

Jan. 20, 1948.

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2,434,713

BEAM DEFLECTION TUBE HAVING PARALLEL FOCUSING AND BEAM DEFINING PLATES

Filed Nov. 1, 1944

2 Sheets-Sheet 1

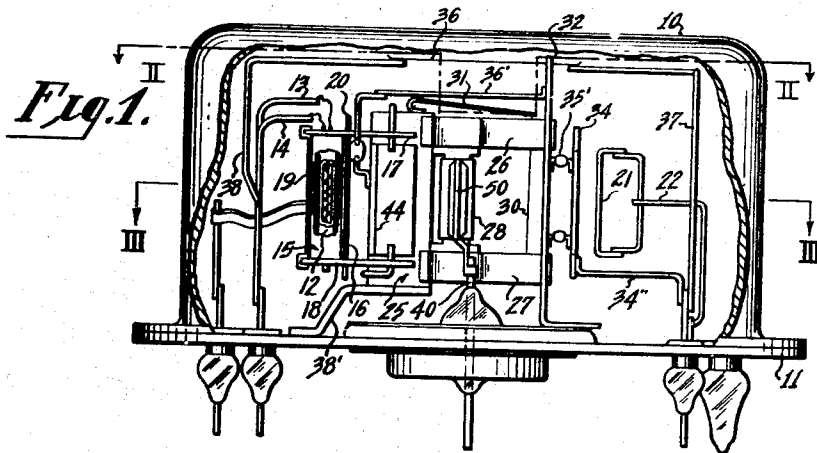


Fig. 2.

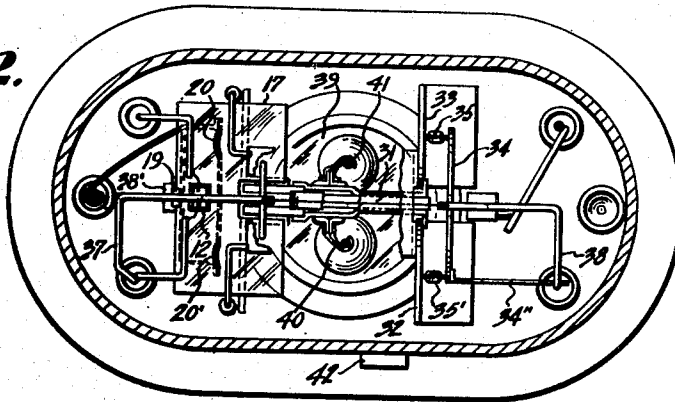
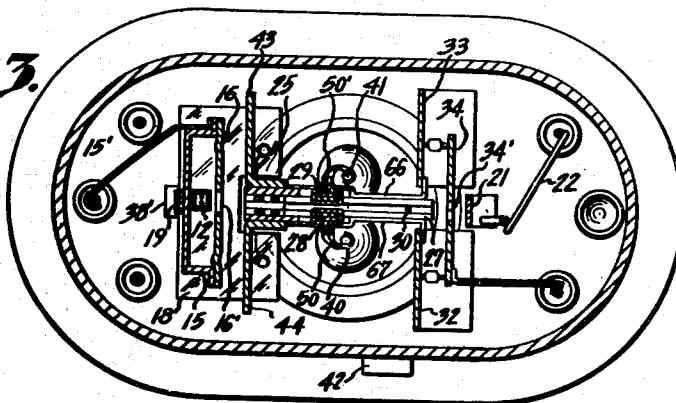


Fig. 3.



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2 Sheets-Sheet 2

Fig. 4.

