

Aug. 18, 1942.

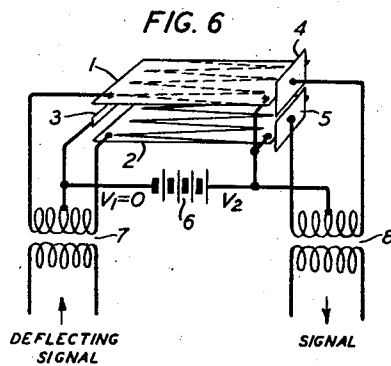
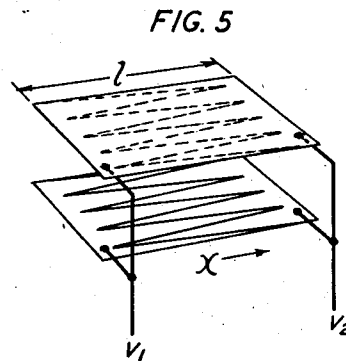
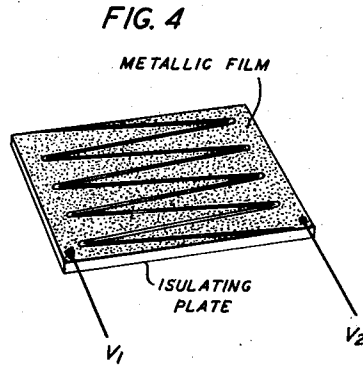
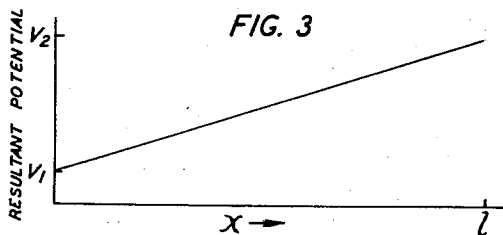
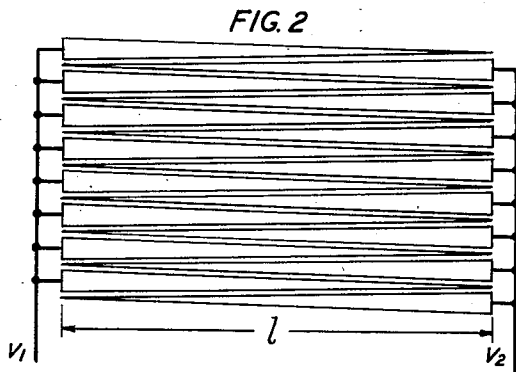
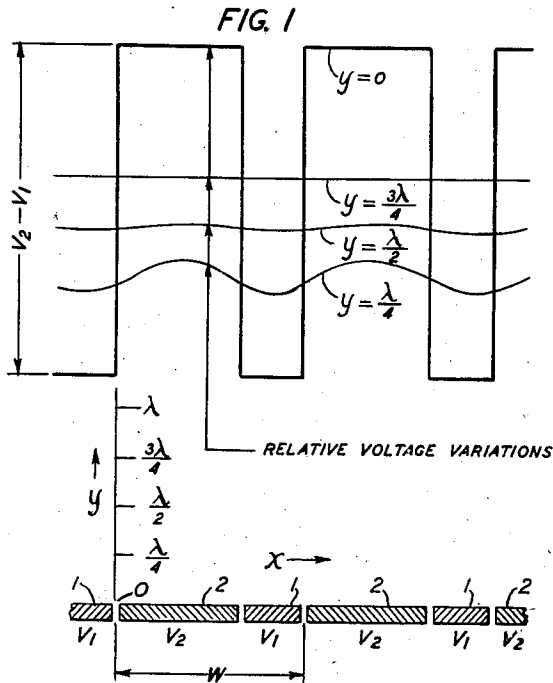
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2,293,539

