

Oct. 12, 1943.

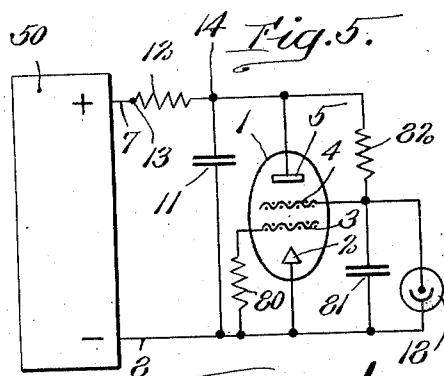
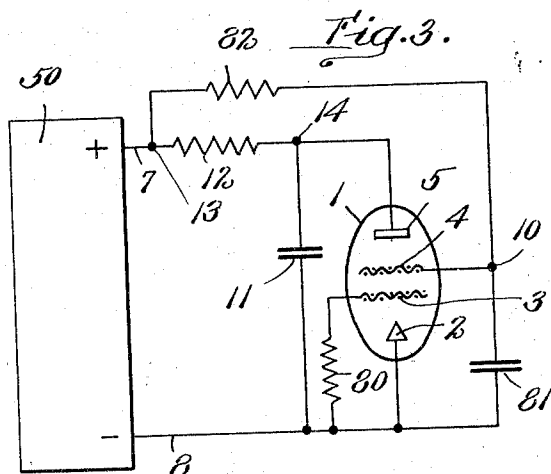
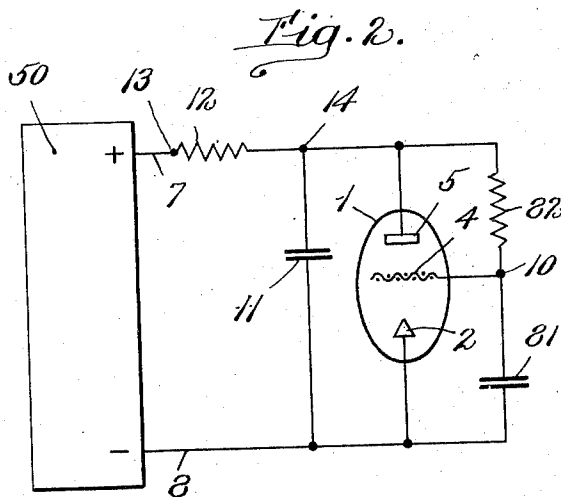
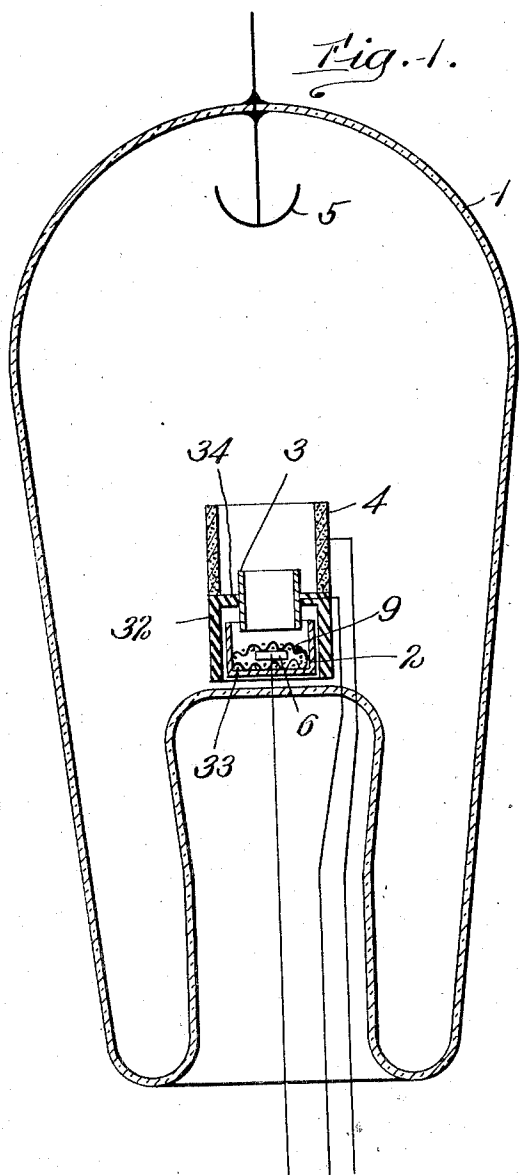
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2,331,771

GASEOUS ELECTRICAL DISCHARGE TUBE SYSTEM

Filed March 29, 1939

3 Sheets-Sheet 1



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GASEOUS ELECTRICAL DISCHARGE TUBE SYSTEM

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3 Sheets-Sheet 2

Fig. 9.

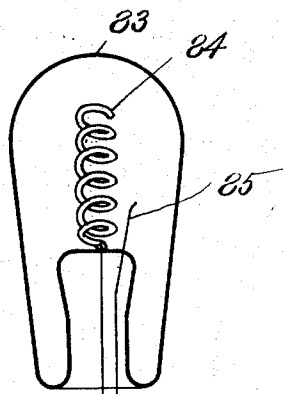
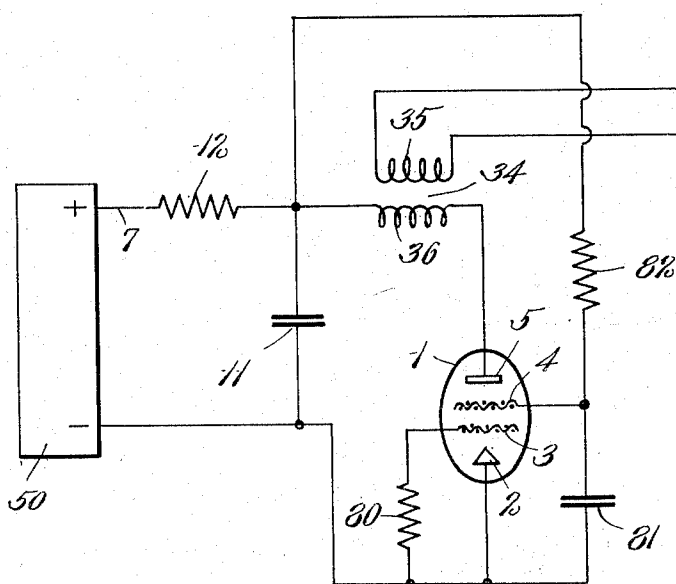
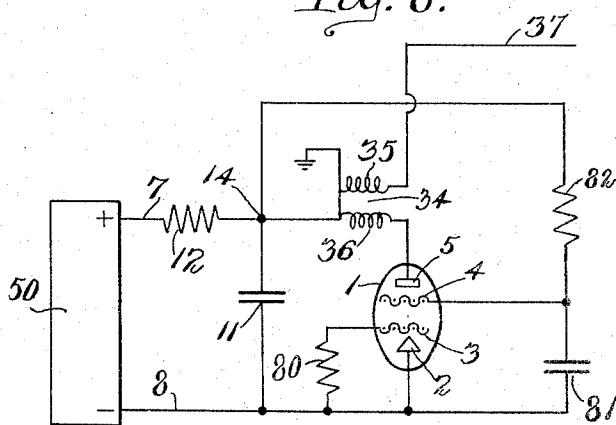


Fig. 8.



