June 12, 1945. F. J. G. VAN DEN BOSCH ET AL 2,378,164

ELECTRON DISCHARGE DEVICE

Filed April 10, 1942 3 Sheets-Sheet 1

Fig. 1.

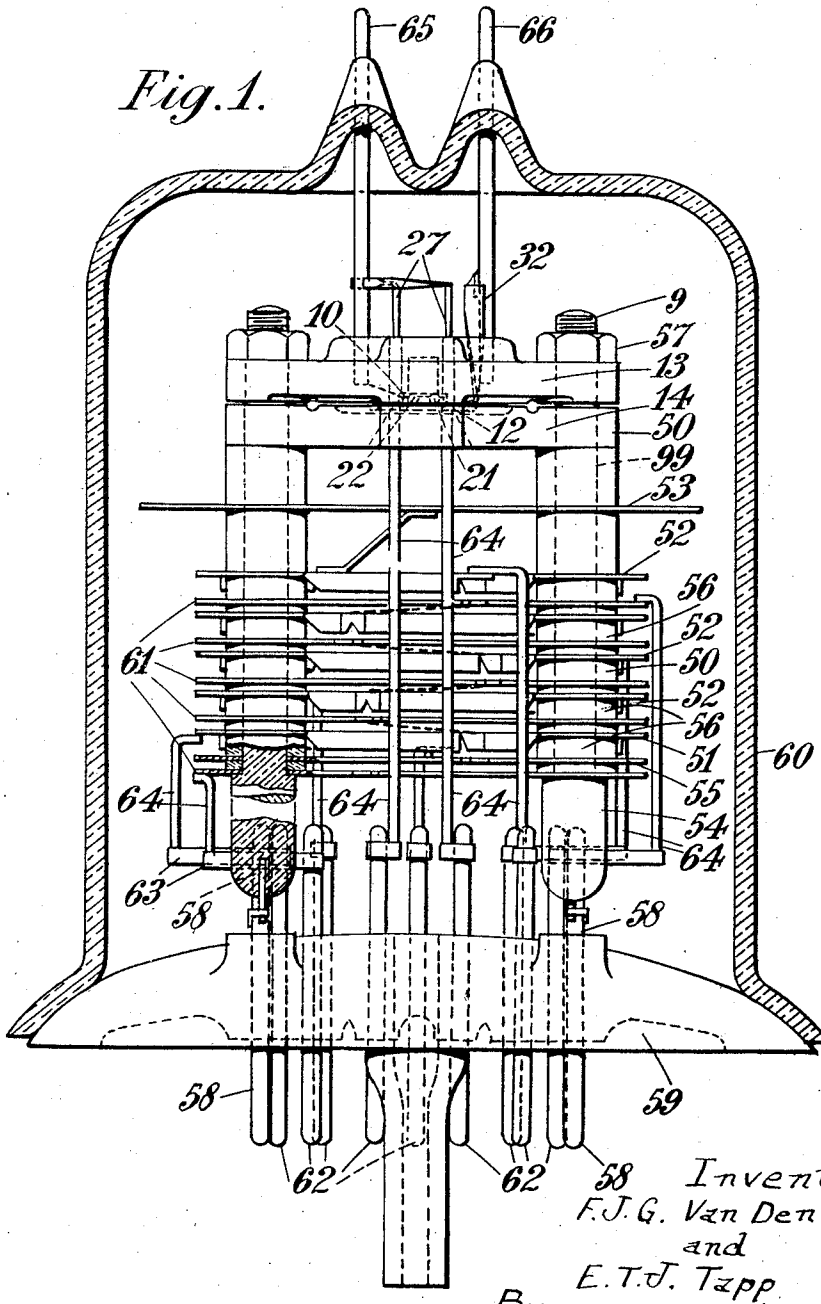

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Fig. 2.

