Aug. 23, 1949. S. LALEWICZ 2,479,846

GAS-FILLED ELECTRIC DISCHARGE DEVICE

Filed Sept. 20, 1944

Fig. 1

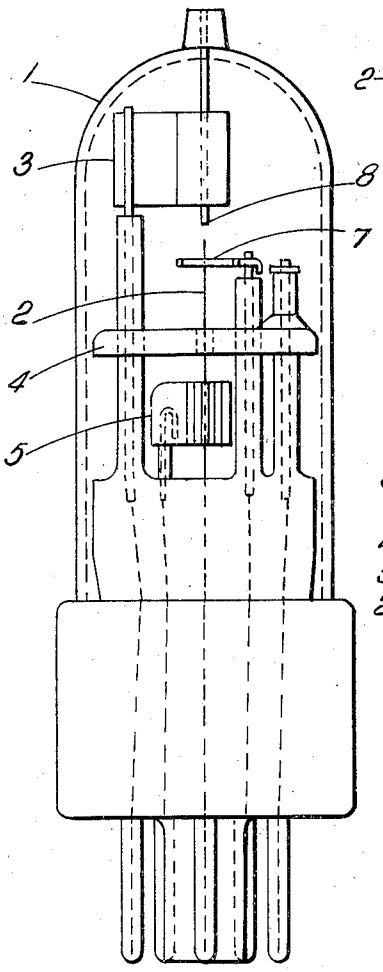


Fig. 2

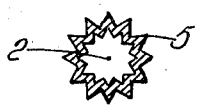


Fig. 3.

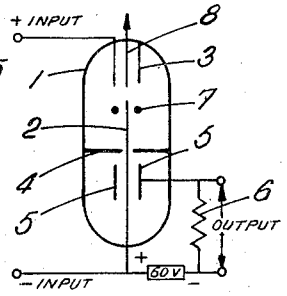


Fig. 4.

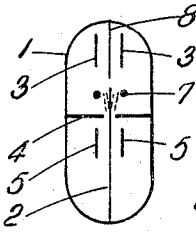


Fig. 5.

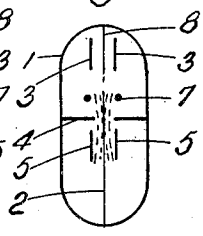


Fig. 7.

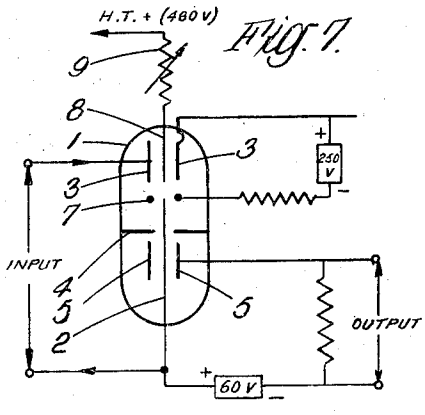
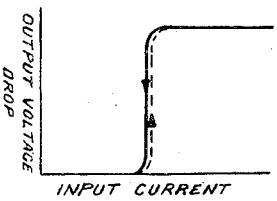


Fig. 6.



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Patented Aug. 23, 1949 2,479,846

UNITED STATES PATENT OFFICE

2,479,846

GAS-FILLED ELECTRIC DISCHARGE DEVICE

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Application September 20, 1944, Serial No. 554,880
In Great Britain August 18, 1943

Section 1, Public Law 690, August 8, 1946
Patent expires August 18, 1963

8 Claims. (Cl. 250—27.5)

1

This invention relates to gas-filled electric discharge devices and has for its chief object to provide such a device which is capable of producing a substantial voltage drop over a resistance connected to its output electrode upon a slight increase in current on its input electrode while at the same time preserving the valuable property of all electric gas discharge devices, namely, that an increase of current has little or no influence on the input voltage.

