Feb. 11, 1947. N. H. GREEN ET AL 2,415,481

BEAM DEFLECTION TUBE HAVING PARALLEL FOCUSING AND BEAM DEFINING PLATES

Filed June 30, 1943 2 Sheets-Sheet 1

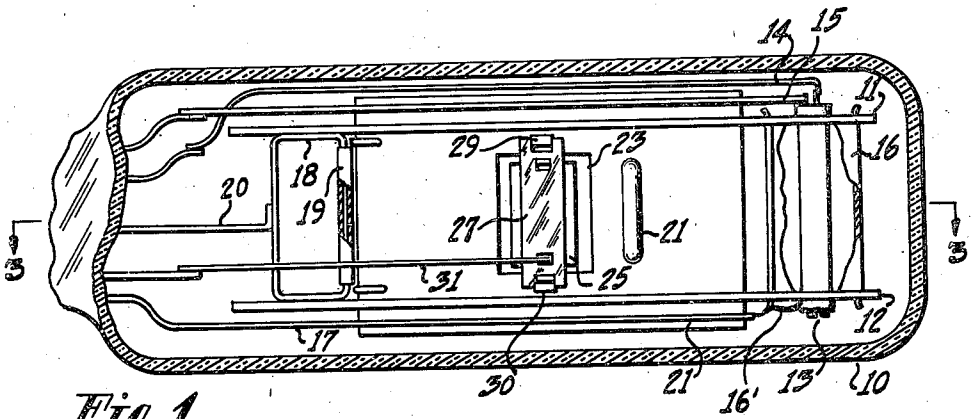

Fig. 1.

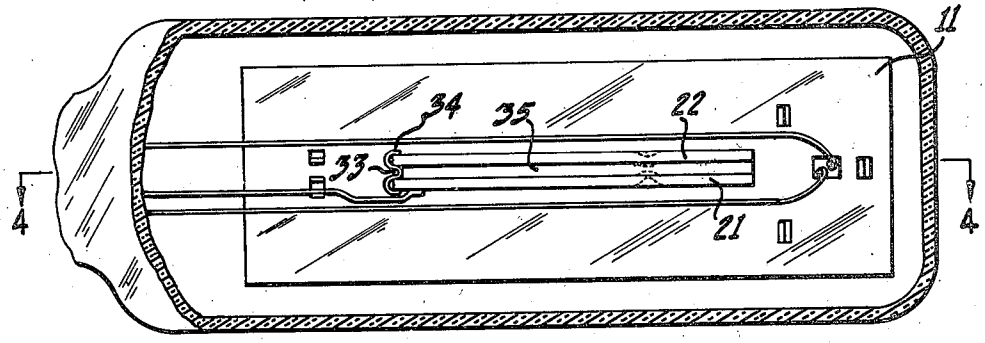

Fig. 2.

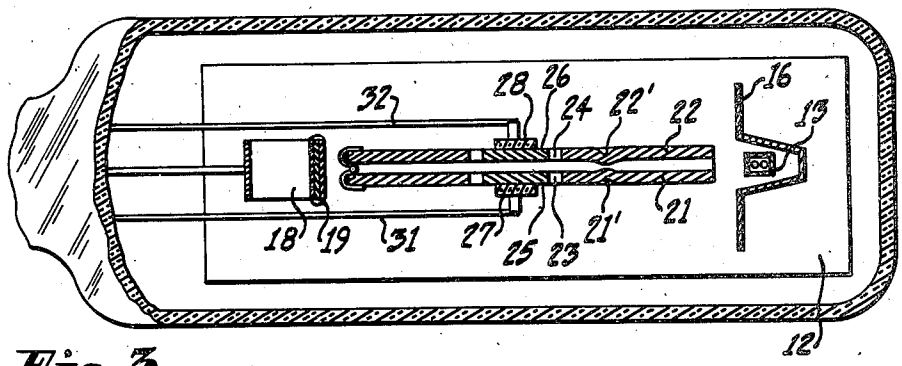

Fig. 3.

