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2,832,009

GLOW DISCHARGE SYSTEMS

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2 Sheets-Sheet 1

Fig. 1

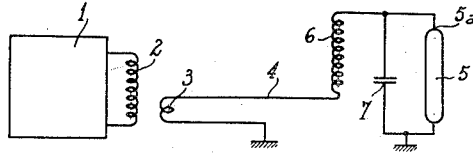


Fig. 2

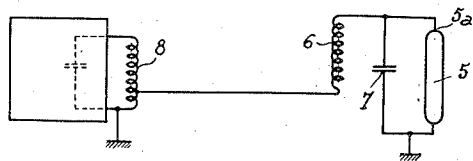


Fig. 3

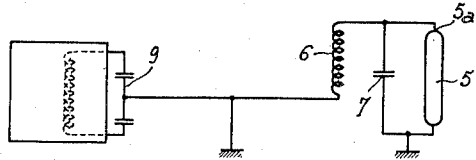


Fig. 4

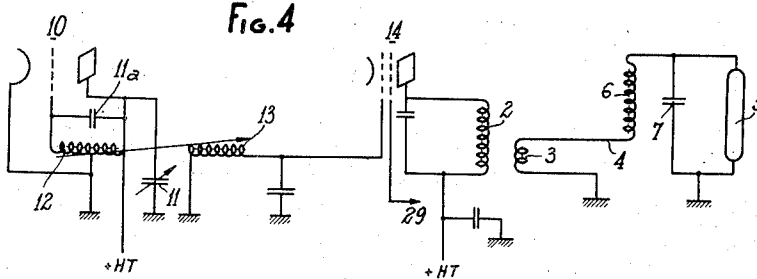
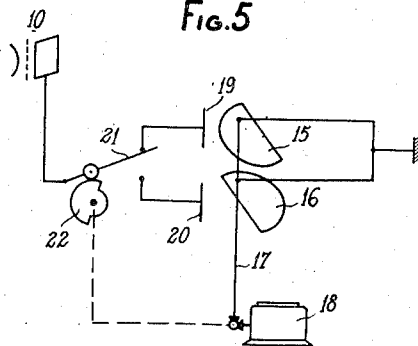


Fig. 5



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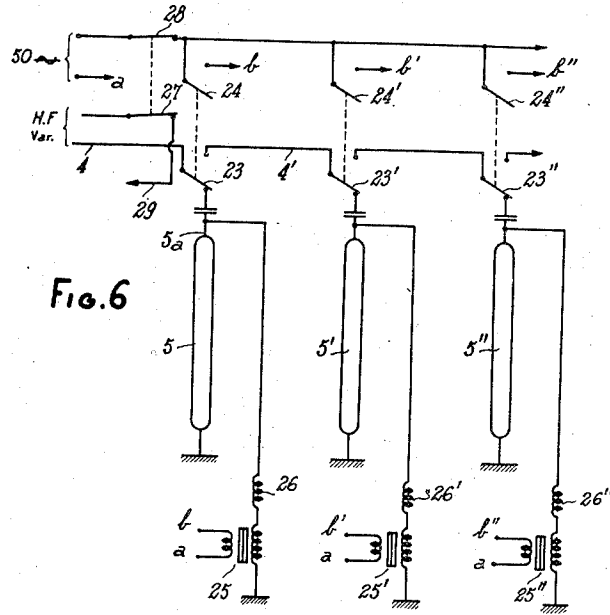


