June 11, 1946. G. R. KILGORE 2,401,740

ELECTRON DISCHARGE DEVICE

Original Filed May 28, 1941

Fig. 1.

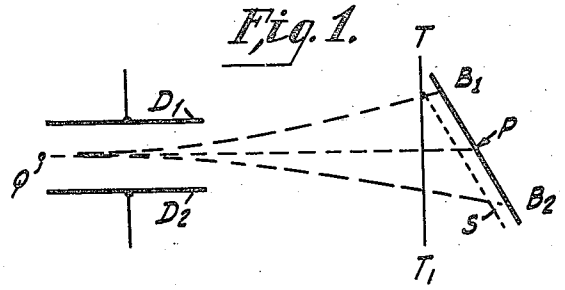


Fig. 2.

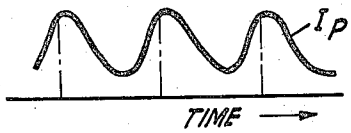


Fig. 3.

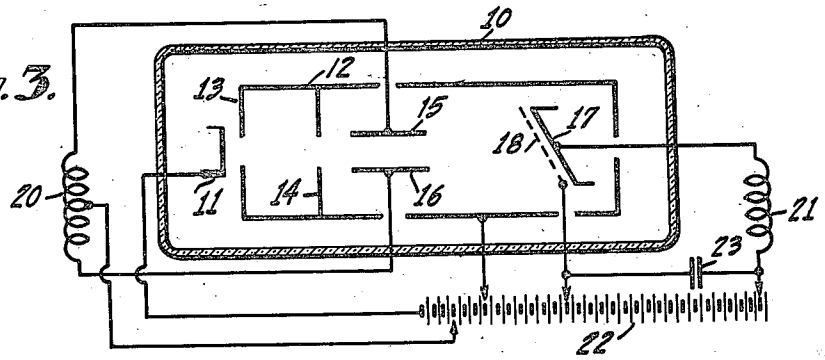
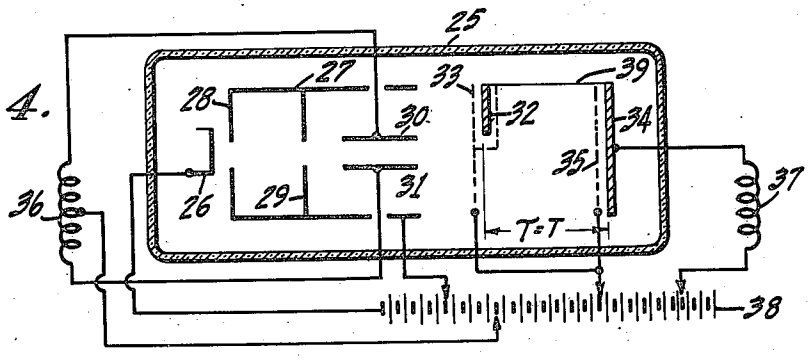


Fig. 4.



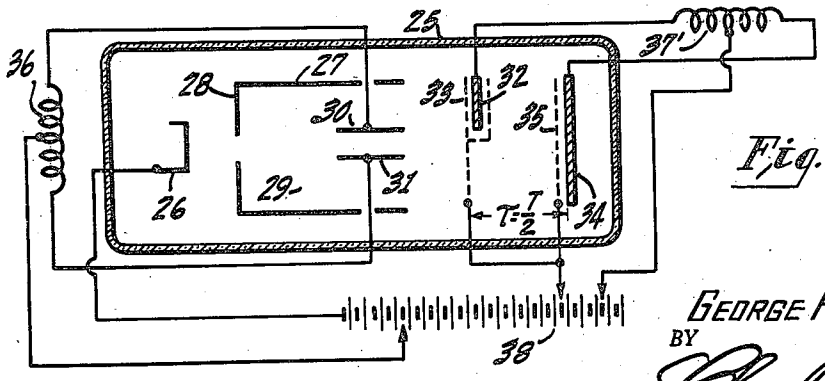


Fig. 5.

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ELECTRON DISCHARGE DEVICE

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Original application May 28, 1941, Serial No. 395,621, now Patent No. 2,372,282, dated March 27, 1945. Divided and this application January 29, 1944, Serial No. 520,234

4 Claims. (Cl. 250—27)

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My invention relates to electron discharge devices, more particularly to such devices suitable for use at high frequencies and employing a beam of electrons and deflecting means for said beam to produce a modulated output current.

