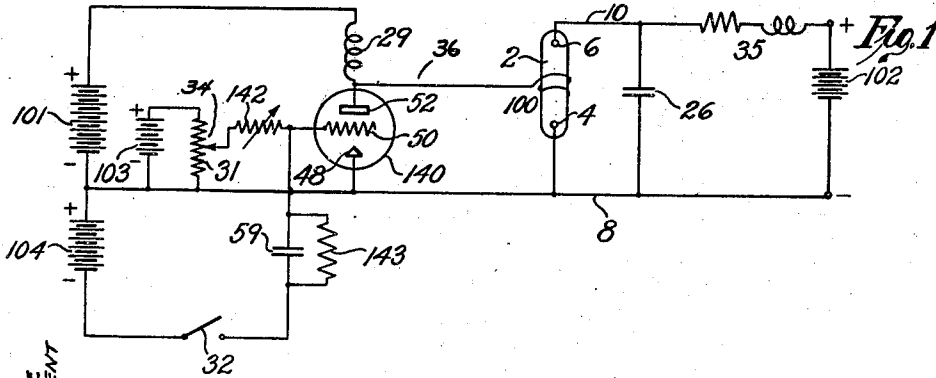
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ELECTRIC SYSTEM FOR PRODUCING INTERMITTENT OR FLASHING LIGHT

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ELECTRIC SYSTEM FOR PRODUCING INTERMITTENT OR FLASHING LIGHT

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26 Claims. (Cl. 315-230)

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The present invention relates to electric systems, and more particularly to systems for producing intermittent or flashing light. Among the applications of the invention are stroboscopes, high-speed electrical flash photography and high-speed-motion-picture photography. Electrical-discharge tubes in general use may be broadly divided into two categories: those operating principally on the thermionic principle; and those usually designated as gas-filled or gas-containing tubes. Though both these types of tubes are commonly referred to as vacuum tubes, the tubes of the thermionic type are characterized by a higher degree of vacuum, and will be referred to herein as vacuum tubes. Thermionic tubes operate upon the principle of a pure-electron discharge. Though usually containing some gas, the amount of gas so contained is relatively so very small that relatively very little gas ionization takes place. Tubes of this character accordingly operate under relatively high voltages and low currents, resulting from the substantial absence of gas ionization. It is, therefore, proper to distinguish thermionic tubes by this characteristic from the gas-filled or vapor, or combination of gas-and-vapor or gas-containing tubes, by referring to the latter as gas tubes.

Gas tubes contain gas or vapor or both at pressures sufficiently high so that electrons, by colliding with the gas particles, ionize them. They may, therefore, be operated at lower voltages and higher currents, rendered possible by the positive ionization of the gas or vapor particles through impact of the emitted electrons. The large currents are rendered possible by the neutralization of the space charge between the electrodes by the positive ions, and even when the electrodes are subjected to only a small potential drop. The current is carried largely by the electrons. The ions drift slowly in the space, neutralizing the space charge. The ions aid also in extracting electrons from the cathode. The electrodes of gas tubes may be non-thermionic; they may be caused to emit electrons at room temperature or by bombardment, but they may also be operated at the high temperature necessary for thermal electron emission.

In each of Letters Patent of the United States 2,181,879, issued December 5, 1939, and 2,186,013, issued January 6, 1940, there is disclosed a gaseous-discharge lamp for producing a light flash upon the discharge therethrough of a condenser. The moment of discharge of the condenser is determined by a gas-filled grid-controlled tube that is instrumental in applying a short-time high-

voltage pulse to a starting electrode of the gaseous-discharge tube.

For some purposes, it is often desirable to energize the starting electrode from a vacuum tube, instead of from the gas-filled grid-controlled tube before mentioned, and an object of the invention is to provide a new and improved system of the above-described character comprising a vacuum tube for starting an electrical flash-lamp.

The use of vacuum tubes, as distinguished from the said gas-filled tubes, for controlling the operation of the condenser has usually been attended with practical difficulties. Among other factors, the conventional vacuum tubes ordinarily employed in amplifiers, oscillators and the like, owing to their relatively small cathodes and relatively large impedances, are not adapted for the passage of current surges large enough to supply the necessary current for the condenser discharge in the trip circuit.

A further object of the present invention, however, is to provide a novel circuit in which conventional vacuum tubes may be employed to produce high-voltage surges of short duration.