FIG. 6

FIG. 7

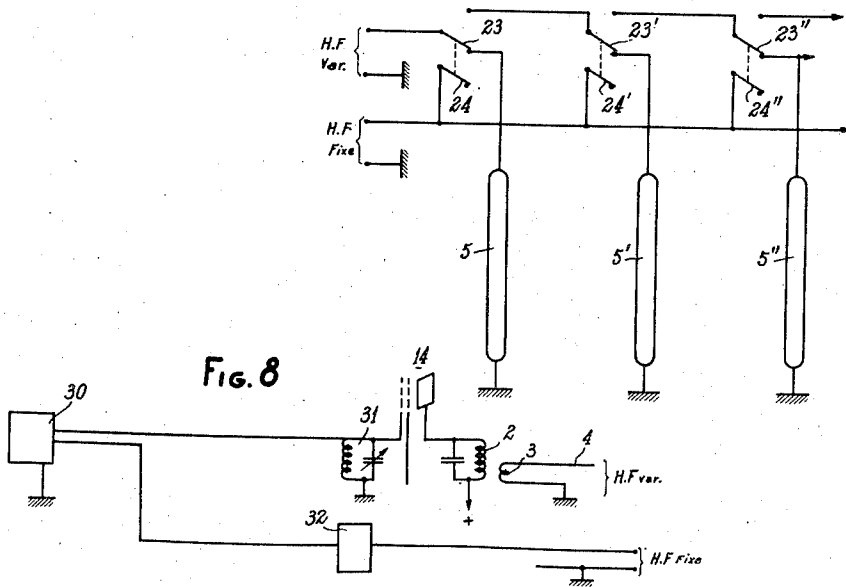


FIG. 8

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GLOW DISCHARGE SYSTEMS

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5 Claims. (Cl. 315—183)

This invention relates to glow discharge tubes and similar devices and provides improved method and means of controlling such devices, as well as systems comprising a plurality of such devices. More particularly, the invention relates to methods and means of so controlling one or more glow discharge tubes as to obtain a gradual increase in the illumination thereof from zero to a maximum.

It is a general object of the invention to provide an improved method of, and apparatus for, controlling the discharge intensity in a glow discharge system.

Another object is to provide methods and means for gradually increasing the illumination in a glow discharge tube in a more efficient and economical way than was possible heretofore.

Another object is to provide improved, novel and attractive glow discharge systems for advertising, display and related purposes.

A further object is to provide such systems which are operated in a new and improved manner for producing a successive and gradual illumination of all the tubes comprising the system.

Further objects include the provision of such systems, which operate more efficiently, reliably and cheaply than heretofore and which utilize radio frequency generating means; the provision of such systems utilize radio-frequency generating means for supplying the tube or tubes during the gradually increasing illumination stage of the operation thereof, and a steady alternating voltage source, such as an A.-C. network, during the steady illumination stage of said operation, and the provision of such systems which will not be a source of serious radio disturbance.

A further object is the provision of improved control systems for glow discharge devices; the provision of such control systems which will achieve novel and attractive lighting effects for display, advertising and the like purposes, in a more simple, efficient, reliable and cheaper manner than heretofore.

The above and other objects and advantages of the invention will appear as the description proceeds.

Various systems have been proposed for so controlling a glow discharge tube as to produce a gradual increase in the brightness of the discharge from zero to a maximum intensity. Such a result can, broadly, be obtained by applying to one electrode of a glow tube a variable-amplitude high-frequency voltage, while the other electrode of the tube is held at or near zero potential, so that the discharge will gradually progress from the end of the tube containing the first electrode towards the opposite end. In practice, however, none of the systems previously put forward for carrying out this idea have met with any commercial success. This failure has been due

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to various reasons inherent to the design and operation of such prior control systems.

In the previously suggested systems there was provided between the high frequency oscillation generator and the tube electrodes, an energy transmission line inductively coupled at one end with the output of the oscillation generator and at its other end with an input circuit connected across the terminals of the tube. Since the impedance of the line must be held to a low value, and the input voltage at the input end of the line should be low whereas the output voltage at the output end high, the electrical efficiency of the system was necessarily poor. Moreover, owing to the presence of two inductive couplings in cascade relation, it is practically very difficult to obtain a correct loading of the generator.

According to one feature of the present invention, an energy transmission line is coupled with the high frequency generator at its input and is connected at its output across the tube terminals, and contains a high-impedance inductance element interposed therein in series with the tube input, and a capacitance in parallel across the tube input. It has been found that such an arrangement makes it possible to produce a perfectly gradual illumination over a tube several yards long.

It has been recognized also that it is particularly advantageous to use radio-frequency oscillations of the order of 100 kc. The use of such frequencies is desirable in the first place because it is remote from the broadcasting frequency ranges. Moreover, as will more fully be described hereinafter, high capacity values may then be used for the condenser connected across the tube input, in order to obtain resonance for the input circuit while maintaining a high L/C ratio. The value of said capacity may then be selected so large as to dwarf any stray capacitance present in the tube and the associated circuit. This makes it possible to construct glow system control apparatus which will operate satisfactorily under all conditions.

According to the invention, the value of the inductive impedance in the input circuit may be made substantially equal to the capacitive impedance for the resonant condition in which the input frequency equals the natural frequency f_0 of the input circuit, in which condition the tube is fully illuminated.

Further according to the invention, means are provided for gradually illuminating all the tubes in a plurality of tubes in succession, through the use of a switching arrangement, more fully described hereinafter, whereby on ignition of each particular tube, the tube is supplied from a steady A.-C. source, and the next tube in the plurality is then ignited. The steady source may be provided by the usual alternating means. The switching arrangement may be operated by a camming system.

