

Aug. 27, 1940.

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2,212,645

ELECTRON TUBE

Filed May 29, 1937

2 Sheets-Sheet 1

FIG. 1.

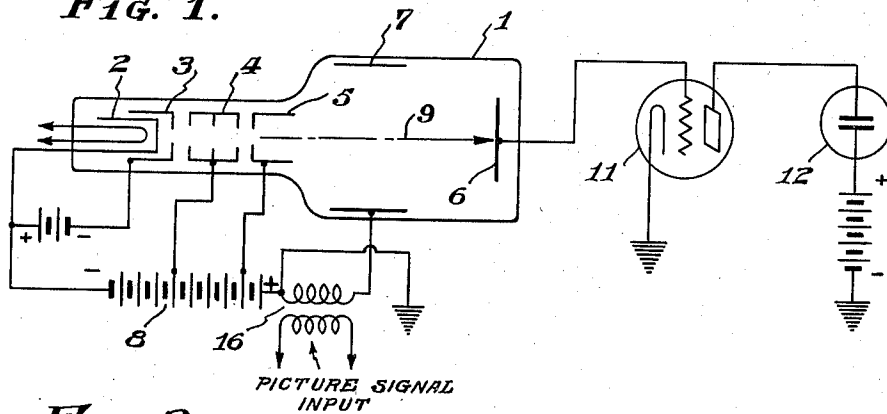


FIG. 2.

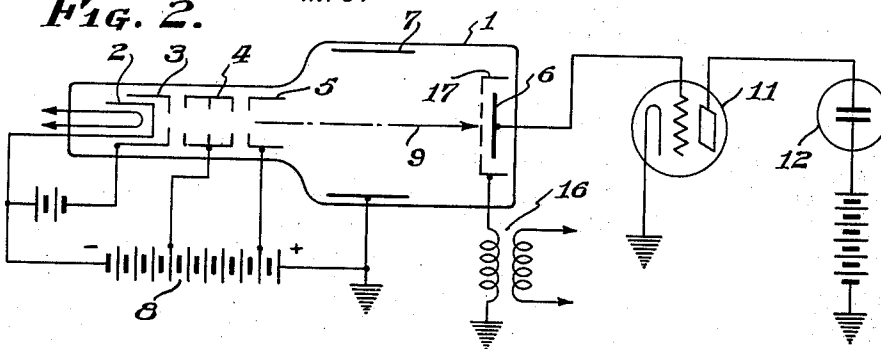
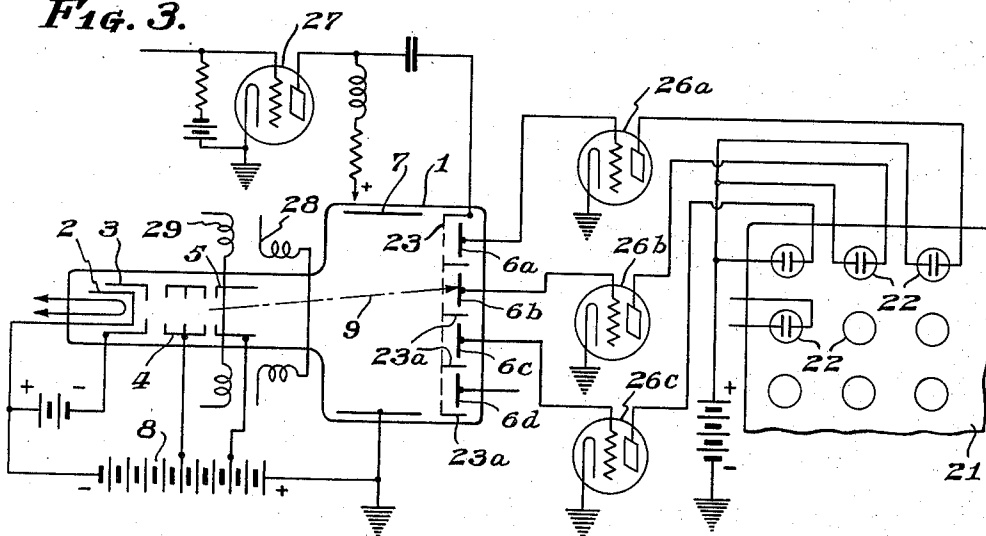


FIG. 3.