ELECTRON DISCHARGE DEVICE

Filed Aug. 16, 1939

4 Sheets-Sheet 1



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ELECTRON DISCHARGE DEVICE

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FIG. 7

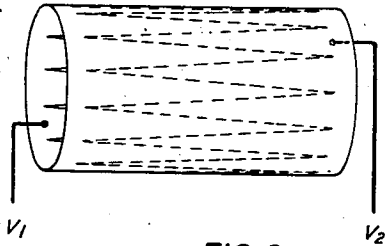


FIG. 8

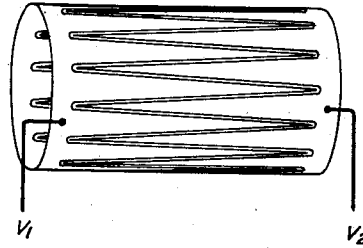


FIG. 9

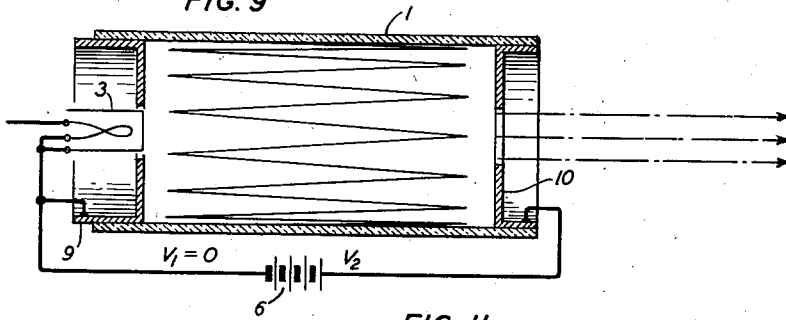


FIG. 11

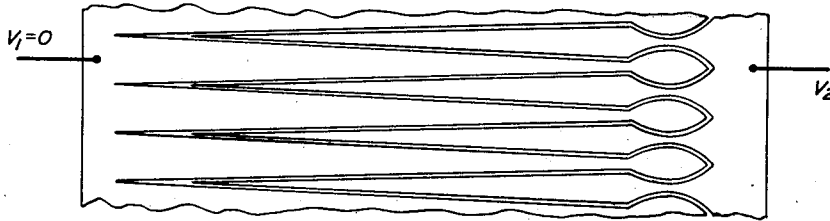


FIG. 10

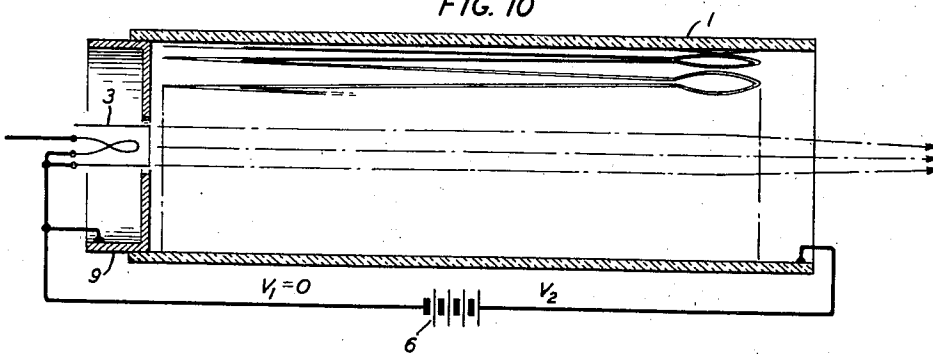


FIG. 12



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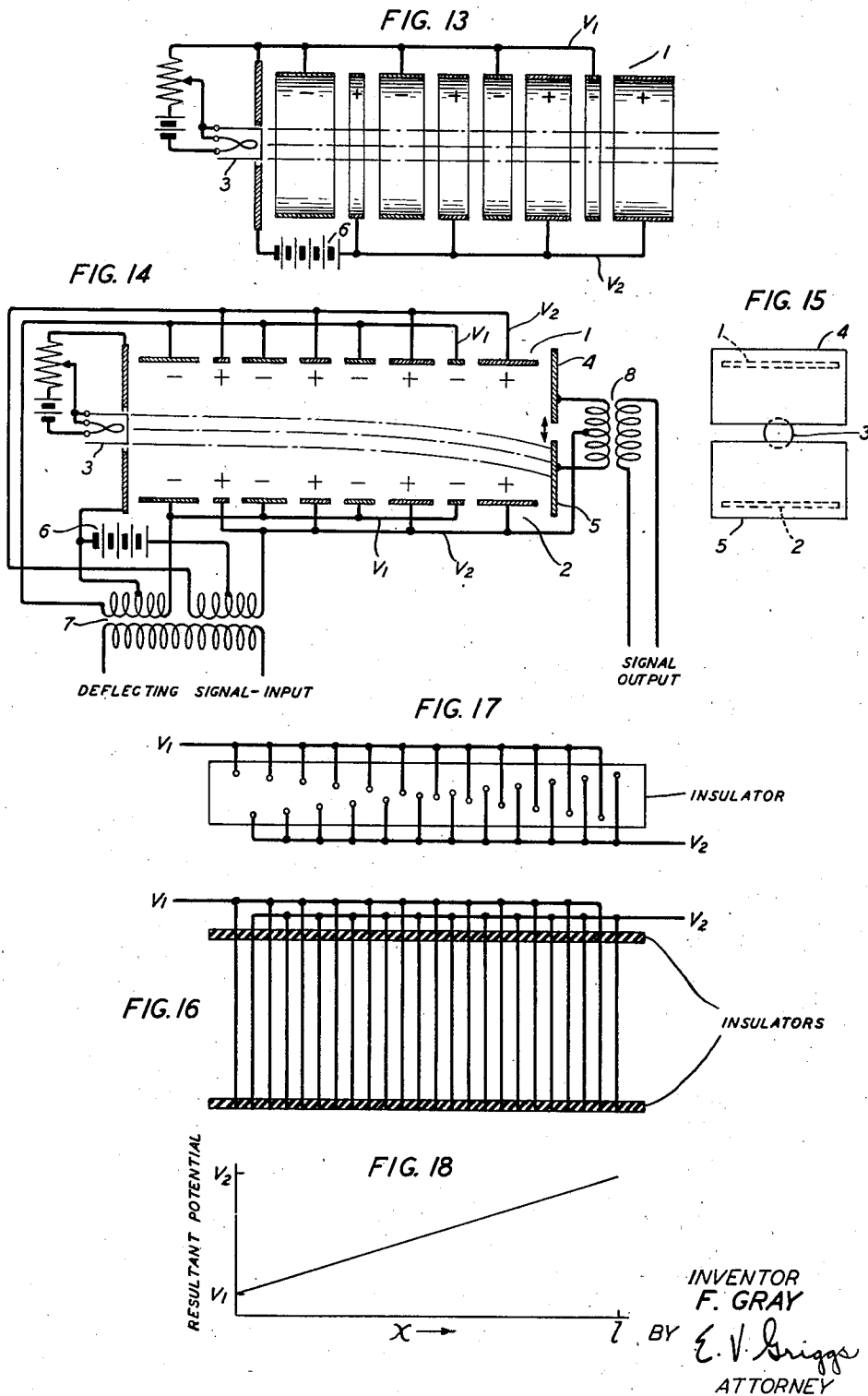
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FIG. 19