Further features of the invention will appear as the disclosure proceeds with reference to the accompanying drawings wherein:

Fig. 1 is a simplified diagram illustrating an improved glow discharge system according to an embodiment of the invention;

Fig. 2 illustrates a modified circuit;

Fig. 3 shows a further modification;

Fig. 4 illustrates a form of embodiment of the high frequency generator, connected in a circuit similar to Fig. 1;

Fig. 5 is a schematic illustration of the variable condenser arrangement and cam-operated switch means associated therewith for automatically varying the frequency

of input oscillations to successive tubes according to a predetermined sequence;

Fig. 6 is a partial diagram illustrating the control of a plurality of tubes to be operated in succession according to the invention;

Fig. 7 shows a modified system;

Fig. 8 illustrates a circuit whereby a common high frequency generator may be utilized both to ignite a tube gradually and to maintain the energization thereof at a steady value.

First referring to the circuit diagram of Fig. 1, a high frequency oscillator 1 has its output connected with an inductance coil 2. Inductively coupled with coil 2 is a coil 3 connected in the circuit 4 serving to transmit the energy from a high-frequency oscillator 1 to a discharge tube 5. Connected in this circuit in series with the secondary winding 3 is an inductive impedance 6 and a capacitance 7 is connected in parallel across the tube 5. As shown, one end of winding 3 and one end of the tube 5 are grounded to provide a return connection for the circuit.

It will be noted that the circuit just described involves only a single coupling, the inductive coupling between windings 2 and 3. Moreover, the arrangement of inductance coil 6 and capacity 7 makes it possible to impart to the circuit the requisite characteristics for obtaining a highly smooth and gradual illumination of the tube as the R.-F. energizing voltage applied to the tube is increased.

With the glow tube 5 cut off, the R.-F. frequency input voltage is applied to the upper terminal 5a thereof and the amplitude of the input voltage is gradually increased in a manner to be later described. As the input voltage is increased, the tube lights up gradually along its length until it has become entirely illuminated throughout.

Instead of the circuit shown in Fig. 1, alternative circuits may be used as illustrated by way of example in Fig. 2 and in Fig. 3. In the Fig. 2 modification, the coupling of the input energy is produced by means of an auto-transformer 8; while in the modification of Fig. 3, a capacitive coupling is used, by means of the condensers 9. In other respects both the circuits of Figs. 2 and 3 are similar to the embodiment disclosed in connection with Fig. 1.

Any suitable type of oscillator may be utilized in accordance with the invention, for deriving the variable-amplitude input voltage for the tube. Fig. 4 illustrates one particularly desirable type of oscillator circuit usable for the purposes of the invention. The circuit includes an oscillator stage 10 comprising a conventional triode having a resonant circuit consisting of an inductance 12 and condenser 11a in parallel connected between the grid and anode thereof. A mid-point of the inductance 12 is connected to the cathode and to ground. Connected between the anode and ground is a variable condenser 11 serving to adjust the output frequency of the oscillator. The output winding 12 is inductively coupled with a winding 13 inserted in series with the control grid of an output amplifier tube 14, and the anode of this tube has connected with it a parallel resonant circuit including a condenser in parallel with an inductance winding 2, which serves as the primary winding likewise designated 2 in any one of Figs. 1, 2 and 3. The remainder of the circuit of Fig. 4 has been shown identical with the circuit of Fig. 1, but it will of course be understood that this part of the circuit may instead be made identical with Fig. 2 or with Fig. 3.

In operation, adjustment of condenser 11 varies the frequency of the output produced by oscillator 10 and hence varies the output frequency from power tube 14. As a result there is applied across the input of glow tube 5 a variable voltage which has a minimum amplitude when the over-all circuit is far from its resonant condition and which gradually increases in amplitude as the circuit approaches resonance.

Let f_0 = the resonant frequency of the circuit comprising inductance 3, line 4, inductance 6, condenser 7 and glow tube 5; this is the frequency value for which the glow tube 5 is fully illuminated. The resonant frequency f_0 may be approached in either of two ways, i. e. starting from lower frequencies or starting from higher frequencies. In practice it is desirable to start from the higher frequencies and to reduce the frequency until resonance has been reached. This procedure is preferable since on ignition of the tube its capacity rises due to the ionization of the gas therein; hence the quantity

$$1/(2\pi\sqrt{LC})$$

diminishes; therefore if one starts from frequencies above the resonant frequency and as the frequency is gradually reduced, the quantity just noted will be varied in the same sense as the frequency, so that a very gradual increase in illumination of the glow tube is obtained.

