

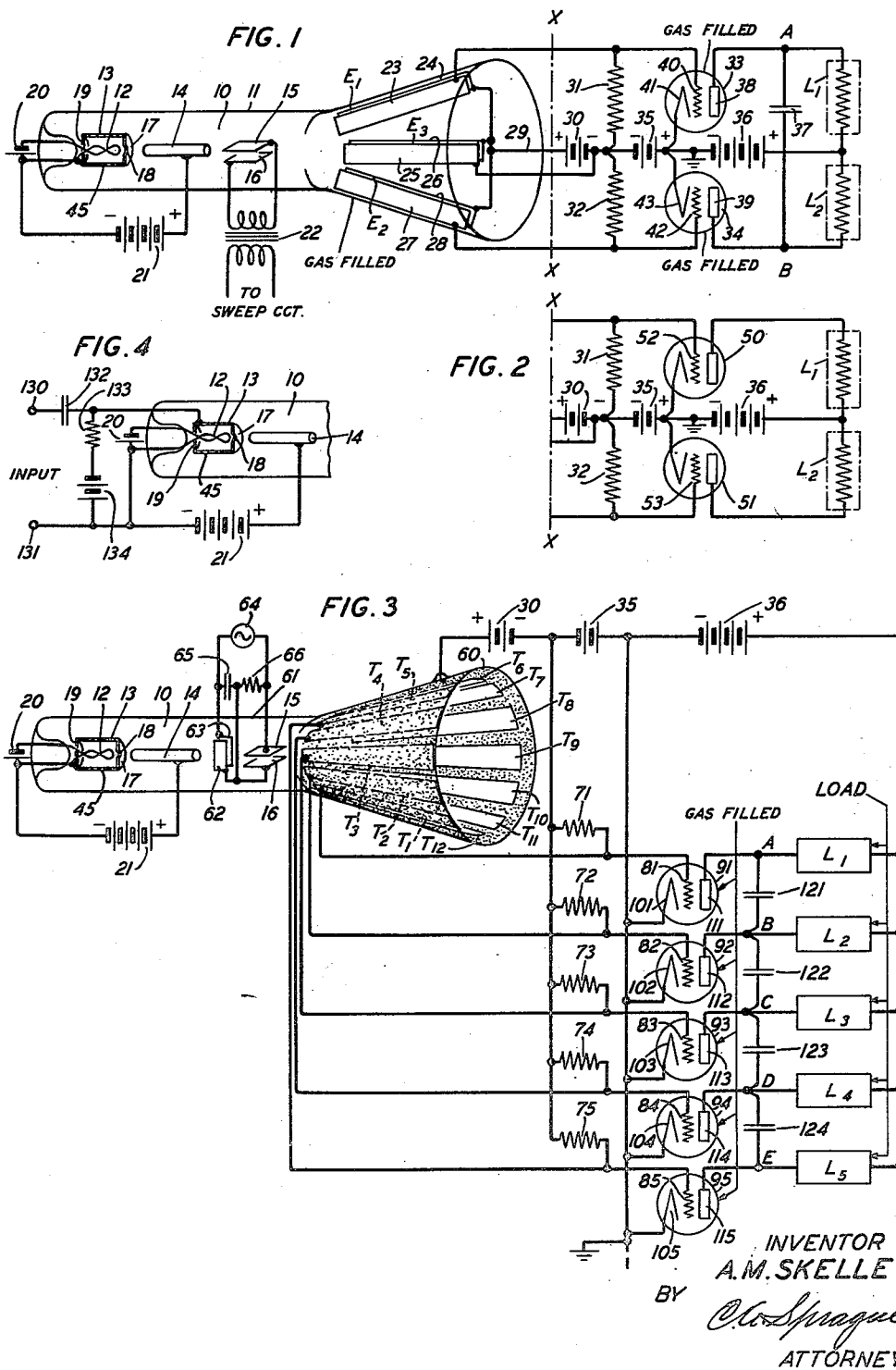
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A. M. SKELLETT

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ELECTRON DISCHARGE DEVICE

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## ELECTRON DISCHARGE DEVICE

Albert M. Skellett, Madison, N. J., assignor to Bell  
Telephone Laboratories, Incorporated, New  
York, N. Y., a corporation of New York

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This invention relates to electron discharge devices and more specifically to devices of this character which operate by controlling the deflection of an electron beam.