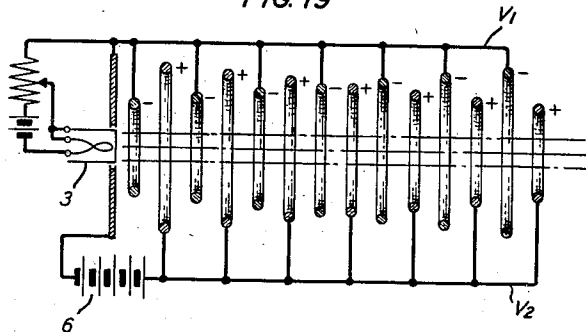


FIG. 20

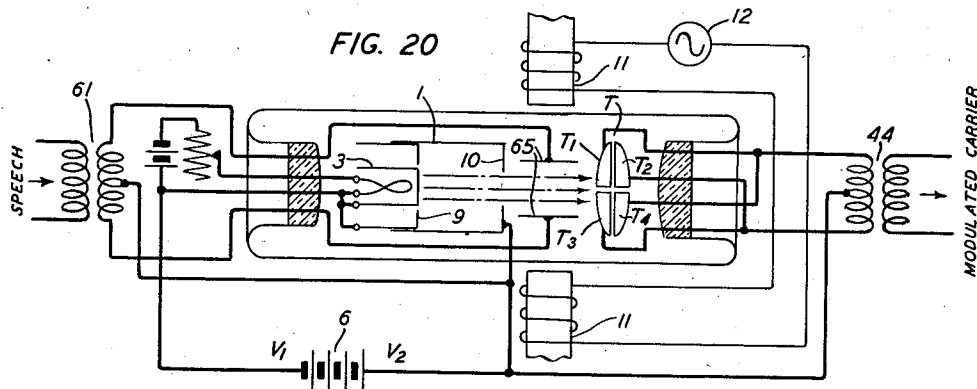
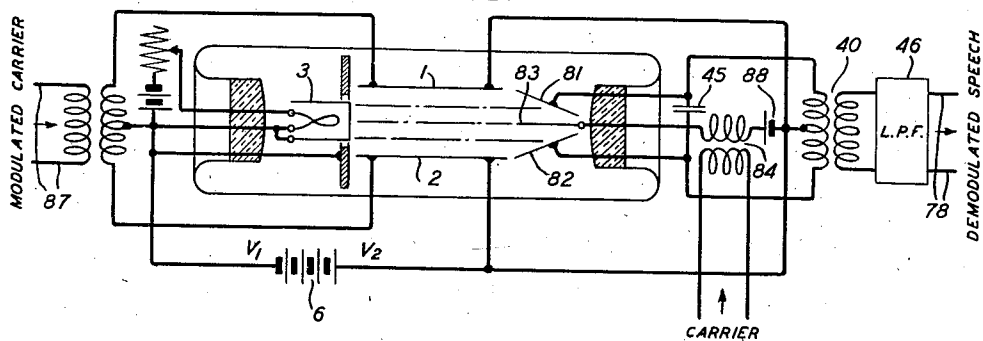


FIG. 21



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2,293,539

ELECTRON DISCHARGE DEVICE

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Application August 16, 1939, Serial No. 290,359

16 Claims. (Cl. 250-155)

This invention relates to electron discharge devices, and, more particularly, to means for providing in such devices a uniform electric field for accelerating and deflecting a stream of electrons.

A principal object of the invention is to provide an accelerating field for an electron stream which is sufficiently uniform to prevent dispersion of the electrons and maintain the stream parallel over a considerable distance without the use of excessively large electrodes.

Another object is to provide deflecting electrodes which will at the same time produce a longitudinal accelerating field.

Another object is to provide an accelerating field of a predetermined non-uniform type, that is for instance, one which is parallel for a distance when altered in a way to focus an electron stream traversing it.

In electron discharge tubes where it is desired to project the electron stream over a considerable distance or where a stream of considerable cross-sectional area is to be projected, an accelerating field which is uniform for a considerable distance to avoid dispersion of the electrons or which varies in a predetermined manner is frequently required. To approximate such fields with transverse flat plate or other conventional electrodes requires the electrodes to be large compared with the dimensions of the electron path. The composite electrode which is the subject of this invention overcomes this difficulty and offers other advantages since it encloses the field and need be little larger in directions transverse to the electron beam than the beam itself.

This composite electrode consists of two or more parts at different voltages interleaved in such a manner that the resultant voltage near the surface of the electrode varies from one region of its surface to another. Since the individual parts of the electrode contribute to the resultant voltage and their contributions vary from one region of the electrode to another, the resultant voltage is caused to vary in a corresponding manner. This spacial variation in voltage is the important feature of the composite electrode. The electrode may be constructed as an array of parts, or small electrodes, lying in a common surface, the parts being at different voltages and the relative areas varying from one region of the surface to another. Another form of construction is to arrange the parts of the composite electrode not in a common surface but interleaved so as to shield one another, the degree of shielding varying from one region to another, and in this manner causing a correspond-

ing variation in the resultant voltage over the surface of the electrode.

