

July 4, 1950

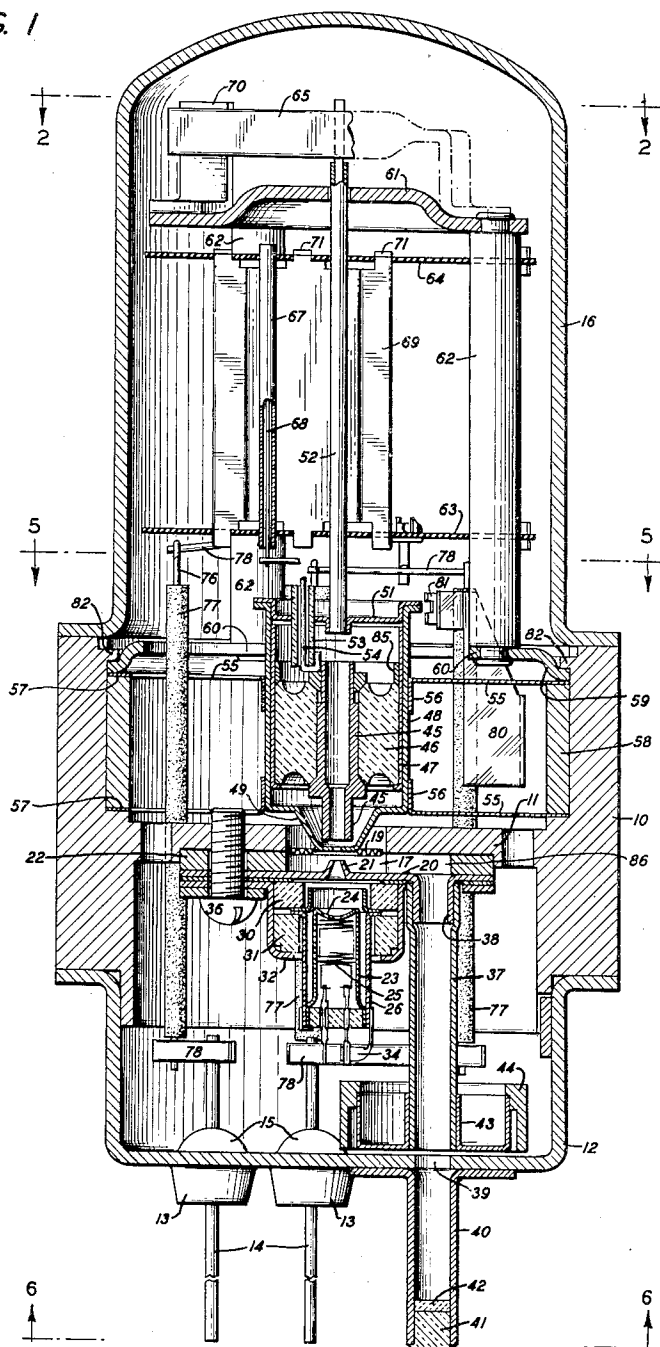
F. H. BEST
ELECTRON DISCHARGE DEVICE INCLUDING
A TUNABLE CAVITY RESONATOR

2,513,277

Filed Feb. 1, 1945

4 Sheets-Sheet 1

FIG. 1



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FIG. 2

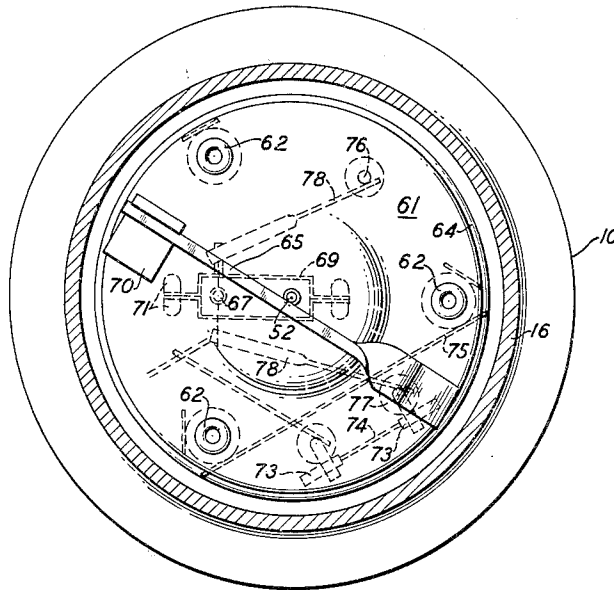
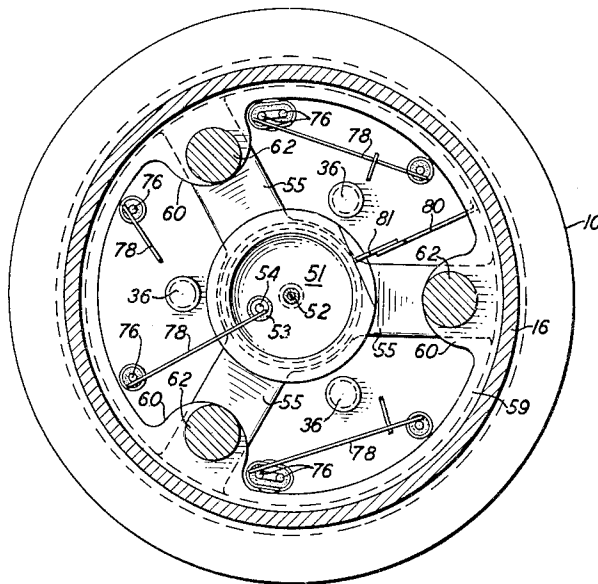