5 Electron discharge devices of the cathode ray type have been used in the past as commutators for switching from one circuit or element to another quickly and without inertia. In these devices an electron beam generally makes contact with a number of metallic elements in order, thus completing, in turn, a corresponding number of external circuits. The current which is available to complete the external circuits is limited by the number of electrons in the beam.

15 It is an object of this invention to provide an electronic switching or distributing device of novel construction in which a cathode ray beam is utilized to actuate a succession of gas discharges within the tube, whereby an amplified current is produced in comparison with that which would be produced in tubes of the type known in the past.

In accordance with the invention, several forms of cathode ray tubes are provided, each of which comprises an envelope filled with gas at a relatively low pressure which encloses an electron gun for generating a beam of electrons, a number of pairs of electrode elements, and deflecting means for causing the beam to successively pass between the electrodes of each pair to thereby cause a flow of current between the electrodes of each pair. This current flow may be and generally is larger than the current produced by the electron gun which originates the beam.

35 In one embodiment of the invention, a cathode ray tube is provided which is filled with gas at a relatively low pressure and which encloses an electron gun for generating a beam of electrons, three pairs of electrode plates which are arranged generally parallel to the axis of the beam as it passes between the plates of each pair, and a pair of electrostatic deflecting plates adapted to be connected to an appropriate sweep circuit for causing the beam to successively pass between the various pairs of plates. When the beam passes between (but does not touch) any pair of plates, a leakage current is established between the plates of the pair due to the ionization of the gas in the vicinity of the beam. One plate of each of the outside pairs is connected respectively to the grid of a gas-filled grid-controlled electron discharge device, the other terminal of each of the outside pairs being connected, respectively, through a source of potential to the cathodes of the two gas-filled electron

discharge devices. Between the two outside pairs of plates is connected an auxiliary pair of plates, one plate of which is connected to the respective plates of the two outside pairs of plates which are connected to the cathodes of the gas-filled electron discharge devices, and the other plate of which is connected to the cathodes of the gas-filled electron discharge devices through a second source of potential. The auxiliary pair of plates acts as a shield between the two outside pairs of plates and prevents ions from migrating from one pair of electrode plates to the other, which would tend to disturb the action of the electronic switching device. This shielding feature is particularly valuable in the case where the beam is modulated with multiplex current and it is desired to prevent cross-talk between the various channels into which the various parts of the multiplex current are directed by the electronic switch, one set of control plates being connected to each channel. In the external circuit the gas-filled electron discharge devices are arranged so that as one discharge device becomes conducting (when a current flows between the corresponding control plates within the cathode ray tube) the discharge in the other gas-filled electron discharge device is extinguished. As a modification high vacuum tubes may be used in place of the gas-filled electron discharge devices in the external circuit.

In another embodiment of this invention, a conductive coating on the glass wall of the tube acts as a common collector of ions and thus a single electrode plate at each contact position of the beam suffices. In this arrangement the beam is swept in a circular path and successively passes between the conducting coating on the walls of the tube and the various collector or control plates arranged generally parallel thereto. A gas-filled grid-controlled electron discharge device is connected in circuit with each of the collector plates and each discharge device in the external circuit is "on" when the beam is between its corresponding collector plate and the tube coating. As the discharge device goes "on", that is, when the discharge starts, it extinguishes the discharge in the one that has been previously discharging. With this device it is possible to make 20,000 to 100,000 contacts per second without noticeable effect due to the inertia of the positive ions. Between adjacent control or collector electrodes may be placed auxiliary electrodes to act as shields in a manner similar to that described in the preceding embodiment.