Another object of the invention is to provide a relay or "trigger" device which reduces the well known Miller effect which would be caused in a tube of a preceding stage in the circuit more effectively than hitherto thus providing a device long sought in communication systems.

According to the present invention a gas-filled electric discharge device comprises an input cathode, an input anode and an output electrode, wherein said output electrode is rendered sensibly free from the direct influence of said input anode by means of an ionization screen interposed between said input anode and said output electrode, said screen being maintained at a potential intermediate the potentials of said input anode and said output electrode.

According to a further feature of the invention a gas-filled electric discharge device comprises a screen, an input anode, an output electrode, an input cathode extending between said input anode and said output electrode and passing with clearance through said screen, said screen comprising means to avoid the direct influence of said input anode on said output electrode while at the same time allowing a difference of potential to be applied between said input anode and said output electrode which difference of potential is greater than the glowing voltage for the gas employed as filling whereby a potential which is negative with respect to said input cathode can be applied to said output electrode.

According to a further feature of the invention said output electrode and/or said screen are composed of a material which differs from that of which said input cathode is composed, the material chosen being one which requires the application thereto of a higher glow voltage than does the material of which said input cathode is composed.

According to a further feature of the invention, an auxiliary electrode which may be termed a glow electrode for producing an auxiliary glow discharge in the device is arranged between the input anode and the screen whereby when a suitable current is applied to said glow-up electrode,

2

a subsidiary ionisation is obtained above said screen together with a continuous glow.

In order that the said invention may be clearly understood and readily carried into effect, the same will now be described more fully with reference to the accompanying drawings, in which—

Figure 1 is a side elevation of a device according to the invention.

Figure 2 is an enlarged cross section of the output electrode showing the disposition of the input cathode.

Figure 3 is an diagram showing the input and output connections of the device.

Figure 4 is a diagram showing how the glow can be maintained on the input cathode alone.

Figure 5 is a diagram showing how the glow can be increased in area to extend to the output electrode.

Figure 6 is a diagram showing the characteristics of the device.

Figure 7 is a diagram of a circuit wherein an auxiliary anode is employed.

Referring to the drawings, the device comprises a glass envelope 1 having a neon or other rare gas filling in which envelope is centrally mounted an input cathode 2, consisting of a vertical wire of tungsten, nickel-plated steel or other suitable material approximately 0.3 mm. in diameter. If desired, the input cathode 2 may be of cylindrical form. An input anode 3 consisting of a cylinder is arranged at the upper end of the envelope 1. Situated midway of the envelope 1 is an ionization screen 4 having an aperture therein through which the input cathode 2 passes. The screen 4 is composed of a material which requires the application thereto of a higher glow voltage than does the material of which the input cathode 2 is composed. Preferably, said screen is made of copper but specially treated carbon may be used if desired. An output electrode 5 is located on the side of the screen opposite to that on which the input anode 3 is situated, the said output electrode being of cylindrical form and adapted to surround the input cathode 2 just below the screen 4. The output electrode 5 is preferably of star-shaped cross section as shown in Figure 2 as will be more particularly described hereinafter. As in the case of the screen 4, the output electrode 5 is composed of a material which requires the application thereto of a higher glow voltage than does the material of which the input cathode is composed, suitable materials for this purpose being copper or specially treated carbon. As diagrammatically shown in Figure 3, the output is arranged across

a suitable resistance 6 which is placed between the output electrode 5 and a potential negative with respect to the input cathode. A glow electrode 7 in the form of a ring of tungsten, nickel or the like, surrounds the input cathode 2 and is arranged between the input anode 3 and the screen 4. When a suitable current is applied to the glow electrode 7, a glow discharge is established in the immediate region between the glow electrode 7 and the cathode 2 thereby accelerating the spreading of the glow on the input cathode 2 upon the necessary conditions in the input circuit being established. In this manner, the device functions much more rapidly than known gas discharge devices. An auxiliary anode 8 comprising a vertical wire is located inside or adjacent to the input anode, its lower end being in close proximity to the input cathode 2.

