Sept. 27, 1960 J. O. HAMILTON 2,954,498

REFLEX KLYSTRON

Filed May 5, 1958

FIG. 1

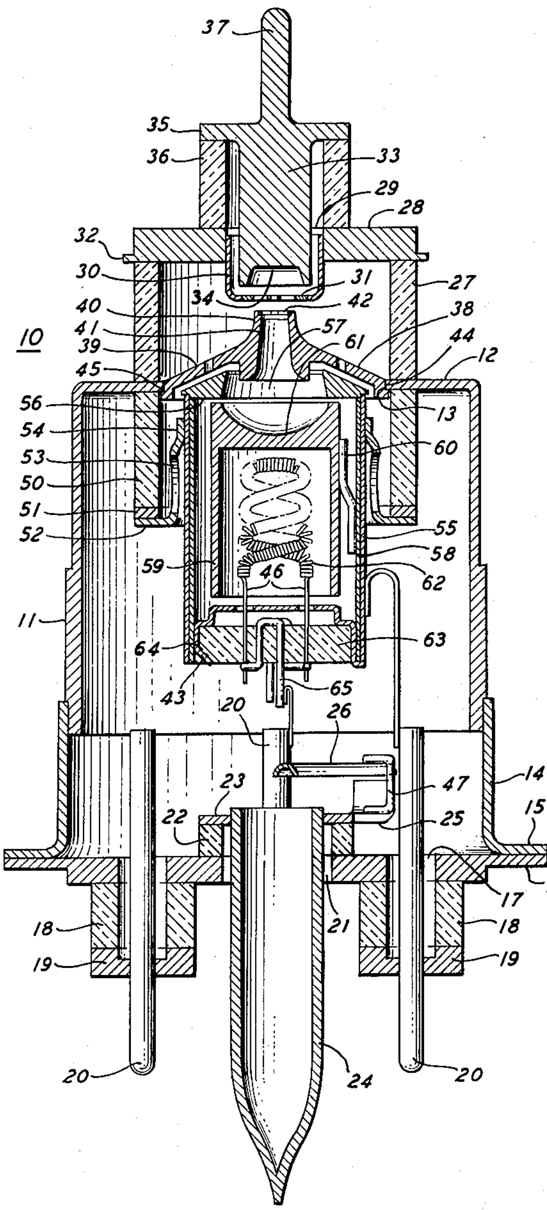
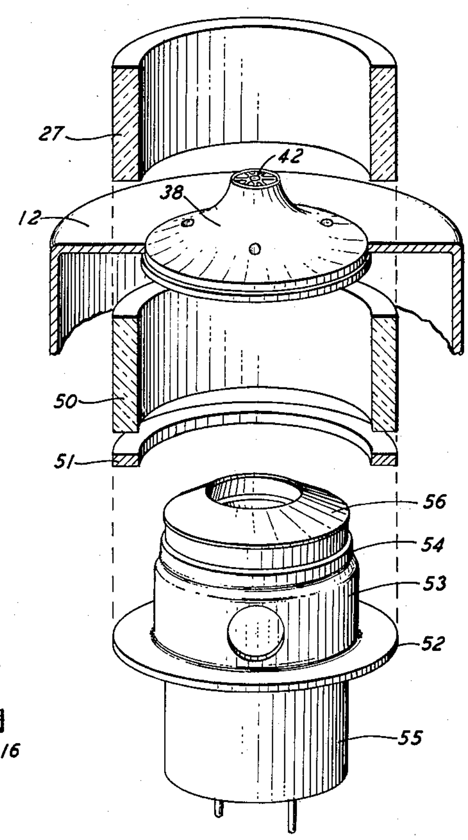


FIG. 2



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REFLEX KLYSTRON

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This invention relates to electron discharge devices and, more particularly, to velocity variation oscillators of the reflex type having a single external cavity resonator.