The invention will be more readily understood

by referring to the following description taken in connection with the accompanying drawing forming a part thereof, in which:

Fig. 1 is a schematic diagram of an electron discharge switching device embodying the principles of this invention;

Fig. 2 shows an alternate external circuit which may be used with the switching device shown in Fig. 1;

Fig. 3 shows another electron discharge device embodying the principles of this invention; and

Fig. 4 shows an arrangement for modulating the beam in the tubes of Figs. 1 and 3.

Referring more specifically to the drawing, Fig. 1 shows an electron discharge device 10 of the cathode ray type and its associated apparatus and circuits, the device 10 being used as a means to rapidly switch without inertia between two external circuits or loads  $L_1$  and  $L_2$ .

The cathode ray device 10 comprises an envelope 11 provided with a filling of an inert gas, such as argon, and at very low pressure, for example,  $5 \times 10^{-3}$  mm. of mercury, and enclosing a helical filamentary cathode 12, a shield 13 for the cathode, an anode 14, a pair of deflecting plates 15 and 16, and three pairs of electrode elements  $E_1$ ,  $E_2$  and  $E_3$ , preferably arranged in two vertical planes which are perpendicular to the planes of the deflecting plates 15 and 16.

The helical cathode 12, which may comprise a platinum or nickel ribbon coated with barium and strontium oxides, is supported in axial alignment with the anode 14. The metallic shield 13, preferably of nickel, substantially completely encloses the cathode 12, and comprises a tubular shell 45 concentrically disposed about the cathode 12 which is closed by a metallic disc 17 provided with an aperture 18 adjacent the anode 14. The shield 13, which is also closed by a metallic disc 19 provided with apertures through which the cathode supports and leads extend, is preferably connected electrically to one of the cathode support wires. For uses when it is desired to modulate the beam this shield is connected to the modulating potential in the usual manner. Heating current for the filamentary cathode 12 is provided by a source 20. A function of the shield 13 formed by the shell 45 and the discs 17 and 19 is to protect the cathode 12 from deterioration by positive ion bombardment.

The anode 14 preferably comprises a tubular element which is placed at a positive potential with respect to the potential of the cathode 12 and of the shield member 13 by means of a source 21. The disc 17 and the anode 14 serve as a focusing means to concentrate the electron stream from the cathode 12 to the anode 14 into a beam of electrons, the well-known principle of gas concentration being used. For a further description of an electron gun arrangement utilizing gas focusing similar to that herein described, reference may be made to Patent 1,980,196, issued November 13, 1934 to M. S. Glass.

Between the pair of electrostatic deflecting plates 15 and 16 is applied a suitable sweep potential by any appropriate means such as, for example, the transformer 22. As an example of a sweep circuit for producing oscillations of sawtoothed form, reference may be made to an application of Frank Gray, Serial No. 65,606, filed February 25, 1936 wherein several sweep circuits suitable for this purpose are described. For some applications, a sine wave can be used.

Because of the action of the sweep potentials

applied between the electrostatic deflecting plates 15 and 16, the electron beam generated and focused by the action of the cathode 12, the shield 13 and the anode 14 is caused to pass successively between the plates 23 and 24 constituting the pair  $E_1$ , between the plates 25 and 26 constituting the pair  $E_3$ , and between the plates 27 and 28 constituting the pair  $E_2$  and then return to a position between the plates  $E_1$ .

The even numbered plates of each pair, that is, plates 24, 26 and 28, are connected together and their common connection 29 is connected to the positive terminal of a source of potential 30, the negative terminal of which is connected to the plate 25 and to the common terminal of the resistances 31 and 32, the other terminals of which are connected respectively to the plates 23 and 27. The resistances 31 and 32 are in the input circuits respectively of two gas-filled grid-controlled electron discharge devices 33 and 34 which may be, for example, of the type generally known as "Thyratrons". Also included in the input circuits of each of these tubes is the biasing source of potential 35. The output circuit of the device 33 includes the load  $L_1$  and the source of plate potential 36, while the output circuit of the device 34 includes the load  $L_2$  and the source of plate potential 36. A condenser 37 is connected between the anode 38 of the device 33 and the anode 39 of the device 34 for a purpose which will be explained hereinafter.