The propagation of a glow along the surface of a cathode with an increase of current in the cathode circuit is a well known phenomenon in gas discharge devices. According to the present invention, however, two cathodes are employed, viz. the input cathode 2 and the output electrode 5 which latter is used as a virtual cathode. Between the input cathode 2 and the input anode 3 current is obtained which causes a glow around the input cathode 2. When the current increases the voltage increases causing the glow to extend its area along the input cathode until it reaches the output electrode 5. This is diagrammatically illustrated in Figures 4 and 5, where the two conditions of glow are shown. In Figure 4 the glow is confined to the upper part of the input cathode in which the device may be said to be in the "passive" state while in Figure 5 the glow has increased in area so as to extend to the output electrode or virtual cathode when the device may be said to be in the "active" state.

The screen 4 should be maintained at a potential intermediate the potentials of the input anode and the output electrode and functions as an ionization screen to prevent the direct influence of the input anode 3 on the output electrode or virtual cathode 5 while at the same time allowing a difference of potential to be applied between the input anode 3 and the output electrode 5 which is greater than the glowing voltage for the gas employed as filling. In this manner, a potential which is negative with respect to the input cathode can be applied to the output electrode thus substantially increasing the output voltage.

Another well known phenomenon in connection with gas discharge devices is the finite time required to produce the ionisation necessary for the normal functioning of the device. This disadvantage is considerably lessened by the present invention by means of the glow electrode 7 which, causing ionization, creates a reserve of ionised gas in the upper half of the envelope 1 so as to give a continuous glow.

The general characteristics of the device are as follows:

As the input current is increased, there is, at first, practically no output current. Then at a predetermined point, the full output current is obtained with a very small additional increase in input current. Upon a further increase in input current, the output current can be maintained at a constant value. It is important to mention that when this process is reversed, i. e. when the input current is again decreased, the new curve obtained almost retraces the curve obtained for an increasing input current as illustrated in Figure 6. While changing from the passive to the active state or vice versa, that is changing the output voltage drop as shown in Figure 6, the input voltage (i. e. the voltage between the input anode and the input cathode) remains practically constant, overcoming throwback which is usually connected with the well known Miller effect upon a preceding tube in the circuit in which the device may be included. At the same time, however, the variation in output voltage (effected through the change of output current through the output resistance) can reach nearly 100 volts, which in turn may be employed to modulate a tube in a succeeding circuit to which the device of my invention may be connected.

It is possible to vary the characteristics of the device by means of applying a variable positive potential to the screen 4. Thus, when the said screen is raised to a higher positive potential with respect to the potential of the output electrode, the sensitivity of the device increases while at the same time, the maximum voltage obtainable in the output decreases. When, however, the screen 4 is reduced in positive potential, the sensitivity of the device is reduced but the output voltage may be increased. The correct potential to be applied to the screen 4 can be determined in known manner by means of a suitable potential divider connected across the input cathode 2 and input anode 3.

The auxiliary anode 8 serves two main purposes, firstly, to separate completely the glow electrode circuit from the input anode circuit, and secondly to control the initial glow on the input cathode independently of the input circuit thereby rendering the device extremely sensitive.

Figure 7 illustrates a suitable circuit wherein use is made of the auxiliary anode 8. In this case, the glow electrode 7 is employed as an auxiliary cathode. Since the device incorporates the circuits of two independent sources of current, the electrode or electrodes which are adapted to initiate the glow discharge can be supplied with current from a source which is independent of that which supplies the other electrode or electrodes. Thus, the main transformer supplying the device could, for example, be provided with an independent winding connected to the electrode or electrodes which is, or are, required to initiate the glow discharge through a rectifying circuit and/or a filter circuit or the like. By this means the glow of the said electrode or electrodes will be maintained without being influenced or interfered with by the other elements of the device. Furthermore, due to the fact that the whole circuit is independent of the circuit or circuits of the main current, the mean potential of the circuit supplying the current necessary for the glowing of the said electrode or electrodes may be of any value and may, for example, be increased in order to effect that saturation of the glow of the said electrode or electrodes. Moreover, by means of the variable resistance 9 included in the auxiliary anode circuit, the initial glow can be adjusted so as to extend just above the screen, then with a slight increase of current in the input, the full output current will be obtained.