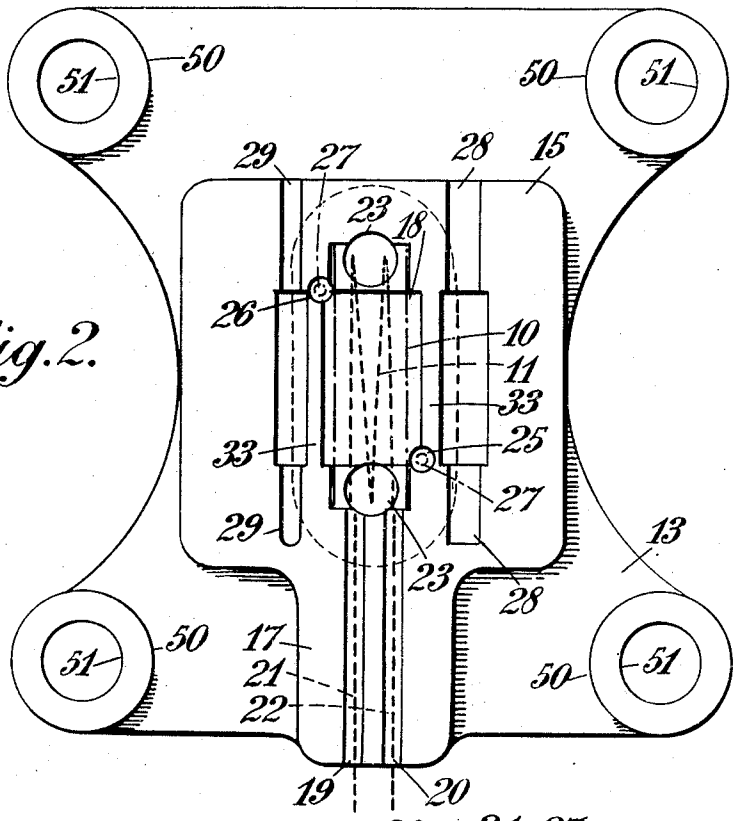


Fig. 4.

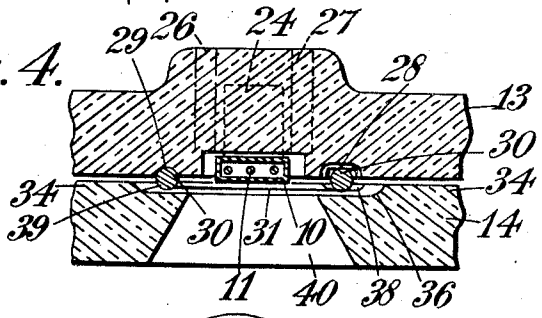
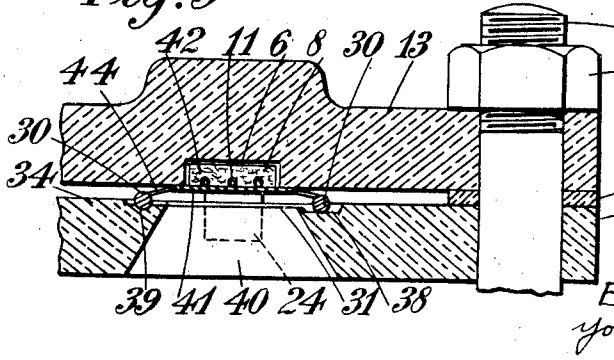


Fig. 5



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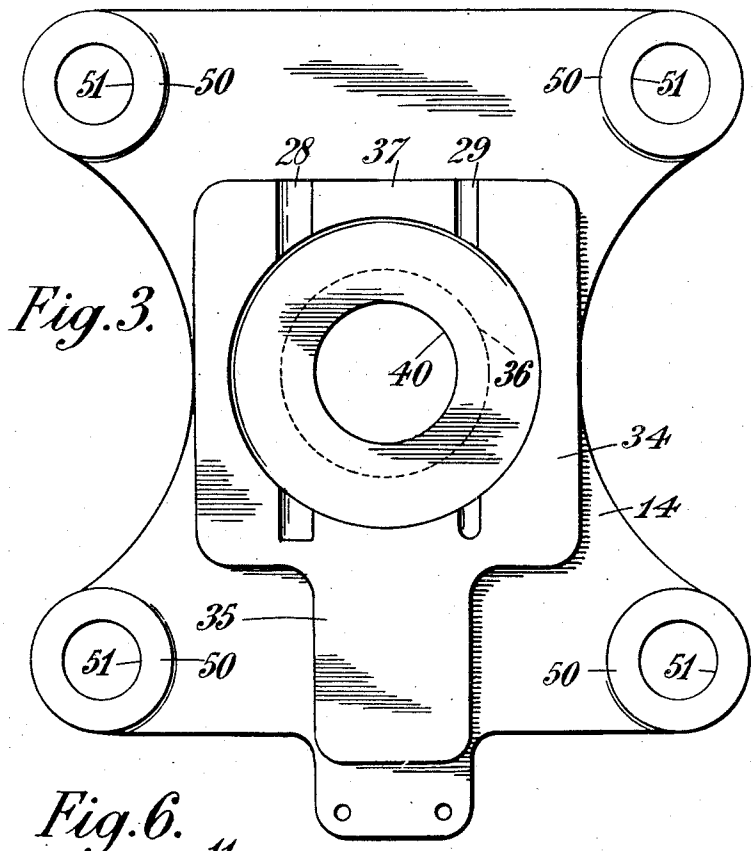