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GASEOUS ELECTRICAL DISCHARGE TUBE SYSTEM

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3 Sheets-Sheet 3

*Fig. 6.*

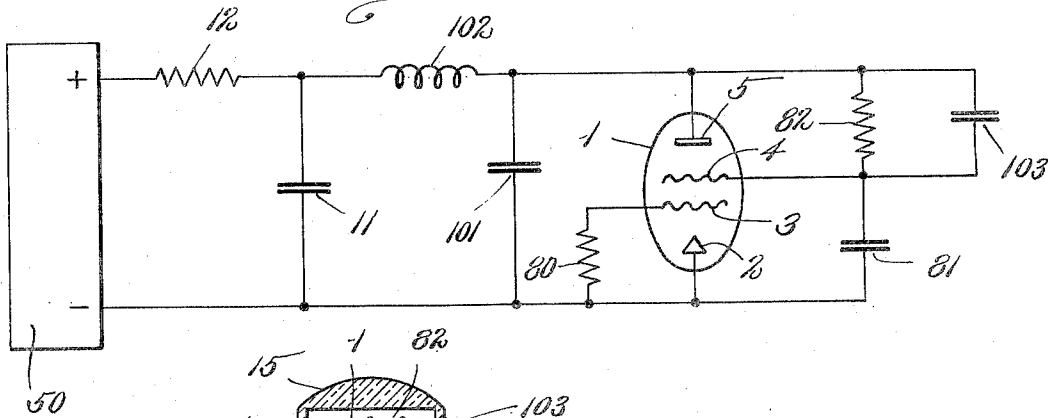


*Fig. 4.*

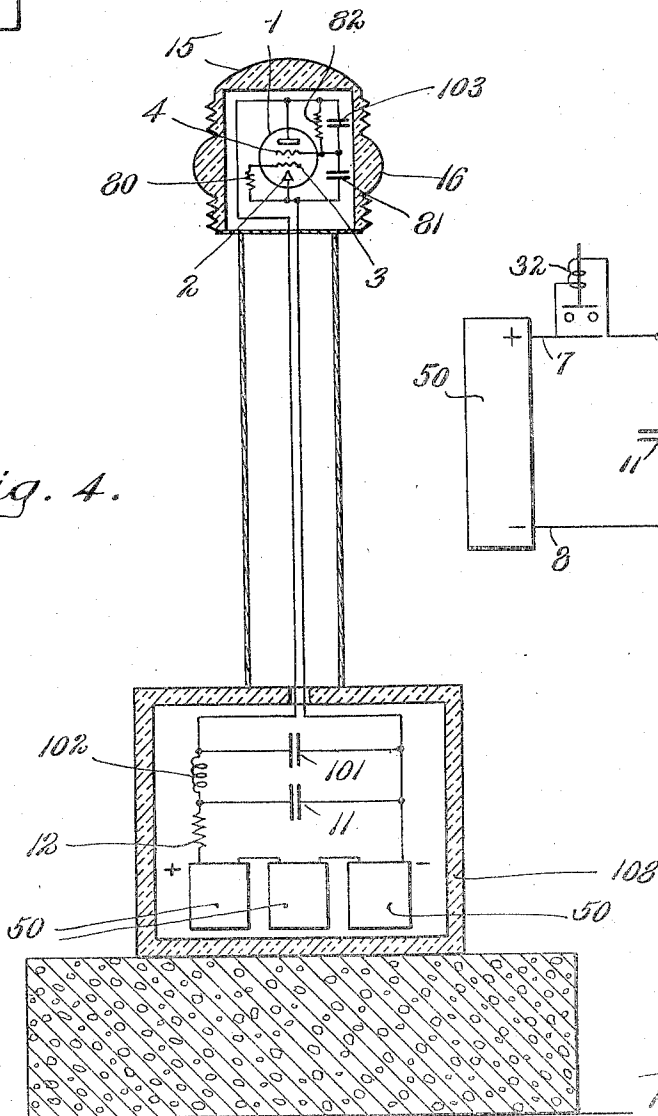
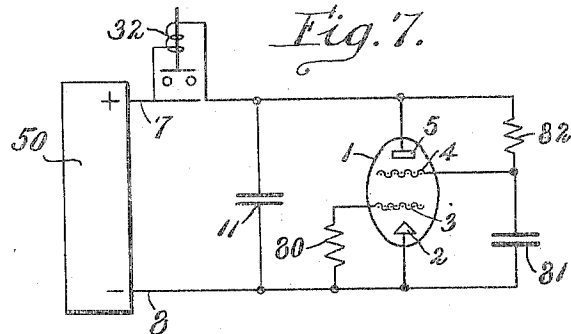


*Fig. 7.*



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## UNITED STATES PATENT OFFICE

2,331,771

GASEOUS ELECTRICAL DISCHARGE TUBE  
SYSTEMKenneth Joseph Germeshausen and Herbert  
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Application March 29, 1939, Serial No. 264,846

43 Claims. (Cl. 176—124)

The present invention relates to electric systems, and more particularly to systems employing gaseous-discharge relays.

An object of the present invention is to provide a new and improved simple dependable source of intense flashes of light.

Another object is to provide a novel electric system employing short condenser discharges for signal purposes.

Still another object is to provide a system of the above-described character that may be used as a fixed-internal flasher.

A further object is to provide a system of the said character that may be shut off during the day, when daylight prevails.

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

For a consideration of what we believe to be novel and our invention, attention is directed to the accompanying description and the claims appended thereto.

In the accompanying drawings, Fig. 1 is a longitudinal section of a gaseous-discharge tube that may be embodied in the present invention; Fig. 2 is a circuit diagram embodying the invention; Fig. 3 is a modified circuit diagram in accordance with the invention; Fig. 4 is a diagrammatic view of circuits and apparatus illustrating a practical light-controlled flasher embodying the present invention in preferred form; Fig. 5 is a similar view illustrating a modification of the same; Fig. 6 is a similar view of a further modification, embodying a circuit diagram for producing light the apparent intensity of which is greater than that produced by the apparatus of Fig. 4; and Figs. 7, 8 and 9 are views of still further modifications.