The present application is a division of my copending application, Serial No. 395,621 filed May 28, 1941, Patent No. 2,372,282, dated March 27, 1945, and assigned to the same assignee as the present application.

In conventional devices employing a beam and utilizing deflection means, the electron stream is modulated by deflecting the beam past an aperture in an apertured electrode. Such a device is inefficient insofar as the intercepted current which becomes waste current is concerned, and requires the use of an additional electrode, that is the apertured electrode. This electrode adds electrode capacity to the tube, which at the higher frequencies is undesirable since this further affects the efficiency of the tube as well as increases the number of leakage paths between the various electrode leads.

Hence, it is an object of my invention to provide an electron discharge device particularly useful at high frequencies and employing a beam and deflecting means for the beam for producing a modulated output current.

More specifically, it is an object of my invention to provide such an electron discharge device in which the transit time of the electrons, the shape and position of the electrodes and the frequency of the controlling voltage or voltages are such that the action of the deflection means produces a modulated current in the output of the electron discharge device.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a diagram explaining the theory of operation of an electron discharge device made according to my invention, Figure 2 represents the output current of a device made according to my invention, Figure 3 is a diagrammatic longitudinal section of an electron discharge device and circuit made according to my invention, Figure 4 is a modification of the device shown in Figure 3 and its associated circuit, and Figure 5 shows a tube corresponding to the tube in Figure 4 but used in the push-pull output circuit arrangement.

Referring to the drawing in Figure 1, the point Q represents an electron source for providing a

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beam of electrons directed between a pair of deflecting electrodes D_1 and D_2. These electrons are directed toward an anode or output electrode P having positioned in front of it a screen S. As the beam is deflected, the path length of the electrons from Q to plate P is varied and the transit time of the electrons will vary accordingly. If B_1 and B_2 represent the maximum excursion of the beam and the difference in transit time along the paths QB_1 and QB_2 is made to equal one-half the period of the applied alternating control voltage on plates D_1, D_2, then on the upward swing of the beam, an electron will reach B_1 at the same instant an electron which left the source of electrons Q one-half cycle earlier reaches B_2. Thus, it is possible by the application of proper biasing voltages and proper controlling voltage to have all the electrons which pass through the same plane T—T' on the upward swing reach the output electrode P at approximately the same instant of time.

On the downward deflection, however, the electrons will reach the plate P at wider and wider intervals. As a result the electron current reaching the output electrode P will have a wave shape something like that shown in Figure 2. Thus, with a uniform flow of electrons from the source Q a modulated current is produced in the output electrode P. The screen S is introduced close to the plate P so that the high frequency current induced in the output electrode P will not be reduced appreciably by transit time effects.

The incorporation of an electrode structure corresponding to that shown in Figure 1 in an electron discharge device, and its associated circuit, is shown in Figure 3. An indirectly heated cathode 11 provides a source of electrons which is formed into a beam by means of the longitudinal cylindrical electrode system having the apertured inserts 13 and 14, the apertures being aligned to provide beam formation. The beam is directed between a pair of deflecting electrodes 15 and 16 toward output electrode 17 inclined with respect to the beam, a screen electrode being provided in front of the output electrode. The cylindrical electrode system 12 may surround the output electrode and screen to completely screen it from output interference, if so desired. Input circuit 20 is connected between the deflecting electrodes 15 and 16 and a positive point on the voltage source 22, the output 21 being connected between the voltage source 22 and the output electrode 17, by-passing of the high frequency current of the screen being accomplished by means of high frequency condenser 23 which also

permits a different D.-C. voltage to be applied to the anode and the screen. The frequency of the voltage applied to the input circuit **20** and biasing voltages applied to the other electrodes are such that the velocity of the electrons and the deflection caused by the controlling voltage makes the electron transit time difference between the maximum points of swing equal to one-half the period of the frequency of the applied voltage to the deflecting electrodes **15** and **16**, in this way obtaining an output such as shown in Figure 2.