The output electrode 5 is incorporated in the device for connection to the output circuit. Mechanically this electrode must be as near as possible to the input cathode 2 while electrically it must be protected from the direct influence of the input anode 3. The desired mechanical proxim-

ity is achieved by the shape of the output electrode 5 which, as illustrated on an enlarged scale in Figure 2, is a sinuous member preferably of star-shaped cross-section which provides sufficient space for the glow to spread to the input cathode 3 and at the same time to approach the inner edges of the output electrode 5. The protection of the output electrode from the direct influence of the input anode is achieved in two ways. Firstly, by the interposition between the input anode 3 and the output electrode of the screen 4 whereby the electric field produced by the anode potential and its variation is practically limited to the surface of the screen. The electric field between the screen 4 and the output electrode 5 is a constant one, and the voltage between these electrodes is lower than the striking voltage required for the gas filling. Secondly, as stated above, to protect the output electrode 5 from a direct glow between the input anode and the output electrode a material is used for the output electrode which requires a higher voltage for the glow than that existing between the input electrodes. Thus, a direct glow between the input anode and the output electrode is impossible. This protection is efficient even if the output electrode is polarised to a potential lower than that of the input cathode.

As previously stated, the polarisation of the output electrode 5 in practice is achieved by the connection of a large resistance between that electrode and a potential which is negative in relation to the input cathode. In the passive state of the device, when the majority of the glow is restricted to the upper part of the tube only a very small current flows through the resistance, the major part of the input current flowing to the upper part of the input cathode. The lower part of the cathode and the output electrode are protected against the influence of the glow by the screen 4, which sub-divides a small part of this input current. However, the screen current never reaches a high value because its potential is more positive than that of the input cathode. Thus only those ions which are remote from the cathode can reach the screen and produce screen current. When the active state of the device commences, the increase of input current increases the glow to such an extent, that the upper part of the input cathode is saturated and further increase in the input current is possible only when the major part of the input cathode surface is in a state of glow. This phenomenon produces an extension of the cathode glow below the screen level and introduces positive ionisation in the lower part of the tube. The positive ions in the first instance are attracted by the negatively biased output electrode and, in practice, nearly the whole input current flowing to the lower part of the tube flows to the output electrode. This condition is maintained until the potential of the output electrode changes as a result of the charge of existing output capacities, and especially until the Miller effect of the grid of the thermo-electronic tube connected to the output electrode 5 is neutralised. When the new potential of the output electrode 5 stabilises itself, the current flowing to this electrode is reduced to the current resulting from the voltage drop over the resistance connected to the output electrode. The potential of the output electrode in the active state of the device depends on the input current and the resistance of the output electrode and its polarisation potential. In practice this potential establishes itself slightly above the input cathode potential, unless limited by a limiter or the grid current of the succeeding thermo-electronic tube in the circuit. However if the device is used with pure voltage output only, and if the input current variations are considerable, the part of the output electrode voltage characteristic more positive than the input cathode potential can be used.

It will be appreciated that the device provided by the present invention is a relay or "trigger" device which has numerous applications and especially for control work. Since the device does not depend for its operation on thermionic emission, it is particularly useful as it completely eliminates the large amount of energy normally required in the heater circuits of other valves which is an important advantage in cases where the duration of the "stand-by" periods is considerable.