In the description to follow, the principle of operation of the composite electrode is explained in more detail and illustrations of its application to circuits are given.

In the drawings,

Fig. 1 is a chart showing that voltage irregularities introduced by the use of necessarily discrete electrode elements extend into the space adjacent to the composite electrode only a very short distance from its surface;

Fig. 2 shows a form of structure of a composite electrode to produce a uniform field over an extended region;

Fig. 3 is a graph showing the distribution of the resultant potential along the length of the electrode of Fig. 2;

Fig. 4 shows a convenient method of constructing an electrode of the type shown in Fig. 2;

Fig. 5 shows the way two composite plate electrodes as shown in Fig. 4 may be assembled to produce a uniform field;

Fig. 6 shows how two composite plate electrodes may be used to produce a ribbon-like beam of electrons and sweep the beam over a target;

Fig. 7 shows a tubular composite electrode for producing a uniform field;

Fig. 8 shows an alternative equivalent form of structure wherein a solid self-supporting cylinder is cut into two closely adjacent parts which may be maintained at the two voltages V_1 and V_2 to enclose a uniform electric field;

Fig. 9 shows an arrangement of the tubular electrode for producing a beam of electrons in a simple manner;

Fig. 10 shows a tubular composite electrode designed to act as a lens system and focus an electron beam;

Fig. 11 shows the development of a portion of the electrode surface of Fig. 10;

Fig. 12 shows a lens system which is the optical equivalent of the electrical system of Fig. 10;

Fig. 13 shows an alternative form of tubular composite electrode for producing a uniform field;

Fig. 14 shows an alternative form of composite plate electrode adapted to accelerating and deflecting an electron beam in a manner similar to that shown in Fig. 6;

Fig. 15 is an end view of the assembly shown in Fig. 14;

Fig. 16 shows a form of flat, plate type, composite electrode where the voltage variations are

obtained through shielding effects of the elements of the electrode;

Fig. 17 is a side view of the assembly shown in Fig. 16;

Fig. 18 is a graph showing the distribution of the resultant potential over the length of the electrode of Fig. 16;

Fig. 19 illustrates a tubular form of electrode utilizing shielding effects as shown in Fig. 16;

Fig. 20 shows an application of the composite electrode to a linear modulator circuit; and

Fig. 21 shows the application of composite electrodes to a demodulator circuit.

In order that the functioning of the composite electrode may be clearly understood, the results of a mathematical analysis of the field of a simple form of such an electrode are shown in Fig. 1. The electrode is indicated as made up of a long array of two groups of narrow strips 1, 1, 1 and 2, 2, 2. Alternate strips, 1, 1, 1 . . . , are maintained at voltage V_1 and those in between, 2, 2, 2 . . . , are maintained at voltage V_2 , the strips at voltage V_1 being twice as wide as those at voltage V_2 . Assuming that the electric field is uniform at an infinite distance in front of the electrode and taking W as the combined width of two successive strips, the solution for the electric potential V at a point in space any distance y in front of the electrode is

$$V = ay + \frac{2V_2 + V_1}{3} + \sum b_n \sin \frac{2\pi nx}{W} \text{Exp.} \left(-\frac{2\pi ny}{W} \right)$$

where n has successive integral values, and

$$b_n = \frac{2}{\pi n} \sin \left(\frac{2\pi n}{3} \right) (V_2 - V_1)$$

At a given distance y from the electrode surface the variation in potential is given by the series of sinusoidal terms. The exponential factor reduces the variation rapidly with increasing distances from the electrode and the electric field soon becomes substantially uniform. The curves show the potential V as a function of x at distances 0, $W/4$, $W/2$ and $3W/4$ from the electrode surface. It will be seen that while the voltage variation along the electrode in the x direction indicated is $V_1 - V_2$ at the surface of the electrode it is about one-tenth of that at a distance $y = W/4$ and at distances greater than $3W/4$ the field is substantially uniform. At such distances the potential is

$$V = ay + \frac{2V_2 + V_1}{3}$$

This is the potential that would occur if the composite electrode were replaced by a continuous plane electrode at the voltage

$$\frac{2V_2 + V_1}{3}$$

This is the resultant voltage of the composite electrode and it is seen to equal the mean voltage taken according to areas.

From the above it may be reasoned that any composite electrode made up of small electrodes lying in a common plane will behave in a manner analogous to this simple example. At distances away from the composite electrode greater than the dimensions of the component electrodes the potential is smoothed out and the field produced is the same as if the composite electrode were a continuous surface at a voltage equal to the mean voltage taken according to area.

The above analysis of the general principle of the composite electrode has been based on an

electrode in which the relative areas of the two interleaved electrodes are proportioned the same over the entire area considered. The electrodes generally used are constructed so that the relative areas at the different voltage components vary from one region of the surface to another, causing the resultant voltage to vary in a corresponding manner. The above analysis can, of course, be applied directly to any component small region of such an electrode.

Fig. 2 shows an arrangement for a type of such an electrode (in which the relative areas of the two interleaved electrodes and, consequently, the resultant voltage vary from one region of the surface to another) to produce a uniform electric field over an extended region. This is a type of field that requires an inconveniently large structure when it is produced with the usual parallel plates. It is composed of a series of wedge-shaped strips with the alternate wedges pointing in opposite directions. One set of wedges is at a voltage V_1 and the other set is at a voltage V_2 . The resultant voltage of the composite electrode then varies uniformly in the direction of the length of the strips, from V_1 at one end of the electrode to V_2 at the other end as shown by the graph Fig. 3.