Reflex type velocity variation oscillators, or reflex klystrons as they are more commonly known, comprise, in general, a cavity resonator through which an electron beam is projected and a bunching region adjacent thereto. The cavity resonator includes two grids defining a gap across which a radio frequency field is maintained for modulating the electron beam by varying the velocity of electrons therein. After the beam emerges from the gap, it enters the bunching region, which includes a repeller electrode, where the velocity variations are converted to density variations. The repeller electrode reverses the direction of travel of the beam back toward the gap. Upon reentering the gap, the density variations of the beam cause energy to be given up to the cavity resonator, thereby sustaining oscillations.

There are at least two types of reflex klystron; those having the resonant cavity within the envelope, and those having the resonant cavity external to and distinct from the envelope. In both types, a long predictable operating life is desirable. In the external cavity klystron the problem of obtaining such long life is complicated by the necessity of having electromagnetic wave permeable material between the gap and the cavity to preserve vacuum integrity, which in turn necessitates ceramic-metallic seals. Various other problems and complications also arise in the use of the external cavity tube. The external resonant cavity reflex klystron is normally less complicated in design, however, and displays greater resistance to mechanical shock than internal cavity klystrons, since fewer delicate internal components are necessary.

The excitation of an external cavity is commonly accomplished through a ceramic or glass electromagnetic wave permeable window member positioned about the gap portion of the interaction region of the klystron. This glass ceramic member forms a portion of the envelope and is attached to other, normally metallic, portions thereof. To insure long life in a reflex klystron, those internal components subjected to high temperatures during operation are directly connected, when possible, to metallic portions of the envelope to allow a path for heat transfer to the exterior of the device. Since adjoining ceramic and metallic portions of the envelope have, in general, different coefficients of expansion, stresses are created during operation at the junctions between these portions. Other stresses are caused during operation by the thermal expansion of the internal components of the klystron which are mounted directly to external envelope portions. Any of the aforementioned stresses may subvert the strength advantages obtained by the use of external resonant cavities, so means to minimize their effect is desirable.

Further, to insure a long and efficient operating life for the klystron, the means for mounting the internal components must be simple, strong, easily alignable, and accurate, and must consist of as few distinct parts as possible. These mounting requirements are especially important in a device to be used at relatively high frequencies, since incremental variances have more effect where small components are in use, as with such high frequencies. It is, therefore, important that each component used in mounting the internal structure of the reflex klystron lend accuracy and strength, not only to the immediate component that it mounts, but to the whole of the internal structure and to the whole of the device.

It is an object of this invention to provide a reflex klystron of sturdy construction, thereby insuring consistent, predictable operating qualities throughout its operating temperature range.

It is another object of this invention to provide an external cavity reflex klystron having an all-metallic and ceramic envelope with accurately alignable internal components.

It is a still further object of this invention to distribute the stresses set up during operation at the ceramic-metal junctions of an external cavity reflex klystron by a novel electron gun mounting arrangement.

These and other objects of this invention are accomplished in an illustrative embodiment in which a novel electron gun subassembly mounting member is utilized to relieve the stresses present at the junction between a metallic envelope portion which supports the anode of the gun arrangement and the electromagnetic wave permeable window surrounding the interaction region. In this illustrative embodiment the anode is mounted in an aperture of a metallic envelope portion extending transverse to the klystron axis. To this metallic portion is affixed the electromagnetic wave permeable window. During operation the anode heats and expands, exerting pressure outward on the metallic portion and causing shear stresses at the junction of that portion with the window. To relieve these stresses and further to mount the electron gun subassembly a hollow ceramic cylindrical member is affixed to the side of the metallic portion remote from the window. Also, in this embodiment, all of the components which require accurate positioning are so constructed that either a machined slip fit or a direct positioning by machine tool jig of each such component is possible.

It is a feature of this invention that the stresses, due to operational heating and thermal expansion therefrom, present at a junction between an electromagnetic wave permeable window envelope portion and a metallic envelope portion be reduced by a hollow cylindrical ceramic member mounted to the opposite side of the metallic envelope portion than the electron permeable window.

It is another feature of this invention that a cylindrical ceramic member be mounted at one end to a metallic envelope portion and at the other end support the electron gun subassembly of a reflex klystron.

It is a further feature of this invention that the components of a klystron requiring accurate alignment be so constructed as to allow positioning by either a machined slip fit or by a machine tool jig.