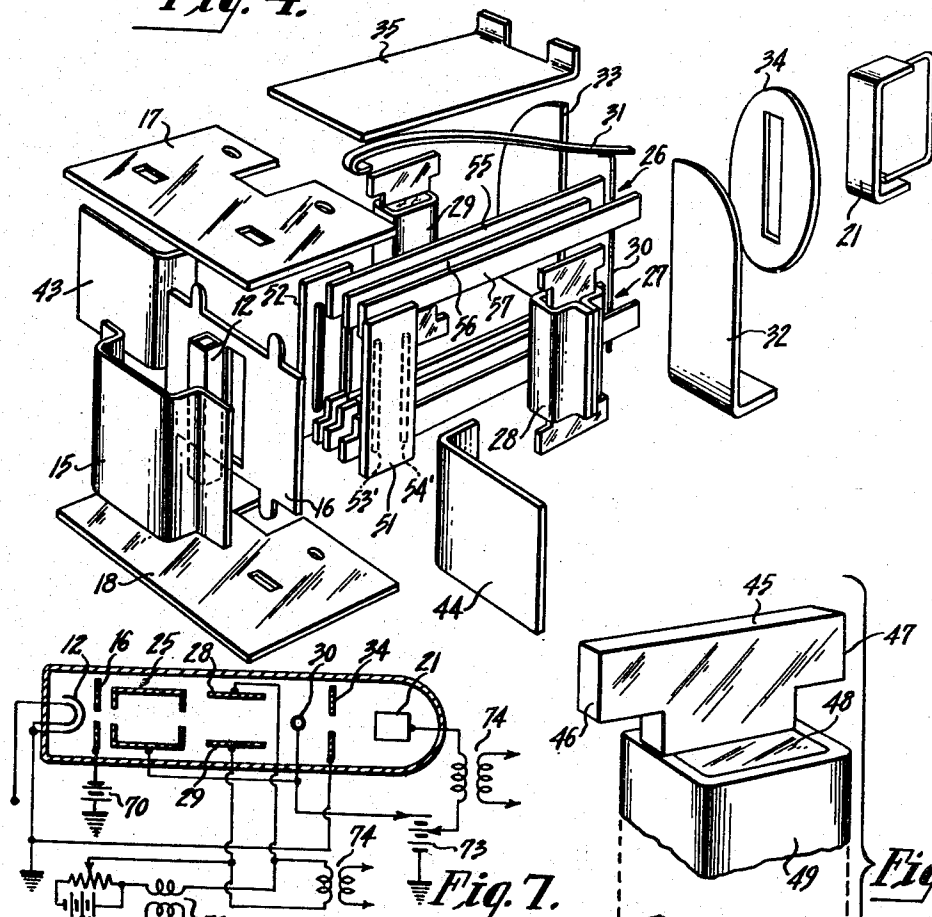


Fig. 7.

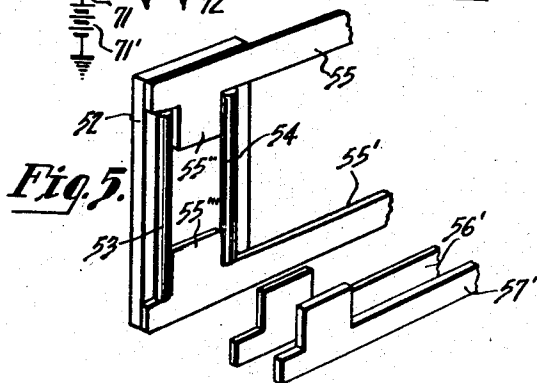


Fig. 5.

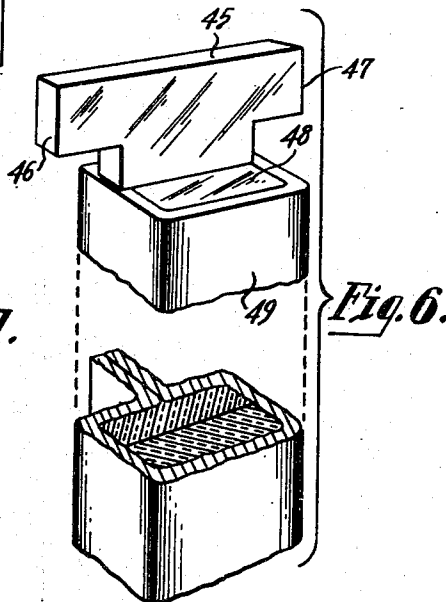


Fig. 6.