The tube 1 employed in the circuits embodying the present invention may be of the 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 1, filled with a suitable gas, such as neon, or any of the other noble gases, such as argon and helium. The tube contains several electrodes, namely, a solid cathode 2, an anode or plate 5, and one or more grids, inner and outer grids being shown at 3 and 4, between the anode 5 and the cathode 2. Either grid may be used as the control electrode, depending upon the polarity and the magnitude of the control voltage. In single-grid tubes, the grid 3, for example, may be omitted, as illustrated diagram-

matically in Fig. 2; or, if present, it may simply not be connected into circuit.

As illustrated in Fig. 1, the cathode 2 may comprise a metal cup 33, secured within and substantially closing the lower end of a ceramic insulating cylinder 32, upon which the grids 3 and 4 may be supported through the medium of an inwardly projecting flange 34. In the cup is a pill 6 that may be constituted of a mixture of materials that can react chemically to produce a substance of relatively low work-function, and that do not combine chemically with the gas in the envelope 1. The pill constitutes the active material of the cathode, and is held in place on its conducting support 33 by a wire-mesh screen 9.

The source of the electrons is a bright cathode spot on the surface of the cathode 2. This cathode spot is more easily formed on a pill 6 of caesium chloride and aluminum filings or powder than on pure caesium. As explained in the said Letters Patent, however, other materials than caesium chloride and aluminum may be used for the pill 6, and other metals than caesium, such as the alkali metals, the alkali-earth metals, or the rare-earth metals, may be used to provide the active material of the cathode. The action of the cathode spot should evolve a material of low work-function, so that advantage can be taken of the ease of cathode-spot formation on these materials. Further details may be obtained by reference to the said Letters Patent.

The present invention may be used for many purposes, such as for the transmission of intelligence. It may be described in connection with Fig. 2 as providing a simple dependable source of intense flashes of light that may be utilized as a warning signal or beacon flasher at street intersections, along coastal water-ways and inland river shores, at airports, and the like. The anode 5 and the cathode 2 are shown connected across a condenser 11 that is continuously charged, by way of conducting wires 7 and 8, from a suitable direct-current source 50 of, say, 150 to 300 volts. The wire 7 is shown as the positive lead, and the wire 8 as the negative lead. The source 50 of voltage supply is connected to the condenser 11 through a variable current-limiting charging impedance 12. The source 50 may, for example, be constituted of one or more batteries, as illustrated in Fig. 4, or thermionic or gaseous-discharge rectifiers (not shown) for producing direct current from alternating current. For concreteness, it may be hereinafter referred to as a battery 50. The im-

pedance 12 may be a resistor, an inductor, or a combination of resistance and inductance; the hereinafter-described operation of the charging impedance will, in all cases, be substantially the same. The impedance 12 is shown connected in the lead 7, with one end 13 connected to the source 50, and its other end 14 to the anode 5 and the condenser 11. One terminal of an impedance 82, which may be constituted of a resistor, an inductor, or a combination of resistance and inductance, and one terminal of an impedance 81, shown as a condenser, are joined together at 10 to the grid 4. The other end of the condenser 81 is connected to the cathode 2, and the other end of the impedance 82 is connected to the plate 5 and the terminal 14 of the impedance 12. The condenser 11 is thus connected to the condenser 81 and the impedance 82 connected in series, and though the impedance 12 constitutes a charging impedance for the condenser 11, the impedances 12 and 82 together constitute charging impedances for the condenser 81. When the grid 3 is employed, it may be connected to the cathode 2 through an impedance 80. The grid 3 is at the same potential as the cathode 2 and the grid 4 is positive with respect to the grid 3 or the cathode 2.

The condenser 81 is not necessarily a pure condenser. It will serve the purpose of the present invention fully if the impedance 81 is predominantly capacitive, or, at least, if it has a capacitative component greater than its resistive or inductive component, bearing in mind that there is also an inherent capacity between the cathode 2 and the grid 4. Though not necessarily a pure condenser, therefore, the impedance 81 must have some capacity, else there will be insufficient energy storage for starting that element.

If the condenser 81 is replaced by some other impedance, inductive or resistive, therefore, the circuits will not operate as a flasher, in the absence of definite time constants. In order to have a satisfactory beacon light, it is necessary to have about one flash a second, which cannot be obtained except with the aid of definite time constants.

The time constant of the resistor 82 and the condenser 81 may be approximately one second. It requires approximately one second to charge the condenser 81 to two-thirds of the battery voltage through the particular resistance 82. The time constant of the resistor 12 and the condenser 11 is made less than one second, preferably around one-tenth of a second. Though the condenser 11 thus becomes fully charged in about two-tenths of a second, it requires approximately one second for the impedance 81 to become charged sufficiently to operate the tube. The time constant of the impedance 81 in conjunction with the impedance 82 is of the order of one second, substantially longer than the time constant of the discharge condenser 11 coupled with its impedance 12. This difference in time constants separates the functions of timing the flashes and storing the energy for the flashes.

In operation, the tube 1 is normally non-conductive. As the direct-current source 50 starts to charge the condenser 11, the voltage across the condenser 11 starts to increase because of the action of the impedance 12 through which it is charged. With the rise in voltage at the terminal 14 of the impedance 12, energy is supplied from the source 50 to the condenser 81 through its charging impedances 12 and 82. The impedances

12 and 82 and the condensers 11 and 81 are chosen with time constants such that the condenser 11 shall be fully charged, and its voltage shall be substantially that of the source 50, before the voltage across the condenser 81 and the grid voltage shall have risen high enough to energize the tube 1 and cause it to ionize. This insures a constant and maximum amount of energy to be stored up for every flash. Because the condenser 81 is connected between the grid 4 and the cathode 2, the tube 1 will trip as soon as the voltage across the condenser 81 becomes of the proper predetermined value. The condenser 11 will thereupon discharge through the tube 1, between the anode 5 and the cathode 2, producing an intense flash of light of extremely short duration. When the tube is ionized, the energy that produces the heavy current and intense flash of light is supplied from the condenser 11, and not from the source 50, because the charging impedance 12 prevents the flow of an appreciable amount of current during the instant that the condenser 11 is discharging. When the condenser 11 fully discharges—a matter of  $\frac{1}{40,000}$  to  $\frac{1}{100,000}$  second—the voltage across its terminals and across the tube, and the potential of the point 14 and of the condenser 11, will drop to zero, thereby extinguishing or deionizing the tube, and allowing the energy to begin to accumulate in the condenser 11 for the next cycle or flash. The condenser 11 becomes thus periodically charged from the source 50, and then discharged through the tube 1, at a frequency determined by the values of the impedances 12 and 82 and the condensers 11 and 81. This repetitive operation will take place only if there is a charging impedance 12 in series with the energy storage condenser 11.