As previously stated herein, the oscillator may be used for gradually illuminating in succession a number of glow tubes constituting, for example, an advertising sign or the like. Fig. 5 illustrates a circuit arrangement suitable for such purpose. As shown, the variable condenser 11 of Fig. 4 is herein replaced by two condensers in parallel each diagrammatically indicated as comprising a fixed electrode 19, 20 respectively, and a rotatable electrode 15, 16 respectively. The movable electrodes 15 and 16 of the two condensers are displaced 180° from each other and are secured on a common shaft 17 adapted to be driven in rotation from a suitable electric motor 18. The fixed electrodes 19 and 20 are connected to the respective fixed contacts of a reverser switch whose movable reversing contact arm 21 is connected to the anode of the oscillator tube 10. The reverser switch arm 21 is actuated between its positions in engagement with the two fixed contacts, by a cam device 22 driven from motor 18 through a suitable transmission indicated in dotted lines.

In operation, it will be apparent that the two variable condensers are made alternately operative and the adjustments may readily be made in such manner that, as soon as one glow tube has become fully illuminated, this condition being reached when one of the condensers has attained its maximum capacity, the frequency is suddenly switched back to a value for which the said tube is cut off, owing to the fact that the first mentioned condenser is switched out of circuit by the action of the reverser switch and the other condenser, which at the time stands at its minimum capacitance value, is connected in circuit instead. Now the net tube is gradually made to glow until it is fully illuminated, whereupon it is cut off and the cycle is repeated. It will be apparent that this arrangement can be used with any number of glow tubes which can thus be made to light up gradually in succession, each tube being cut off as the next tube of the series starts to glow.

In order to maintain the discharge in the tube after it has been ignited, switching means may be used whereby a tube on being fully ignited is thereafter supplied from a steady frequency source, at radio frequency or network frequency. Such a switching arrangement may be operated in synchronism with the switching arrangement described in the foregoing paragraphs, in such a way that on ignition of any tube the variable R.-F. input is disconnected therefrom and the constant-frequency source is connected thereto instead. An example of one such arrangement is illustrated in Fig. 6.

A plurality of glow tubes, e. g. three as shown, are indicated at 5, 5' and 5'', and may for example form parts of a shop sign, e. g. they may be so shaped and disposed as to form the letters of a name, etc. Each tube has one terminal grounded and the other terminal connected across the line 4 through a respective switch 23, 23', 23''. With the tubes cut off, a R.-F. voltage is gradually applied to the terminal 5a of the first tube 5, and its amplitude is gradually increased in the man-

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ner indicated above. As the applied voltage increases, the tube progressively becomes illuminated along its length until it glows throughout. At this time the switch 23 disconnects the tube 5 from the variable-amplitude energizing R.-F. source and connects the source instead to the line 4' for energization of the next tube 5'.

Moreover, there is associated with each switch 23, 23', 23'', a switch 24, 24', 24'', so connected that whenever a switch 23 disconnects the related tube from the variable voltage source, the switch 24 associated therewith will connect the tube to a constant-frequency supply source which will serve to maintain the discharge therein.

In the exemplary circuit illustrated in Fig. 6, the constant amplitude supply is provided by the normal A.-C. network, through suitable transformers 25, 25', 25''. Choke coils 26, 26', 26'' are provided for blocking the high frequency during the starting period.

The ganged switches 23—24, 23'—24', 25''—25'', are operated by cams driven from a motor 18, the shape and setting of the cams being so predetermined as to cause them to perform the desired functions with the requisite timing, that is, successively to disconnect each tube as it has been ignited from the variable-amplitude high frequency source, and connect it instead to the fixed-amplitude low frequency source for maintaining the tube in ignited condition and simultaneously connecting the next tube to the variable-amplitude high-frequency source.

Fig. 7 illustrates a modified circuit wherein the discharge in the ignited tubes is maintained by energization from a steady-voltage high frequency source. In other respects this circuit operates in the same manner as described in connection with Fig. 6.

After all the tubes such as 5, 5', 5'', etc., forming the electric shop sign or the like, have been ignited, they may be simultaneously extinguished and then the cycle may be recommenced by gradually re-igniting the initial tube, and so on. The shaping and setting of the cams can readily be determined to produce the desired cut-off of all the tubes at the end of a cycle.