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2,434,713

BEAM DEFLECTION TUBE HAVING PARALLEL FOCUSING AND BEAM DEFINING PLATES

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Application November 1, 1944, Serial No. 561,339

15 Claims. (Cl. 250—158)

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The invention covered herein may be manufactured and used for or by the Government of the United States for any governmental purpose without payment to me or assigns of any royalty thereon.

My invention relates to electron discharge devices, more particularly to such devices suitable for use at ultra high frequencies and utilizing a beam of electrons which is periodically deflected for varying the output current of the device.

Electron discharge devices to which the present invention is directed are used as mixers and amplifiers, particularly at high frequencies where advantages of low input conductance and capacity are important. One form of beam deflection tube includes a cathode and associated elements for providing a directed beam of electrons of rectangular cross section, which beam is directed toward a collector through a beam deflection system, the electron beam being deflected across an aperture to determine the amount of current to the collector. Positioned between the cathode and the collector is the electron lens and beam deflection electrode assembly. The aperture may be bisected by a rod-like element, thus producing in effect a double aperture. Positioned between the collector and apertured element may be a suppressor having an aperture aligned with an aperture in the apertured element.

In the copending application of Noval H. Green and William Hoyt Warren, Serial No. 492,808, filed June 30, 1943, issued as Patent 2,415,481, February 11, 1947, and assigned to the same assignee as the present application, there is disclosed a tube of the type described above, utilizing a flat plate type of construction for insuring accurate alignment of the various electrodes. Flat plates provide the lens system and deflecting system. These flat plates are elongated and have ribs oppositely disposed from each other for providing the beam apertures. Oppositely disposed openings are provided in the plates in which the deflecting electrodes are mounted for deflecting the electron beam across a wire or rod positioned between the two plates prior to collection of the electrons by the collecting electrode. The plates are separated by a center spacer. In this construction the metallic surfaces between the openings and the intercepting wire or rod are close to the beam and any oxide or other foreign material on these surfaces will support a surface charge.

However, it has been determined that small apertures of the order of .003 inch and a thinner wire target for intercepting the electrons and of

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the order of .005 inch result in a tube having more desirable characteristics. However, such an arrangement requires a general tightening of tolerances introducing manufacturing difficulties in the way of accurate control of critical dimensions and the incorporation of the structure in high frequency circuits.

It is, therefore, an object of my invention to provide an improved design of an electron discharge device particularly suitable for use at ultra high frequencies and utilizing a beam of electrons periodically deflected to vary the output of the device.

Another object of my invention is to provide a device of the type described in which more desirable and greater uniformity of characteristics is obtained, and in which surface charges effecting the beam are substantially eliminated.

A further object of my invention is to provide such a device of improved and simplified construction which can be easily and quickly assembled and in which accurate alignment of various electrodes and apertures in the electrode assembly is insured.

A still further object of my invention is to provide an improved and novel construction for the electron lens system and aperture assembly for an electron discharge device utilizing electron beams.

A further object of my invention is to provide improvements in the deflecting electrode construction.

Another object of my invention is to provide such a device in which accurate control of the critical dimensions of the tube is insured.

Another object of my invention is to reduce the number of critical adjustments which must be made during assembly of the device.

A still further object of my invention is to provide a flexible design in which the dimensions may be easily changed for obtaining predetermined characteristics.

A still further object of my invention is to provide such a device which is completely shielded so that internal feedback at high frequencies is avoided and so constructed that the device is suitable for plug-in operation and in which the deflecting electrodes can be provided with a parallel wire input circuit.

In practice it has been found that in some few instances the beam does not line up properly, thereby affecting the characteristics of the tube due to a warping or bending of the beam.

It is, therefore, another object of my invention to provide means for correcting misalignment of

the beam in finished devices when said misalignment occurs.

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 side view with part of envelope removed to show details of construction of an electron discharge device made according to my invention, Figure 2 is a transverse section along line 2—2 of Figure 1, Figure 3 is a transverse section taken along the line 3—3 of Figure 1, Figure 4 is an exploded perspective view of the various parts forming the electrode assembly, Figure 5 shows details of construction in exploded perspective of the aperture portion of the device made according to my invention, Figure 6 is a perspective showing details of construction of the deflecting electrode assembly, and Figure 7 is a diagram of a circuit in which a device made according to my invention may be employed.