Fig. 3.

Fig. 6.

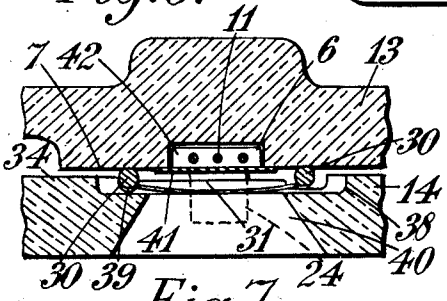


Fig. 7.

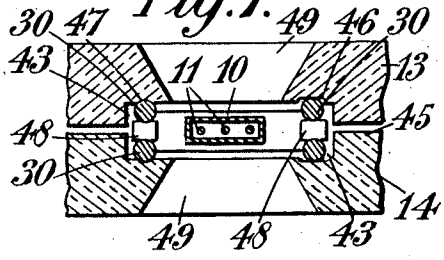
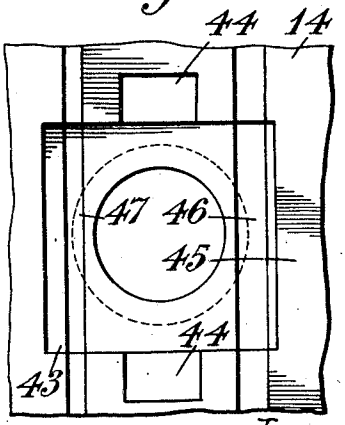


Fig. 8.



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Patented June 12, 1945

2,378,164

UNITED STATES PATENT OFFICE

2,378,164

ELECTRON DISCHARGE DEVICE

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Application April 10, 1942, Serial No. 438,502
In Great Britain February 10, 1941

15 Claims. (Cl. 250—27.5)

This invention relates to electron discharge devices comprising a thermionic cathode, and the invention is especially applicable to electron multipliers having one or more secondary cathodes, together with a collector or anode. Certain objects of the invention are to provide a more rigid mounting for the cathode so as to prevent objectionable vibrations and to provide means by which the electron stream is appropriately directed.

According to the present invention an electron discharge device is characterised in that one or more of the electrodes is or are located within a housing formed from refractory insulating material, which housing is provided with an aperture arranged to permit the electron stream to flow in a required direction. Preferably, said housing is formed by two insulating members having flat opposed faces, at least one of which is formed with a recess or recesses for locating said electrode or electrodes and means for clamping said insulating members together with or without intervening spacing members.

In the case where two electrodes are housed between the insulating members they are spaced the required distance apart by means which hold them against appropriate faces on either or both said members. For example, means may be provided for resiliently pressing the two electrodes respectively against the faces on the two insulating members. Thus, the distance apart of the two electrodes may be adjusted by adjusting the distance apart of the two insulating members.

Alternatively, both said electrodes may be resiliently pressed against faces on one and the same insulating member. In this instance the spacing apart of the two electrodes may be effected by appropriately designing those parts thereof which abut against the faces. Preferably, the faces on the insulating member are coplanar which facilitates the manufacture thereof.

The above construction is particularly suitable for housing a thermionic cathode which is so located as to extend across the aforesaid opening. The direction of the beam of electrons produced by the cathode may thus be determined by the position of the opening in the insulating member and stray emission is prevented

In the case where a grid is housed between the insulating members it may comprise two side frame members between which grid wires extend and means are provided for locating said grid both axially and laterally with respect to the walls of the housing, for example, grooves may be provided in one or both said insulating members for accommodating said side frame members of the grid, which grooves may be spaced away from either side of a recess for accommodating another electrode.

