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ELECTRON DISCHARGE TUBE

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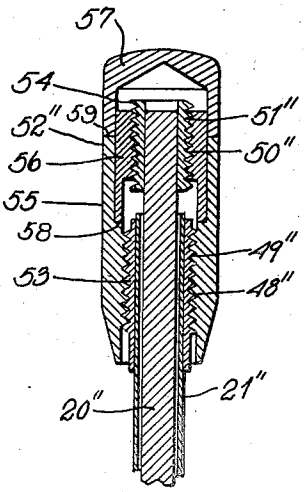


Fig. 3.

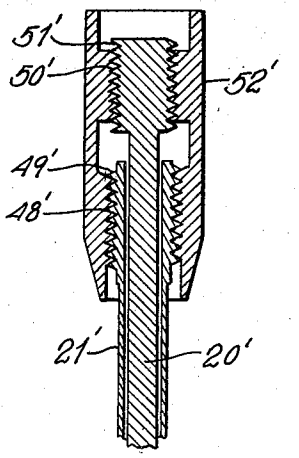


Fig. 2.

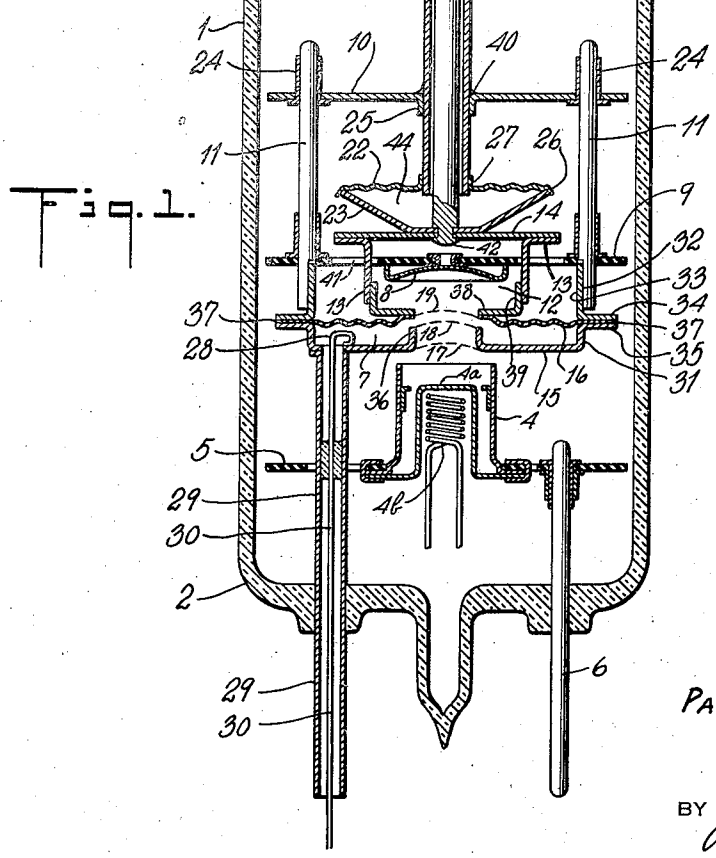


Fig. 1.

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ELECTRON DISCHARGE TUBE

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This invention refers to electron discharge tubes and, more particularly, to vacuum tubes containing elements whose mutual position can be changed during operation by external mechanical control means.

External mechanical control of the distance between electrodes or other tube elements enclosed in an evacuated envelope may be required for the tuning of velocity modulated tubes of the cavity resonator type, for focusing test specimens in electron microscopes, or for the experimental determination of the change of characteristics of conventional amplifier tubes in response to variations of interelectrode spacing, and for other purposes.

The mechanical transfer of an external control motion into the evacuated space enclosed in a tube envelope is usually carried out by means of flexible metal members, as metal bellows or corrugated metal sheets or discs which form part of the external tube envelope. In many cases the external envelope is made of glass, and it is then necessary to seal the metal member into an opening in the glass envelope. The mechanical deformation of the flexible metal member necessary for the transfer of motion exerts undesirable stresses on the glass-to-metal seals and may result in breakage of these seals. The flexible part of the envelope must be carefully protected against injury or uncontrolled mechanical motion which might interfere with the precise control of the motion which is desired to be transferred.

It is therefore an object of the invention to provide an improved coupling member for the transfer of external mechanical motion into motion inside an evacuated envelope.