FIG. 5



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FIG. 3.

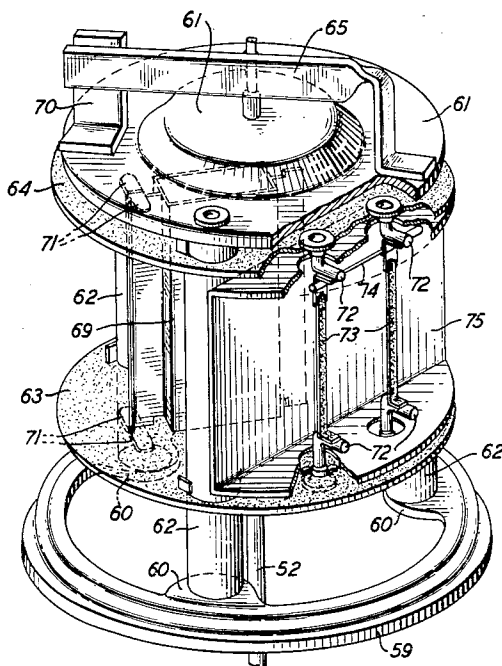
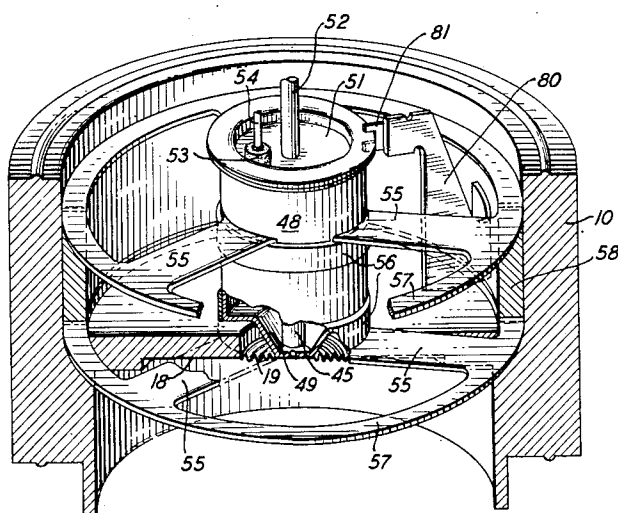


FIG. 4.