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BEAM DEFLECTION TUBE HAVING PARALLEL FOCUSING AND BEAM DEFINING PLATES

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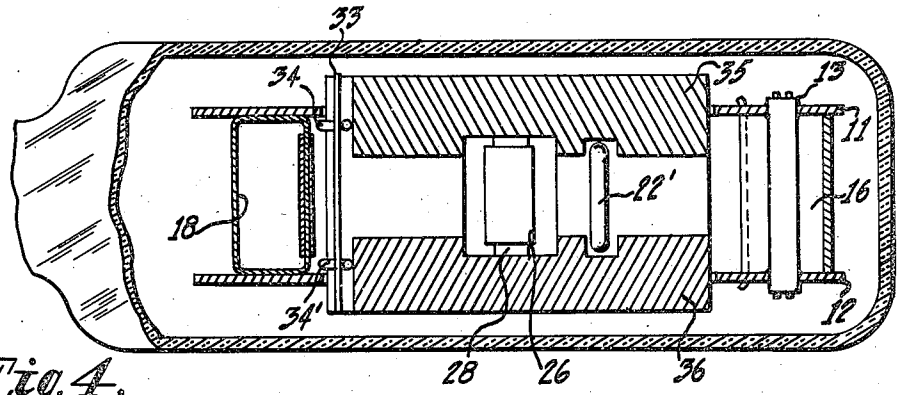

Fig. 4.

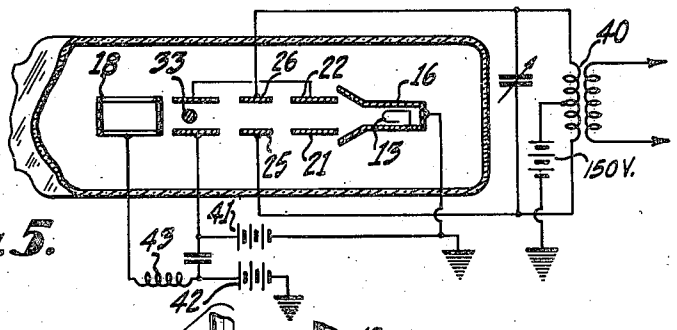

Fig. 5.

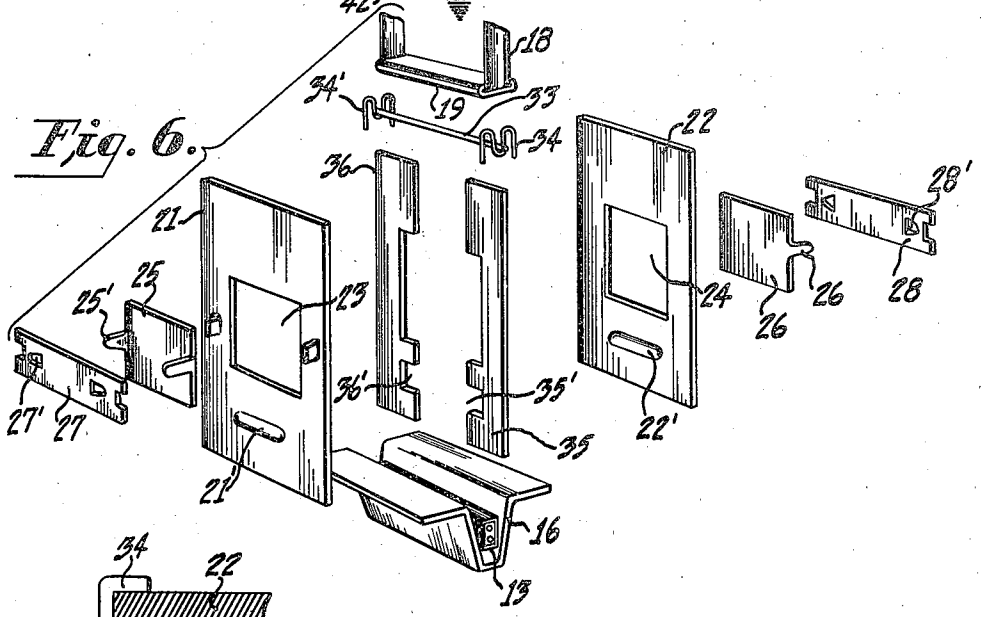

Fig. 6.