With these ends in view, a feature of the invention resides in operating the vacuum tube with a high plate or output voltage at the moment of the surge. This high-surge voltage appears suddenly across a coil the circuit of which is connected to the said starting electrode at the instant the current is stopped. Control of the instant of flash through the gaseous-discharge lamp is thus made positive and certain, and without the necessity for supplying an abnormally large current through the vacuum tube.

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

The invention will now be described in connection with the accompanying drawings, in which Fig. 1 is a diagrammatic view of circuits and apparatus arranged and constructed according to one embodiment of the invention; Figs. 2, 3 and 4 are explanatory diagrams illustrating, respectively, as ordinates, the current in the coil 29 (Fig. 1) or 30 (Fig. 5) or in the plate or output circuit of the vacuum tube, the voltage across the said coil or across the vacuum tube, and the grid voltage on the vacuum tube, the time being represented along the axis of abscissae; and Fig. 5 is a view similar to Fig. 1 of a modification.

A luminescent normally non-conductive electric flash-lamp is illustrated as of the gaseous-discharge, three-electrode type, provided with two principal internal electrodes in a glass envelope

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or tube 2, and a normally unenergized starting or control electrode 100 external thereto for rendering the lamp conductive between the cathode and the anode. Lamps 2 having more than two electrodes may obviously also be employed. The lamp 2 may be straight, as illustrated, or it may be bent into U-shape, or twisted into spiral form, or it may have any other convenient shape. The gas contained in the tube may, for example, be mercury vapor, argon, neon, krypton or xenon, or the lamp may be filled with a mixture of any of these or other suitable gases.

The internal electrodes are illustrated as a solid metal cathode 4 and a solid metal anode 6. If desired, one or both may be coated with other materials for facilitating starting the lamp. The starting or control electrode 100 is shown in Fig. 1 as a wire twisted externally around the lamp. In Fig. 5, the starting electrode 100 is indicated in more general fashion than in Fig. 1. The electrodes may, of course, assume other forms than those illustrated. The cathode 4 may, for example, as illustrated in the said Letters Patent, be constituted of a pool of mercury, and the starting electrode 100 may be in the form of an external metal band opposite to the meniscus of the mercury.

The cathode 4 and the anode 6 are shown connected in the output circuit of the tube 2, directly across a main discharge condenser 26, by means of wire conductors 8 and 10. The electrical flash-lamp 2 is flashed by the discharge of this condenser therethrough after it has become charged, through a current-limiting charging impedance 35, from any suitable source of direct-current energy, such as a battery 101. The impedance 35 is usually a combination of resistance and inductance. The quantity of light flashed through the lamp 2 is determined by the amount of energy in the condenser 26 and by circuit conditions.

To cause the flash-lamp 2 to start, the starting electrode 100 is shown excited from an inductance coil or winding 29 (Fig. 1) or 30 (Fig. 5), in circuit with a vacuum trigger tube 140. The vacuum tube 140 is designed to cut the coil 29 off suddenly. The operation of the vacuum tube 140 to cut off the current in the coil 29 may be effected in any desired manner; as by means of a switch 32, shown in Fig. 1, or a grid-controlled gas-filled tube 130, illustrated in Fig. 5 and described hereinafter. The switch 32 may be manipulated by hand; but if periodic flashes are desired through the lamp 2, as for stroboscopic purposes, the switch 32 may be replaced by a periodically operating contact-making-and-breaking apparatus, such as a commutator or relay. The current carried by the switch 32 is usually negligible, since the switching is effected in the grid circuit of the tube 140.

The winding 29 or 30 is shown connected, in series with a source of direct-current energy, such as a battery 101, in the power output or control input or plate circuit of the vacuum tube 140, between the cathode 48 and the plate or anode 52. This power output circuit may be traced from the cathode 48, through the tube 140, to the anode 52, through the coil 29 or 30, and the battery 101, back to the cathode 48. The input or grid circuit of the vacuum tube 140 may be traced from the cathode 48, through a control electrode or grid 50, and a resistor 31, back to the cathode 48. The switch 32, the grid-controlled rectifier 130, or other mechanism for operating the vacuum tube 140, operates by producing a negative surge upon the grid 50. In Fig. 1, the complete coil 29 is

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shown so connected into circuit; in Fig. 5, the anode 52 is shown connected to the coil 30, which constitutes an auto-transformer, by a variable tap 28. The use of this auto-transformer 30, in substitution for the inductance coil 29, provides for impressing a lower voltage on the plate 52 of the tube 140 than for the starting circuit. The output circuit of the tube 140 is connected to the electrode 100 by a conductor 36.