Briefly, the device made according to my invention is housed within a non-magnetic metallic envelope provided with leads so that the device may be plugged into a proper socket or circuit. It comprises a cathode assembly at one end of the envelope for providing a directed beam of electrons and a collector at the other end of the envelope for receiving the electrons with a beam focussing and deflecting electrode assembly positioned between the cathode and collector.

As shown in Figures 1 to 3, inclusive, the envelope 10 of oval shape is provided with a metallic header 11 through which the various leads and supports for the electrodes extend, said leads being insulatingly sealed through the header member. The envelope and header may be made of non-magnetic material such as stainless steel. Mounted within the envelope is a cathode electrode assembly comprising the indirectly heated cathode 12 provided with heater-cathode leads 13 and 14. The cathode is surrounded by means of the shielding member 15 having a front cover member 16 provided with an elongated aperture 16' through which the electrons from the cathode 12 are directed. This electrode assembly is mounted between a pair of insulating spacer members 17 and 18 and clamped to the same by means of the strap 19 and positioned by means of the ears such as 20—20'. Mounted at the other end of the envelope is a collector 21 in the form of a loop supported by means of the support and lead 22.

Positioned between the cathode and the collector is the aperture, lens and beam deflecting electrode assembly. The aperture, lens and beam deflecting electrode assembly is formed as a unit and includes the aperture portion, designated generally at 25 and which will be described in greater detail below, provided with horizontally extending arms 26 and 27 which support the deflecting electrodes 28—29 and the intercepting wire 30 anchored at its lower end and maintained in tension by means of the spring anchor 31 permitting expansion and contraction of the wire but always assuring alignment. The wire is guided by the slot in the arms 26 and 27 as shown. Mounted at the end of the assembly is a pair of shields 32 and 33 which are supported from the header. These shields in turn support the apertured suppressor electrode 34 having the aperture 34' by means of the glass bead assemblies such as 35 and 35'. A lead 34'' is provided

for the suppressor. The end of the aperture and deflecting electrode assembly adjacent the cathode 12 is provided with a pair of transverse shield members 43 and 44. These shield members provide a linear accelerating field for the electron beam and prevent stray electrons from striking the deflecting plates.

Electrons from cathode 12 pass through the aperture 16 through the aperture assembly 25 between the deflecting electrodes 28 and 29 and are deflected across the intercepting wire 30 passing through the aperture 34' to the collector 21. The cathode end of the assembly is supported by the bracket 38'.

A getter trough 36 is mounted at the top of the envelope at the ends of the conductors and leads 37 and 38. A shield 36' is provided between the getter and the top of the electrode assembly.

The header is provided with a glass press 39 through which the leads 40 and 41 extend, these being in turn connected to deflecting electrodes 29 and 28 by means of clips 50 and 50' electrically connected to the deflecting electrodes and the leads 40 and 41. The leads 40 and 41 extend parallel to each other through the envelope so that a coaxial line or Lecher wire system may be conveniently connected to the same.

The details of the aperture and deflecting electrode assembly are shown in Figures 4 to 6, inclusive. The lens assembly comprises a pair of oppositely disposed plates 51 and 52 having on their inner surfaces parallel rods or wires 53 and 54 and 53' and 54' extending transversely of the beam path. The wires or rods 53 and 54 are oppositely disposed to wires 53' and 54' and register with each other. The plates are appropriately spaced in a manner to be described in order to provide a pair of successive apertures between registering wires through which the beam is directed.