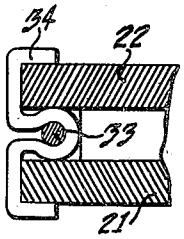

Fig. 7.

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BEAM DEFLECTION TUBE HAVING PARALLEL FOCUSING AND BEAM DEFINING PLATES

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Application June 30, 1943, Serial No. 492,808

14 Claims. (Cl. 250—158)

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Our 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 especially 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 electrode system, the electron beam being deflected across an aperture to determine the amount of current going to the collector. Positioned between the cathode and collector is an electron lens and beam deflection electrode assembly. It comprises a cylinder coaxial with and surrounding the beam path. At one end of the cylinder is positioned a transverse partition provided with apertures through which the beam is directed. A second and similar transverse apertured partition is provided at the other end of the cylinder, the apertures in the two partitions being aligned. The aperture in the second partition is bisected by means of a rod-like element positioned centrally of the aperture, thus producing in effect a double aperture. A third partition, also apertured, is positioned between the other two partitions and its aperture must also be properly aligned with the other apertures. These partitions may be in the form of shallow caps, the lips of which are welded to the cylinder. A pair of deflecting electrodes are mounted within the cylinder and between the second and third apertured partitions for deflecting the beam of electrons across the double aperture. The potential difference between the deflecting plates and the third apertured partition forms an electron lens which focuses the rectangular beam in the plane of the aperture in the end partition in the cylinder. The collector is coated with secondary electron emitting material and is maintained at a lower potential than the deflecting electrode assembly. The cylinder collects the secondary electrons. Current in the collector or secondary emitter circuit is then proportional to the difference between the secondary charges drawn back to the cylinder and the number of electrons in the primary or incident beam. A tube of this kind is described in Patent 2,294,659 Herold, assigned to the same assignee as the present application.

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As pointed out above, for some cases a small wire is centered along the major axis of the last aperture and a cross bias between the deflecting plates is provided to center the beam on this wire so that with zero signal the beam is effectively blocked from the secondary emitter. When an alternating signal is applied between the deflecting plates, the beam is deflected to either side of the center, while causing the secondary emitter or output current to rise sharply as the beam leaves the blocking wire. Since the transconductance of the device is given by the slope of the output current-deflecting voltage characteristic, it is essential that for best sensitivity the three apertures, center wire and deflecting plates be perfectly aligned so that the beam is completely blocked at zero signal and so that it will leave the wire abruptly as the signal is applied. Small deviations from the true rotational or axial alignment of these parts will distort the output current characteristic such that the tube may be inoperative. To maintain the required alignment, each aperture must be formed to center with the edges of the cup-shaped partition, then the cups must be carefully centered in the cylinder for rotational alignment before they are welded. This results in a slow and tedious assembly for manufacture.

It is, therefore, an object of our 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 our invention is to provide a device of the kind described in which greater uniformity of characteristics between devices is obtained.

Another object of our invention is to provide such a device of improved and simplified construction which can be easily and quickly assembled and in which alignment of various electrodes and apertures in the electrode assembly is assured.

A still further object of our invention is to provide a novel construction for forming electron lens systems and beam forming and controlling electrode assemblies in electron discharge devices utilizing electron beams.

The novel features which we believe to be characteristic of our 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 drawings in which

Figure 1 is a side elevation of an electron discharge device made according to our invention but with the base removed and parts in section; Figure 2 is a top view of Figure 1; Figure 3 is a section taken along the line 3—3 of Figure 1; Figure 4 is a section taken along the line 4—4 of Figure 2; Figure 5 is a schematic diagram of an electron discharge device made according to our invention and its associated circuit; Figure 6 is an exploded perspective view of the electrode mount assembly utilized in the device shown in Figures 1 to 4, inclusive, and Figure 7 shows details of construction.