In Fig. 1, the grid 50 is shown connected to the resistor 31 in series with a variable resistor 142. The connection is through a tap 34, and the resistor 31 is supplied with energy from a battery 103, in order that the resistor 31 may serve as a bias potentiometer. Though the resistor 142 and the battery 103 are omitted from Fig. 5, other connections are provided so that the resistor shall still serve, in the system of Fig. 5, as a potentiometer. The connections of Fig. 5 are more fully described hereinafter.

The negative bias surge imposed upon the grid 50 is very large, much larger than is the case with vacuum tubes as ordinarily operated. This may, indeed, be termed an abnormal use of the vacuum tube 140, under conditions of a very high plate potential, which requires a very large grid voltage to obtain cut-off of the plate current. With values hereinafter given, a voltage of 100 volts on the battery 101 may yield an output voltage of 10,000 across the coil 29.

According to this abnormal use of the vacuum tube 140, current normally flows through its output circuit, including the inductance 29 or 30, the energy being supplied from the battery 101. At the instant that the grid 50 becomes subjected to a suitable stimulus, however, as when the switch 32 of Fig. 1 becomes closed, or the grid-controlled rectifier 130 of Fig. 5 becomes operative, the current normally flowing in the circuit of the vacuum tube 140 is suddenly cut off by the tube 140. The consequent rapid change of current in the output circuit of the tube 140 and the coil 29 or 30 therein results in applying accurately, reliably and rapidly a sudden positive high-voltage pulse, through the conductor 36 on the grid 100 of the flash-tube 2. The energy for producing this high-voltage pulse comes from inductively stored energy in the coil 29 or 30.

The high-potential-pulse gradient that is thus established accurately, reliably and rapidly between the starting electrode 100 and the cathode 4 is indicated by the left-hand half-cycle peak surge 37 shown in the graph of Fig. 3. Because of this surge, a flash is produced momentarily through the lamp 2, between its cathode 4 and anode 6.

The method just described is also effective for starting gas-filled tubes for rectifiers or inverters as well as for light-flash sources. In the case of tubes having mercury-pool cathodes 4, the pulse on the starting electrode 100 causes a source of electrons to exist on the mercury-pool cathode, thereby to render the tube conducting. Tubes of this character have been used successfully for stroboscopic purposes. In all cases, the vacuum tube 140 controls the operation of the starting electrode to control the discharge of the condenser 26 through the discharge tube 2.

A typical oscillogram of the variation of the potential of the grid 50 is represented in Fig. 4. The grid 50 is at first positive, as shown at 39, or, perhaps, slightly negative by an amount determined by the setting of the bias potentiometer 31. If grid current flows in the grid or input circuit, the series resistor 142 also controls the

initial bias, and thereby the plate current through the coil 29 or the auto-transformer 30. The initial plate current is proportional to the high-voltage pulse, the magnitude of which may be conveniently varied to suit desired conditions by adjustment of the potentiometer 31, or the resistor 142, or both. The cut-off point 41 of the curve of Fig. 4 is directly below the point 43 of the curve of Fig. 2 where the curve of Fig. 2 starts to become positive. That point determines the tube cut-off bias.

The switch 32 may be employed also to impress a continuous negative bias on the grid 50. It is preferred, however, to employ a condenser type of circuit, as illustrated in Fig. 1, with a condenser 59, in parallel with a leak resistor 143, connected between a battery 104 and the grid 50 through the switch 32. The grid 50 is connected to one side of the switch 32 through the condenser 59. The other side of the switch 32 is connected through the battery 104 to the cathode 48. This condenser-type of circuit automatically permits the plate current, after each flash, to build up for the next flash. As the condenser 59 becomes charged from the battery 104, the bias varies exponentially with time, as illustrated in Fig. 4. The time constant is determined by the size of the capacitor 59 and the resistor 142. A correction is necessary if the resistance of the potentiometer is comparable in value with resistor 142.

The plate current in the vacuum tube 140 and the inductance 29 decreases to zero in a very short interval of time, as shown in Fig. 2. The energy that was stored in the magnetic field of the inductance of the coil 29 now becomes stored in the distributed capacity of this coil, the tube 140 and their associated circuit. Since this capacity is small, the voltage will be high.