The separating members which provide supporting arms 26 and 27 of which there is one at the top and bottom edges of the plates, include three stacked spacers which are secured together. The upper spacer member comprises the elements 55, 56 and 57, each of which elements is provided with an inwardly extending lug, such as 55'', which extends between the aperture elements 53—54. The bottom spacer assembly includes elements 55', 56' and 57' also provided with lugs such as 55''', likewise extending upwardly between the aperture elements. The intermediate elements 56 and 56' are thinner than the others and have a thickness substantially that of the diameter of the intercepting wire 30 and is shorter than the outer elements, such as 55 and 57, so that a slot is provided between the two members 55 and 57 at their ends remote from the cathode into which the intercepting wire is inserted and positioned. This accurately aligns the apertures and the intercepting wire.

Supported on the arms 26 and 27, which provide the spacer elements, are the deflecting electrode assemblies 28 and 29 including a mica element such as 45, reference to be had to Figure 6, including tabs or ear-like extensions such as 46 and 47 at its ends. A spacer element 48 is mounted in contacting relationship with the mica and a thin foil, preferably gold, wrapped around these elements to provide the deflecting electrode. The wrapped foil produces a smooth lens edge eliminating any burrs. These deflecting electrodes are assembled on the arms 26 and 27 so that the tabs or lugs, such as 46, abut the edge

of the plate 42, thus insuring positive positioning and accurate positioning of the deflecting electrodes with respect to the apertures formed between the plates. The aperture plate assembly and deflecting electrodes provide an electron lens as described in a copending application of George Ross Kilgore, Serial No. 342,625, filed June 27, 1940, granted as Patent Number 2,392,155 on January 1, 1946, and assigned to the same assignee as the present application. These deflecting electrode assemblies are retained on the arms 26 and 27 by means of the straps, such as 66 and 67. see Figure 3. This construction eliminates any surfaces between the deflecting electrodes and the intercepting wire and on which any surface charges could exist.

Because all parts are held against flat surfaces tilting of electrodes is avoided. The aperture plate assembly is simple to make and the lens edge easier to control.

In assembling the aperture plate the two rods, such as 53 and 54, are assembled on a jig having recesses for receiving the rods, and the plate is mounted on top of the rods, this assembly being clamped together and then subjected to diffusion welding of the wires, which are preferably copper, copper alloy or copper plated metal, to the plates which may be of copper alloy, Nichrome or other non-magnetic material. The diffusion technique is well adapted for fastening the wires to the plates because they are fastened uniformly over their entire length. By using a V-groove in the assembly jig for clamping the wires to the plate, that portion of the wire closest to the beam is not deformed. It is, of course, obvious that triangular or rectangular shaped rods could be fastened to the apertured plates. The triangular shaped would have two advantages, namely, a sharper edge can be obtained and a larger surface of diffusion obtained. A larger surface gives a stronger binding and less tendency for the wire to press flat against the plate, resulting in small change in dimensions.

The three plates of the separators may be also diffused together. By changing the thickness of the thin inner piece of the separator any size of wire may be used, and in changing the thickness of the outer pieces any distance between apertured plates can be independently determined and hence the aperture opening. It is, of course, obvious that the separator could be made of one thickness and a slot formed in the end to receive the interceptor wire.

A diffusion weld is formed by the material of one piece diffusing into the other piece, thus forming a tight bond. Temperatures of 800° C. to 900° C. have been used for diffusing copper and copper alloys to each other or to Nichrome. This lower temperature causes less distortion of the material and also eliminates the use of solder. Local heating and the consequent tendency to warp which results from welding is also avoided.

In the tube described the beam is approximately .300 inch wide and .001 inch thick. In order that the maximum performance of the device be attained, the electron beam must be aligned with the edge of the intercepting wire over its entire length, this intercepting wire having a dimension of .005 inch in diameter. It sometimes happens that the beam may not be aligned with the wire. This need not be entirely due to mechanical defects but may be due to spurious surface potentials on the electrodes. The tilting of the beam produces undesirable characteristics and, therefore, must be avoided. Electrostatic meth-

ods require additional electrodes and leads. Mechanical correction would be cumbersome. The best solution is to use a non-uniform magnetic field which is most conveniently obtained from a small bar magnet.