In Figure 1 an electron discharge device made according to our invention includes an evacuated envelope 10 having within it the mount assembly mounted between the insulating spacer members 11 and 12, preferably of mica, which are supported from various leads from the press and base, not shown. The cathode assembly comprises the indirectly heated cathode 13 provided with heater wires 14 and 15, one of which may also serve as the cathode lead and the beam forming and beam directing shielding electrode 16 surrounding the cathode on three sides. This shield may be provided with the lead 17 so that it may be biased at a different potential from the cathode. Mounted at the other end of the envelope is the collector or secondary emitting electrode 18, which is in the form of a loop and provided with a secondary emitting shell or coating 19, this electrode being supported by lead and support wire 20.

Mounted between the cathode and the collector or secondary emitting electrode is the beam focusing and deflecting electrode assembly which comprises a pair of flat plate-like members 21 and 22 spaced by means of spacer members 35 and 36 mounted at the top and bottom between the plate-like members 21 and 22. As shown in Figures 4 and 6 these plates are so formed that they provide a space and passageway for the electron beam between their oppositely disposed inner edges. The two side plates 21 and 22 are provided with inwardly extending depressions 21′ and 22′ which provide aperture ribs between which the electron beam passes and by which the beam current is limited. These ribs register with the notched portions 35′ and 36′ of the spacer plates 35 and 36. Deflecting plates 25 and 26 are mounted within the apertures 23 and 24 of the side plates and supported in position by mica straps 27 and 28 provided with apertures 27′ and 28′ through which tabs 25′ and 26′ on the plates extend. These mica straps are secured to the side plates by means of tabs 29 and 30 fastened to the side plates so that the deflecting electrodes are mounted in insulating relationship with the side plates 21 and 22. These side plates are provided with lead wires 31 and 32 for applying the desired alternating potentials to the deflecting plates. The side plates and deflecting electrodes during operation provide a lens system for focusing the beam on rod-like element 33.

Mounted at the end of the side plates 21 and 22 and spaced from the plates but between the plates to provide a double aperture, is the rod-like conducting element or wire 33 supported between the plates as best shown in Figures 2 and 3 and Figure 7, by means of the clips 34 and 34′, which center the rod and maintain it in spaced relationship with the surfaces of the side plates so as to provide a double aperture. Thus a beam directed from the cathode passes between

the side plates, through the passageway provided by the spacing plates 25 and 26, between the aperture ribs 21′ and 22′ and deflecting plates 25 and 26 which deflect the beam across the wire 33 to the secondary emitting surface 19 of electrode 18, the secondary emission electrons being collected by the side plates of the deflecting electrode mount assembly.

In assembly the side plates 21 and 22 and separating plates 35 and 36 can be quickly stacked upon each other in a jig provided for this purpose and quickly welded. The result is perfect alignment of the parts.

Rapid assembly is obtained simply by threading the side plates and separators over a rectangular center post in the welding jig provided for this purpose. The center post may be dimensioned to provide a slip fit with the portions of the plates and separators blanked for the deflecting plates, and the assembly is welded before removing from the jig.

Positioning the wire 33 and clips 34 and 34′ between the ends of the side plates 21 and 22 automatically aligns the wire with the longitudinal axis of the deflecting electrode assembly. The ribs 21′ and 22′, which are pre-stamped in the side plates, provide a limiting aperture. In order to narrow the beam width to any desired value, one or more pairs of ribs may be used.

Accurate centering of the wire in the last apertures is obtained by setting the strip thickness of the clip 34 to

$$t=\frac{T-D}{2}$$

where T is equal to the thickness of the separator plate and D is equal to the center wire diameter. The deflecting plates are then positioned in the blanked windows of the partial mount and positioned in the plane of the side plates by clips which engage the supporting micas 27 and 28 and which are fastened to the side plates. The cathode shield, cathode, partial mount assembly and secondary emitter are then mounted and supported within the two micas 11 and 12 as shown in the figures.

In Figure 5 showing the circuit diagram, the deflecting electrodes 25 and 26 are connected to opposite sides of the input circuit 40 and the output is taken by means of the output circuit 43. The voltage source 41 provides the necessary voltage between the cathode shield 16 and the deflecting electrode assembly and the voltage source 42 provides the collector voltage. The cathode 13 is tied to shield 16 by lead 16′. The collector may be maintained at a lower voltage than the deflecting electrode assembly.