It is another object of the invention to provide means for restricting the motion of a movable tube element with respect to other fixed tube elements to a single direction.

According to another object of the invention means are provided for the external control of the distance between two grids or control electrodes of a cavity resonator mounted inside an evacuated envelope.

A feature of the invention refers to the external control of the tuning of a reflex klystron by mechanical means.

Another feature relates to a vacuum tube of the glass bulb type having a movable internal electrode and a flexible diaphragm-like member for preserving the vacuum, which latter member is located within the bulb.

According to another feature of the invention,

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the tuning of a cavity resonator is controlled by a shaft passing through a metal tube which is sealed through the glass envelope in a vacuum tight manner.

The invention will now be described in connection with the drawing, in which

Fig. 1 is a sectional view of an electron discharge tube of generally axial symmetry, according to one embodiment of the invention.

Figs. 2 and 3 show modifications of the external control device shown in the upper part of Fig. 1.

Referring now to Fig. 1, numeral 1 represents a cylindrical glass envelope closed at the bottom by glass header 2. In the envelope 1 are mounted the electrodes of a reflex klystron, viz., cathode assembly 4, cavity resonator 7 and a concave reflector electrode 8 with its concavity facing the cathode. Through the header 2 are sealed in a vacuum tight manner lead-in pins 6 (only one of which is shown), for connecting the external voltage supply to the cathode, to the cavity resonator and to the reflector, in a manner known in itself and not shown in the drawing. The cathode assembly 4 which may consist of an electron emitter 4a heated by a separate heater 4b is supported by insulator table 5 carried by pins 6 sealed into header 2. All other electrodes are substantially carried by metal tubing 21 sealed axially into the envelope 1 at 3 by a vacuum tight metal-to-glass seal. Additional supporting members may be provided from the header end, if desired. Supporting disc 10 is firmly attached to metal tubing 21, which passes through a central hole 40 of disc 10, by means of a central flange 25, which is welded or brazed to the outer surface of tubing 21. Four rods 11 (two of them shown in Fig. 1) are rigidly connected at their upper ends to disc 10 by eyelets 24. To the lower ends of supports 11 is rigidly connected insulator disc 9, carrying centrally and rigidly attached at its lower side the reflector electrode 8. A metal ring 32, with cylindrical portion 33 of a diameter so as to fit snugly from the inside into the lower ends of support rods 11, is welded to these support rods. Ring 32 is provided with an annular flange 34 at its lower end. Cavity resonator 7 consists of a flat metal box, with generally disc-like bottom plate 15, a flexible top plate 16 and ring-shaped cylindrical wall 31. At the top of ring 31 a ring-shaped flange 35 is provided, on which rests the peripheral rim 37 of top plate 16. Rim portion 37 of plate 16 is welded or brazed between flanges 34 and 35. In this way cavity resonator 7 is firmly supported by support disc 10 and rigidly spaced

from insulator plate 9 and reflector electrode 8. A short cylindrical wall 36 in the central part of cavity resonator 7 forms the inner part of the cavity resonator, to which are transversely joined accelerator grid 17 and first buncher grid 18. Second buncher grid 19 is connected transversely across the central opening of flexible top plate 16 and to a central opening in the bottom of shielding electrode 12. Electrode 12 is generally cup-shaped, having a flat annular disc-shaped bottom 38 and cylindrical wall 39. Four right-angled metal struts 13 are firmly attached at their lower ends to the top of electrode 12, passing through four holes 41 in insulator disc 9. At their upper ends, the struts 13 are welded or otherwise rigidly connected to metal plate 14, which is carried at its center 42 by movable shaft 20 passing through tubing 21.

As described so far, it is evident that any motion of shaft 20 with respect to tubing 21 in axial direction (i. e., up and down in the figure) will be transferred to an equal motion of grid 19, while the positions of grid 18 and reflector electrode 8 remain fixed. Top plate 16 of cavity resonator 7 is preferably made of a metal disc having a series of circular corrugations to facilitate an axial linear motion of grid 19. Oscillatory energy of a frequency controllable by the distance between grids 18 and 19 can be extracted from cavity resonator 7 by means of metal loop 28 and concentric transmission line 29, 30 passing through header 2. Concentric line 29, 30 may also be used as a bottom support for cavity resonator 7, and may be supplemented by additional bottom supports rigidly attached to header 2, if desired.