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FIG. 4.

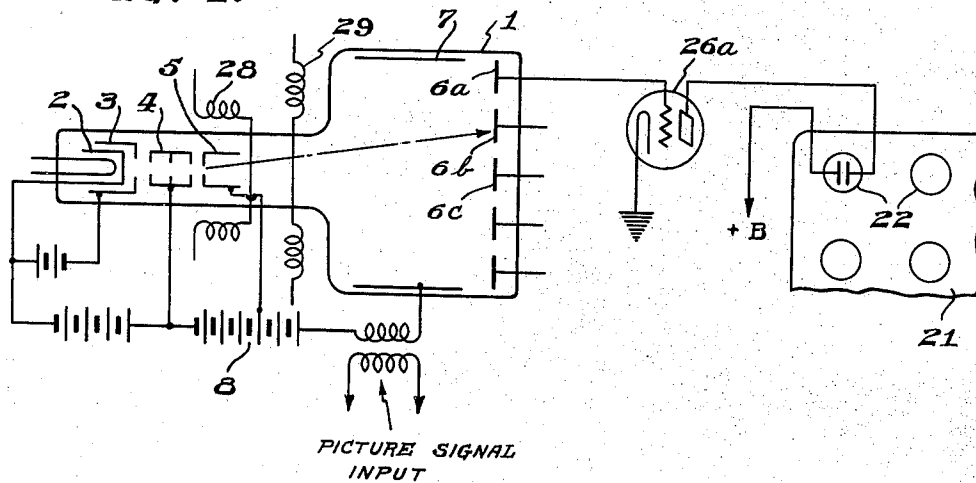
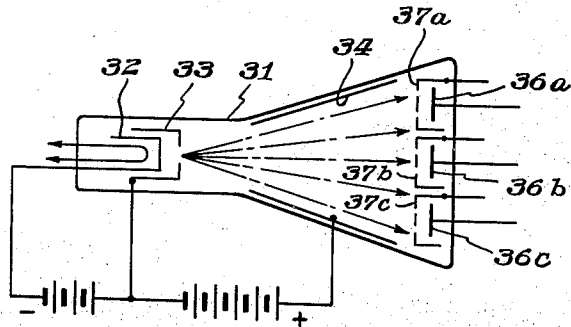


FIG. 5.



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ELECTRON TUBE

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10 Claims. (Cl. 250—27)

My invention relates to electron tubes wherein the phenomenon of secondary emission is utilized for control purposes.

If an insulated element is bombarded by an electron beam, it must assume an equilibrium potential such that as many electrons leave the element as reach it. If it emits no secondary electrons, it will go sufficiently negative to prevent any primary electrons from reaching it. If it emits secondary electrons, it will assume a potential such that the ratio of primary to secondary electron is unity. The potential of the bombarded element will in this case be determined by the potential of the element in the tube which collects the secondary electrons, or which controls the field around the element being bombarded. Therefore, by regulating the potential of this controlling element, the potential of the bombarded element can be adjusted to any desired value, or varied at will.

If the element is not insulated, but is connected to some other point in such a way that the current leaving it is small compared with the beam current, the same method can be applied. If the current leaving or reaching the element through this connection is comparable with the beam current, its potential may be controlled in the same way, but the equilibrium secondary emission ratio will not be unity. This method may be applied to a single element in the tube, to a number of elements which are struck simultaneously by the beam, or it may be applied to an element or elements which are scanned by an electron beam.

My invention may be applied to various circuits such as television receiver systems. It is especially useful in systems wherein it is desired to cause each of a plurality of electrodes to acquire a potential determined by a control voltage, and wherein it is further desired that each of said electrodes remain at this potential for a certain period of time.

From the foregoing discussion, it will be apparent that an object of my invention is to provide an improved electron discharge tube wherein the potential of an electrode is to be controlled.