Spring means may be connected between said side frame members of the grid to maintain the grid wires taut, and at least one of the grooves may be arranged to permit relative lateral movement between a side frame member and the insulating members when the insulating members are clamped together. For example, one of said grooves is arranged to prevent lateral displacement of a side frame member which it engages, whereas the other groove is of greater width than the side member, thus permitting the two side members to spread apart due to heat expansion, or to compensate for differences in manufacture.

The aforesaid spring means may comprise flexible arched connecting members secured between the grid frame members and arranged to abut against a face on one of said insulating members and in addition to spreading apart of the side frame members when the insulating members are clamped together will also resiliently press the side frame members against their locating faces. With this arrangement means are provided for preventing the insulating members from clamping at least the member in the wider groove.

The thermionic cathode may comprise a tubular metal electrode through which extends a heater, while a recess in one of said insulating members is so shaped as to support the end of the tubular member while leaving a gap along each side thereof to reduce the conduction of heat from the cathode to the insulating member.

Alternatively, the thermionic cathode may comprise a flat plate arranged to close a recess in one of said insulating members, in which recess is located a heater.

A resilient bed of refractory material, such as asbestos fibre, may be arranged in said recess for preventing vibration of the heating element and for holding it in resilient contact with said cathode plate.

In any of the arrangements referred to above grooves may be formed in one or both of said insulating members for accommodating lead-in wires for said electrode or electrodes, which grooves are arranged to shield said wires from the electron stream.

The invention is also applicable to a thermionic electron discharge device in which a thermionic cathode has a grid and anode on each side thereof. In such an arrangement there is housed

between the two insulating members, said thermionic cathode and a grid disposed on each side thereof, and each said insulating member is provided with an aperture for the electron stream.

In applying the invention to an electron multiplier, the housing for the thermionic cathode and grid is, together with the other electrodes, mounted on insulating rods as set out in the specification of U. S. Patent application No. 438,503.

The following is a description of the invention applied to an electron multiplier, reference being made to the accompanying drawings, in which—

Figure 1 is a side elevation of the multiplier;

Figure 2 is a view of the inner face of one of the insulating members;

Figure 3 is a view of the inner face of the other insulating member;

Figure 4 is a cross-section through the centre part of the two insulating members showing the cathode and grid in position;

Figure 5 is a cross-section through an alternative arrangement of the electrodes between the insulating members;

Figure 6 is a cross-section through yet a further alternative arrangement of electrodes between the insulating members;

Figure 7 is a cross-section through two similar insulating members which house a grid disposed on each side of a cathode, and

Figure 8 is a face view of one of the insulating members.

Referring to Figures 1 to 3, the primary cathode **10**, its heater **11** and a control grid **12** are housed between two insulating members **13** and **14** which are in the form of plates of approximately rectangular form and constructed of a refractory insulating material such as that known under the registered trade mark "Steatite." The plate **13** has a slightly raised portion **15** at its centre on the inner face thereof, which central portion is provided with an extension **17** to one edge of the plate. The surface of this raised portion is ground flat. In the centre of the raised portion there is an elongated recess **18** in line with the aforesaid extension **17** and also in line with two grooves **19** and **20** formed in the extension between the recess and the edge of the plate. The width of the recess **18** is smaller at its ends than at its centre and these smaller ends are arranged to locate the primary cathode in the recess. The primary cathode **10** comprises a rectangular tubular element as best seen in Figure 4, within which is located the heating element **11** in the form of a zig-zag heating wire. The leads **21** and **22** for the heating element are accommodated in the aforesaid grooves **19** and **20**. At the bottom and at each end of the recess **18** is a small cylindrical depression **23** for accommodating a resilient element, such as a plug of asbestos **24**, for pressing the primary cathode into engagement with the other plate **14**. The plate **13** has also two holes **25** and **26** extending through it for the passage of leads **27** to the cathode tube. These holes are arranged at opposite ends of the recess **18** at locations where the recess changes from its wider to narrower width. There are also formed in the raised central portion of the inner face of the plate **13** two grooves **28** and **29** for receiving the side frame members **30** between which the grid wires **31** extend. These grooves extend to the edge of the raised portion on the opposite side to the aforesaid extension **17** and one or both of the frame members **30** is or are connected by a lead **32** to a conductor **66**. The walls **33** thus provided between the recess **18** and the grooves **28** and **29** operate to heat-insulate the grid side frame members from the cathode.