This invention is not to be confused with stroboscopes. A stroboscope does not operate slowly enough to serve as a flasher for signal and similar purposes. With suitable values of capacitance and resistance for the elements 11, 12, 81 and 82, the device may be so timed that the apparatus will flash, say, once every second, or any other desired time interval that is relatively long compared to the rapid flashing of a stroboscope. The intensity of the light may be varied by varying either the condenser 11 or, within limits, the potential of the voltage source 50. The circuit elements are so chosen as to prevent the continuance of a glow after the tube flashes. The immediate source of energy is the storage condenser 11, not the battery 50, and an arc discharge is produced, not a glow.

Representative constants of a flasher embodying the present invention are:

Voltage of the source 50=180 volts  
 Impedance 12=10,000 ohms resistance  
 Condenser 11=12 microfarads  
 Impedance 82=40 megohms resistance  
 Condenser 81=0.03 microfarad  
 Voltage of the grid=100 volts approximately  
 Instantaneous current through the tube=100-200 amperes  
 Average current supplied by the source 50=2 milliamperes

Flashers heretofore, such as those employing mercury tubes, have been operated by means of contactors. Though the present invention may, from certain points of view, embody other tubes, in combination with the condenser 81, connected into circuit as before described, the above-

described tube has been found to be particularly useful for signal-flashing and other purposes, for it yields an unusual quantity of light. Other tubes yield too little light, and light, furthermore, that is not of the proper red color for warning-signal purposes.

By connecting the resistor or other impedance 82 between the junction point 10 and the terminal 13 of the impedance 12, as in Fig. 3, the possibility of changes of frequency due to changes of battery voltage will become minimized. This is particularly desirable in connection with batteries 50 the voltage of which decreases with age. The reasons why the circuit of Fig. 3, as the battery dies down, maintains a more constant frequency than the circuit of Fig. 2 will be understood from the following considerations. The time constants of the condenser 81 and the resistor 82 are dependent upon the rising voltage at the terminal 14. With the impedance 82 connected to the positive side of the source 50, rather than to the terminal 14, the time constant will be more nearly the same for varying battery voltages. This advantage is not, however, obtainable when the condenser 81 is replaced by a resistor or an inductor. Such resistor or inductor, furthermore, would increase the drain upon the battery 50, decreasing its life. In the circuit of Fig. 8, however, the condenser 81 may be replaced by a resistor or an inductor or both, and the impedance 82 may be connected to point 14 as shown, or it may be connected directly to the anode 5 of the tube 1.

As illustrated in Figs. 4 and 5, the circuit of Fig. 2 may be made sensitive to light falling upon it, so as to shut the flashing-tube signal off during daylight hours. The operation of the arrangement illustrated in Fig. 4 depends upon the fact that the cathode is photo-sensitive, so that it emits electrons when light falls upon it.

As illustrated in Fig. 4, a lens 15 may be used to image the sky upon the cathode 2 of the tube 1 mounted in the Fresnel lens 16 on the box 108 containing therein the source of energy 50. Because of the shape of the cathode-grid structure, the electrons are drawn to the grid, and produce a tube-energizing grid current that varies approximately as the amount of light falling upon the cathode. If the grid resistor 82 is large enough, the drop therein caused by the photocurrent will be enough to lower the grid potential below the ignition point of the tube 1, thereby shutting off the signal whenever there is sufficient illumination on the cathode. A simple light-controlled flash is thus produced.

A column of the desired height is attached to the top of the box 108, terminating in the lamp and the reflector, or the lens assembly. This whole unit may be placed on a concrete pedestal, at the center of the intersection at which the warning is desired.

In cases, however, where it is desired to employ a horizontally disposed parabolic reflector, with the tube 1 also set horizontally, so that no light can reach the cathode 2, an external photocell 18 may be supplied, as shown in Fig. 5, connected in shunt to the condenser 81. This photocell 18 has the same function as the photocathode tube of the circuit of Fig. 4. The cathode of the tube is not, as in the case of Fig. 4, affected by light from the outside, but the photocell 18 supplies the same action as the normally photo-sensitive cathode 2, as before described.

The flasher may, however, be controlled otherwise than by means of light; for example, by a

contactor (not shown). With the aid of a contactor, one may control the time at which the signal will flash, at will. A flashing circuit of this character may be useful for visual signalling at night; for instance, between two navy boats.

If the charging impedance 12 of any of these circuits is constituted of an inductance, such inductance 12 may constitute the operating coil of a relay 32, as illustrated in Fig. 7. As this relay 32 will thus be actuated every time that the tube 1 flashes and the condenser 11 is charged, it could be used to control any external circuit. Instead of a relay armature, the magnetic circuit of the relay could be employed to drive the clapper of a bell (not shown), thereby producing an audible as well as a visual signal from the same power source. The impedance 12 could be employed to drive also other electromechanical devices.

The operation of such relay, bell, or similar apparatus, in the charging circuit of the condenser 81, does not impose any additional drain upon the battery 50, because it turns into useful work some of the energy that would normally be dissipated as heat in the charging impedance 12 if it were constituted of a resistor.

By inserting the primary winding 36 of a step-up transformer 34 in the plate circuit of the tube 1, as illustrated in Figs. 8 and 9, an intense high-frequency voltage is produced in the secondary winding 35 every time that the tube flashes and the discharge current flows through the primary winding 36. The transformer may also be connected in the cathode circuit. By applying this high secondary voltage to a wire 37 strung up on insulated posts (not shown), an excellent fence to keep animals in or out of a given area, by electrically shocking them, is produced. Prior-art fences employing a mechanical interrupter in the primary winding of the transformer are not very efficient from the power-consumption point of view.

Reference has been made above to contactor-controlled flashers. The efficiency of devices of this character depends upon the maintenance of a very small time of contact, and a very large time of non-contact. When the contact members close to charge up the primary of the high-voltage transformer, they should remain closed for a very brief period of time, and should become immediately reopened. With time, however, as the parts wear, the time of contact increases, with the result that there is an unnecessary drain on the battery. Not only do the parts wear out, but the unnecessary drain on the battery reduces the battery voltage, thereby reducing the amount of light, besides shortening the battery life. No contact members are employed according to the present invention. There is simply the gas-tube relay 1. This tube 1, moreover, yields a larger intensity-giving quality of signal at a reasonably large distance for the same power than the contactor devices which, furthermore, repeatedly get out of adjustment.

