

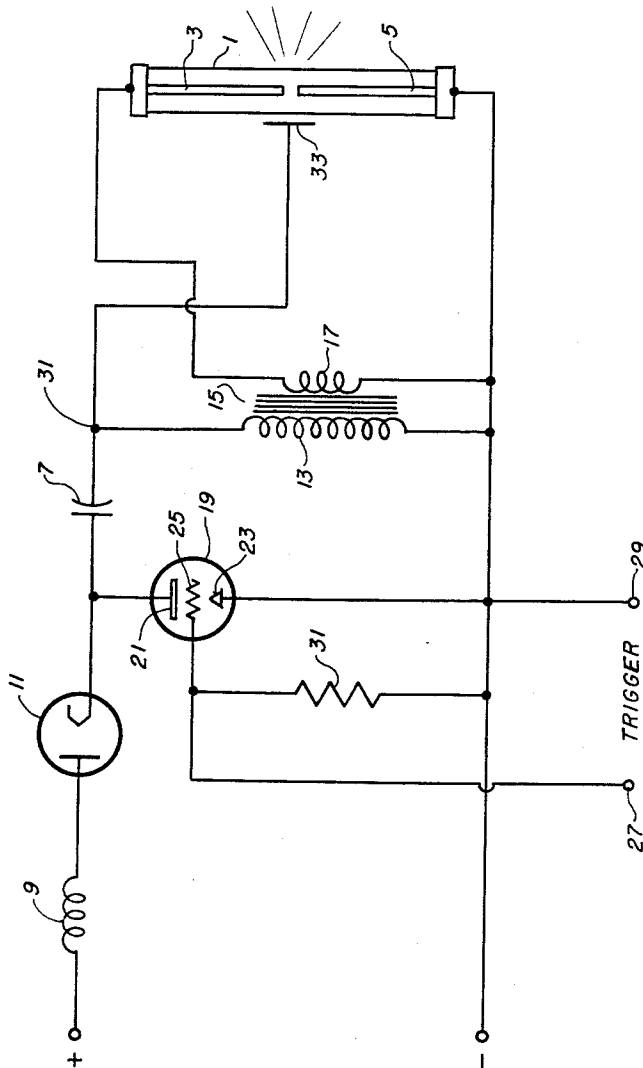
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ELECTRIC-DISCHARGE SYSTEM

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ELECTRIC-DISCHARGE SYSTEM

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The present invention relates to electric-discharge systems, and, more specifically, to systems embodying electric flash devices, such as gaseous-discharge tubes and the like, to produce a single flash or a repetition of flashes for such purposes as flash-photography and stroboscopic work.

As described in United States Letters Patent Nos. 2,478,901 through 2,478,907, inclusive, issued to one of the applicants herein, Harold E. Edgerton, on August 16, 1949, and in Letters Patent 2,722,629, issued on November 1, 1955 to the other applicant herein, Kenneth J. Germeshausen, a wide variety of electrical circuits may be utilized to cause energy stored in a capacitor to discharge through an electric-discharge device, such as a gaseous-discharge flashtube, spark gap and the like, to produce a brief flash of light. As explained in the said Letters Patent, these circuits may also be used to flash or pulse other types of electric-discharge tubes or load devices. The energy-storing capacitor or capacitors is or are controlled by a switching device, such as a mechanical switch or a gaseous-discharge switch of the thyatron type, to discharge energy at an appropriate moment or moments through the electric-discharge tube or other load device, such as through the before-mentioned gaseous-discharge flashtube, either directly or through a step-up transformer or inductor device.