The motion of shaft 20 in axial direction is used for tuning the cavity resonator in accordance with the invention. In order to separate the vacuum space in the envelope from the external pressure entering through top 43 of tubing 21, a separating chamber 44 is provided at the lower end of tubing 21 and shaft 20. It consists of a rigid inverted conical metal wall 23, brazed in an air tight manner to the lower end of shaft 20, and of a flexible corrugated top disc 22, connected at its inner periphery 27 in a vacuum-tight manner to tubing 21, and at its outer periphery 26 to the large diameter upper opening of conical wall 23. The flexible corrugated disc 22 is the only delicate and fragile part of the tube which is exposed to air pressure, and it is easily seen from the drawing that it is completely enclosed by the walls of the glass envelope, and thus not exposed to accidental external injury. The motion of shaft 20, and therefore that of grid 19, is substantially entirely a translational motion in axial direction, and a tilting of grid 19, which mght lead to unsymmetrical distribution of the electron orbits with respect to the tube axis, is prevented by the construction, as tubing 21 represents a long guide for shaft 20. The clearance between shaft 20 and tubing 21 can be made very small, without danger of sticking.

The translational motion of shaft 20 with respect to tubing 21 in the direction of the axis of these two parts may be controlled by nut 47, resting with a shoulder on top 43 of tubing 21, by means of cooperating threads 45 and 46 cut into the nut 47 and into shaft 20. In this embodiment, the tension of the corrugated metal membranes 22 and 16 must be so adjusted that it provides a downward pull on shaft 20. Turning of nut 47 to the right will then lift the shaft mechanically. When nut 47 is turned to the left, the elastic

forces of the metal membranes will pull the shaft down as far as the shoulder of nut 47 resting on top 43 of tubing 21 will permit. Shaft 20 is prevented from rotating with respect to tubing 21 by the mechanical connections at the lower end, as previously described.

A more sensitive control of the motion of grid 19 and shaft 20 may be obtained, by replacing the simple nut and screw arrangement shown in Fig. 1 by the differential screw combination illustrated in Fig. 2, wherein parts corresponding to those of Fig. 1 bear the same numerals primed.

In this embodiment of the control member, the upper ends of shaft 20' and of tubing 21' are provided with threads of different pitches, e. g. with thread 51' of 25 T. P. I. on shaft 20' and a thread 49' of 20 T. P. I. on tubing 21'. Corresponding threads, 50' on the upper section of nut 52' and 48' on the lower section of nut 52' cooperate with threads 51' and 49' respectively. A full turn of nut 52' will thus produce a motion of shaft 20' with respect to tubing 21' in axial direction equal to the difference of the full turn heights of the two threads, i. e., .050'' minus .040'', viz., .010''. Any other pair of pitches may, of course, be chosen in place of the 25 and 20 T. P. I., which served for illustration in the above example. The choice of the pitches depends on practical considerations.

Fig. 3 illustrates a further development of the differential screw control member shown in Fig. 2, wherein parts corresponding to those of Fig. 2 bear the same numerals double primed. In Fig. 3, the threads 49'' and 51'' are not cut directly into tubing 21'' and shaft 20'', but separate sleeves 53 and 54 are threaded, with threads 49'' and 51'', whose pitches are chosen as described in connection with Fig. 2. These threaded sleeves are brazed to tubing 21'' and shaft 20'' at a certain stage of processing of the tube, as will be explained later on. Nut 52'' consists of two parts, lower section 55 and cap 57. Thread 48'' is cut into the lower part of section 55. It has the same pitch as thread 49'' of the sleeve 53. No thread is cut into the upper part of nut 52'', which would fit into thread 51'' of sleeve 54. A separate pretuning nut 56 is provided, having a thread 50'' equal in pitch to that of thread 51'' of sleeve 54''. The outer diameter of pretuning nut 56 is slightly less than the inner diameter of the upper unthreaded part of section 55. The lower end of pretuning nut 56 rests on a shoulder 58 of nut 52''. After nut 52'' has been screwed in over tubing 21'', pretuning nut 56 is inserted into thread 51'', until its lower end rests on shoulder 58 of nut 52''. The purpose of pretuning nut 56 is to adjust the center tuning range around which the tube is desired to operate. Accordingly, nut 56 is turned until the correct center tuning range is obtained. When this adjustment has been made, it may be brazed with its outer surface to the inner surface of lower section 55. Finally, cap 57 is joined to top 59 of section 55, preventing any dust entering into the control member.