The following numerical example illustrates the order of magnitude of the quantities that have been used experimentally. A coil 29 was used having 15,000 turns, an outside diameter of 2½ inches and a length of 4 inches, its inductance being about one henry. The current through this coil 29, before cut-off, was about 0.2 ampere. Equating the stored energy

$$\frac{LI^2}{2}$$

in the magnetic field to the stored energy

$$\frac{CE^2}{2}$$

in the electrostatic field, the voltage obtained when the current was suddenly reduced to zero is seen to be:

$$E = I\sqrt{\frac{L}{C}} \text{ volts}$$

Assuming the capacity to be 400×10^{-12} farads, the peak computed plate voltage, as plotted in Fig. 3, is 10,000 volts. The frequency of oscillation is determined by the circuit constants:

$$f = \frac{1}{2\pi\sqrt{LC}} = \text{about 4,000 cycles}$$

Usually the frequency is higher than given in this illustrative example.

The damping of the oscillation can be increased by using an inductance coil 29 of high resistance, or by using a resistor (not shown) across the terminals of this coil 29.

The grid-voltage power supply 104 must be enough to cut off the plate current with the high-surge voltage on the plate. In the example just

given, assuming an amplification factor of 10, the necessary bias will be about

$$\frac{10,000}{10}$$

or 1,000 volts.

The resistor 143 is used to discharge the capacitor 59 between operations. It is high enough in value so as not to influence appreciably the charging cycle.

Fig. 5 illustrates a relaxation oscillator with the gas-filled grid-controlled tube 130 before-mentioned. The tube 130, may, for example, be a thyatron, having a cathode 38, an anode 42 and a grid or control electrode 40. The relaxation oscillator may, however, employ vacuum tubes instead of gas-filled tubes to generate the sudden negative voltage on the grid 50. This oscillator may be either of the self-driven or externally driven type.

A small condenser 27, charged from a battery or other direct-current source 105, operates to trigger the tube 130 to effect flashing of the lamp 2 when the potential of the grid 40 is raised to a predetermined critical value with respect to the cathode 38. One side of the condenser 27 is shown connected to the grid 50 through a coupling condenser 44. The other side of the condenser 27 is shown connected to the cathode 48.

A bleeder resistor 33, in parallel with the battery 105, allows a small current to flow, in order to maintain the proper voltage bias upon the grid 40. The grid 40 is connected so that it is negative with respect to the cathode 38 during most of the cycle. Frequency adjustment is obtained by the use of a variable tap on the resistor 33, or by means of surges or an alternating voltage applied to a transformer 64. The tap on the resistor 33 may be employed to obtain self-oscillation of the circuit of the tube 130. In that event, the separate oscillator 64, of course, will not be needed.

When the grid 40 becomes positive with respect to the cathode 38, the tube 130 becomes conductive, permitting the condenser 27 to discharge therethrough. The potential of the grid 50 is thus raised to a high negative value, with respect to the cathode 48, producing a high potential upon the starting electrode 100, and producing a flash in the lamp 2.

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. An electric system having, in combination, a gaseous-discharge tube that is normally non-conducting when not in operation, a vacuum tube, means for normally passing current through the vacuum tube when the vacuum tube is in operation, means for stopping the flow of current through the vacuum tube, means controlled by the stoppage of current through the vacuum tube for rendering the gaseous-discharge tube conducting, a condenser, means for charging the condenser, and means for discharging the condenser through the gaseous-discharge tube when the gaseous-discharge tube becomes conducting.

2. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, a vacuum tube, means for normally passing current through the tube when

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the tube is in operation, means for stopping the flow of current through the tube, means controlled by the stoppage of current through the tube for rendering the lamp conducting, a condenser, means for charging the condenser, and means for discharging the condenser to produce a momentary luminescent flash in the lamp when the lamp becomes conducting.

3. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, a vacuum tube having an anode, a cathode and a control electrode that is normally unenergized when the tube is in operation, an input circuit in which the cathode and the control electrode are connected, an output circuit in which the cathode and the anode are connected, means for normally passing current in the output circuit when the tube is in operation, means connected with the input circuit for energizing the control electrode to stop the flow of current in the output circuit, means controlled by the stoppage of the flow of current in the output circuit for rendering the lamp conducting, a condenser, means for charging the condenser, and means for discharging the condenser through the lamp to produce a momentary luminescent flash in the lamp when the lamp becomes conducting.

4. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, a vacuum tube having a control electrode that is normally ineffective when the tube is in operation, means for normally passing current through the tube when the tube is in operation, means for rendering the control electrode effective to stop the flow of current through the tube, means controlled by the stoppage of the flow of current through the tube for rendering the lamp conducting, a condenser, means for charging the condenser, and means for discharging the condenser through the lamp to produce a momentary luminescent flash in the lamp when the lamp becomes conducting.

5. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, a vacuum tube operating upon the principle of a pure-electron discharge, an inductance, means controlled by the tube for storing energy in the inductance, means controlled by the energy stored in the inductance for rendering the lamp conducting, a condenser, means for charging the condenser, and means for discharging the condenser through the lamp to produce a momentary luminescent flash in the lamp when the lamp becomes conducting.

6. An electric system having, in combination, a gaseous-discharge tube that is normally non-conducting when not in operation, a vacuum tube, means for normally passing current through the vacuum tube when the vacuum tube is in operation, means for stopping the flow of current through the vacuum tube, an inductance, means controlled by the stoppage of the flow of current through the vacuum tube for storing energy in the inductance, means controlled by the energy stored in the inductance for rendering the gaseous-discharge tube conducting, a condenser, means for charging the condenser, and means for discharging the condenser through the gaseous-discharge tube when the gaseous-discharge tube becomes conducting.

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7. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, a vacuum tube, means for normally passing current through the tube when the tube is in operation, means for stopping the flow of current through the tube, an inductance, means controlled by the stoppage of the flow of current through the tube for storing energy in the inductance, means controlled by the energy stored in the inductance for rendering the lamp conducting, a condenser, means for charging the condenser, and means for discharging the condenser through the lamp to produce a momentary luminescent flash in the lamp when the lamp becomes conducting.

8. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, a vacuum tube having a control electrode that is normally ineffective when the tube is in operation, means for normally passing current through the tube when the tube is in operation, means for rendering the control electrode effective to stop the flow of current through the tube, an inductance, means controlled by the stoppage of the flow of current through the tube for storing energy in the inductance to render the lamp conducting, a condenser, means for charging the condenser, and means for discharging the condenser through the lamp to produce a momentary luminescent flash in the lamp when the lamp becomes conducting.

9. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, the lamp having at least two principal electrodes and a control member associated with one of the principal electrodes for rendering the lamp conducting, a condenser, means for charging the condenser from a source of energy, a vacuum tube, means for normally passing current through the tube when the tube is in operation, means for stopping the flow of current through the tube, and means controlled by the stoppage of the flow of current through the tube for transmitting an electrical impulse to the control member to render the lamp conducting, thereby to effect a discharge of the condenser through the lamp to produce a luminescent flash.

10. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, the lamp having an anode, a cathode and a starting electrode for rendering the lamp conducting that is normally unenergized when the lamp is not in operation, a condenser connected to the anode and the cathode, means for charging the condenser from a source of energy, a vacuum tube, means for normally passing current through the tube when the tube is in operation, means for stopping the flow of current through the tube, and means controlled by the stoppage of the flow of current through the tube for energizing the starting electrode to render the lamp conducting, thereby to effect a discharge of the condenser between the cathode and the anode to produce a luminescent flash through the lamp.

11. An electric system having, in combination, a gaseous-discharge tube that is normally non-conducting when not in operation, the tube having at least two principal electrodes and a control electrode for rendering the tube conduct-

ing, a vacuum tube having an input circuit and an output circuit, an inductance in the output circuit, means for normally passing current in the output circuit when the vacuum tube is in operation, means connected with the input circuit for energizing the control electrode to stop the flow of current in the output circuit, and means controlled by the stoppage of the flow of current in the output circuit for storing energy in the inductance.

12. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, the lamp having an anode, a cathode and a starting electrode for rendering the lamp conducting that is normally unenergized when the lamp is not in operation, a condenser connected to the anode and the cathode, means for charging the condenser from a source of energy, a vacuum tube having an input circuit and an output circuit, an inductance in the output circuit, means for normally passing current in the output circuit when the tube is in operation, means connected with the input circuit for stopping the flow of current in the output circuit, and means controlled by the stoppage of the flow of current in the output circuit for storing energy in the inductance to energize the starting electrode to render the lamp conducting, thereby to effect a discharge of the condenser between the cathode and the anode to produce a luminescent flash through the lamp.

13. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, the lamp having at least two principal electrodes and a control electrode for rendering the lamp conducting, a vacuum tube, means for normally passing current through the tube when the tube is in operation, a grid-controlled gaseous-discharge device for stopping the flow of current through the tube, means controlled by the stoppage of the flow of current through the tube for energizing the control electrode, means controlled by the energized control electrode for rendering the lamp conducting, and means for producing a momentary luminescent flash in the lamp upon the lamp becoming conducting.

14. An electric system having, in combination, a gaseous-discharge tube that is normally non-conducting when not in operation, a vacuum tube having an anode, a cathode and a control electrode that is normally unenergized when the vacuum tube is in operation, an input circuit in which the cathode and the control electrode are connected, an output circuit in which the cathode and the anode are connected, the output circuit having an inductance, means for normally passing current in the output circuit when the vacuum tube is in operation, means connected with the input circuit for energizing the control electrode to stop the flow of current in the output circuit, means controlled by the stoppage of current in the output circuit for storing energy in the inductance to render the gaseous-discharge tube conducting, a condenser, means for charging the condenser, and means for discharging the condenser through the gaseous-discharge tube when the gaseous-discharge tube becomes conducting.

15. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, the lamp having an anode, a cathode, and a control electrode, a vacuum tube hav-

ing an anode, a cathode and a control electrode that is normally ineffective when the tube is in operation, the vacuum tube operating upon the principle of a pure-electron discharge, an input circuit connected between the cathode and the control electrode of the tube, an output circuit connected between the anode and the cathode of the tube, an inductance connected in the output circuit, means controlled by the tube for storing energy in the inductance, means controlled by the stored energy for transmitting an electric impulse to the control electrode of the lamp to render the lamp conducting, a condenser connected to the cathode and the anode of the lamp, means for charging the condenser, and means for discharging the condenser through the lamp to produce a momentary luminescent flash in the lamp when the lamp becomes conducting.

16. An electric system having, in combination, a gaseous-discharge tube that is normally non-conducting when not in operation, the tube having an anode, a cathode and a control electrode, a vacuum tube having an anode, a cathode and a control electrode that is normally ineffective when the vacuum tube is in operation, an input circuit connected between the cathode and the control electrode of the tube, an output circuit connected between the anode and the cathode of the tube, means for normally passing current through the output circuit when the vacuum tube is in operation, means connected with the input circuit for rendering the normally ineffective control electrode effective to stop the flow of current through the output circuit, means controlled by the stoppage of the flow of current through the output circuit for transmitting an electrical impulse to the control electrode of the gaseous-discharge tube to render the lamp conducting, a condenser connected to the anode and the cathode of the gaseous-discharge tube, means for charging the condenser, and means for discharging the condenser through the gaseous-discharge tube when the gaseous-discharge tube becomes conducting.

17. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, the lamp having an anode, a cathode and a control electrode, a vacuum tube having an anode, a cathode and a control electrode that is normally ineffective when the tube is in operation, an input circuit connected between the cathode and the control electrode of the tube, an output circuit connected between the anode and the cathode of the tube, means for normally passing current through the output circuit when the tube is in operation, means connected with the input circuit for rendering the normally ineffective control electrode effective to stop the flow of current through the output circuit, means controlled by the stoppage of the flow of current through the output circuit for transmitting an electrical impulse to the control electrode of the lamp to render the lamp conducting, a condenser connected to the cathode and the anode of the lamp, means for charging the condenser, and means for discharging the condenser through the lamp to produce a momentary luminescent flash in the lamp when the lamp becomes conducting.

18. An electric system having, in combination, a gaseous-discharge tube that is normally non-conducting when not in operation, the tube having an anode, a cathode and a control electrode, a vacuum tube having an anode, a cathode and a control electrode that is normally ineffective

when the vacuum tube is in operation, an input circuit connected between the cathode and the control electrode of the tube, an output circuit connected between the anode and the cathode of the tube, means for normally passing current through the output circuit when the vacuum tube is in operation, means connected with the input circuit for rendering the normally ineffective control electrode effective to stop the flow of current through the output circuit, an inductance connected in the output circuit, means controlled by the stoppage of the flow of current through the output circuit for storing energy in the inductance, means controlled by the stored energy for transmitting an electrical impulse to the control electrode of the gaseous-discharge tube to render the gaseous-discharge tube conducting, a condenser connected to the anode and the cathode of the gaseous-discharge tube, means for charging the condenser, and means for discharging the condenser through the gaseous-discharge tube when the gaseous-discharge tube becomes conducting.

19. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, the lamp having an anode, a cathode and a control electrode, a vacuum tube having an anode, a cathode and a control electrode that is normally ineffective when the tube is in operation, an input circuit connected between the cathode and the control electrode of the tube, an output circuit connected between the anode and the cathode of the tube, means for normally passing current through the output circuit when the tube is in operation, means connected with the input circuit for rendering the normally ineffective control electrode effective to stop the flow of current through the output circuit, an inductance connected in the output circuit, means controlled by the stoppage of the flow of current through the output circuit for storing energy in the inductance, means controlled by the stored energy for transmitting an electrical impulse to the control electrode of the lamp to render the lamp conducting, a condenser connected to the cathode and the anode of the lamp, means for charging the condenser, and means for discharging the condenser through the lamp to produce a momentary luminescent flash in the lamp when the lamp becomes conducting.

20. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, the lamp having an anode, a cathode and a starting electrode for rendering the lamp conducting that is normally unenergized when the lamp is not in operation, a condenser connected to the anode and the cathode, means for charging the condenser from a source of energy, a normally conducting vacuum tube operating upon the principle of a pure-electron discharge, an inductance, and means controlled by the tube for storing energy in the inductance to energize the starting electrode to render the lamp conducting, thereby to effect a discharge of the condenser between the cathode and the anode to produce a luminescent flash through the lamp.

21. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, the lamp having at least two principal electrodes and a control electrode for rendering the lamp conducting, a vacuum tube operating upon the principle of a pure-electron

charge, means controlled by the tube for storing energy, a grid-controlled gaseous-discharge device for controlling the stored energy to energize the control electrode, thereby to render the lamp conducting, and means for producing a momentary luminescent flash in the lamp when the lamp becomes conducting.

22. A stroboscope having, in combination, a gaseous-discharge tube having an anode, a cathode and a starting electrode, a condenser connected between the anode and the cathode, means for charging the condenser, a normally conducting vacuum tube connected in circuit with the cathode and the starting electrode, the vacuum tube operating upon the principle of a pure-electron discharge, and means for intermittently opening and closing the circuit to render the circuit intermittently effective to energize the starting electrode intermittently and thereby to produce intermittently a source of electrons at the cathode, whereby the condenser will become enabled to discharge intermittently between the cathode and the anode to produce intermittent flashes of light.

23. An electric system having, in combination, a gaseous-discharge tube that is normally non-conducting when not in operation, a vacuum tube operating upon the principle of a pure-electron discharge, an inductance, means controlled by the vacuum tube for storing energy in the inductance, means controlled by the energy stored in the inductance for rendering the gaseous-discharge tube conducting, a condenser, means for charging the condenser, and means for discharging the condenser through the gaseous-discharge tube when the gaseous-discharge tube becomes conducting.

24. In combination, a gaseous-discharge tube having an anode and a cathode, a condenser arranged to be charged from a source of electricity connected to the anode and the cathode of the tube, means including a starting electrode for rendering said tube conductive, and means including a normally conducting vacuum tube connected to said starting electrode for controlling the operation of said starting electrode to control the discharge of said condenser through said discharge tube, the vacuum tube operating upon the principle of a pure-electron discharge.

25. In combination, a gaseous-discharge tube that is normally non-conducting when not in operation, the tube having an anode, a cathode and a control electrode for rendering the tube conducting, a vacuum tube operating upon the principle of a pure-electron discharge, means controlled by the vacuum tube for storing energy, means controlled by the stored energy for energizing the control electrode to render the gaseous-discharge tube conducting, a condenser arranged to be charged from a source of electricity connected directly to the anode and the cathode, and means for discharging the condenser through the gaseous-discharge tube when the gaseous-discharge tube becomes conducting.

26. A flash-producing electric system having, in combination, a luminescent gaseous-discharge lamp that is normally non-conducting when not in operation, the lamp having at least two principal electrodes and a control electrode for rendering the lamp conducting, a vacuum tube operating upon the principle of a pure-electron discharge, means controlled by the tube for storing energy, a switch for controlling the stored energy to energize the control electrode, thereby to render the lamp conducting, and means for

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producing a momentary luminescent flash in the lamp when the lamp becomes conducting.

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