A further object of my invention is to provide an improved method of controlling the potential of an electrode in an electric discharge device.

A further object of my invention is to provide an improved electric discharge tube wherein the potentials of a plurality of electrodes are controlled successively.

A still further object of my invention is to provide an improved method of and means for controlling the potential of an insulated electrode.

The invention will be better understood from the following description, taken in connection with the accompanying drawings, in which

Figures 1 and 2 are diagrams of electronic tubes and associated circuits embodying my invention,

Figures 3 and 4 show electronic tubes embodying a preferred form of my invention, which are connected in a television receiver having a bank or mosaic of lamps to form the receiver screen, and

Figure 5 is a view of another embodiment of my invention.

Referring to Fig. 1, this particular embodiment of my invention comprises a highly evacuated envelope 1 having therein an electron gun comprising an indirectly heated cathode 2, a control electrode 3, an anode 4 and a second anode 5. At the opposite end of the envelope there is an electrode 6, the potential of which it is desired to control.

A ring electrode 7, which is maintained at a slightly higher positive potential than the anode 5, by means of a battery 8, functions as a collector of secondary electrons emitted from electrode 6 when it is bombarded by a beam of electrons from the electron gun. The electrons in this beam, which is represented by the broken line 9, will be referred to as the primary electrons, as distinguished from the secondary electrons resulting from bombardment of the electrode 6 by the primary electrons.

The electrode 6 is connected to the grid of a vacuum tube 11, whereby the current flowing through a glow tube 12 will vary in accordance with the potential of electrode 6. It will be seen that the electrode 6 is insulated, whereby it acquires a potential such that the number of secondary electrons leaving it equals the number of primary electrons reaching it. It follows that by controlling the number of secondary electrons leaving the electrode 6, the potential of this electrode is controlled.

Thus, by impressing picture signals, for example, upon electrode 7 through a transformer 10, the potential of electrode 6 is varied in accordance with the picture signal, and the light emitted from glow lamp 12 also varies with the picture signal. The lamp 12 may be located behind a scanning disc, such as a Nipkow disc, to reproduce a television picture in a well known manner.

Considering more specifically the manner in which the potential of electrode 7 controls the potential of electrode 6, it will be apparent that, as electrode 7 is made more negative by an incoming signal, it will draw fewer secondary electrons from electrode 6. Thus electrode 6 becomes more negative until a sufficient number of the primary electrons are being repelled to make the ratio of primary electrons to secondary electrons unity.

In Fig. 2, where parts similar to those in Fig. 1 are indicated by like reference numerals, my electron tube is the same as in Fig. 1, except that an additional control electrode 17 is provided. This control electrode may be one of any shape placed near the electrode 6, but in a preferred form it is in the shape of a ring surrounding electrode 6 and has a screen portion located between electrode 6 and the electron gun. The potential of electrode 6 is varied as previously described, the incoming signal being applied to electrode 17.

In Fig. 3 there is illustrated one of the preferred embodiments of my invention wherein the potentials of a plurality of electrodes may be changed in rapid succession in accordance with a picture signal or the like. In Fig. 3, parts similar to those in Fig. 1 are indicated by like reference numerals.

In my electronic tube shown in Fig. 3, there are a plurality of electrodes 6a, 6b, 6c, 6d, etc. In the particular application of this tube indicated in Fig. 3, that is, in a television receiver having a screen 21 comprising a mosaic of glow lamps 22, the envelope 1 contains many more electrodes, such as 6a, than indicated, and they, like the lamp 22, are arranged as a mosaic.

A control electrode 23 is located between the electrodes 6a, 6b, etc., and the electron gun, this electrode controlling the potentials of electrodes 6a, 6b, etc., in the same way that electrode 17 in Fig. 2 controls the potential of electrode 6. The electrode 23 may be in the form of a screen as indicated. Preferably, metal plates 23a, which may be in the form of a honeycomb structure, are provided to prevent secondary electrons from going from a bombarded electrode such as 6b, to an adjacent electrode such as 6a, instead of to the collector electrode 7. As indicated, the partition plates 23a and the screen forming the main part of electrode 23 are electrically connected.