The construction of the external control as described in connection with Fig. 3 has various advantages over that of Fig. 2. In the first place, it permits the use of materials for tubing 21'' and shaft 20'' having uniform wall-thickness and uniform outer diameter. The pretuning nut 56 facilitates a convenient control of the tuning range, as a last operation after the tube is processed and exhausted. It is, of course, desirable that the tuning threads 48'', 49'' and 50'' and 51'' are not exposed to the high temperatures

required during the baking and exhaust of the tube, as this might lead to corrosion of the threads, and interfere with the tuning in operation.

It is therefore desirable to use the control arrangement of Fig. 1, consisting of thread 46 in shaft 20, and an exhaust nut 47 with thread 45 during exhaust, only for the purpose of adjusting the distance between grids 18 and 19 during that process. After exhaust, nut 47 is removed, sleeves 53 and 54 are fitted over and brazed over the ends of tubing 21 and shaft 20. Then lower section 55 of nut 52'' is screwed over sleeve 53'', and the desired central tuning position is adjusted by inserting pretuning nut 56''.

The differential screw arrangement is preferable for fine tuning, over the single screw shown in Fig. 1, because it insures a positive control of the motion of shaft 20 in both directions by the control nut 52'', while the single screw tuning control of Fig. 1 relies on elastic forces in the metal membranes 22 and 16 for the downward motion of shaft 20.

While adjusting mechanism of the invention is described in detail in its application for tuning a reflex klystron, it is of course understood that this is merely done for purposes of illustration, not by way of limitation.

For a detailed explanation of the operation of the reflex klystron reference may be had to U. S. Patent No. 2,250,511, the disclosure of which is expressly incorporated herein by reference.

What is claimed is:

1. An electron tube comprising an evacuated enclosing glass envelope, a tubular metal member sealed through one end of said envelope, a shaft mounted for sliding movement in said tubular member, expansible means located within said envelope and sealing the inner end of said tubular member to said shaft to allow said shaft to slide while maintaining the vacuum within the envelope, a cavity resonator within the evacuated space of said envelope comprising a fixed boundary wall and a movable boundary wall, means rigidly connecting said movable wall to the inner end of said shaft, means rigidly connecting said fixed wall to said tubular member, means external of the envelope and connected to said shaft for controlling the sliding adjustment of said shaft in said tubular member, and a cathode within the envelope for projecting an electron stream into said resonator.

2. An electron tube, comprising an enclosing envelope, an electrode system within the envelope comprising in longitudinal array an electron emitter, a cavity resonator, a shield electrode and an electron reflector electrode, means supporting said resonator said reflector and shield as a unit from one end of the envelope comprising a tubular metal member sealed vacuum-tight through said end of the envelope, a flexible metal member sealed to the inner end of said tubular member and located wholly within said envelope, a metal rod passing through said tubular member and connected vacuum-tight to said flexible member, means connecting said resonator to the inner end of said rod, means connecting said resonator to said tubular member, and means insulatingly supporting said reflector electrode from said tubular member.

3. An electron tube comprising an enclosing glass envelope, a tubular member sealed vacuum-tight through said envelope, a plurality of support rods extending parallel to said tubular member, means rigidly fastened to said tubular member and to which said support rods are fastened at one end, a cavity resonator fastened to the opposite ends of said rods, one wall of said resonator being movable with respect to another wall, spaced aligned grids carried respectively by the movable wall and the fixed wall, a slidable rod passing through said tubular member and rigidly connected at its inner end to said movable wall, and flexible diaphragm-like means located entirely within the envelope and providing a movable but vacuum-tight joint between said tubular member and said slidable rod, means external to said envelope and connected to said rod for adjusting the position of said rod and thereby adjusting the position of said movable wall, and an electron emitter cathode within said envelope for projecting electrons into said cavity resonator.

4. An electron tube according to claim 3 in which a reflector electrode is insulatingly supported from said support rods in spaced relation to said resonator.

5. An electron tube according to claim 3 in which a concentric line is vacuum-tight sealed through the wall of said envelope and is connected to said resonator forming an additional support therefor, said transmission line terminating in a looped portion located within said resonator.