A complete understanding of this invention and of these and other features thereof may be gained from consideration of the following detailed description and the accompanying drawing, in which:

Fig. 1 is a cross-sectional representation of one specific embodiment of an external cavity reflex klystron in accordance with this invention; and

Fig. 2 is an exploded perspective view of various elements of the embodiments of Fig. 1, including particularly the electron gun subassembly and mounting, the anode, and the electron permeable window member.

Referring now to the drawing, the reflex klystron 10 illustrated in Fig. 1 comprises an evacuated enclosure having a first hollow cylindrical metallic body member 11, closed at one end by a transversely extending end portion 12 having a machined circular aperture 13 located centrally therein. At the other end of body member 11 and depending therefrom is welded or brazed a second hollow cylindrical metallic body member 14. The lower portion of body member 14 is formed into a flange 15 lying in a plane transverse to the axis of the klystron 10 and is closed off by a platform 16, hermetically sealed thereto. Circular platform 16 has a plurality of apertures 17 arranged therein at one radius about its center, with cylindrical ceramic pin insulators 18 depending from and hermetically sealed to the platform 16 at each aperture 17. Hermetically sealing the ends of pin insulators 18 are metallic eyelet plates 19 projecting through the center of which are lead-in conductors 20. Each of conductors 20 is sealed to and supported by a vitreous bead, not shown, filling the center portion of each of pin insulators 18 and adhering thereto. Centrally located in platform 16 is an aperture 21. Hermetically sealed to the inner surface of the platform 16, surrounding aperture 21, is ceramic bushing 22. Bushing 22 is closed at its upper end by metallic washer 23 sealed thereto and supporting at its center an exhaust tubulation 24. Exhaust tubulation 24 projects through aperture 21 in platform 16 and is hermetically sealed to platform 16, ceramic bushing 22, and washer 23 by a glass bead, not shown. Washer 23 has at one point at its circumference a projecting portion 25. Connected to portion 25 is a conductor 47 which is bent up and connected to one end of a getter assembly 26. The other end of getter 26 is connected to one of the lead-in conductors 20 so that it may be flashed by a potential across that lead-in conductor 20 and exhaust tubulation 24. Connected to the other lead-in conductors 20 are conductive means, not shown, for applying potentials to the various members of the device.

Mounted within aperture 13 of end portion 12 of the envelope is an anode 38 having a machined circumference 44 which is an accurate slip fit within aperture 13. The upper surface of a flange 45 on anode 38 is also machined to position the anode 38 axially in klystron 10 by bearing against the internal surface of end portion 12. Anode 38 has a conical outer portion 39 and a centrally located frusto-conical inner portion 40. Extending longitudinally through inner portion 40 is bore 41 through which the electron beam passes during operation. Portion 40 supports and positions at its upper end an electron permeable first grid 42, concentrically located with respect to the axis of klystron 10.

Positioned on end portion 12 to the exterior of and coaxial to body member 11 is an electromagnetic wave permeable window member 27. Window member 27 is a hollow cylindrical member, preferably of a ceramic material, and is positioned in manufacture by means of a jig and hermetically sealed at one end to metallic end portion 12. Accurately positioned with respect to anode 38 at the other end of window member 27 and hermetically sealed thereto is a metallic end plate 28. Centrally positioned in end plate 28 is an aperture 29 in which is mounted by a machine slip fit a grid housing member 30. Grid housing member 30 is a hollow, cylindrical, metallic member having a flange extending inwardly toward its axis at its lower end for mounting a second grid member 31. Grid housing member 30 extends into the space enclosed by window 27 for accurately positioning second grid 31 in close proximity to grid 42. Grids 31 and 42 define therebetween the interaction region of device 10.