The operation of the electronic switching device shown in Fig. 1 will now be described. The gas filling in the tube 10 is at such a pressure that the ionization of the gas in the tube is localized along the path of the electron beam. By means of the sweep potentials applied between the deflecting plates 15 and 16, the beam is caused to pass successively between the pairs of plates  $E_1$ ,  $E_3$  and  $E_2$  and to return to a position between the plates  $E_1$  where the cycle is repeated again, the frequency of the cycle depending upon the frequency of the sweep voltage generated by the sweep circuit applied to the transformer 22. With the beam passing between the plates 23 and 24 constituting the pair  $E_1$ , for example, and a suitable potential difference maintained between them by means of the source of potential 30, the positive ions formed by the beam will travel to the more negative of the two plates, that is, the plate 24, and the released electrons will travel to the more positive of the plates, that is, the plate 23. In other words, with the beam passing between the plates 23 and 24, but not touching either, a leakage current will be established between them due to the ionization of the gas in the vicinity of the beam. With the beam in another part of the tube remote from these plates as, for example, in the region between the pair of plates  $E_3$  or between the pair of plates  $E_2$ , there would be no leakage current between the plates 23 and 24. To insure this condition, the voltage across the plates 23 and 24, as determined by the source of potential 30, must not be great enough to maintain a discharge through the gas, a condition easy of realization since the gas pressure is preferably low. There is a small deflection of the beam produced by the voltage across these plates, tending it to make it strike the more positive of them. However, under the working conditions of high accelerating voltage on the beam, as determined by the source of potential 21, and low collecting potentials across the plates 23 and 24, this de-

flexion may be made negligibly small. If for some potentials the separations of collector plates are such that this deflection becomes troublesome such as in the case where the beam follows a curved path, as in Fig. 3, the collector plates may be bent in such a manner that they follow the curvature of the beam. The same result may also be accomplished by dividing each pair of deflector plates into a number of pairs with adjacent pairs connected oppositely. The beam would then follow a wavy or zig-zag path while in between a set of plates. The plane in which the zig-zag lies is perpendicular to the plane through which the beam sweeps.

The grid 40 of the gas-filled electron discharge device 33 is biased with respect to the cathode 41 thereof by means of the source of potential 35 and the resistance 31 so that substantially no current flows between the anode 38 and the cathode 41 when no current is flowing between the electrode plates 23 and 24. When the electron beam is between the plates 23 and 24, however, a leakage current takes place between these plates and current flows through the resistance 31, decreasing the bias on the grid 40 so that the gas-filled device becomes conducting and a discharge takes place between the cathode 41 and the anode 38, this discharge current also passing through the load  $L_1$ . The current through the load  $L_1$  is limited only by the potential of the source 35 and the impedance of the load and this current may be, and preferably is, much larger than the current in the electron beam in the tube 11. Thus, a small electron beam current may be used to control a very much larger load current and, of course, this load current may be used, if desired, to control an even larger current.

When the beam moves from between the plates 23 and 24, the leakage current between these plates ceases to flow and hence there is no current flowing through the resistance 31 and the potential of the grid 40 swings back to its original more negative bias. Ordinarily, however, the discharge between the anode 38 and the cathode 41 would still take place because of the positive sheath of ions which has been built up around the grid 40 during the discharge, were it not for the action of the condenser 37. With no current flowing in either tube 33 or 34, the anodes 38 and 39 are at the same potential, this potential being the same as the positive terminal of the source 35. Hence there is no charge across the condenser 37 as points A and B are at the same potential. When current begins to flow in the device 33, the voltage drop across the load  $L_1$  causes the potential of point A to swing in a negative direction. The condenser 37 thus takes on a charge and the point A swings negative with respect to the potential of the point B. If the tube 34 is not discharging this negative potential of the point A is not low enough to cause deionization of the gas in the device 33. As soon as the electron beam in the tube 10 passes between the plates 27 and 28 constituting the pair  $E_2$ , the gas-filled tube 34 "fires", that is the discharge is started in a manner similar to that described in the operation of the tube 33, and current flows through the load  $L_2$ . Immediately the condenser 37 is discharged through the tubes 33 and 34 in series and this causes the potential of the point A to swing even more negatively and reduce the positive potential of the anode 38 of the tube 33 to such an extent that deionization occurs, thus stopping the discharge in

that tube. The point B then swings negatively, causing the condenser 37 to become charged.