The gas lamps 22 are in the plate circuits of amplifier tubes 26a, 26b, etc., whereby they are lighted to a brilliance depending upon the potentials of the amplifier tube grids, the potentials of these grids in turn depend upon the potentials of electrodes 6a, 6b, etc., to which they are connected.

The picture signals, or other control signals in the case of other applications of my invention, are impressed upon the electrode 23, preferably through an amplifier 27. The cathode ray 9 is caused to scan successive rows of the electrodes 6a, 6b, etc., by means of scanning coils 28 and 29 through which saw-tooth currents flow. The scanning, of course, is maintained in synchronism with the scanning of the subject at the transmitter in any well known manner.

For the purpose of explanation, it will be assumed that the ray 9 is being deflected rapidly in the plane of the paper and over the row of electrodes 6a, 6b, etc., and that it is being deflected comparatively slowly in a plane perpendicular to the plane of the paper. As the cathode ray is deflected over the row of electrodes 6a,

6b, etc., the upper row of lamps 22 will light up, the action being as follows:

At the instant that the cathode ray strikes the electrode 6a, the control screen 23 is at a certain potential, determined by the incoming picture signal. The electrode 6a emits secondary electrons, the number depending upon the potential of screen 23, whereby the resulting potential of electrode 6a is a function of the picture signal, as previously explained.

As the movement of the cathode ray continues and it strikes electrode 6b, the potential of screen 23 has changed to a different picture signal value, and the electrode 6b acquires a corresponding potential. Electrode 6a, meanwhile, remains at the potential it acquired when it was struck by the cathode ray. Thus electrodes 6a, 6b, 6c, etc., successively acquire potentials in accordance with the incoming picture signal and remain at these potentials until they are again scanned by the cathode ray. When scanned the second time, the action is repeated.

It will be apparent that the grids of tubes 26a, 26b, etc., assume the potentials of electrodes 6a, 6b, etc., whereby each of the lamps 22 glows with an intensity depending upon the illumination of a corresponding picture element of the subject being transmitted. Each glow lamp remains lighted and glows with unchanging intensity until its intensity is changed by the next scanning cycle of the cathode ray 9.

It should be noted that in my above-described tubes the potential of the control electrode with respect to the bombarded electrode (the potential of electrode 23 with respect to electrode 6a in Fig. 3, for example) determines the number of secondary electrons leaving the bombarded element only during the period that the bombarded element is acquiring a new equilibrium potential. As soon as the new equilibrium potential is reached, the ratio of primary electrons to secondary electrons is again unity and the number of secondary electrons leaving the bombarded element is the same as before.

In Fig. 4, where parts similar to those in Fig. 3 are indicated by the same reference numerals, I have illustrated an electronic tube similar to that shown in Fig. 3, but which has the picture signals applied to the secondary electron collector electrode 7, as described in connection with Fig. 1. The operation of this television receiver is the same as that of the receiver in Fig. 3.

In Fig. 5 there is shown an embodiment of my invention in which a plurality of electrodes are bombarded simultaneously by electrons sprayed from an electron gun. It comprises an evacuated envelope 31 having therein an electron gun comprising a cathode 32 and an anode 33. An additional anode 34 is provided for accelerating the electrons and for collecting secondary electrons. A plurality of output electrodes 36a, 36b, etc., are located at the end of the envelope 31 where they are bombarded by the primary electrons from the electron gun.

Each of the output electrodes is provided with a control electrode, as indicated at 37a, 37b, etc. It will be evident that the potentials of the output electrodes may be changed simultaneously for control purposes by varying the potentials of the electrodes 37a, 37b, etc., whereby a plurality of circuits may be controlled simultaneously by the single control tube 31.

By the expression "secondary emission equilibrium potential," used in the claims, is meant the potential of an electrode being bombarded

with a beam of primary electrons with respect to an electrode determining the ratio of secondary electrons leaving the first electrode to the number of electrons in the said beam, said beam being such that the number of said secondary electrons equals the number of said primary electrons.