A convenient method of constructing the composite electrode is to coat an insulating plate with a metallic film, as shown in Fig. 4, with the film cut along the zig-zag line to give the two sets of interleaved wedges which are polarized to two different voltages V_1 and V_2 as shown and described in connection with Fig. 2.

A uniform field is produced by arranging two such composite electrodes parallel to each other as shown in Fig. 5. The potentials between the electrodes are the same as if they were replaced by continuous surfaces at their resultant potentials. The solution for the potential V between the two plates, disregarding end effects, is then

$$V = V_1 + \frac{x}{l} (V_2 - V_1)$$

when x is the coordinate along the length of the wedges and l is the length of the electrode as indicated in both Fig. 2 and Fig. 5. The electric intensity E is

$$E = \frac{V_2 - V_1}{l}$$

and is uniform over practically the entire region between the plates.

Fig. 6 shows how two parallel electrodes, 1 and 2, may be arranged to give a ribbon-like beam of electrons and sweep the beam over a target. In the absence of a deflecting voltage the field is uniform, it draws electrons from the cathode 3 and carries them in a ribbon-like beam to the split target 4, 5. Each of the electrodes, 1 and 2, is composed of two sets of alternate wedges as shown in Fig. 2. One set of wedges in both 1 and 2 is connected to the negative of the polarizing source 6 which is normally connected to the cathode and at ground potential. The other sets of wedges in both 1 and 2 are connected to the positive of the polarizing source 6 and may be at the potential of the target 4, 5. The transformer 7 impresses a deflecting voltage across the two sets of low voltage wedges to deflect the beam over the target 4, 5. When operated in this way with both polarizing and deflecting voltages, the field between the two composite electrodes is substantially a uniform field whose direction changes with the deflecting voltage. This arrangement

will function as an amplifier since through the voltages induced in the two parts of the target, 4 and 5, an output in accordance with the input deflecting signal impressed on the input transformer 7 is delivered through the output transformer 8. As an alternative, the deflecting voltage may be applied across the two sets of positively polarized, high voltage, wedges, or it may be applied to both high and low voltage sets of wedges using connections as shown in Fig. 14. Also, the cathode may be heated directly, or indirectly as shown in Fig. 14 and the electron beam may be ribbon-like as mentioned, or any desired shape. With any of these arrangements the device may be used as a deflection amplifier.

A tubular arrangement for producing a uniform field is shown in Fig. 7. The individual electrodes are wedge-shaped and the two sets of wedges are polarized at two different voltages V_1 and V_2 , as in the plate electrodes of Fig. 4, Fig. 5 and Fig. 6, but the composite surface is a cylinder. The resultant potential of its cylindrical surface varies linearly with distance along the axis and the field within the cylinder is a uniform electric field. This composite electrode can be conveniently constructed by coating the inside of an insulating tube with a metallic film and cutting through the film to form the two sets of interleaved wedges. This type of construction is indicated in Fig. 7. Another form of construction giving an equivalent structure is shown in Fig. 8 where a solid cylinder is cut into two parts which are fitted closely together but spaced to be electrically insulated from each other.

The cylindrical composite electrode may be used as shown in Fig. 9 for producing a beam of electrons in a simple manner. The composite electrode 1 is for example shown as a glass tube with the two sets of wedges formed on its interior by cutting a metallic film deposited thereon. The two sets of wedges are polarized by the battery source 6, the lower voltage set of wedges being connected through the guard plate, or shield 9, which has a push fit into the tube, and the higher voltage set of wedges being connected through the cap 10 which has a push fit into the tube at the opposite end and may be apertured to shape the beam of electrons as shown. The cathode is shown indirectly heated at 3 and electrons drawn from it by the field within the electrode are projected through the aperture in the cap 10 in a parallel beam as shown.

The electrodes which have been described are relatively simple examples which illustrate the principles. It should be understood that composite electrodes can be very broadly applied as they can be constructed to give almost any desired electric field. For example, in the tubular electrode of Fig. 7 the individual electrodes are wedge-shaped to give a linear variation of voltage along the axis. But any other reasonable variation of voltage along the axis can be produced by making a composite surface that gives the corresponding resultant voltage along the cylindrical surface. For instance, an electron focussing system can be made in this manner and an example of such an electron-lens system is shown in Fig. 10. The general arrangement of the figure and the designations are the same as in Fig. 9. To indicate the shape of the individual electrodes a portion of the interior of the electrode tube is shown developed in Fig. 11. It will be noted that the individual electrodes are wedge-shaped at the end toward the cathode

so that a uniform field in the initial portion of the cylindrical electrode draws electrons from the cathode and carries them in a parallel beam to the point where the portions of the electrode at the lower voltage, V_1 , increase in area. This region brings the beam to a point focus at the right of the figure as indicated by convergence of the lines indicating the electron beam in a manner similar to the way the optical lens system shown in Fig. 12 brings a beam of light to a focus. This type of electron gun is useful in oscillograph tubes and other devices where focusing of the electron beam is required.

In the composite electrodes which have been described the individual electrodes have been strip-like in shape and the resultant voltage varied only in the general direction of their length so that they are in a sense one-dimensional electrodes. It is obvious that the composite structure can be made to vary in two dimensions so that the resultant voltage can be made to vary in two dimensions over the surface of the electrode.