As soon as the beam is once again between the plates 23 and 24 the condenser 37 discharges again through the tubes 33 and 34 and this causes the point B to swing more negative, thus deionizing the tube 34 and cutting off the discharge in that tube. It will thus be seen that by this circuit arrangement, the start of the discharge in one gas-filled electron discharge device 33 or 34 stops the discharge in the other device.

The plates 25 and 26 constituting the pair  $E_3$  placed in the center of the tube 10 between the pairs of plates  $E_1$  and  $E_2$  act as a shield between the two pairs  $E_1$  and  $E_2$  to prevent ions from migrating from one pair of plates to the other pair thereby disturbing the action of the switching device. When the beam passes between the plates 25 and 26, a leakage current takes place between them because of the source of potential 30 connected therebetween. A "Thyratron" tube is not connected in this circuit, however, so no element in the external circuit is operative upon the passage of current between the plates 25 and 26. If desired, the flow of current between these plates may be limited by a resistance connected in series with the source 30 and the plates 25 and 26. The plates 25 and 26 serve to collect ions which might otherwise migrate from the pair  $E_1$  to  $E_2$  and vice versa.

By means of the arrangement described above, an electronic switch is provided for quickly switching between two loads without inertia and without interference between the various elements of the tube causing the switching. The loads may be relay circuits or amplifier circuits, if desired. Due to the gas in the tube 10 amplified current for control purposes can be obtained. If desired the beam may be modulated by applying telegraph signal potentials across the terminals 130 and 131 in Fig. 4. By means of the coupling condenser 132 and resistance 133, signal potentials are thus applied between the cathode 12 and the shield 13 to modulate the intensity of the beam. The shield 13 is negatively biased by the resistance 133 and the source 134. (The input circuit for the modulating signals, if desired, may comprise a transformer instead of the resistance-capacity coupling of Fig. 4.) The currents in the loads  $L_1$  and  $L_2$  comprise a series of small pulses representing a dot and a longer series of small pulses representing a dash. If the load circuits include relays, the high frequency component is removed and only the amplified dots and dashes of the original signal remain.

The external circuit to the right of the line XX in Fig. 1 may be replaced by the circuit shown in Fig. 2, all elements to the left of line XX being assumed to be similar to those to the left of the line XX in Fig. 1. The circuit of Fig. 2 is similar to the external circuit shown in Fig. 1 except for the fact that the gas-filled devices 33 and 34 are replaced by high vacuum tubes 50 and 51 and the condenser 37 is omitted. The modulating signals in this modification may be telegraphic or voice or image signals as the output currents of the tubes 50 and 51 are proportional to the input voltages. Due to the fact that the grids 52 and 53 cause the tubes 50 and 51 to be conducting when current flows through the resistances 31 and 32 and to be non-conducting when no current flows through the respective resistances in the input circuits of these

tubes, the condenser 37 in the circuit of Fig. 1 is not necessary in the circuit of Fig. 2. With the exception of these differences, the description of the method and operation of the circuit shown in Fig. 2 is similar to that explained above with reference to Fig. 1.

In the modification shown in Fig. 3, the pairs of plates  $E_1$  and  $E_2$  are replaced by a much larger number of electrode elements arranged in a circular path parallel to the frusto-conical wall of the tube. These electrode elements are designated  $T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, T_{10}, T_{11}$ , etc. A conducting coating 60 on the wall of the tube 61 serves as a common collector of the leakage current.