At the outer rim of end plate 28 is a flange 32 precisely machined for positioning and aligning discharge device 10 within its external cavity, not shown. This external cavity is preferably of the type disclosed in an application by E. W. Houghton, Serial No. 733,092, filed May 5, 1958. Extending through aperture 29 is a metallic member 33 having a shaped repeller 34 formed in its lower surface by a deep cup-like depression. An annular flange 35 on member 33 is hermetically sealed to one end of a hollow ceramic cylindrical member 36 which positions member 33 with respect to anode 38 and which is hermetically sealed at its other end to the upper surface of end plate 28. In manufacture, members 33 and 36 and end plate 28 may be positioned by means of jigs. Ceramic member 36 accurately positions repeller 34 for cooperative association with respect to the interaction region formed by grids 31 and 42 and serves to insulate repeller 34 from the remaining portions of tube 10. Extending from the upper end of member 33 is a pin 37 to which may be applied the proper repeller potential, as well as modulating signals for effecting the operation of device 10.

Affixed to end portion 12, within and coaxial to body member 11, for positioning the electron gun subassembly, is a hollow cylindrical electron gun mounting member 50, which is a ceramic member of substantially the same size, shape, and material as ceramic window member 27. At the end of member 50 remote from portion 12 is a metallic washer 51 to which is affixed, as by welding or brazing, a lower flanged portion 52 of a hollow cylindrical gun support member 53. Member 53 is a metallic member mounted coaxially with body member 11 within gun mounting member 50 and has an upper portion 54 of lesser diameter than its main body portion. This upper portion 54 advantageously supports by slip fit a hollow metallic cylinder 55 which mounts a beam forming electrode 56 at its uper extremity; alternately, beam forming electrode 56 may be made integral with member 55. Beam forming electrode 56 is a metallic member of frusto-conical shape arranged coaxially with body member 11 and has a frusto-conical aperture 57 centrally located for allowing the passage of the electron beam during the operation of the device. In manufacture, members 50, 53, and 55, and washer 51 are all supported by positioning jigs which accurately position beam forming electrode 56 relative to the other members.

Accurately positioned by a slip fit within cylinder 55 is a cathode sleeve 58, a hollow metallic cylinder of lesser diameter and slightly lesser length than cylinder 55, abutting on electrode 56 and joined to cylinder 55 as by welding. Positioned within sleeve 58 is a hollow metallic cathode 59 which is mounted to member 58 by a plurality of cathode support wires 60, only one of which is shown. Each support wire 60 is bent at its mid-point so that its two end portions are parallel and may be affixed, as by brazing, to cathode sleeve 58 and cathode 59. The upper end of cathode 59 has a concave, spherical electron emitting surface 61. Cathode 59 is so positioned within cathode sleeve 58 by support wires 60 that the correct amount of clearance is obtained between emitting surface 61 and beam forming electrode 56 when cathode sleeve 58 abuts the latter member. Preferably cathode 59, sleeve 58, and supports 60 are made from materials having coefficients of thermal expansion such that the cathode 59 will not shift relative to the cathode sleeve 58 as the parts become heated during operation of the device, support wires 60 being of material having low thermal conductivity.

Within the hollow portion of cathode 59 is mounted a heater 62 supported through heater legs 46 by a ceramic heater support member 63 which closes the lower end of cathode sleeve 58 and is held therein by a metallic heater shield 64. Shield 64 is basically a cup-like member fitting within and welded to cathode shield 58 and having tabs 43 crimped to hold heater support member 63. Heater support leads 65 extend upwardly through holes in member 63 and back down through adjacent holes where they are welded to heater legs 46 also extending through holes in member 63.

In the manufacture of device 10 all members except the base, members mounted thereon, cylinder 58, and members mounted thereon, are assembled in one operation and baked to give the requisite cleanliness. The aforementioned excluded members are assembled externally to the tube, thereby assuring precise spacing and alignment of the various components, and then positioned within the envelope of the device and appropriate affixtures and seals made. Thus, cathode shield 58, cathode 59, and related members are accurately assembled by positioning jigs externally. Shield 58, when positioned by slip fit within cylinder 55, accurately positions cathode 59 with respect to all other operating elements. During the assembly operation the spacing between grids 31 and 42 may be accurately set by measurement or, preferably, by mounting the tube 10 in a standard cavity and adjusting the grid spacing. After the grid spacing is determined, the spacing between electrode 56 and anode 38 is measured. Accurate adjustment of this spacing may be had inasmuch as support member 53, which has been fully annealed, may be deformed somewhat to give the desired spacing.