In Fig. 13 is shown an alternative structure for a composite cylindrical electrode. Here instead of using for the individual electrodes tapered strips or wedges placed longitudinally along the length of the electrode, two sets of rings or sections of cylinders of varying lengths are arranged along the common axis of the electrode and the electron beam. Alternate rings are connected to voltages V_1 and V_2 , respectively, as shown. The lengths, and thus the areas, of the rings at the two voltages decrease progressively in opposite directions along the length of the electrode so that the resultant voltage and the electric field produced are obviously very similar to those obtained with the wedge-shaped individual electrodes.

Fig. 14 and Fig. 15 illustrate a similar form of structure for plate electrodes adapted to accelerating and deflecting an electron beam as described in connection with Fig. 6, Fig. 15 being an end view of the structure to show clearly the shape of the electrode plates 1 and 2 and of the parts 4 and 5 of the target. The numerical designations are the same as those of Fig. 6. As will be seen, composite plate electrodes 1 and 2 are each made up of rectangular strips of different widths arranged with their lengths transverse to the axis of the electron beam. Alternate strips are connected to voltages V_1 and V_2 , respectively, as shown. Since the strips at the two voltages decrease in width progressively in opposite directions along the length of the electron path, the resultant voltage and the electric field produced are very similar to those obtained with the individual wedge-shaped electrodes in Fig. 6. It will be noted that in this figure the input transformer 7 has two windings to permit placing the deflecting voltage on both the high and low voltage portions of the electrodes, whereas in Fig. 6 the deflecting voltage is shown connected only to the low voltage parts of the electrodes. Either arrangement may be used. The operation of the circuit of Fig. 14 is the same as that of Fig. 6.

Fig. 16 and Fig. 17 illustrate a type of composite electrode in which the individual electrodes are interleaved and the spacial variation in the resultant voltage is obtained by allowing the individual electrodes to shield one another, the degree of shielding varying from one region to another, thus causing a corresponding variation in the resultant voltage over the surface of the electrode. Fig. 17 is a side view and Fig. 16 a plan

view of the electrode. This electrode is to produce a linear variation in voltage along its surface and is equivalent to the electrode shown in Fig. 2. It is made up of two groups of parallel wires which are located near, but not exactly in, a common plane. One group is at a potential V_1 and the other group at a potential V_2 . At one end of the electrode the wires of group 2 are located so far behind the wires of group 1 that the latter completely shield the former and the resultant potential is determined by group 1 alone. At the other end the wires of group 1 are so shielded that the resultant potential is determined by group 2 alone. The shielding changes gradually from one end of the electrode to the other and in such a manner that the resultant voltage varies linearly along the electrode. It is easily seen, for example, that at the middle of the electrode both groups contribute equally to the resultant voltage and it is equal to

$$\frac{V_1 + V_2}{2}$$

as it should be for linear variation along the electrode. The shielding can, of course, be arranged to give some form of voltage variation other than linear, if desired. The graph in Fig. 18 shows the linear variation of the resultant voltage between the values V_1 and V_2 . Two flat electrodes of the type shown in Fig. 16 can be used for deflecting purposes the same as two of the type shown in Fig. 4 are used in Fig. 6 or as illustrated in Fig. 14.

A composite electrode of the type shown in Fig. 16 can be made in cylindrical form. In Fig. 19, where designations are as in previous figures, is illustrated one method of doing this. The wires shown in section in the figure form circles or hoops, much as grid wires in an ordinary vacuum tube. They are assembled to be coaxial along the axis of the electron beam. Wires at the two voltages V_1 and V_2 alternate along the axis and the circles formed by the wires of each group change in diameter progressively along the axis as indicated to provide shielding effects the same as are obtained with the arrangement of Fig. 16. With the uniform arrangement shown, the resultant voltage along the electrode is proportional to the distance and a uniform field is produced. The wires may be arranged in non-uniform manners to produce non-uniform fields of various types, for instance, such as to obtain focussing effects as described in connection with Fig. 7.

Composite electrodes may be used to advantage also in the modulator and demodulator tubes described in the applicant's copending application Serial No. 276,044.

Fig. 20 shows a cylindrical composite electrode similar to that of Fig. 9 applied to a modulator tube which is equivalent to and operates in a manner similar to that of Fig. 12 in the above-mentioned copending application when using a target of the type shown in Fig. 15 in the same application.

In Fig. 20, of the present application, the composite electrode 1, which it will be seen is constructed and connected as shown in Fig. 9, draws a beam of electrons from the cathode 3 and projects them through a square aperture in the cap 10 toward the target T. The electron beam is moved vertically over the target by the deflecting plates 65 which are energized by the modulating speech or signal through transformer 61. The electron beam is moved horizontally over the target by the field of magnet 11 which is energized by the source 12 of the carrier wave which

is to be modulated. The combined motions of the electron beam over the target result in a modulated output through the transformer 44 as explained in connection with Fig. 12 of the applicant's copending application Serial No. 276,044, previously mentioned. Designations on Fig. 20 of the transformers 61 and 44, the deflecting plates 65 and the target T correspond to those in Fig. 12 and Fig. 15 in that application (Serial No. 276,044). It may be noted in connection with that explanation that if a modulated wave is impressed on the plates 65 instead of a modulating signal the device may be made to act as a demodulator.