The centre part of the inner face of the other insulating plate **14** is also provided with a raised portion **34** and an extension **35** extending up to one edge of the plate, which raised portion and extension are arranged to lie closely adjacent the corresponding raised portion and extension on the other plate. A shallow circular recess **36** is provided at the centre of the raised portion **34** which circular recess is of such a size as not wholly to cover the recess **18** in the other plate and so as to leave localities **37** on the flat raised portion which will engage and support the ends of the cathode **10**, and which form abutments against which the cathode is held by the aforesaid resilient plug **24**.

As will be seen from Figure 4, the grid-wires **31** are disposed close to the bottom of the recess **36** and the side frame members **30** are located in the grooves **38** and **39** in the plate **14**, similar to the grooves **28** and **29** in the other plate. A hole **40** is formed through the plate **14** at the centre of the recess **36**, and, as seen from Figure 4, is of tapering form, so that the diameter of the hole on the outside of the plate is larger than that on the inside of the plate. The depth of the grooves **29** and **39** may be such as to clamp the grid wire **30** which they receive, whereas the depth of the grooves **28** and **38** are such as to permit lateral movement of the side frame member **30** accommodated in them, whereby latitude is allowed for differences in manufacture and also the frame can expand when heated.

In the alternative form of construction shown in Figure 5 the primary cathode is in the form of a plate **41** which is arranged to close a recess **42** on the inner side of the plate **13**, which plate, apart from this respect, is entirely flat over the whole of its surface. The cathode plate is retained in position by means of the resilient pads **24** of asbestos fibre which in this instance are arranged in shallow recesses formed in the plate **14** at either end of the aperture **40**. The cathode plate may be provided at its ends with inturned flanges **6** which locate the plate in the recess and increase the area of the plate which is subjected to the radiation of the heater. Alternatively, or additionally, flanges may be provided along the sides of the plate. The walls of the recess may be undercut and the flanges sprung into position, in which case the resilient pads **24** may be unnecessary. Electrical connection with the plate may be made by one or more leads (not shown) secured to said flanges and passing through holes in the bottom of the recess. The heater may comprise insulated heating wires in known manner which are pressed against the plate by a resilient bed of asbestos fibre **8** disposed in the recess. The side frame members **30** of the grid contact only with the insulating member **14** and are accommodated in the grooves **38** and **39** in that member. They are maintained in said grooves by an arched flexible spring member **44** secured between each end of the side frame members **30** and contacting with the upper insulating member **13**, which spring member has the additional function of maintaining the grid wires **31** taut. As indicated above, the cathode plate **41** is maintained in contact with the upper insulating member **13** by the resilient pad **24**. Thus, the distance at which the grid and cathode plate are spaced apart is determined by the distance in which the insulating members **13** and **14** are

spaced apart, and this may be controlled by a spacing washer 18 disposed between the two members.

The arrangement shown in Figure 6 differs from that last described above in that both the cathode plate and the grid frame are located from one and the same flat face 7 on the upper insulating member 13. For this purpose the spring member 41 is arched the other way to that shown in Figure 5 and abuts against the lower insulating member 14. The side frame member 30 is still located against lateral movement by the groove 39 in the lower insulating member 14.

In the alternative construction shown in Figures 7 and 8, the tubular primary cathode 10 has a grid frame 30 arranged on each side thereof, and in this case the two plates 13 and 14 are similarly constructed. As seen in Figure 8, they are each provided with a rectangular recess 43 which is of sufficient width to accommodate the grid frame. At each end of the recess there is a portion 44 which is of lesser depth and lesser width, which portions are arranged to accommodate the ends of the primary cathode. Both the bottom of the recess and the face of the upraised portion 45 of the plate are provided with grooves 46 and 47 for accommodating the side frame members 30 of the grid. Those portions of the groove which lie within the recess are thus necessarily shallower than those portions which extend across the face of the upraised portion 45. As in the previous construction, the groove 46 is wider than the groove 47. As will be seen from Figure 7, the two grid frames are maintained apart and pressed on to the bottom of their grooves by resilient members 48. Each of the plates is provided with a circular tapering aperture 49. The primary cathode is gripped between the two plates which at the points of gripping is provided with resilient pads (not shown) and the grid frames are resiliently clamped together.