In operation, the electron beam initiated at emissive surface 61 of cathode 59 passes through anode 38 imparting heat thereto as an incident of its passage. Anode 38, preferably a copper member, tends to expand as its temperature increases and exerts certain radial forces on end portion 12 wherein it is mounted. The stresses imparted through the device by these forces and the means for overcoming them may be best understood through a contemplation of Fig. 2, which is an exploded view of end portion 12 of Fig. 1 and the various members mounted immediately thereto. As anode 38 heats, it expands and exerts pressure against end portion 12, creating radial stresses at the junction with window 27. Further, as the coefficients of expansion of anode 38 and ceramic window 27 differ and because these members receive different amounts of heat, other radial shear stresses are set up at the ceramic-metallic seal therebetween. However, by positioning mounting member 50, preferably having like properties to window member 27, to the other side of end portion 12, opposite the region of greatest stress, the shear stresses at the aforementioned seal are substantially reduced by reason of the fact that they are distributed between members 27 and 50 instead of being concentrated in member 27 solely and the life of the device appreciably lengthened. When member 50 is of the same material, size, and shape as member 27, the shear stresses are more evenly divided between the two members, the resulting stresses in either member then being insufficient to damage the member or the seal. In addition, the use of a single ceramic cylinder 50 as a means for mounting the electron gun assembly not only allows the use of fewer members but gives a stronger, more accurate positioning than that employed by most prior art devices. The use of a mounting device shaped as member 50 allows also the use of the two-step assembly process, previously described, which, with the all metallic-ceramic envelope, allows higher temperatures to be used in baking whereby cleaner tubes are obtained. The metallic envelope portions are preferably of a material such as Kovar to facilitate the fabrication of ceramic-metallic seals which may be baked out at high temperatures without injury to the various subassemblies which are assembled and baked separately. In a typical tube the metallic portion of the envelope including portion 12 was of Kovar. Ceramic members 27 and 50 were of a high alumina ceramic manufactured by the Coors Porcelain Company and designated A.I. 200, and anode 38 was of copper. It was found that high temperature strains and stresses did not damage the various parts nor affect to any significant extent the operation of the tube.

It is to be understood that the foregoing embodiments of the principles of this invention are for the purposes of illustration, and many other embodiments may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. An electron discharge device of the reflex klystron type comprising a symmetrical envelope, said envelope comprising a hollow cylinder having an apertured end portion extending transversely to the axis of said envelope, said cylinder completely surrounding a hollow cylindrical mounting member which is sealed to one side of said end portion, a cylindrical electromagnetic wave permeable member sealed to the other side of said end portion, an anode mounted within the aperture of said portion, an electron gun mounted within said cylindrical mounting member, an apertured end plate affixed to one end of said cylindrical window, a grid housing unit mounted within the aperture of said end plate, a repeller electrode having a flange thereon extending through said aperture of said end plate, and a hollow cylindrical envelope portion affixed to said end plate and said repeller electrode, the inner diameter of said hollow envelope portion being equal to the diameter of the aperture in said end plate and the outer diameter of said cylindrical envelope portion being equal to the outer diameter of said flange.

2. An electron discharge device of the reflex klystron type comprising an envelope having a central axis, first, second, third and fourth hollow cylinders arranged coaxially in that order about said axis, said first cylinder mounted on said second cylinder, said second cylinder mounted on said third cylinder, a cathode mounted within and affixed to said first cylinder, a focusing electrode affixed to one end of said second cylinder, said fourth cylinder having an apertured end portion extended transversely to said axis, said third cylinder being sealed to one side of said end portion, a cylindrical electromagnetic wave permeable window sealed to the other side of said end portion, an apertured end plate affixed to one end of said cylindrical window, an apertured anode mounted within the aperture of said end portion, a first grid mounted within the aperture of said anode, a second grid mounted within the aperture of said end plate, a repeller electrode having a flange thereon, and a cylindrical envelope portion affixed on one end to said end plate, and on the other end to said flange.

3. The reflex klystron of claim 2 wherein said third cylinder comprises means for distributing stresses between said window and the end portion of said fourth cylinder, said third cylinder being of the same size, shape and material as said window.

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