Where more light is needed or desired, the system of Fig. 9 may be employed; and embodied, if desired, in the apparatus of Fig. 4. The secondary winding 35 of the high-voltage transformer 34 is connected to a glow tube 83. The tube 83 may be of any desired type, such as a long straight tube, but preferably it is a small-source tube containing a spirally-coiled tube 84 in the form of a so-called pig-tail sealed within a clear-glass bulb and held on the base of the tube 83. One terminal of the secondary winding

35 is connected to the pig-tail 84 and the other to an electrode 85 fixed to the base of the glass tube 84 and held in the chamber formed by the bulb. The transformer secondary winding 35 is connected to the bottom of the pig-tail 84 and to the electrode 85. In operation, the arc is forced to travel from the electrode 85 to the upper open end of the pig-tail 84, then down through the interior of the spiral path of the glass tube and back. A long-arc path is thus provided in a small-diameter bulb.

The circuit of Fig. 6 may be employed to increase the apparent intensity of the flash; and it is this circuit that is illustrated in Fig. 4. The operation is such that, every time the tube 1 operates, it produces a burst of several lower-intensity flashes instead of one high-intensity flash. This burst of smaller flashes is more visible than the single large flash. To produce this effect, a condenser 101 and an inductive impedance 102 are inserted between the tube 1 and the energy-storage condenser 11, as shown. A condenser 103, furthermore, is connected in parallel with the impedance 82. In operation, the condenser 11 charges from the source 50 through the impedance 12 and also the condenser 101 is charged through the impedances 12 and 102 in series. These condensers 101 and 11 are fully charged before the voltage across the impedance 81, that is, the voltage between the grid 4 and the cathode 2, becomes sufficient to cause a glow and subsequent formation of an arc in the tube. When this occurs, the condenser 101 discharges through the tube. As the impedance 102 prevents the condenser 11 from discharging through the tube, the voltage across the tube goes to zero and it deionizes. The condenser 101 then charges from the condenser 11 through the impedance 102. The elements 12, 11, 102 and 101 are so proportioned that the voltage on the condenser 101 rises very rapidly when it is charged from the energy stored in the condenser 11. This rapid rise is coupled to the impedance 81 through the condenser 103 and causes the tube to flash again. The operation continues until the repeated charging of the condenser 101 depletes the energy stored in the condenser 11 to the point that the tube fails to flash because the voltage on the condenser 11 and, of necessity, on the condenser 101, is below the value necessary for operation. The oscillations of the circuit, therefore, come to rest until the condenser 11 has had time to charge up again from the source 50. Inasmuch as this rate of charge is relatively slow, the coupling condenser 103 has no effect, and the time at which the action repeats is determined by the impedances 81 and 82.

With the specified constants,

Voltage of the source 50=180 volts  
Impedance 12=10,000 ohms  
Condenser 11=12 microfarads  
Impedance 80=10,000 ohms  
Impedance 82=40 megohms  
Condenser 81=0.03 microfarad  
Condenser 103=0.01 microfarad  
Impedance 102=90 henries  
Condenser 101=2 microfarads

the circuit produces a burst of flashes approximately one second apart, each burst consisting of four or five flashes at the rate of about thirty per second.

Further modifications will occur to persons skilled in the art, and all such are considered to

fall within the scope and spirit of the invention.

What is claimed is:

1. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a grid, a condenser connected between the cathode and the grid, a second condenser connected between the cathode and the anode, a source of energy, an impedance connected between the grid and the source, a second impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source through the second impedance, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the second impedance preventing the flow of an appreciable current between the source and the gaseous-discharge device during the discharge of the second condenser between the anode and the cathode, and the time constants of the impedances and the condensers being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the grid have risen high enough to effect the discharge of the second condenser between the anode and the cathode.

2. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a grid, a condenser connected between the cathode and the grid, a second condenser connected between the cathode and the anode, an impedance connected between the grid and the anode, a source of energy, a second impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source through the second impedance, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the second impedance preventing the flow of an appreciable current between the source and the gaseous-discharge device during the discharge of the second condenser between the anode and the cathode, and the time constants of the impedances and the condensers being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the grid have risen high enough to effect the discharge of the second condenser between the anode and the cathode.

3. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a grid, a condenser connected between the cathode and the grid, a second condenser connected between the cathode and the anode, a source of energy, an impedance connected directly between the source and grid, a second impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source through the second impedance, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the second impedance preventing the flow of an appreciable current between the source and the gaseous-discharge device during the discharge of the second condenser between

the anode and the cathode, and the time constants of the impedances and the condensers being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the grid have risen high enough to effect the discharge of the second condenser between the anode and the cathode.

4. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, and a grid disposed between the anode and the cathode, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, an impedance connected between the anode and the grid, a condenser connected between the cathode and the grid, a second condenser, means connecting the second condenser to the anode and the cathode, a source of energy, a second impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source through the second impedance, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the second impedance preventing the flow of an appreciable current between the source and the gaseous-discharge device during the discharge of the second condenser between the anode and the cathode, and the time constants of the impedances and the condensers being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the grid have risen high enough to effect the discharge of the second condenser between the anode and the cathode.

5. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, and a grid disposed between the anode and the cathode, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, an impedance connected between the anode and the grid, a condenser connected between the cathode and the grid, a second condenser, means connecting the second condenser to the anode and the cathode in parallel to the impedance and the first-named condenser connected in series, a source of energy, means for periodically charging the second condenser from the source, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the time constants of the circuit being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the grid have risen high enough to effect the discharge of the second condenser between the anode and the cathode.

6. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, and a grid disposed between the anode and the cathode, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, a condenser connected between the cathode and the grid, a

second condenser, means connecting the second condenser to the anode and the cathode, a source of energy, an impedance connected between the source and the grid, means for periodically charging the second condenser from the source through the impedance, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the time constants of the circuit being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the grid have risen high enough to effect the discharge of the second condenser between the anode and the cathode.

7. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, a grid disposed between the anode and the cathode, and a grid disposed between the cathode and the first-named grid, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, an impedance connected between the anode and the first-named grid, a condenser connected between the cathode and the first-named grid, a second condenser, means connecting the second condenser to the anode and the cathode, a second impedance connected between the cathode and the third-named grid, a source of energy, a third impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source through the third impedance, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the time constants of the circuit being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the grid have risen high enough to effect the discharge of the second condenser between the anode and the cathode.

8. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, a grid disposed between the anode and the cathode, and a grid disposed between the cathode and the first-named grid, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, an impedance connected between the anode and the first-named grid, a condenser connected between the cathode and the first-named grid, a second condenser, means connecting the second condenser to the anode and the cathode in parallel to the impedance and the first-named condenser connected in series, an impedance connected between the cathode and the second-named grid, a source of energy, means for periodically charging the second condenser from the source, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the time constants of the circuit being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the grid have risen high enough to

effect the discharge of the second condenser between the anode and the cathode.

9. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, a grid disposed between the anode and the cathode, and a grid disposed between the cathode and the first-named grid, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, a condenser connected between the cathode and the first-named grid, a second condenser, means connecting the second condenser to the anode and the cathode, an impedance connected between the cathode and the second-named grid, a source of energy, an impedance connected between the source and the first-named grid, means for periodically charging the second condenser from the source, through the last-named impedance, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the time constants of the circuit being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the grid have risen high enough to effect the discharge of the second condenser between the anode and the cathode.

10. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, and a grid disposed between the anode and the cathode, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, an impedance connected between the anode and the grid, a condenser connected between the cathode and the grid, a second condenser, means connecting the second condenser to the anode and the cathode, a source of energy, a second impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source through the second impedance, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the values of the impedances being such that the time of flashing will be of the order of one flash per second.

11. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a grid, a condenser connected between the cathode and the grid, a second condenser connected between the cathode and the anode, a source of energy, an impedance connected between the source and the second condenser, a second impedance connected between the source and the grid, means for periodically charging the second condenser from the source through the first-named impedance, and means responsive to light rays for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope.

12. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, and a grid disposed between the anode and the cathode, the cathode being

constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, an impedance connected between the anode and the grid, a condenser connected between the cathode and the grid, a second condenser, means connecting the second condenser to the anode and the cathode, a source of energy, a second impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source and means responsive to light rays acting upon the cathode for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope.

13. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a grid, a condenser connected between the cathode and the grid, a second condenser connected between the cathode and the anode, a source of energy, an impedance connected between the source and the second condenser, a second impedance connected between the source and the grid, means for periodically charging the second condenser from the source through the second impedance, means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, and a photo-electric cell in parallel to the first-named chamber.

14. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a grid, a condenser connected between the cathode and the grid, a second condenser connected between the cathode and the anode, a source of energy, an impedance connected between the source and the second condenser, a second impedance connected between the source and the grid, means for periodically charging the second condenser from the source through the first-named impedance, means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the circuit comprising a visual indicator, and means for causing the visual indicator to indicate the electrical discharge visually.

15. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a grid, an impedance connected between the cathode and the grid having a capacitive component greater than its inductive or resistance component, a condenser connected between the cathode and the anode, a source of energy, a second impedance connected between the grid and the source, a third impedance connected between the source and the condenser, means for periodically charging the condenser from the source through the third impedance, and means for periodically discharging the condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the time constants of the impedances and the condenser being such that the condenser shall be charged to substantially the voltage of the source before the voltage across the first-named impedance and the voltage of the grid have risen high enough to effect the discharge of the condenser between the anode and the cathode.

16. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a grid, a condenser connected between the cathode and the anode, a second condenser connected between the cathode and the anode, a source of energy, an impedance connected between the source and first-named condenser, a second impedance connected between the condensers in series with the source and the first-named impedance, means for charging the first-named condenser from the source through the first-named impedance and the second condenser from the source through both impedances, and means for periodically discharging the second condenser between the anode and the cathode to pass a burst of electrical discharges between them through the gas in the envelope.

17. A flash-producing system having, in combination, a gaseous-discharge flashing device comprising an envelope containing gas and having an anode, a cathode and a control electrode, a predominantly capacitive impedance connected between the cathode and the control electrode, a condenser connected between the cathode and the anode, a second impedance connected between the control electrode and a source of energy, a third impedance connected between the source and the condenser, means for periodically charging the condenser from the source through the third impedance, and means for periodically discharging the condenser between the anode and the cathode to pass an electrical flash discharge between them through the gas in the envelope, the third impedance preventing the flow of an appreciable current between the source and the flashing device during the discharge of the condenser between the anode and the cathode, and the time constants of the impedances and the condenser being such that the condenser shall be charged to substantially the voltage of the source before the voltage across the first-named impedance and the voltage of the grid have risen high enough to effect the discharge of the condenser between the anode and the cathode.

18. A flash-producing system having, in combination, a gaseous-discharge flashing device comprising an envelope containing gas and having an anode, a cathode and a control electrode, an impedance connected between the cathode and the control electrode having a capacitive component greater than its inductive or resistive component, a condenser connected between the cathode and the anode, a second impedance connected between the control electrode and a source of energy, a third impedance connected between the source and the condenser, means for periodically charging the condenser from the source through the third impedance, means for periodically discharging the condenser between the anode and the cathode to pass an electrical flash discharge between them through the gas in the envelope, and means for controlling the rate of the flash discharge.

19. A flash-producing system having, in combination, a gaseous-discharge flashing device comprising an envelope containing gas and having an anode, a cathode and a control electrode, an impedance connected between the cathode and the control electrode having a capacitive component greater than its inductive or resistive component, a condenser connected between the cathode and the anode, a second impedance connected between the control electrode and a

source of energy, a third impedance connected between the source and the condenser, means for periodically charging the condenser from the source through the third impedance, means for periodically discharging the condenser between the anode and the cathode to pass an electrical flash discharge between them through the gas in the envelope, and means for controlling the rate of the flash discharge, the circuit elements having time constants such that the duration of the flash discharges is very much less than the time between the flash discharges.

20. A flash-producing system having, in combination, a gaseous-discharge flashing device comprising an envelope containing gas and having an anode, a cathode and a control electrode, the cathode being constituted of a material that will break down under the action of a cathode spot and form a surface coating thereon of a material of low work-function, two circuits, namely, an input circuit connecting the cathode and the control electrode and an output circuit connecting the cathode and the anode, means for periodically subjecting the cathode and the anode to energy sufficient in character and amount to form a cathode spot on the cathode, but without supplying sufficient heat to the cathode to cause destruction of the cathode by heat, to produce periodically an electrical flash discharge between the anode and the cathode through the gas in the envelope, and means in one of the said two circuits for introducing a time delay, thereby to control the rate of the flash discharge.

21. A flash-producing system having, in combination, a gaseous-discharge flashing device comprising an envelope containing gas and having an anode, a cathode and a control electrode, an impedance connected between the cathode and the control electrode having a relatively large capacitive component, a condenser connected between the cathode and the anode, a second impedance connected between the anode and the control electrode, a third impedance connected between a source of energy and the condenser, means for periodically charging the condenser from the source through the third impedance, and means for periodically discharging the condenser between the anode and the cathode to pass an electrical flash discharge between them through the gas in the envelope, the time constants of the first-named impedance and the second impedance being approximately one second.