Thus with the improved mount design for beam deflection tubes, automatic alignment of apertures and center wire is provided and this obviates the need for several of the parts required for previous designs. Rapid assembly is insured as well as accurate positioning of all parts. Since automatic alignment results, characteristics are more uniform.

The flat elements which permit stacking obviate the necessity for prefabricating individual apertures to the critical dimensions demanded for the cylindrical structure; flat structures permit higher assembly speeds for stacking and welding, and accurate rotational and axial alignment of the apertures, deflecting plates and center wire is insured by the new construction and without resorting to the unwieldy methods necessary to obtain this alignment in previous designs.

While we have indicated the preferred embodiments of our invention of which we are now aware and have also indicated only one specific application for which our invention may be employed, it will be apparent that our 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 our invention as set forth in the appended claims.

What we claim as new is:

1. An electron discharge device having means for providing a beam of electrons, means for receiving said electrons, means positioned between said beam providing means and said receiving means and through which the beam of electrons passes during operation of said electron discharge device, and including a pair of conducting plate-like members spaced apart to provide a passageway therebetween, means on said plate-like member extending toward each other for restricting said passageway, said plate-like members having oppositely disposed apertures and deflecting electrodes positioned within said apertures.

2. An electron discharge device having means for providing a beam of electrons, means for receiving said electrons, means positioned between said beam providing means and said receiving means and through which the beam of electrons passes during operation of said electron discharge device, and including a pair of conducting plate-like members spaced apart to provide a passageway therebetween, said plate-like members having oppositely disposed apertures, and deflecting electrodes positioned within said apertures.

3. An electron discharge device having means for providing a beam of electrons, means for receiving said electrons, means positioned between said beam providing means and said receiving means and through which the beam of electrons passes during operation of said electron discharge device, and including a pair of conducting plate-like members spaced apart to provide a passageway therebetween, said plate-like members having oppositely disposed apertures, deflecting electrodes positioned within said apertures, and a rod-like element at one end of said plate-like members and positioned between the ends of said plate-like members and in spaced relationship.

4. An electron discharge device having a cathode for supplying a directed beam of electrons, and another electrode for receiving said electrons, and means positioned between said cathode and said receiving electrode and including an electrode assembly for periodically deflecting said electron beam and including a pair of spaced parallel side plates provided with oppositely disposed registering apertures, and depressed portions in said plates extending toward each other and in registering relationship for providing a restricted aperture between said plates, a pair of separating elements positioned at opposite edges of said plates for maintaining said plates in spaced relationship, and deflecting electrodes positioned within the apertures in the side plates.

5. An electron discharge device having a cathode for supplying a directed beam of electrons, and another electrode for receiving said electrons, and means positioned between said cathode and said receiving electrode and including an electrode assembly for periodically deflecting said electron beam and including a pair of spaced parallel side plates provided with oppositely disposed registering apertures, and depressed portions in said plates extending toward each other and in registering relationship for providing a restricted aperture between said plates, a pair of separating elements positioned at opposite edges of said plates and having recessed portions on the inner edges thereof registering with said depressed portions and other recessed portions registering with the apertures in said side plates, and a rod-like element positioned at one end of the plates and centrally of the space between said plates, and deflecting electrodes positioned within the apertures in the side plates.

6. An electron discharge device having a cathode for supplying a directed beam of electrons, a shield partially surrounding said cathode, and another electrode for receiving said electrons, and means positioned between said cathode and said receiving electrode and including an electrode assembly for periodically deflecting said electron beam and including a pair of spaced parallel side plates provided with oppositely disposed registering apertures and depressed portions within said plates extending toward each other and in registering relationship for providing a restricted aperture between said plates, a pair of separating elements positioned at opposite edges of said plates and having recessed portions on the inner edges thereof registering with said depressed portions, and other recessed portions registering with the apertures in said side plates, and a rod-like element positioned at one end of the plates and centrally of the space between said plates and deflecting electrodes positioned within the apertures in the side plates and supported therein by insulating members secured to said plates.