In accordance with my invention, therefore, I utilize a permanent magnet, such as 42, which is secured to the outer surface of the envelope after assembly. This magnet may be of the type employing aluminum-nickel-cobalt alloys which have a high degree of stability and high field strength or a similar material. While a rectangular form is shown, other shapes may be used. Thus by using different length magnets or different material for the magnets, various field distributions can be obtained.

In assembly the method of applying a magnet is as follows: The magnet is tinned by the use of phosphoric acid or other suitable flux and soft solder. The tube is then mounted on its side with its long axis horizontal in a test set associated with the appropriate circuit to trace a curve on an oscillograph proportional to the transconductance of the tube. The magnet is then moved about the surface of the tube and its direction changed until the maximum transconductance is obtained. While the magnet is held accurately in position it is subjected to a gas torch to melt the solder. After the solder hardens the magnet is attached to the tube and the excess flux washed off with water. This method has proved extremely successful in those cases where tilted beams are encountered.

The advantages of my invention are that the magnet is made a permanent part of the tube, it provides a better and easier adjustment than can be made with a horseshoe magnet, an external adjustment reduces the required accuracy and reduces the expense of the internal structure, and the number of tubes which would be rejected because of faulty beam alignment is materially reduced.

In Figure 7 is shown a diagrammatic representation of an electron discharge device made according to my invention and its associated circuits and voltage sources. Like numbers in this figure correspond to numbers in the other figures. As shown a negative bias is applied to the beam forming shield member 15-16 by means of the voltage source 70. Transverse biasing of the deflecting electrodes 28-29 to direct the beam on the intercepting wire 30 is accomplished by means of the voltage source 71, the input signal being applied through input circuit 72 and the local oscillator voltage, if desired, by means of the circuit 74. The aperture element 25 and intercepting wire 30 may be biased from voltage source 73 as is the collector 21. A source of focusing voltage 71' is also provided. The output is taken by means of the output circuit 74.

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 providing a beam of electrons, electrode means toward which said electrons are directed,

means positioned between said cathode and said electrode means and including an electrode assembly for periodically deflecting the beam of electrons, said assembly including a pair of conducting plate-like members extending transversely of the path of the beam of electrons and spaced apart to provide a passageway therebetween through which the beam path lies, said plate-like members having oppositely disposed registering portions extending toward each other to provide an aperture, spacing means positioned at opposite edges of said plate-like members and extending parallel to the beam path from one side of said plates for providing supporting arms, and a pair of deflecting electrodes supported in spaced relation with said plate-like members by said spacing means and between which the beam path lies.

2. An electron discharge device having a cathode for providing a beam of electrons, electrode means toward which said electrons are directed, means positioned between said cathode and said electrode means and including an electrode assembly for periodically deflecting the beam of electrons, said assembly including a pair of conducting plate-like members extending transversely of the path of the beam of electrons and spaced apart to provide a passageway therebetween through which the beam path lies, said plate-like members having oppositely disposed registering portions extending toward each other to provide an aperture, spacing means positioned at opposite edges of said plate-like members and extending parallel to the beam path from one side of said plates for providing supporting arms, and a pair of deflecting electrodes supported in spaced relation with said plate-like members by said spacing means and between which the beam path lies and an intercepting rod-like element supported at the ends of said supporting arms remote from said plate-like members and registering with the aperture between said plate-like members.

3. An electron discharge device having a cathode for providing a beam of electrons, means for receiving said electrons, means positioned between said cathode and said receiving means and including an electrode assembly for periodically deflecting the electron beam, said assembly including a pair of registering conducting plate-like members extending transversely of the path of the beam and spaced apart to provide a passageway therebetween through which the beam path lies, said plate-like members having a plurality of pairs of oppositely disposed registering portions extending toward each other to provide a pair of successively positioned apertures, spacing means positioned at opposite edges of said plate-like members and extending parallel to the beam path from one side of said plate-like members towards said electron receiving means for providing a pair of supporting arms, and a pair of deflecting electrodes supported by said arms on opposite sides of the beam path and spaced from said plate-like members toward said receiving means.