It should however be noted that the shaping of the cam contours must be determined with great precision in order to avoid having some of the tubes remain in ignited condition even a short time after the remaining tubes have been cut off. Moreover, even where the cams are accurately formed and set originally, wear is apt to affect this condition after some time. Accordingly, a different arrangement may be provided in accordance with the invention to produce the desired simultaneous cut-off of all the tubes at the end of each cycle.

The arrangement comprises a switch 27 operated by a cam so as to cut off the supply circuit to the screen grid 29 of the output triode 14 as soon as the last glow tube of the series has become fully illuminated, and another cut-off switch 28 ganged with cut-off switch 27, for simultaneously cutting off the supply circuit.

As shown in Fig. 8, an oscillator 30 may be used which yields a constant-amplitude high frequency output (e. g. at 120 kilocycles), which output serves to supply two circuits of the system. One circuit comprises a variable impedance 31 and the control grid of output stage tetrode 14, whereby said grid may be operated at a variable voltage and thereby a high constant frequency, variable amplitude input may be obtained for igniting the glow tubes. The other channel includes an amplifier 32 whose output provides the fixed amplitude high frequency input required to maintain the discharge in the tubes.

It will be understood that the invention is not to be limited to the forms of embodiment illustrated and described, but that various modifications may be made therein, particularly as to the type of oscillator used to derive the variable-amplitude, high-frequency voltage supplying the glow tube or tubes. Similarly, apparatus

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according to the invention may be applied in such a way as to produce a gradual illumination of a tube starting from both ends together and progressing towards the middle of the tube for which purpose an artificial zero point may be established intermediate the ends of the tube. The glow tubes used may be of the known type wherein internal electrodes are omitted, and replaced by externally located armatures.

What is claimed is:

1. In a luminous display apparatus for progressively illuminating a gaseous discharge tube, input terminals for said tube, a high frequency generator, primary windings, secondary windings, a circuit connecting said high frequency generator and said primary windings, a variable condenser connected in said circuit for varying the frequency supplied to said primary windings from an initial to a final value, a second circuit connecting said secondary windings to said terminals, an inductance in said second circuit and a condenser connected across said terminals, said second circuit including said second named condenser having a resonant frequency approximating the final value of the variable frequency whereby when the variable frequency is progressively varied said tube will be progressively illuminated to complete illumination at the resonant frequency of said second circuit.

2. Apparatus as claimed in claim 1 in which said high frequency generator includes a triode and said variable condenser is connected between the anode of said triode and the ground.

3. In a luminous display apparatus for progressively illuminating a gaseous discharge tube, input terminals for said tube, a high frequency generator, primary windings, secondary windings, a circuit connecting said high frequency generator and said primary windings, a variable condenser connected in said circuit for varying the frequency supplied to said primary windings from a high frequency progressively to a lower frequency, a second circuit connecting said secondary windings to said terminals, an inductance in said second circuit and a condenser connected across said terminals, said second circuit including said second named condenser having a resonant frequency approximating the lower frequency of the variable frequency whereby when the variable frequency is progressively reduced said tube will be progressively illuminated to complete illumination at the resonant frequency of said second circuit.

4. In a luminous display apparatus for progressively illuminating a gaseous discharge tube, input terminals for said tube, a high frequency generator, primary windings, secondary windings, a circuit connecting said high frequency generator and said primary windings, a variable condenser connected in said circuit for varying the frequency supplied to said primary windings from a high frequency progressively to a lower frequency, means connecting one side of said secondary windings to a terminal of said tube, an inductance connected in series in said means, means connecting the other side of said secondary windings and the other terminal of said tube, and a condenser connected across said terminals, said means, said inductance and said condenser comprising a second circuit having a resonant frequency approximating the lower frequency of the variable frequency whereby when the variable frequency is progressively reduced said tube will be progressively illuminated to complete illumination at the resonant frequency of said second circuit.

5. In a luminous display apparatus for progressively illuminating a gaseous discharge tube, input terminals for said tube, a high frequency generator, an output winding connected to said generator, variable condenser means for varying the frequency supplied to said output winding from a high frequency progressively to a lower frequency, an output amplifier tube having a control grid, a winding connected in series with said control grid and inductively coupled to said output winding, primary windings connected to said amplifier tube, secondary wind-

ings, a circuit connecting said secondary windings to said terminals, an inductance in said circuit and a condenser connected across said terminals, said circuit including said condenser having a resonant frequency approximating the lower frequency of the variable frequency whereby, when the variable frequency is progressively reduced said tube will be progressively illuminated to complete illumination at the resonant frequency of said circuit.

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