There are cases, however, where the load device presents such a very low impedance to the discharge circuit during the discharging process, that an inordinately large discharge current flows through the switching device. In the case of thyatron switching tubes, such a large current may destroy the tube. Included in such low-impedance load devices are extremely small-dimensioned, high-pressure gaseous-discharge flashtubes, such as those described, for example, in application Serial No. 341,181, now Patent No. 2,893,289, of the said Harold E. Edgerton, filed March 9, 1953 for Microscope Flash-Photography Systems and Apparatus, in application Serial No. 588,906, filed June 1, 1956 by the said Harold E. Edgerton for Flash Tube and Apparatus, and in application Serial No. 235,480, now Patent No. 2,756,361, of the said Kenneth J. Germeshausen, filed July 6, 1951 for Gaseous-Discharge Device and Method of Making the Same. Such small flashtubes are useful in microscope flash-photography, as described in the said application Serial No. 341,181, now Patent No. 2,893,289, and for other purposes where small point or line light sources are required, including stroboscopic and moving-picture systems such as those described in United States Letters Patent No. 2,186,013, issued on January 19, 1940 to the said Harold E. Edgerton. In order to limit the discharge current through the switching tube or device, of course, an impedance may be placed in series with the flashtube in the discharge circuit. In view of the low impedance of the conductive flashtube, this results, however, in very little discharge voltage being developed across the flashtube and hence very poor light output efficiency. The flashtube impedance can, of course, itself be increased by increasing the

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size of the flashtube and the spacing between the electrodes thereof. This, however, does not provide the desired small point or line source of flash illumination for the purposes above mentioned.

5 An object of the present invention, accordingly, is to provide a new and improved electric system that permits the use of such small flashtubes of very low impedance with increased light-output efficiency.

A further object is to provide such an electric system in which the switching device, such as the before-mentioned thyatron, is protected from excessive discharge currents despite the very low impedance of the flashtube. In summary, this end is achieved through causing the effective impedance presented by the flashtube to the discharge circuit, including the switching device, to be stepped-up. Preferred constructional details are hereinafter presented.

An additional object is to provide a new and improved electrical discharge or pulsing system of general utility.

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

The invention will now be described in connection with the accompanying drawing the single figure of which is a circuit diagram illustrating the invention in preferred form, applied, for purposes of illustration, to the important application of small-dimensioned flashtubes and the like. Such a flashtube is diagrammatically illustrated at 1 having a pair of closely spaced principal electrodes 3 and 5 which may be disposed in, for example, a high-pressure argon, xenon or other gaseous medium within the light-transparent quartz or similar envelope 1. The separation between the electrodes may, for example, be of the order of a few millimeters for gas pressures of the order of one or more atmospheres. Other types of flashtubes may, of course, also be used including those described in the said copending applications. When conductive, as during an electrical discharge between the principal electrodes 3 and 5, flashtubes of this character have the before mentioned very low impedance of the order of 0.8 of an ohm, more or less, which, in the ordinary flash-producing circuit, such as those described in the said Letters Patent, could result in the passing of inordinately high currents through the switching tube or other device in the discharge circuit.

45 A flash capacitor or capacitors 7, is or are caused to charge or store energy from a source +, -, which may, for example, be a source of direct-current potential, through an oscillatory series-resonant charging circuit of the type disclosed in the said Edgerton Letters Patent 2,478,907, that causes the stored voltage to assume a value in excess of that of the source +, -; ideally, twice the said value. The oscillatory charging circuit comprises a current-limiting impedance, such as an inductor 9, an electric check valve 11, the capacitor or capacitors 7, and a winding 13 of a transformer 15. The voltage stored in the capacitor or capacitors 7 is discharged at an appropriate desired moment, or at successive moments or intervals of time of period sufficient to permit the oscillatory charging circuit to develop the desired voltage, as described in the said Letters Patent 2,478,907. The discharge may be effected with the aid of a switching device which may comprise a mechanical or electrical switch such as the preferred gaseous-discharge thyatron switching tube 19 disposed with its anode electrode 21 connected to the left-hand terminal of the capacitor or capacitors 7 and its cathode electrode 23 connected to the - terminal of the energy source. The switching tube 19, for example, may be of the type described in United States Letters Patent 2,542,556, issued on April 15, 1952 to the said Kenneth J. Germeshausen. When a trigger impulse is applied to terminals 27, 29 between a control-grid electrode 25 and

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the cathode 23 of the tube 19, across the input resistor 31, the tube 19 conducts and permits the capacitor or capacitors 7 to discharge through the tube 19 between its anode 21 and its cathode 23 and through the transformer winding 13. Other types of switching devices, such as those described in the previously cited patents and applications may also be employed, to effect the discharge of the charged capacitor or capacitors 7 through the transformer winding 13.