4. An electron discharge device having a cathode for providing a beam of electrons, means for receiving said electrons, means positioned between said cathode and said receiving means and including an electrode assembly for periodically deflecting the electron beam, said assembly including a pair of registering conducting plate-like members extending transversely of the path of the beam and spaced apart to provide a pas-

sageway therebetween through which the beam path lies, spacing means positioned at opposite edges of said plate-like members and extending parallel to the beam path, and a pair of deflecting electrodes supported by said spacing means on opposite sides of the beam path, each of said spacing means comprising three registering elements secured together as a unit, the intermediate element being shorter than the outside elements for providing a slot at the end of said spacing means remote from said plate-like members and an intercepting rod-like element mounted within said slots.

5. An electron discharge device having a cathode for providing a beam of electrons, means for receiving said electrons, means positioned between said cathode and said receiving means and including an electrode assembly for periodically deflecting the electron beam, said assembly including a pair of registering conducting plate-like members extending transversely of the path of the beam and spaced apart to provide a passageway therebetween through which the beam path lies, said plate-like members having oppositely disposed registering portions extending toward each other to provide an aperture, spacing means positioned at opposite edges of said plate-like members and extending parallel to the beam path, and a pair of deflecting electrodes supported by said spacing means on opposite sides of the beam path, each of said spacing means comprising three registering elements secured together as a unit, the intermediate element being shorter than the outside elements for providing a slot at the end of said spacing means remote from said plate-like members, and an intercepting wire-like element having its ends extending within said slots, a spring tensioning device mounted at one end on said plate-like members and spacing means, said wire-like element having one end connected to said spring tensioning device and its other end to one of said spacing means.

6. An electron discharge device having a cathode for providing a beam of electrons, means for receiving said electrons, means positioned between said cathode and said receiving means and including an electrode assembly for periodically deflecting the electron beam, said assembly including a pair of registering conducting plate-like members extending transversely of the path of the beam of electrons and spaced apart to provide a passageway therebetween, said plate-like members having oppositely disposed registering portions extending toward each other to provide an aperture through which the beam path is directed, spacing means positioned at opposite edges of said plate-like members and extending parallel to the beam path for providing supporting arms, and a pair of deflecting electrodes supported by said spacing means on opposite sides of the beam path, each of said spacing means having a slot in the end of said spacing means remote from said plate-like members, and an intercepting rod mounted within said slots and extending between said spacing means.

7. An electron discharge device having a cathode for providing a beam of electrons, means for receiving said electrons, means positioned between said cathode and said receiving means and including an electrode assembly for periodically deflecting the electron beam, said assembly including a pair of registering conducting plate-like members extending transversely of the path of the beam and spaced apart to provide a passageway therebetween through which the beam path

lies, said plate-like members having oppositely disposed portions extending toward each other to provide an aperture, spacing means positioned at opposite edges of said plate-like members and extending parallel to the beam path, and a pair of deflecting electrodes supported by said spacing means on opposite sides of the beam path, shield members supported by and extending transversely of said plate-like members adjacent said cathode, and other shield members extending transversely of said spacing means at the ends of said spacing means remote from said plates.

8. An electron discharge device having a cathode for providing a beam of electrons, means for receiving said electrons, means positioned between said cathode and said receiving means and including an electrode assembly for periodically deflecting the electron beam, said assembly including a pair of registering conducting plate-like members extending transversely of the path of the beam and spaced apart to provide a passageway therebetween through which the beam path extends, means positioned at opposite edges of said plate-like members and extending parallel to the beam path, and a pair of deflecting electrodes supported by said last means on opposite sides of the beam path, each of said deflecting electrodes comprising an insulating member having a metallic coating, said insulating member having extensions thereon abutting said plate-like members for positioning said deflecting electrodes with respect to said plate-like members.

9. An electron discharge device having a cathode for providing a beam of electrons, means for receiving said electrons, means positioned between said cathode and said receiving means and including an electrode assembly for periodically deflecting the electron beam, said assembly including a pair of registering conducting plate-like members extending transversely of the path of the beam and spaced apart to provide a passageway therebetween through which the beam path lies, said plate-like members having means extending from opposite edges and parallel to the beam path for providing supporting elements, and a pair of deflecting electrodes supported by said supporting elements on opposite sides of the beam path, each of said deflecting electrodes comprising an elongated insulating member extending between said supporting elements and a metal foil wrapped around said insulating member.