In the arrangement shown in Fig. 3, the cathode 12, the shield 13 and the anode 14 are similar to the corresponding elements described above with reference to Fig. 1 and they operate in the same manner. If desired the beam may be modulated as shown in Fig. 4. The deflecting plates 15 and 16 serve to cause vertical deflection of the beam and these plates are supplemented by an additional pair of deflecting plates 62 and 63 to cause horizontal deflection of the beam. Between the pairs of plates 15 and 16 and 62 and 63 are applied voltages of a wave form which is suitable to cause the electron beam to move in a circular path between each one of the electrode elements  $T_1, T_2, T_3$ , etc. and the common conducting coating 60 in succession. As a means for producing this circular sweep potential wave there is provided a sine wave oscillator 64 connected across a condenser 65 and a resistance 66 in series. The potential across the resistance 66 is applied between the plates 15 and 16 while the potential across the condenser 65 is applied between the plates 62 and 63. The values of the capacity of the condenser 65 and the resistance of the element 66 are so chosen that the voltage drops across these elements are equal at the frequency of the oscillations generated by the device 64. As these drops are substantially 90 degrees apart in phase, a beam is caused to move in a circular path in a manner well-known to the art.

The conducting coating 60 is connected to the positive terminal of a source of potential 30, the negative terminal of which is connected through resistances 71, 72, 73, 74, 75, etc. to the grids 81, 82, 83, 84, 85, etc. of the gas-filled tubes 91, 92, 93, 94, 95, etc. The grids 81, 82, 83, 84, 85, etc. are biased negatively with respect to the cathodes 101, 102, 103, 104, 105, etc. by means of the source of potential 35. The anodes 111, 112, 113, 114, 115, etc. of the gas-filled grid-controlled devices are connected respectively through loads  $L_1, L_2, L_3, L_4, L_5$ , etc. to the positive terminal of the source of plate potential 36, the negative terminal of which is connected to the cathodes 101, 102, 103, 104, 105, etc. Between anode 111 and anode 112 is connected condenser 121; between anode 112 and anode 113 is connected condenser 122; between anodes 113 and 114 is connected condenser 123; and between anode 114 and anode 115 is connected condenser 124. These condensers perform the same function as the condenser 37 in Fig. 1, that is, when tube 92 "fires" it extinguishes the discharge in tube 91, when tube 93 "fires" it extinguishes the discharge in tube 92, etc.

The operation of the device shown in Fig. 3 will now be explained. The beam of electrons generated and focused by the cathode 12, the shield 13 and the anode 14, in cooperation with the gas filling in the tube, is caused to move in a

circular path in succession between the electrode elements  $T_1, T_2, T_3$ , etc. and the conducting coating 60. When the beam is between  $T_1$  and the conducting coating 60, due to the potential difference between the plate  $T_1$  and the coating 60 caused by the source of potential 30, a leakage current takes place between these members similar to the leakage current taking place between the plates 23 and 24 comprising the pair  $E_1$  in Fig. 1, and this leakage current passing through the resistance 71 causes the negative bias on the gas-filled grid-controlled electron discharge device 91 to be decreased thus causing the tube 91 to become conducting and pass current through load  $L_1$  in its anode-cathode circuit. As soon as a discharge starts in the tube 91, point A swings in a negative direction causing the condenser 121 to assume a charge. Now, as soon as the beam moves from between the plate  $T_1$  and the conducting coating 60 to a position between the plate  $T_2$  and the conducting coating 60, the leakage current causes the tube 92 to become conducting in a manner similar to that described above in connection with tube 91. Upon the start of the discharge in the tube 92, the point B swings negative and this causes the point A to swing more negative decreasing the potential of the anode 111 to the point where deionization of the gas in the tube 91 sets in. In a similar manner when the beam is between the plate  $T_3$  and the conducting coating 60, tube 93 "fires" and upon the starting of the discharge in this tube 93 the discharge in the tube 92 is extinguished. By means of this arrangement, the tubes 91, 92, 93, 94, 95, etc. are caused to discharge in rotation, thus setting up currents through the loads  $L_1, L_2, L_3, L_4, L_5$ , etc., in rotation which load currents may be used to control other circuits if desired. As these tubes 91, 92, 93, 94, 95, etc. are conducting, by means of the circuit arrangement of Fig. 3, the discharge in the tube which has been "fired" previously is extinguished.