22. A flash-producing system having, in combination, a gaseous-discharge flashing device comprising an envelope containing gas and having an anode, a cathode and a control electrode, an impedance connected between the cathode and the control electrode having a relatively large capacitive component, a condenser connected between the cathode and the anode, a second impedance connected between the anode and the control electrode, a third impedance connected between a source of energy and the condenser, means for periodically charging the condenser from the source through the third impedance, means for periodically discharging the condenser between the anode and the cathode to pass an electrical flash discharge between them through the gas in the envelope, the time constants of the first-named impedance and the second impedance being approximately one second, and the time constants of the condenser

and of the third impedance being substantially less than one second.

23. A flash-producing system having, in combination, a gaseous-discharge flashing device comprising an envelope containing gas and having an anode, a cathode and a control electrode, an impedance connected between the cathode and the control electrode having a relatively large capacitive component, a condenser connected between the cathode and the anode, a second impedance connected between the anode and the control electrode, a second condenser in parallel to the second impedance, a third impedance connected between a source of energy and the first-named condenser, means for periodically charging the first-named condenser from the source through the third impedance, and means for periodically discharging the first-named condenser between the anode and the cathode to produce a burst of electrical flash discharges between them through the gas in the envelope.

24. A flash-producing system having, in combination, a gaseous-discharge flashing device comprising an envelope containing gas and having an anode, a cathode and a control electrode, a condenser connected between the cathode and the anode, a source of energy, there being impedance between the source and the condenser, means for periodically charging the condenser from the source, means for periodically discharging the condenser between the anode and the cathode to pass an electrical flash discharge between them through the gas in the envelope, the impedance preventing the flow of an appreciable current between the source and the flashing device during the discharge of the condenser between the anode and the cathode, and an electric network connected to the control electrode and having time constants in relation to the time constants of the condenser and the impedance such that the condenser shall be charged to substantially the voltage of the source before the voltage on the control electrode shall have risen high enough to effect the discharge of the condenser between the anode and the cathode.

25. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a control electrode, a condenser connected between the cathode and the control electrode, a second condenser connected between the cathode and the anode, a source of energy, an impedance connected between the control electrode and the source, a second impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source through the second impedance, means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the second impedance preventing the flow of an appreciable current between the source and the gaseous-discharge device during the discharge of the second condenser between the anode and the cathode, and the time constants of the impedances and the condensers being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the control electrode have risen high enough to effect the discharge of the second condenser between the anode and the cathode, the circuit comprising a visual indicator, and

means for causing the visual indicator to indicate the electrical discharge visually.

26. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, and a control electrode disposed between the anode and the cathode, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, an impedance connected between the anode and the control electrode, a condenser connected between the cathode and the control electrode, a second condenser connected between the cathode and the anode, a source of energy, a second impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source through the second impedance, means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the second impedance preventing the flow of an appreciable current between the source and the gaseous-discharge device during the discharge of the second condenser between the anode and the cathode, and the time constants of the impedances and the condensers being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the control electrode have risen high enough to effect the discharge of the second condenser between the anode and the cathode, the circuit comprising a visual indicator, and means for causing the visual indicator to indicate the electrical discharge visually.

27. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, and a control electrode disposed between the anode and the cathode, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, a condenser connected between the cathode and the control electrode, a second condenser connected between the cathode and the anode, a source of energy, an impedance connected between the source and the control electrode, means for periodically charging the second condenser from the source through the impedance, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the second impedance preventing the flow of an appreciable current between the source and the gaseous-discharge device during the discharge of the second condenser between the anode and the cathode, and the time constants of the impedances and the condensers being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the control electrode have risen high enough to effect the discharge of the second condenser between the anode and the cathode, the circuit comprising a visual indicator, and means for causing the visual indicator to indicate the electrical discharge visually.

28. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a control electrode, a condenser

connected between the cathode and the control electrode, a second condenser connected between the cathode and the anode, a source of energy, an impedance connected between the source and the second condenser, a second impedance connected between the source and the control electrode, means for periodically charging the second condenser from the source through the first-named impedance, means responsive to light rays for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the circuit comprising a visual indicator, and means for causing the visual indicator to indicate the electrical discharge visually.

29. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, and a control electrode disposed between the anode and the cathode, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, an impedance connected between the anode and the control electrode, a condenser connected between the cathode and the control electrode, a second condenser connected between the cathode and the anode, a source of energy, a second impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source through the second impedance, means responsive to light rays acting upon the cathode for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the circuit comprising a visual indicator, and means for causing the visual indicator to indicate the electrical discharge visually.

30. A flash-producing system having, in combination, a gaseous-discharge flashing device comprising an envelope containing gas and having an anode, a cathode and a control electrode, a condenser connected between the cathode and the anode, a source of energy, there being impedance between the source and the condenser, means for periodically charging the condenser from the source, means for periodically discharging the condenser between the anode and the cathode to pass an electrical flash discharge between them through the gas in the envelope, the impedance preventing the flow of an appreciable current between the source and the flashing device during the discharge of the condenser between the anode and the cathode, and an electric network connected to the control electrode and having time constants in relation to the time constants of the condenser and the impedance such that the condenser shall be charged to substantially the voltage of the source before the voltage on the control electrode shall have risen high enough to effect the discharge of the condenser between the anode and the cathode, the system comprising a visual indicator, and means for causing the visual indicator to indicate the said electrical flash discharge visually.

31. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a control electrode, a condenser connected between the cathode and the control electrode, a second condenser connected between the cathode and the anode, a source of energy,

an impedance connected between the control electrode and the source, a second impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source through the second impedance, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the second impedance preventing the flow of an appreciable current between the source and the gaseous-discharge device during the discharge of the second condenser between the anode and the cathode, and the time constants of the impedances and the condensers being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the control electrode have risen high enough to effect the discharge of the second condenser between the anode and the cathode, the gaseous-discharge device constituting a visual indicator.

32. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, and a control electrode disposed between the anode and the cathode, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, an impedance connected between the anode and the control electrode, a condenser connected between the cathode and the control electrode, a second condenser to the anode and the cathode, a source of energy, a second impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source through the second impedance, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the second impedance preventing the flow of an appreciable current between the source and the gaseous-discharge device during the discharge of the second condenser between the anode and the cathode, and the time constants of the impedances and the condensers being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the control electrode have risen high enough to effect the discharge of the second condenser between the anode and the cathode, the gaseous-discharge device constituting a visual indicator.

33. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, and a control electrode disposed between the anode and the cathode, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, a condenser connected between the cathode and the control electrode, a second condenser, means connecting the second condenser to the anode and the cathode, a source of energy, an impedance connected between the source and the control electrode, means for periodically charging the second condenser from the source through the impedance, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge be-

tween them through the gas in the envelope, the time constants of the circuit being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the control electrode have risen high enough to effect the discharge of the second condenser between the anode and the cathode, the gaseous-discharge device constituting a visual indicator.

34. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a control electrode, a condenser connected between the cathode and the control electrode, a second condenser connected between the cathode and the anode, a source of energy, an impedance connected between the source and the second condenser, a second impedance connected between the source and the control electrode, means for periodically charging the second condenser from the source through the first-named impedance, and means responsive to light rays for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the gaseous-discharge device constituting a visual indicator.

35. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, and a control electrode disposed between the anode and the cathode, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, an impedance connected between the anode and the control electrode, a condenser connected between the cathode and the control electrode, a second condenser, means connecting the second condenser to the anode and the cathode, a source of energy, a second impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source through the second impedance, and means responsive to light rays acting upon the cathode for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the gaseous-discharge device constituting a visual indicator.

36. A flash-producing system having, in combination, a gaseous-discharge flashing device comprising an envelope containing gas and having an anode, a cathode and a control electrode, a condenser connected between the cathode and the anode, a source of energy, there being impedance between the source and the condenser, means for periodically charging the condenser from the source, means for periodically discharging the condenser between the anode and the cathode to pass an electrical flash discharge between them through the gas in the envelope, the impedance preventing the flow of an appreciable current between the source and the flashing device during the discharge of the condenser between the anode and the cathode, and an electric network connected to the control electrode and having time constants in relation to the time constants of the condenser and the impedance such that the condenser shall be charged to substantially the voltage of the source before the voltage on the control electrode shall have risen high enough to effect the discharge of the condenser between the anode and the cathode, the gaseous-discharge device constituting a visual indicator.

37. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a control electrode, a condenser connected between the cathode and the control electrode, a second condenser connected between the cathode and the anode, a source of energy, an impedance connected between the source and the second condenser, a second impedance connected between the source and the control electrode, means for periodically charging the second condenser from the source through the first-named impedance, means responsive to light rays for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, and a transformer having a primary winding in circuit with the anode and a secondary winding.

38. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a control electrode, a condenser connected between the cathode and the control electrode, a second condenser connected between the cathode and the anode, a source of energy, an impedance connected between the source and the second condenser, a second impedance connected between the source and the control electrode, means responsive to light rays for periodically charging the second condenser from the source through the first-named impedance, means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, a transformer having a primary winding in circuit with the anode and a secondary winding, and a glow tube connected to the secondary winding.

39. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a control electrode, a condenser connected between the cathode and the control electrode, a second condenser connected between the cathode and the anode, a source of energy, an impedance connected between the control electrode and the source, a second impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source through the second impedance, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the second impedance preventing the flow of an appreciable current between the source and the gaseous-discharge device during the discharge of the second condenser between the anode and the cathode, and the time constants of the impedances and the condensers being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the control electrode have risen high enough to effect the discharge of the second condenser between the anode and the cathode, a transformer having a primary winding in circuit with the anode and a secondary winding, and a visual indicator connected to the secondary winding.

40. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, and a control electrode dis-

posed between the anode and the cathode, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, an impedance connected between the anode and the control electrode, a condenser connected between the cathode and the control electrode, a second condenser, means connecting the second condenser to the anode and the cathode, a source of energy, a second impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source through the second impedance, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the second impedance preventing the flow of an appreciable current between the source and the gaseous-discharge device during the discharge of the second condenser between the anode and the cathode, and the time constants of the impedances and the condensers being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and the voltage of the control electrode have risen high enough to effect the discharge of the second condenser between the anode and the cathode, a transformer having a primary winding in circuit with the anode and a secondary winding, and a visual indicator connected to the secondary winding.

41. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, and a control electrode disposed between the anode and the cathode, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, a condenser connected between the cathode and the control electrode, a second condenser, means connecting the second condenser to the anode and the cathode, a source of energy, an impedance connected between the source and the control electrode, means for periodically charging the second condenser from the source through the impedance, and means for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, the time constants of the circuit being such that the second condenser shall be charged to substantially the voltage of the source before the voltage across the first-named condenser and

the voltage of the control electrode have risen high enough to effect the discharge of the second condenser between the anode and the cathode, a transformer having a primary winding in circuit with the anode and a secondary winding, and a visual indicator connected to the secondary winding.

42. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a cathode and a control electrode, a condenser connected between the cathode and the control electrode, a second condenser connected between the cathode and the anode, a source of energy, an impedance connected between the source and the second condenser, a second impedance connected between the source and the control electrode, means for periodically charging the second condenser from the source through the first-named impedance, and means responsive to light rays for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, a transformer having a primary winding in circuit with the anode and a secondary winding, and a visual indicator connected to the secondary winding.

43. An electric circuit having, in combination, a gaseous-discharge device comprising an envelope containing gas and having an anode, a solid cold cathode, and a control electrode disposed between the anode and the cathode, the cathode being constituted of a material having a relatively low work-function and that does not combine chemically with the gas in the envelope, an impedance connected between the anode and the control electrode, a condenser connected between the cathode and the control electrode, a second condenser, means connecting the second condenser to the anode and the cathode, a source of energy, a second impedance connected between the source and the second condenser, means for periodically charging the second condenser from the source through the second impedance, and means responsive to light rays acting upon the cathode for periodically discharging the second condenser between the anode and the cathode to pass an electrical discharge between them through the gas in the envelope, a transformer having a primary winding in circuit with the anode and a secondary winding, and a visual indicator connected to the secondary winding.

HERBERT E. GRIER.

KENNETH J. GERMESHAUSEN.

## CERTIFICATE OF CORRECTION.

Patent No. 2,331,771.

October 12, 1943.

KENNETH JOSEPH GERMESHAUSEN, ET AL..

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, second column, line 47, strike out the syllable "con-"; page 2, second column, line 65, for "tube=100-200" read --tube 1=100-200--; page 3, second column, lines 38 to 42 inclusive, strike out the following sentence -

"Prior-art fences employing a mechanical interrupter in the primary winding of the transformer are not very efficient from the power-consumption point of view.";

page 4, first column, line 56, for "repeates" read --repeats--; page 5, second column, line 32, claim 7, for "third-named" read --second-named--; page 6, second column, line 28, claim 13, for "second" read --first-named--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of January, A. D. 1944.

(Seal)

Henry Van Arsdale,  
Acting Commissioner of Patents.