In connection with the receiving and transmission of all types of continuous wave trains (i. e. for D. C. amplification in telegraphy, television, &c.) the device is a definite improvement. By means of it, all time delay (existing in normal circuits where condensers are necessary) can be eliminated while at the same time, the well known Miller effect can be very efficiently reduced. This renders possible the attainment of speeds which have hitherto been unobtainable on high resistors and inputs.

I claim:

1. An electric glow discharge device comprising a gas filled envelope, an elongated input cathode extending within said envelope, an input anode mounted within said envelope adjacent to one end of said input cathode, an output electrode within said envelope mounted co-axially with respect to the other end of said input cathode, and a screen electrode mounted within said envelope extending transversely of said input cathode between said input anode and said output electrode, and having an aperture through which said input cathode extends.

2. An electric glow discharge device comprising a gas filled envelope, an elongated input cathode extending within said envelope, an input anode mounted within said envelope adjacent to one end of said input cathode, an output electrode within said envelope mounted co-axially with respect to the other end of said input cathode, and a screen electrode mounted within said envelope extending transversely of said input cathode between said input anode and said output electrode, and having an aperture through which said input cathode extends, said screen being formed of a material differing from the material of said input cathode.

3. An electric glow discharge device comprising a gas filled envelope, an elongated input cathode extending within said envelope, an input anode mounted within said envelope adjacent to one end of said input cathode, an output electrode within said envelope mounted co-axially with respect to the other end of said input cathode, and a screen electrode mounted within said envelope extending transversely of said input cathode between said input anode and said output electrode, and having an aperture through which said input cathode extends, said output electrode being formed of a material differing from the material of said input cathode.

4. An electric glow discharge device comprising a gas filled envelope, an elongated input cathode extending within said envelope, an input anode mounted within said envelope adjacent to

one end of said input cathode, an output electrode within said envelope mounted co-axially with respect to the other end of said input cathode, and a screen electrode mounted within said envelope extending transversely of said input cathode between said input anode and said output electrode, and having an aperture through which said input cathode extends, said screen and output electrode being formed of a material differing from the material of said input cathode.

5. An electric glow discharge device comprising a gas filled envelope, an elongated input cathode extending within said envelope, an input anode mounted within said envelope adjacent to one end of said input cathode, an output electrode within said envelope mounted co-axially with respect to the other end of said input cathode, a screen electrode mounted within said envelope extending transversely of said input cathode between said input anode and said output electrode and having an aperture through which said input cathode extends, and an auxiliary glow electrode within said envelope mounted co-axially with respect to that portion of the input cathode between said screen and said input anode.

6. An electric glow discharge device comprising a gas filled envelope, an elongated input cathode extending within said envelope, an input anode mounted within said envelope adjacent to one end of said input cathode, an output electrode within said envelope mounted co-axially with respect to the other end of said input cathode, a screen electrode mounted within said envelope extending transversely of said input cathode between said input anode and said output electrode and having an aperture through which said input cathode extends, an auxiliary cathode within said envelope mounted co-axially with respect to that portion of the input cathode between said screen and said input anode, and an auxiliary anode within said envelope mounted co-axially with respect to said input anode.

7. An electric glow discharge device comprising a gas filled envelope, an elongated input cathode extending within said envelope, an input anode mounted within said envelope adjacent to one end of said input cathode, an output electrode within said envelope mounted co-axially with respect to the other end of said input cathode, a screen electrode mounted within said envelope extending transversely of said input cathode between said input anode and said output electrode and having an aperture through which said input cathode extends, and an auxiliary anode within said envelope mounted co-axially with respect to said input anode.

8. An electric glow discharge device comprising a gas filled envelope, an elongated input cathode extending within said envelope, an input anode mounted within said envelope adjacent to one end of said input cathode, an output electrode in the form of a sinuous cylinder within said envelope mounted co-axially with respect to the other end of said input cathode, and a screen electrode mounted within said envelope extending tranversely of said input cathode between said input anode and said output electrode and having an aperture through which said input cathode extends.

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