As a modification, the gas-filled tubes 91, 92, 93, 94, 95, etc. may be replaced by high vacuum tubes similar to those described above in connection with Fig. 2. With such an arrangement the condensers 121, 122, 123, 124 etc. are not necessary. If desired, the intensity of the beam may be modulate by a multiplex signal, and the various components of this signal are then switched into their respective channels represented by the loads  $L_1, L_2, L_3, L_4$  and  $L_5$ .

As a further modification, auxiliary single plates corresponding in function to the pair  $E_3$  in Fig. 1 may be provided between  $T_1$  and  $T_2$ , between  $T_2$  and  $T_3$ , etc. for shielding purposes.

Although specific embodiments of this invention have been illustrated and described, it is to be understood, of course, that other modifications may be made without departing from the scope and spirit of the invention as defined in the appended claims.

What is claimed is:

1. A cathode ray device comprising an envelope filled with gas and enclosing a number of pairs of plate electrodes, those of each pair being spaced relatively close together, means for biasing one electrode of each pair with respect to the other, means for generating a beam of electrons, and means for causing said beam to pass between the plates of each of the pairs of electrodes in turn to thereby cause a flow of current between the plates of each pair in turn.

2. A cathode ray device comprising an envelope filled with gas and enclosing a number of pairs

of electrodes, the electrodes of each pair being spaced relatively close together, means for biasing one electrode of each pair with respect to the other, means for generating a beam of electrons, and means for causing said beam to pass between the plates of each of the pairs of electrodes in succession to thereby cause successively a flow of current between the plates of each pair in turn.

3. A cathode ray device comprising an envelope filled with gas and enclosing a number of pairs of plate electrodes spaced relatively close together, auxiliary pairs of electrodes located between adjacent pairs of electrodes, cathode ray means for causing discharges between the plates of said first-mentioned pairs of electrodes in order, and means comprising said auxiliary pairs of electrodes for preventing discharges between the plates of one pair of electrodes from affecting the other pairs of electrodes.

4. An electron discharge device comprising an envelope filled with gas and enclosing means for generating a beam of electrons, a number of electrodes located in a circular path, an electrode common to all of said electrodes arranged in a circular path, and means for causing said beam to pass successively between each of the number of electrodes and the common electrode to thereby successively cause a flow of current between each of the number of electrodes and the common electrode.

5. An electron discharge device comprising an envelope filled with gas and enclosing means for generating a beam of electrons, a number of electrodes located in a circular path, an electrode common to all of said electrodes arranged in a circular path, said common electrode comprising a conducting coating placed on the inside wall of the envelope, and means for causing said beam to pass successively between each of the number of electrodes and the common electrode to thereby successively cause the flow of current between each of the number of electrodes and the common electrode.

6. An electron discharge device comprising an envelope filled with gas and enclosing means for generating a beam of electrons, a number of electrodes so arranged that their intercepts in any plane transverse to the longitudinal axis of the envelope lie substantially on the perimeter of a circle, the center of which lies on the longitudinal axis of the envelope, and means for causing said beam to be so deflected that it passes successively close to but does not touch each of the number of electrodes in turn to thereby ionize the gas in the immediate region of each of the number of electrodes in turn.

7. An electron discharge device comprising an envelope filled with gas and enclosing means for generating a beam of electrons, means for deflecting said beam so that it repeatedly traces the same path in any plane through which it passes, a number of electrodes so positioned that the beam of electrons during each deflecting cycle passes close to but does not touch each electrode in succession, and a single electrode arranged generally parallel to and biased with respect to all of said number of electrodes and on the opposite side of the beam of electrons therefrom, whereby said beam passes in turn between each of the number of electrodes and the single electrode to thereby successively cause a flow of current between each of the number of electrodes and the single electrode.

8. An electron discharge device comprising an

envelope filled with gas and enclosing means for generating a beam of electrons, a number of electrodes in said envelope, an additional electrode in said envelope common to all of said number of electrodes arranged in a closed path and biased with respect thereto, auxiliary electrodes located between adjacent ones of the number of electrodes, means for causing said beam to pass successively between each of the number of electrodes and the common electrode to thereby successively cause a flow of current between each of the number of electrodes and the common electrode, and means comprising said auxiliary electrodes for preventing discharges between the number of electrodes and the common electrode from affecting the other electrodes of the said number of electrodes.