I claim as my invention:

1. In an electric discharge device having an insulated or floating electrode to be controlled and a control electrode, the method of causing said first electrode to assume any one of a plurality of desired potentials which comprises bombarding said first electrode with a beam of primary electrons with sufficient velocity to release a quantity of secondary electrons therefrom such that the ratio of secondary electrons to primary electrons may be greater than unity, said secondary electrons causing said first electrode to assume substantially secondary emission equilibrium potential with respect to said control electrode, and changing the potential of said control electrode to make said first electrode assume a different desired potential.

2. The method of controlling the potential of an insulated or floating electrode which comprises bombarding said electrode with primary electrons with sufficient velocity to release a quantity of secondary electrons therefrom such that the ratio of secondary electrons to primary electrons may be greater than unity and whereby said electrode assumes substantially secondary emission equilibrium potential and controlling the instantaneous electric field in the region of said electrode to control the instantaneous ratio of secondary electrons to primary electrons whereby said electrode assumes a different potential which is substantially secondary emission equilibrium potential.

3. An electric discharge tube comprising an evacuated envelope having therein means for generating a beam of electrons having a certain velocity, a plurality of insulated or floating electrodes capable of secondary electron emission and positioned to be bombarded by said beam with sufficient velocity to release a quantity of secondary electrons therefrom such that the ratio of secondary electrons to primary electrons may be greater than unity, each of said electrodes having an output conductor extending outside said envelope, and means for controlling the number of secondary electrons leaving said electrodes for the purpose of controlling their potentials.

4. The invention according to claim 3 characterized in that said last means includes a control electrode common to said plurality of electrodes.

5. In combination, an electric discharge tube comprising an evacuated envelope having therein means for generating a beam of electrons having a certain velocity, a plurality of insulated or floating electrodes capable of secondary electron emission and positioned to be scanned by said beam with sufficient velocity to release a quantity of secondary electrons therefrom such that the ratio of secondary electrons to primary electrons

may be greater than unity, means for deflecting said beam across said electrodes, each of said electrodes having an output conductor extending outside said envelope, and means for controlling the number of secondary electrons leaving said electrodes for the purpose of controlling their potentials.

6. The invention according to claim 5 characterized in that said last means includes a control electrode common to said plurality of electrodes.

7. In combination, an electric discharge tube comprising an evacuated envelope having therein means for generating a beam of electrons having a certain velocity, a plurality of insulated or floating electrodes capable of secondary electron emission and positioned to be scanned by said beam with sufficient velocity to release a quantity of secondary electrons therefrom such that the ratio of secondary electrons to primary electrons may be greater than unity, means for deflecting said beam across said electrodes whereby secondary electrons are released therefrom, each of said electrodes having an output conductor extending outside said envelope, an electrode for collecting said secondary electrons, and means for controlling the number of secondary electrons leaving said electrodes for the purpose of controlling their potentials.

8. The invention according to claim 7 characterized in that said last means includes a control electrode common to said plurality of electrodes.

9. An electric discharge tube comprising an evacuated envelope having therein means for generating a beam of electrons, a plurality of electrodes positioned to be bombarded by said beam, each of said electrodes being substantially insulated or floating whereby it may acquire substantially a secondary emission equilibrium potential, each of said electrodes being adapted to be connected to an element for controlling its potential, and means for controlling the number of secondary electrons leaving said electrodes and thereby causing them to acquire a new potential which is substantially the secondary emission equilibrium potential.

10. In combination, an electric discharge tube comprising an evacuated envelope having therein means for generating a beam of electrons, a plurality of electrodes positioned to be bombarded by said beam, each of said electrodes being substantially insulated or floating whereby it may acquire substantially a secondary emission equilibrium potential, each of said electrodes having an output connection, means for controlling the number of secondary electrons leaving said electrodes for the purpose of controlling their potentials, and electric discharge means comprising a plurality of electrically insulated electrodes, each of said output connections being connected to one of said last-named insulated electrodes, said output connections being the sole connections to said last named electrodes.

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