7. An electron discharge device having a cathode for supplying a directed beam of electrons, and another electrode for receiving said electrons, and means positioned between said cathode and said receiving electrode and including an electrode assembly for periodically deflecting said electron beam and including a pair of spaced parallel side plates provided with oppositely disposed registering apertures, a pair of separating elements positioned at opposite edges of said plates and having recessed portions on the inner edges thereof registering with the apertures in said side plates, and a rod-like element at one end of said plates and positioned centrally of the space between said side plates, and conducting loops surrounding the rod-like element at the ends of said element for supporting and spacing said element from said plates, and deflecting electrodes positioned within the apertures in the side plates.

8. An electron discharge device having a cathode for supplying a directed beam of electrons and another electrode for receiving said electrons, and means positioned between said cathode and said receiving electrode and including an electrode assembly for periodically deflecting an electron beam and through which said beam is directed, and including a pair of spaced parallel conducting side plates provided with oppositely disposed registering apertures, a pair of separating elements positioned at opposite edges of said side plates for maintaining said side plates in spaced relationship and deflecting electrodes positioned within the apertures in said side plates.

9. An electron discharge device having means for providing a beam of electrons, means for receiving said electrons, means positioned between said beam providing means and said receiving means and through which the electrons pass during operation of said electron discharge device,

and including a pair of plate-like members lying in parallel planes and spaced apart to provide a passageway therebetween, means on said plate-like members extending toward each other for restricting said passageway, said plate-like members having deflecting electrodes associated therewith and lying in planes parallel to the planes in which said plates lie, and positioned between the restricted passageway and said receiving means.

10. An electron discharge device having a cathode for supplying a directed beam of electrons and another electrode for receiving said electrons, and means positioned between said cathode and the receiving electrode and including an electrode assembly for periodically deflecting said electron beam, and including a pair of spaced parallel conducting side plates, and means on said plates extending toward each other and in registering relationship for providing a restricted aperture between said plates, and separating elements positioned on opposite edges of said plates for maintaining said plates in spaced relationship, and deflecting electrodes associated with said plates and positioned between the restricted aperture and the receiving electrode, the beam path passing through the restricted aperture and between the deflecting electrodes.

11. An electron discharge device having means for providing a beam of electrons, means for receiving said electrons, means positioned between said beam providing means and said receiving means, and including an electrode assembly for periodically deflecting the electron beam, said assembly including a pair of conducting plate-like members spaced apart to provide a passageway therebetween, said plate-like members having oppositely disposed portions removed to provide open spaces for receiving deflecting electrodes, and deflecting electrodes mounted within said open spaces.

12. An electron discharge device having means for providing a beam of electrons, means for receiving said electrons, means positioned between said beam providing means and said receiving means, and including an electrode assembly for periodically deflecting the electron beam, said assembly including a pair of conducting plate-like members spaced apart to provide a passageway therebetween, said plate-like members having oppositely disposed portions removed to provide open spaces, oppositely disposed deflecting electrodes registering with said open spaces, and a rod between the planes of said plates at the

ends of said plates removed from said beam providing means.

13. An electron discharge device having a cathode for supplying a directed beam of electrons, and another electrode for receiving said electrons, and means positioned between said cathode and said receiving electrode and including an electrode assembly for periodically deflecting said electron beam said assembly including a pair of parallel side plates provided with oppositely disposed registering open spaces therein, portions on said plate extending toward each other in registering relationship for providing a restricted passageway for said beam of electrons, separating elements positioned at opposite edges of said plates for maintaining said plates in spaced relationship, and oppositely disposed deflecting electrodes registering with said open spaces in said plates.

14. An electron discharge device having a cathode for supplying a directed beam of electrons, and another electrode for receiving said electrons, and means positioned between said cathode and said receiving electrode and including an electrode assembly for periodically deflecting said electron beam said assembly including a pair of parallel side plates provided with oppositely disposed registering open spaces therein, portions on said plate extending toward each other in registering relationship for providing a restricted passageway for said beam, separating elements positioned at opposite edges of said plates for maintaining said plates in spaced relationship, oppositely disposed deflecting electrodes registering with the open spaces in said plates, and a rod-like element positioned between the planes of said plates adjacent the receiving electrode end of said plates.

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