9. An electron discharge device comprising an envelope filled with gas and enclosing means for generating a beam of electrons, a number of electrodes in said envelope, an additional electrode in said envelope common to all of said number of electrodes and biased with respect thereto, and means for causing said beam to pass successively between each of the number of electrodes and the common electrode to thereby successively cause a flow of current between each of the number of electrodes and the common electrode.

10. An electron discharge device comprising an envelope filled with gas and enclosing means for generating a beam of electrons, a number of electrodes in said envelope, a conducting coating placed on the inside wall of the envelope which is common to all of said number of electrodes and biased with respect thereto, and means for causing said beam to pass successively between each of the number of electrodes and the conducting coating to thereby successively cause a flow of current between each of the number of electrodes and the conducting coating.

11. A cathode ray device comprising an envelope filled with gas and enclosing two pairs of plate electrodes, the members of each pair being positioned relatively close together, an auxiliary pair of electrodes located between the two pairs of electrodes, cathode ray means for causing discharges between the respective plates of the two pairs of electrodes in succession, and means comprising said auxiliary pair of electrodes for preventing a discharge between the plates of one pair of electrodes from affecting the other pair of electrodes.

12. The combination with a gas-tight container having a filling of gas therein, of a conducting member in said container, a second conducting member all parts of which are spaced a small distance from said first member, said second member having at least one substantially straight edge of length much greater than said distance between said members, means for electrically charging one of said members positively with respect to the other whereby an electric field is established between them, means for producing a beam within said container, and means other than said conducting members to cause said beam to move sidewise past said edge into said field so that its position is substantially parallel to said edge as it enters said field whereby the gas between said members is ionized substantially simultaneously throughout the length of the space therebetween.

13. The combination with a gas-tight container having a filling of gas therein, of a conducting member in said container, a second conducting member all parts of which are spaced

a small distance from said first member, said second member having at least one substantially straight edge of length much greater than said distance between said members, means for electrically charging one of said members positively with respect to the other whereby an electric field is established between them, means for producing a beam within said container, and means other than said conducting members to cause said beam to move sidewise past said edge into said field so that its position is substantially parallel to said edge as it enters said field whereby the gas between said members is ionized substantially simultaneously throughout the length of the space therebetween and to cause the beam to be quickly removed.

14. The combination with a gas-tight container having a filling of gas therein, of a conducting member in said container, a second conducting member all parts of which are spaced a small distance from said first member, said second member having at least one substantially straight edge of length much greater than said distance between said members, means for electrically charging one of said members positively with respect to the other whereby an electric field is established between them, means for producing a beam of substantially constant intensity within said container, and means other than said conducting members to cause said beam to move sidewise past said edge into said field so that its position is substantially parallel to said edge as it enters said field whereby the gas between said members is ionized substantially simultaneously throughout the length of the space therebetween.

15. A cathode ray device comprising an enve-

lope filled with gas and enclosing a number of pairs of plate electrodes, those of each pair being spaced relatively close together, means for biasing one electrode of each pair with respect to the other, means for generating a beam of electrons, means for modulating said beam, and means for causing said beam to pass between the plates of each of the pairs of electrodes in turn to thereby cause a flow of current between the plates of each pair in turn.

16. The combination with a gas-tight container having a filling of gas therein, of a conducting member in said container, a second conducting member all parts of which are spaced a small distance from said first member, said second member having two substantially straight edges of length much greater than the distance between the members, said edges being tapered, means for electrically charging one of said members positively with respect to the other whereby an electric field is established between them, means for producing a beam within said container, and means other than said conducting members to cause said beam to move sidewise past one of said tapered edges into said field, the taper of said edge being such that the beam is substantially parallel to said edge as it enters the field, whereby the gas between said members is ionized substantially simultaneously throughout the length of the space therebetween, and to cause said beam to move sidewise past the other of said tapered edges out of said field, the taper of the other of said edges being such that the beam is substantially parallel to this edge as it passes out of said field.

ALBERT M. SKELLETT.