In the modification shown in Figure 4 a special case is shown in which a pair of output electrodes are displaced a distance equal to a multiple of one-half period of the transit time of an electron during half a period. Here again cathode **26** supplies electrons which are formed into a beam by an electrode system which comprises cylinder **27** and apertured electrodes **28** and **29**. The beam of electrons passes between deflecting electrodes **30—31** to output electrode elements **32** and **34** screened by means of screen electrodes **33** and **35**. Electrode **33** may be on both sides of electrode element **32** to completely shield it from the electron stream when it passes to electrode **34**. The input voltage is applied by means of input circuit **36** to the deflecting electrodes **30—31**, and output circuit **37** is connected to the electrode **34** electrically connected to electrode **32** by means of conductor **39**. The spacing between electrodes **32** and **34** is such that the transit time of electrons between the two electrodes **32** and **34** is a multiple of one-half period of the applied controlling voltage. In the case shown the transit time τ is made equal to one period T. Thus the current pulses reach **32** and **34** in phase. The result of this is a current having twice the amplitude flowing for a half period of the applied input voltage.

In Figure 5 the output electrodes **32** and **34** are connected to opposite sides of a push-pull output transformer. Inasmuch as the transit time space between the two electrodes is made equal to one-half period, the current flowing to each output electrode is in the proper phase relationship to bring about excitation of the output transformer **37'**.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

What I claim as new is:

1. An electron discharge device having a cathode for supplying electrons and means for forming electrons from said cathode into a directed beam, an output electrode for receiving said electrons and a pair of deflecting electrodes between which said beam is directed to said output electrode, said output electrode including a member having a plane surface positioned at an angle to the path of said beam, said beam forming means comprising a tubular member surrounding said deflecting electrodes and said output electrode and having a transverse element closing one end of said tubular member adjacent said cathode and provided with an aperture registering with said cathode and the other end of said tubular member being closed by a transverse element, whereby said deflecting electrodes and output electrode are completely shielded, an input circuit connected to said deflecting electrodes for applying an alternating controlling voltage to said deflecting electrodes, an output circuit connected to said output electrode, a source of voltage, means connected between said source of voltage and said electron discharge device for providing biasing voltages, the frequency of said controlling voltage being such that the difference in transit time between the output electrode surface nearest said deflecting electrodes and the part of said output electrode most distant from said deflecting electrodes is of the order of one-half period of oscillation of the controlling voltage.

2. An electron discharge device having a cathode for supplying electrons and means for forming the electrons from said cathode into a directed beam, an output electrode for receiving said electrons and a pair of deflecting electrodes between which said beam is directed to said output electrode, said output electrode including a member having a plane surface positioned at an angle to the path of said beam, and a screen electrode adjacent said output electrode, said beam forming means comprising a tubular member surrounding said deflecting electrodes, said output electrode and said screen electrode and having a pair of spaced transverse elements closing one end of said tubular member adjacent said cathode and provided with apertures registering with said cathode, and a transverse element closing the other end of said tubular member, whereby said deflecting electrodes, output electrode and screen electrode are completely shielded, an input circuit connected to said deflecting electrodes for applying an alternating controlling voltage to said deflecting electrodes, an output circuit connected to said output electrode, a source of voltage, means connected between said source of voltage and said electron discharge device for providing biasing voltages, the frequency of said controlling voltage being such that the difference in transit time between the output electrode surface nearest said deflecting electrodes and the part of said output electrode most distant from said deflecting electrodes is of the order of one-half period of oscillation of the controlling voltage.

3. An electron discharge device having a cathode for supplying electrons and means for forming the electrons from said cathode into a directed beam, an output electrode for receiving said electrons and a pair of deflecting electrodes between which said beam is directed to said output electrode, said output electrode including a member having a plane surface positioned at an angle to the path of said beam, and a screen electrode adjacent said output electrode, said beam forming means comprising a tubular member surrounding said deflecting electrodes, said output electrode and said screen electrode and having a pair of spaced transverse elements closing one end of said tubular member adjacent said cathode and provided with apertures registering with said cathode, and a transverse element closing the other end of said tubular member, whereby said deflecting electrodes, output electrode and screen electrode are completely shielded.

4. An electron discharge device having a cathode for supplying electrons and means for forming the electrons from said cathode into a directed beam, an output electrode for receiving

said electrons and a pair of deflecting electrodes between which said beam is directed to said output electrode, said output electrode including a member having a plane surface positioned at an angle to the path of said beam, and a screen electrode adjacent said output electrode, said beam forming means comprising a tubular member surrounding said deflecting electrodes, said output electrode and said screen electrode

and having a transverse element closing one end of said tubular member adjacent said cathode and provided with an aperture registering with said cathode, and a transverse element closing the other end of said tubular member whereby said deflecting electrodes, output electrode and screen electrode are completely shielded.

GEORGE ROSS KILGORE.