In all the arrangements referred to above, each plate may be provided at its four corners with bosses 50 which are provided with holes 51 for receiving clamping bolts 9, by means of which the two plates are clamped together. The complete electrode assembly of the electron multiplier is built up on these four bolts which are formed from an insulating material such as "Steatite," as described in the specification of U. S. Patent application No. 438,503.

As will be seen in Figure 1, the collector electrode 51, the secondary cathodes 52 and accelerator 53 are all of disc-like form having lugs with holes therein for assembling on these bolts. The bolts are provided with heads 54 at one end providing shoulders on which a final secondary cathode 55 rests. Each of the secondary cathodes and the collector has a perforated plate 61 spaced away and connected to it. The various electrodes are spaced apart by "Steatite" washers 56 which encircle said bolts and the whole assemblage of electrodes is clamped together by nuts 57 also formed of "Steatite" and which encircle the threaded ends of the bolts. The four bolts are carried by metal pins 58 which are inset in the heads 54 and which pass through and are sealed in the disc-seal 59. Also as will be seen from Figure 1, various other leading in wires 62 pass through this disc-seal and are connected by clips 63 to the various conductors 64 which are in their turn connected by leads with the electrodes. The whole assemblage is housed in an envelope 60 which is secured to said disc-seal. Lead-in wires 65 and 66 are sealed in the other end of the envelope and are connected respectively to the leads 27 and 32 for the cathode and grid.

In the event of a gap being formed, e. g. by washers 18a (Fig. 5) between the two insulating plates this gap may be closed by a compressible packing (not shown) such as an asbestos cord located in a groove (not shown) around the raised portion of one or both plates; alternatively, one of the plates may be formed with a lip (not shown) around the cathode and grid and the plate with a part (not shown) fitting into this lip. To assist the directing of the electrons emitted by the primary cathode the wall of the hole in the cover plate may be glazed or may have a metallic coating arranged to have a suitable electric potential with respect to the cathode. Furthermore, the outer surface of the member may have a more extensive conductive coating for use at cathode potential in order to control the field distribution in the neighbourhood of the cathode.

It is to be understood that the construction and arrangement of the primary cathode with or without a control grid between insulating members according to this invention is applicable to thermionic devices other than electron multipliers, for example to thermionic valves, especially those of the beam-power type and also to cathode-ray tubes. Furthermore, the insulating members may have more than one opening for the electron emission to provide different electron streams for use in conjunction with different groups of other electrodes.

We claim:

1. An electron discharge device comprising two refractory insulating members having opposed faces one of which is formed with a recess said members forming between them a housing having an opening for the passage of electrons, two electrodes located between said members in said housing, locating faces on said insulating members spacing said electrodes the required distance apart, means pressing the two electrodes respectively against the faces of the two insulating members, and means securing said insulating members together.

2. An electron discharge device comprising two refractory insulating members having opposed faces one of which is formed with a recess said members forming between them a housing having an opening for the passage of electrons, two electrodes located between said members in said housing, locating faces on said insulating members spacing said electrodes the required distance apart, and means resiliently pressing said electrodes against one and the same insulating member.

3. An electron discharge device comprising two refractory insulating members having opposed faces, one of which is formed with a recess said members forming between them a housing having an opening for the passage of electrons, two electrodes located in said housing and completely surrounded by refractory surfaces thereof except at said opening, locating faces on said insulating members spacing said electrodes the required distance apart, and means resiliently pressing said electrodes against coplanar faces on one and the same insulating member.

4. An electron discharge device comprising two refractory insulating members having opposed faces, one of which is formed with a recess said members forming between them a housing for the passage of electrons, and a grid in said hous-

ing having two side frame members and grid wires extending between said members, one of said insulating members being provided with grooves accommodating the side frame members of the grid, which grooves are spaced away from either side of said recess.

5. An electron discharge device comprising two refractory insulating members having opposed faces, one of which is formed with a recess said members forming between them a housing for the passage of electrons, a grid in said housing having two side frame members and grid wires extending between said members, one of said insulating members being provided with grooves accommodating the side frame members of the grid said grooves being spaced away from either side of said recess, and spring means connected between said side frame members of the grid to maintain the grid wires taut, one of said grooves being deep enough to permit relative lateral movement between its side frame member and the insulating members when the insulating members are clamped together.