Fig. 21 shows two flat plate composite electrodes as shown in Fig. 4 and Fig. 6 applied to a demodulator tube which is similar to that of Fig. 18 in the applicant's copending application Serial No. 276,044, referred to above. Except for the cathode 3, composite electrodes 1 and 2 and the electrode polarizing battery 6, which designations correspond to those in Fig. 6, the designations of circuit elements of Fig. 21 correspond to those of Fig. 18 in the copending application. Here the composite electrodes 1 and 2 produce a uniform accelerating field as well as serving as deflecting plates making unnecessary separate accelerating and focussing electrodes such as 80 and 86 in Fig. 18 of the copending application referred to. The deflecting signal, in this case the modulated carrier input at 87, is connected to the portions of the electrodes 1 and 2 which are maintained by battery 6 at potential V_1 as illustrated in Fig. 4 and Fig. 6. The battery 6 also polarizes the other parts of electrodes 1 and 2 and electrode 83 at voltage V_2 . The uniform field between the composite electrodes 1 and 2 draws electrons from the cathode 3 and projects them toward the split target 81, 82. The deflections of the electron beam in conjunction with the voltage variations of collector 83 caused by the carrier impressed on transformer 40 and produce a demodulated output as explained in connection with Fig. 18 in the applicant's copending application referred to.

The advantages of the composite electrode in these last two applications, as in others, are that the electrodes are relatively small, that they can deflect and focus as well as accelerate an electron beam and in general facilitate the production and control of high current electron beams.

The field of application of composite electrodes as herein disclosed, whereby desired types of electric fields are obtained through spacial variation of voltage over the surfaces of such electrodes, is very large and many forms of construction are possible so that the illustrative embodiments shown are necessarily in the nature of examples only. It is to be understood, therefore, that the invention is not to be considered as limited to the particular embodiments described herein.

What is claimed is:

1. In an electron discharge device, a plurality of combined accelerating and deflecting electrodes of composite type each composed of a plurality of conducting elements insulated from each other which may be charged to different potentials to produce an electric field along the length of the electrodes, the relative areas of the elements of each electrode being varied throughout the length of the electrode in a manner to vary the intensity of the longitudinal field linearly, the composite electrodes being insulated

from each other so that potentials may be superposed between them to produce transverse deflecting fields at substantially right angles to the longitudinal field.

2. In an electron discharge device, a plurality of combined accelerating and deflecting electrodes of composite type each composed of a plurality of electrically separated conducting strips arranged adjacent to each other along the direction of the electron path with their widths extending in the direction of the electron path and their lengths transverse to the path, the strips being of progressively non-uniform widths, and such that they may be charged electrically so that each strip is of opposite polarity from that which is physically nearest to it on either side, the wider strips farther from the cathode being the more positive and the wider strips nearer the cathode being the more negative to produce an accelerating field along the electron path, the electrodes being such that potentials may be superposed between them to produce deflecting fields at substantially right angles to the longitudinal accelerating field.

3. An electron discharge tube having a cathode, at least one pair of composite plate electrodes between which is located the path of the electron stream, each composite electrode being composed of two or more conducting elements insulated from each other and with those portions of the surfaces of adjacent elements which are exposed to the path commingled so that the combined surface which is exposed to the electron stream, and so capable of affecting it, varies along the direction of the path from being substantially entirely of one element at one place to being substantially entirely of the adjacent element at another, while in between the combined exposed surface is a mixture of the two elements the portion of each diminishing in the direction of where the other preponderates and a two-part anode at the end of the discharge path, the elements of the composite electrodes being adapted to be charged at different potentials such that the element which preponderates farthest from the electron emitter is most positive, to produce an accelerating field in the direction of the electron stream, the composite electrodes being such that alternating voltages may be applied between them to produce an alternating deflecting field transverse to the electron path and deflect the electron stream from one part of the anode to the other.

4. In an electronic device, a composite electrode utilizing a series of conducting elements in the form of rods positioned along the discharge path, the rods being insulated from each other and each extending transverse to the direction of the path, the individual rods being placed outside of the zone of the discharge path and at various distances from the discharge path so that the nearer ones shield the electron stream from the influence of the more distant ones to a greater or less degree depending upon the relative positions of the rods, the individual rods being adapted to be charged electrically so that in different regions of the electrode rods charged to different potentials will preponderate nearest to the electron path.

5. In an electron discharge device, a plurality of combined accelerating and deflecting electrodes of composite type, each electrode comprising a plurality of conducting elements insulated from each other and displaced from each other in a direction generally longitudinal with

respect to the electron stream which may be charged to different potentials to produce an accelerating electric field along the length of the electrode in the region and direction of the electron path, the composite electrodes being insulated from each other and displaced from each other in a direction generally transverse with respect to the electron stream so that potentials may be superposed between them to produce transverse deflecting fields at substantially right angles to the longitudinal accelerating field.

6. In an electron discharge device, a plurality of combined accelerating and deflecting electrodes of composite type, each electrode comprising a plurality of conducting elements insulated from each other and displaced from each other in a direction generally longitudinal with respect to the electron stream which may be charged to different potentials to produce an accelerating electric field along the length of the electrode in the region and direction of the electron path, the variation in intensity of the accelerating field along the length of the electrode being predetermined by appropriate variations in the relative dimensions and positions of the elements along the length of the electrode, the composite electrodes being insulated from each other and displaced from each other in a direction generally transverse with respect to the electron stream so that potentials may be superposed between them to produce transverse deflecting fields at substantially right angles to the longitudinal accelerating field.