In accordance with the present invention, the voltage stored in the capacitor or capacitors 7 is not directly applied between the principal electrodes 3 and 5 of the flashtube 1 in view of its very low impedance, as before discussed. To the contrary, the energy discharge through the winding 13 is applied to a preferably step-down secondary winding 17 of the transformer 15 to convert the discharged energy into a lower-voltage electrical impulse that is applied between the flashtube electrodes 3 and 5 as a consequence of the connection therebetween of the upper and lower terminals of the secondary winding 17. Further to assist in the breaking down of the high-pressure gaseous medium within the flashtube 1, between the principal electrodes 3 and 5, a preferably external trigger or control electrode 33 may be employed, if desired, connected to a predetermined point of the before-described discharge circuit, illustrated as the point 31 between the capacitor or capacitors 7 and the upper terminal of the primary winding 13 of the transformer 15. As the voltage stored in the capacitor or capacitors 7 is discharged through the primary winding 13, producing the electrical impulse in the secondary winding 17 to effect a discharge between the principal flashtube electrodes 3 and 5, accordingly, a trigger voltage is substantially simultaneously applied from the point 31 to the trigger electrode 33 to aid in effecting a discharge in the flashtube 1 that, in turn, gives rise to a flash of illumination. Through the use of the step-down transformer, moreover, the effective impedance presented by the flashtube 1 to the discharge circuit (between the point 31 and the lower terminal of the primary winding 13) is increased by a factor determined by the square of the turns ratio between the number of turns in the windings 13 and 17. In actual practice, the leakage inductance of the step-down transformer 15 supplements the effective impedance increase so that the discharge current through the switching tube 19 is limited even though the actual flashtube 1 itself is of very low impedance when conductive.

As an illustration, the voltage source +, - may supply 4 kilovolts of direct-current voltage. With a series inductor 9 of about 0.3 henries, a type 3B28 check valve 11, and a capacitor 7 of about 0.01 microfarads, substantially 8 kilovolts may be developed between the point 31 and the lower terminal of the transformer primary winding 13. The switching tube 19 may be a type 4C35 thyratron and the transformer 15 may have a step-down ratio between the turns in its primary and secondary windings 13 and 17 of 4 to 1. Under such circumstances, the effective impedance presented to the discharge circuit by a small flashtube of the type before mentioned, will be increased at least sixteen times, and actually more in view of the leakage inductance of the transformer windings. If, for example, it is desired to keep the discharge current passed through the switching tube 19 to 100 amperes, the effective resistance presented by the flashtube 1 to the discharge circuit should be 80 ohms for the 8 kilovolt potential before-mentioned. Had an 80-ohm resistor been used

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in series with an 0.8-ohm flashtube directly in the discharge circuit, only one percent of the discharge voltage would be converted into a light-energy flash through the flashtube 1. This poor efficiency is vastly increased in accordance with the present invention as a result of the effective increased impedance presented by the flashtube 1 to the capacitor discharge circuit.

Modifications will occur to those 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, an electric discharge device having a low impedance during such discharge, a source of electric pulse energy for said discharge device, and impedance conversion means for coupling said discharge device to said source and for increasing the effective impedance presented by said discharge device to said source during the coupling of said pulse energy from said source to said device.

2. The system of claim 1, said discharge device being a gaseous discharge device.

3. The system of claim 1, said discharge device being a flash tube.

4. The system of claim 1, said impedance conversion means comprising a step-down transformer having a primary winding connected to said source and a secondary winding connected to said discharge device.

5. The system of claim 1, said discharge device having a pair of closely spaced principal electrodes and a triggering electrode, said principal electrodes being connected to said source through said impedance conversion means, and said triggering electrode also being connected to said source.

6. The system of claim 1, said source comprising an electric energy storage device and switch means for causing said storage device to discharge its energy to said electric discharge device through said coupling means.

7. The system of claim 1, said impedance conversion means comprising a step-down transformer having a secondary winding connected to said electric discharge device and a primary winding, said source comprising an electric charge storage device connected to said primary winding and to a power supply, and switch means for causing said storage device to discharge through said primary winding.

8. The system of claim 7, said source comprising a resonant charging circuit for said storage device including an electric check valve connecting said storage device to said power supply, said switch means comprising a gaseous discharge device connecting said storage device to said primary winding.

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