6. An electron discharge device comprising two refractory insulating members having opposed faces, one of which is formed with a recess said members forming between them a housing for the passage of electrons, a grid in said housing having two side frame members and grid wires extending between said members, one of said insulating members being provided with grooves accommodating the side frame members of the grid, said grooves being spaced away from either side of the recess, flexible arched connecting members secured between the grid frame members and abutting against one of said insulating members and spreading apart said side frame members, and locating faces on said insulating member and against which said side members are resiliently pressed by said flexible members, one of which grooves is deep enough to permit relative lateral movement between its side frame member and the insulating members when the insulating members are clamped together.

7. An electron discharge device comprising two refractory insulating members having opposed faces one of which is formed with a recess said members forming between them a housing having an opening for the passage of electrons, a tubular metal thermionic cathode in said recess the wall of which supports the end of the tubular member while leaving a gap along each side thereof, means securing said insulating members together, and a heater extending through said tubular metal cathode.

8. An electron discharge device comprising two refractory insulating members having opposed faces, each of which is provided with a recess and an opening forming between them a housing having a throughway for electrons, a thermionic cathode disposed in said housing, a grid on each side of said cathode, locating faces on said insulating members locating the cathode, other locating faces engaging said grids, and means resiliently pressing said grid against said faces.

9. An electron discharge device comprising a number of plate-like electrodes, two plate-like refractory members having opposed faces providing a recess with an opening for the cathode stream, a cathode and heater located in said recess, clamping means extending through said plate-like electrodes and said plate-like members and holding them together, an envelope enclosing said electrodes and refractory members, and means attaching said clamping means to said envelope.

10. An electron discharge device comprising a number of plate-like electrodes, two plate-like refractory members having opposed faces providing a recess with an opening for the cathode stream, and two sets of locating faces, a cathode and control grid having parts thereof mounted in said recess and having other parts mounted opposite said locating faces, means extending through said plate-like electrodes and said plates clamping them together, which two sets of locating faces space the cathode and control grid a predetermined distance apart when the plates are clamped together, an envelope enclosing said electrodes and refractory members, and means attaching said clamping means to said envelope.

11. An electron discharge device comprising a number of plate-like electrodes, two plate-like refractory members having opposed faces providing a recess with an opening for the cathode stream, and two sets of locating faces, a cathode and control grid having parts thereof mounted in said recess and having other parts mounted opposite said locating faces, means extending through said plate-like electrodes and said plates and clamping them together, which locating faces engage and hold a part of the cathode when the plates are clamped together, resilient means pressing the control grid against its locating face spacing it a predetermined distance away from the cathode, an envelope enclosing said electrodes and refractory members, and means attaching said clamping means to said envelope.

12. An electron discharge device comprising a number of plate-like electrodes, two plate-like refractory members having opposed faces providing a recess with an opening for the cathode stream, and a locating face, a cathode and control grid having parts thereof mounted in said recess and other parts mounted opposite said locating face, resilient means disposed between said plate-like members, clamping means extending through said plate-like electrodes and said members holding them together, said resilient means, when the members are clamped together, pressing the parts of said cathode and control grid against said locating face, an envelope enclosing said electrodes and refractory members, and means attaching said clamping means to said envelope.

13. An electron discharge device comprising a number of plate-like electrodes, two plate-like refractory members, one of which is provided with a recess, and the other with an opening, a heater disposed in said recess, a flat plate thermionic cathode mounted over said recess, clamping means extending through said plate-like electrodes and said plate-like members, holding them together and maintaining the cathode over said recess, an envelope enclosing said electrodes and refractory members, and means attaching said clamping means to said envelope.

14. An electron multiplier comprising a number of plate-like electrodes, two plate-like refractory members having opposed faces providing a recess and an opening leading from said recess, a cathode and heater located in said recess, clamping means extending through said plate-like electrodes and said plate-like members and holding them together and supporting a plurality of secondary cathodes opposite said opening, an envelope enclosing said electrodes and refractory members, and means attaching said clamping means to said envelope.

15. An electron multiplier comprising a num-

ber of plate-like electrodes, two plate-like refractory members having opposed faces providing a recess and an opening leading into the said recess, a cathode and heater and control grid located in said recess said control grid being disposed between the cathode and said opening, clamping means extending through said plate-like electrodes and said plate-like members and holding them together and a plurality of secondary cathodes supported by said clamping means opposite said opening, an envelope enclosing said electrodes and refractory members, and means attaching said clamping means to said envelope.

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