6. An electron tube of the klystron type, comprising an enclosing evacuated envelope, a cavity resonator within the envelope comprising an annular trough-like member of rigid metal, first and second grids attached transversely across the inner annular wall of said trough-like member in spaced relation to each other, a flexible annular diaphragm, a third grid attached transversely to the inner annular margin of said flexible annular diaphragm, means biasing said diaphragm with said third grid carried thereby in spaced relation to said second grid, a reflector electrode insulatingly mounted in alignment with said grids and in spaced relation to said third grid, a reciprocable rod passing through the wall of the envelope and connected to said diaphragm, a tubular metal member through which said rod passes and sealed vacuum-tight through the envelope wall, the inner end of said tubular metal member being vacuum-tight sealed to the inner end of said rod by means of a flexible corrugated metal member located entirely within the envelope, means external to the envelope and connected to said rod for adjusting said rod and said third grid, an electron-emitting cathode for projecting electrons into said cavity resonator.

7. An electron tube according to claim 6 in which a shield electrode surrounds said reflector electrode, said shield having an opening in alignment with said grids and rigidly supported from the end of said rod.

8. An electron tube of the reflex klystron type, comprising an enclosing evacuated envelope, an elongated tubular metal member sealed vacuum-tight through said envelope, a pair of support rods rigidly supported at one end from said tubular member, a cylindrical metal member rigidly fastened to the lower ends of said rods, said cylindrical member having a flat annular peripheral flange, an annular trough-like metal member also having a flat annular peripheral flange in abutting relation with the first-mentioned flange, a corrugated flexible metal annular member fastened at its outer margin between

said abutting flanges, first and second grids extending transversely across the inner annular wall of said trough-like member in spaced relation to each other, a third grid extending transversely across the central opening in said corrugated annular member, a cup-like metal shield member having a central opening in its bottom and fastened to the inner margin of said corrugated annular member, a reflector electrode carried by an insulator member extending between said support rods, said reflector electrode being in alignment with said grids, an adjusting rod extending through said tubular metal member and connected at its lower end to said shield member, means external to said envelope and connected to said rod for adjusting said rod and thereby to vary the position of said third grid with respect to said second grid and with respect to said reflector electrode, and an electron-emitting cathode for projecting electrons into the space between said first and second grids.

9. A tube according to claim 8 in which said trough-like member and said corrugated annular member form a cavity resonator, and a concentric transmission line is vacuum-tight sealed through said envelope and terminates in a metal loop which extends into said cavity.

10. An electron tube, comprising an evacuated enclosing envelope, an electrode system mounted within said envelope including an adjustable electrode whose position is adjustable with respect to one or more of the other electrodes, means to effect said adjustment externally of the envelope while maintaining the vacuum, the last-mentioned means including a tubular metal member vacuum-tight sealed through the envelope, a rod passing through said tubular metal member and connected to said adjustable electrode, said rod and tubular member each having a portion external of the envelope, each external portion carrying a separate threaded section of different pitch, a differential adjusting nut cooperating with said threaded sections, and an electron emitter for projecting electrons into the space between said electrodes.

11. An electron tube according to claim 10 in which the external end of said tubular metal member carries an external threaded sleeve and the external end of said rod also carries a threaded sleeve, and means are provided to set the normal position of said rod with respect to said tubular member comprising a threaded nut cooperating with the thread on the first-mentioned sleeve, and another threaded nut cooperating with the thread on the second-mentioned sleeve, said nuts being independently adjustable to set said normal position, means fastening the nuts together as a unit, and differentially threaded means engaging said nuts to effect a differential movement of said rod for adjustment of the position of said adjustable electrode.

12. An electron tube construction of the klystron type having an enclosing envelope, a movable electrode within the evacuated envelope of the tube, and means to effect adjustment of said electrode while maintaining the vacuum, the last-mentioned means including a tube sealed through said envelope, a slidable rod passing through said tube and the envelope and connected to the movable electrode, and a flexible corrugated metal plate vacuum-tight sealed between the inner end of the rod and the envelope, said plate being wholly located within the envelope whereby it is protected by the envelope against injury.

13. An electron discharge device having an evacuated envelope, a tubulation sealed into and through the wall of said envelope, a rigid rod telescoped through said tubulation and extending at one end into the envelope, the other end of the rod being accessible externally of the envelope, an electrode within the envelope and movably mounted therein, a connection between said rod and said movably mounted electrode, and expansible vacuum-tight means sealing the inner end of said tubulation.

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