7. An electron discharge device comprising a plurality of combined accelerating and deflecting electrodes of composite type, each electrode comprising a plurality of conducting elements insulated from each other and displaced from each other in a direction generally longitudinal with respect to the electron beam which may be charged to different potentials to produce an accelerating electric field along the length of the electrode in the region and direction of the electron path, the intensity of the field at points along the electron path being dependent upon the resultant potentials produced at those points by the adjacent portions of the differently charged electrode elements and consequently upon the charging potentials, sizes and positions of the adjacent portions of elements, the composite electrodes being insulated from each other and displaced from each other in a direction generally transverse with respect to the electron stream so that potentials may be superposed between them to produce transverse deflecting fields at substantially right angles to the longitudinal accelerating field.

8. In an electron discharge device, a plurality of combined accelerating and deflecting electrodes of composite type each composed of a plurality of conducting elements insulated from each other which may be charged to different potentials to produce an electric field along the length of the electrodes, the relative areas of the elements of each electrode and the relative positions of the elements being related throughout the length of the electrode so as to vary the intensity of the longitudinal field in a desired manner, the composite electrodes being insulated from each other so that potentials may be superposed between them to produce transverse deflecting fields at substantially right angles to the longitudinal field.

9. In an electron discharge device, a plurality of combined accelerating and deflecting elec-

trodes of composite type each composed of a plurality of conducting elements insulated from each other which may be charged to different potentials to produce an electric field along the length of the electrodes, the elements of each electrode being shaped and positioned with respect to each other throughout the length of the electrode so as to vary the intensity of the longitudinal field in a desired manner, the composite electrodes being insulated from each other so that potentials may be superposed between them to produce transverse deflecting fields at substantially right angles to the longitudinal field.

10. In an electron discharge device, an electrode comprising conducting elements spaced along the electron path of the device insulated from each other and adapted to be charged electrically from a source of direct potential in alternate fashion so that alternate elements are at the same potential and each element is of opposite polarity from that which is physically nearest to it on either side, each element being electrically disconnected from the elements adjacent to it on either side, the elements being outside of the zone of the electron path and at varying distances from the electron path so that the elements nearer the path shield the electron stream from the influence of the elements farther from it to a greater or less degree depending upon the relative positions of the elements so that at different points along the path elements preponderating nearest the path will be charged to different potentials.

11. An electron discharge device having an electron emitter and an electron collector, a composite electrode for producing an electric field in the region of the electron path between the emitter and collector, the electrode comprising a plurality of elements spaced along the path, alternate elements being electrically connected to each other and being varied along the path in the relative areas exposed to the electron stream, and the remaining elements of the electrode being insulated from the alternate elements and electrically connected to each other, the distance between the elements and the center of the electron stream being of the order of three-quarters of the combined exposure along the path of two adjacent elements.

12. An electron discharge device having an electron emitter and an electron collector, a composite electrode for producing an electric field in the region of the electron path between the emitter and collector, the electrode comprising a plurality of elements spaced along the path, alternate elements being electrically connected to each other and being varied along the path in the relative areas exposed to the electron stream, and the remaining elements of the electrode being insulated from the alternate elements and electrically connected to each other, the distance between the elements and the center of the electron stream being greater than three-quarters of the combined exposure along the path of two adjacent elements.

13. An electron discharge device having an electron emitter and an electron collector, a composite electrode for producing an electric field in the region of the electron path between the emitter and collector, the electrode comprising a plurality of elements spaced along the path, alternate elements being electrically connected

to each other and being varied along the path in the relative areas exposed to the electron stream, and the remaining elements of the electrode being electrically connected to each other and being varied along the path in their relative areas exposed to the electron stream in a fashion which is the converse of that of the alternate elements.

14. In an electronic device, a composite electrode utilizing a series of conducting elements in the form of rods positioned along the discharge path a short distance therefrom, each rod extending transverse to the direction of the path, the individual rods being placed outside of the zone of the discharge path and at various distances from the path so that the nearer ones shield the electron stream from the influence of the more distant ones to a greater or less degree depending upon the relative positions of the rods, the rods also being interconnected in at least two groups which are electrically disconnected from each other, extend generally along the direction of the electron path and are adapted to be charged to different polarizing potentials so that in different regions along the path rods charged to different potentials will preponderate nearest to the path.

15. In an electron discharge device, at least one pair of combined accelerating and deflecting electrodes of composite type, each such electrode comprising a plurality of conducting elements insulated from each other and displaced from each other in a direction generally longitudinal with respect to the electron stream whereby the elements may be charged to different potentials to produce an accelerating electric field along the length of the electrode in the region and direction of the electron path, the composite electrodes comprising a pair being insulated from each other and displaced from each other in a direction generally transverse with respect to the electron stream so that potentials may be superposed between them, with the same superposed potential applied to the elements of each electrode as a group, to produce transverse deflecting fields at substantially right angles to the longitudinal accelerating field.

16. In an electric discharge device, at least one pair of combined accelerating and deflecting electrodes of composite type, each such electrode comprising a plurality of conducting elements insulated from each other and displaced from each other in a direction generally longitudinal with respect to the electron stream whereby the elements may be charged to different potentials by connecting elements adjacent to each other in longitudinal spacing to opposite poles of a single potential difference source to produce an accelerating electric field along the length of the electrode in the region and direction of the electron path, the composite electrodes comprising a pair being insulated from each other and displaced from each other in a direction generally transverse with respect to the electron stream so that potentials may be superposed between them, with the same superposed potential applied to the elements of each electrode as a group, to produce transverse deflecting fields at substantially right angles to the longitudinal accelerating field.

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