10. An electron discharge device having a metallic envelope containing a cathode for providing a beam of electrons, means for receiving said electrons, means positioned between said cathode and said receiving means and including an electrode assembly for periodically deflecting the electron beam and including a pair of plate-like members spaced apart to provide a passageway therebetween and through which the beam path lies, and deflecting electrodes associated therewith for deflecting said beam of electrons, and an intercepting wire mounted in a plane passing between and parallel to said plates, and magnetic means external of the envelope and permanently affixed to said envelope for permanently effecting the path traveled by said beam of electrons.

11. An electron discharge device having a metal envelope containing a cathode for supplying a directed beam of electrons and another electrode toward which the electron path is directed, and means positioned between said cathode and said electrode and including an electrode assembly for periodically deflecting the electron beam and

through which the path of said beam is directed, said assembly including a pair of spaced parallel side plates having oppositely disposed means extending toward each other for providing an aperture, said plates having at opposite ends supporting elements extending parallel to the beam path, deflecting electrodes positioned by and supported on said supporting elements, said envelope having an aperture registering with said deflecting electrodes, an insulating member within said aperture and hermetically sealing said aperture, and a pair of parallel leads extending through said insulating member and connected to said deflecting electrodes.

12. An electron discharge device having a metal envelope containing a cathode for supplying a directed beam of electrons and another electrode toward which the electron path is directed, and means positioned between said cathode and said electrode and including an electrode assembly for periodically deflecting the electron beam and through which the path of said beam lies, said assembly including a pair of spaced parallel side plates having oppositely disposed elements extending toward each other for providing an aperture, and deflecting electrodes positioned between apertures and said other electrode and on opposite sides of the beam path, said envelope having an aperture registering with said deflecting electrodes, an insulating member within said aperture and a pair of parallel leads extending through said insulating member and connected to said deflecting electrodes.

13. An electron discharge device having a cathode for supplying a directed beam of electrons and another electrode for receiving electrons, means positioned between said cathode and said receiving electrode and including an electrode assembly for periodically deflecting the electron beam and through which the beam path is directed, said assembly including a pair of spaced parallel side plates having elements extending transversely of the beam path and extending toward each other for providing a pair of successively positioned apertures, and separating means at the opposite ends of said plates and including elongated conducting members lying parallel to the beam path and having lugs registering with the space between apertures, and deflecting electrodes positioned and supported by said separating means, and an intercepting wire positioned at the ends of said separating means remote from said plates.

14. An electron discharge device having a cathode for supplying a directed beam of electrons and another electrode for receiving electrons, means positioned between said cathode and said receiving electrode and including an electrode assembly for periodically deflecting the electron beam and through which the beam path is directed, said assembly including a pair of spaced parallel side plates each having a pair of spaced rod-like elements on the opposed surfaces thereof and extending transversely of the beam path and registering with each other for providing a pair of successively positioned apertures, and separating elements at the opposite ends of said plates, each of said separating elements including a plurality of registering contacting elongated conducting members lying parallel to the beam path and having lugs registering with the space between apertures, and deflecting electrodes positioned and supported by said separating elements, and an intercepting

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wire positioned at the ends of said separating elements remote from said plates.

15. An electron discharge device having a cathode for supplying a directed beam of electrons and another electrode for receiving electrons, means positioned between said cathode and said receiving electrode and including an electrode assembly for periodically deflecting the electron beam and through which the beam path is directed and including a pair of spaced parallel side plates each having a pair of spaced rod-like elements extending transversely of the beam

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path, each pair extending toward the other pair for providing a pair of successively positioned apertures, and separating means at the opposite ends of said plates and including elongated conducting members lying parallel to the beam path and having lugs registering with the space between said apertures, and deflecting electrodes positioned on opposite sides of the beam path and supported by said separating means in spaced relation with said plates.

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