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FIG. 6

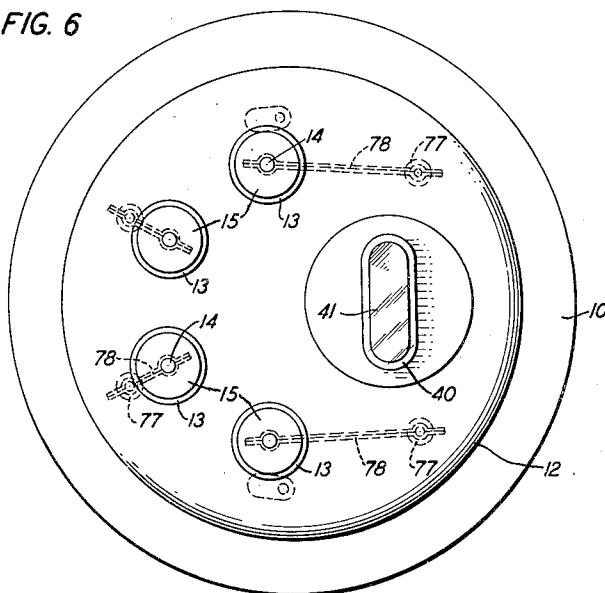
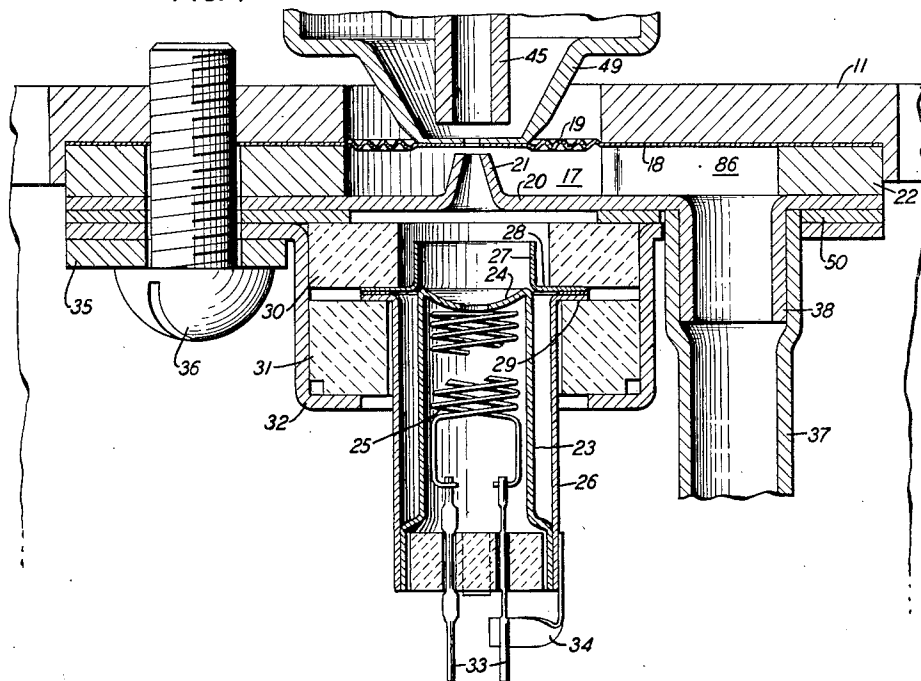


FIG. 7



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6 Claims. (Cl. 315-5)

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This invention relates to electron discharge device including a tunable cavity resonator and more particularly to microwave devices of the type comprising an electronic system embodying a cavity resonator, for example a reflex oscillator unit, and thermally sensitive means constituting a part of a thermionic unit, for controlling or adjusting the configuration of the cavity resonator and, hence, its resonant frequency.

One general object of this invention is to improve the construction of electron discharge devices of the type noted above.

More specifically, objects of this invention are to:

Facilitate the fabrication of such devices and particularly microwave devices wherein accurate physical relationships between the elements of the electronic system are of paramount importance;

Expedite the realization of highly accurate coaxial relation of the electrodes and resonator gap in a microwave device, such as a reflex oscillator;

Improve the sensitivity and accuracy of control of the resonant frequency of a cavity resonator by a thermally sensitive element forming a part of a thermionic tuner unit; and

Maintain a fixed prescribed relation between the electrodes of a reflex oscillator and the elements bounding the gap in the cavity resonator thereof despite variations in the gap length occasioned by alteration of the resonator configuration during the tuning thereof.

In one illustrative embodiment of this invention, an electron discharge device comprises a cavity resonator having aligned apertures in two opposite walls thereof, one of the walls being flexible, an electron gun and repeller electrode on opposite sides of the resonator and aligned with the apertures noted, a thermionic tuner unit including a driving member mounted to expand and contract longitudinally in accordance with temperature variations due to controlled electron bombardment thereof, and a coupling between the driving member and the flexible wall of the resonator, whereby this wall is displaced in accordance with elongation and shortening of the driving member and the resonator configuration and, hence, its frequency are adjusted accordingly.

In accordance with one feature of this invention, the cavity resonator, electron gun, tuner unit and coupling are constructed and arranged to be fabricable as independent assemblies wherein the elements of each assembly are in prescribed alignment, and the several assemblies are mounted in stacked relation upon a common body and in coaxial alignment.

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In accordance with another feature of this invention, the coupling aforementioned is mounted, as by spider members, in such manner as to be movable substantially only linearly parallel to the driving member and normal to the flexible wall of the cavity resonator whereby linear relationship between expansion and contraction of the driving member and displacement of the flexible wall is obtained.

In accordance with a further feature of this invention, the repeller electrode is mechanically integral with the coupling so that it moves therewith, whereby the spacing between the repeller electrode and the flexible wall, and, hence, between the repeller electrode and the operating gap in the resonator, remains fixed at a prescribed value despite variations in the resonator configuration and frequency due to displacement of the flexible wall.

The invention and the above-noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing, in which:

Fig. 1 is an elevational view, mainly in section, of an electron discharge device illustrative of one embodiment of this invention;

Fig. 2 is a sectional view of the device, taken along plane 2-2 of Fig. 1;

Fig. 3 is a perspective view of the thermal tuner unit assembly included in the device shown in Fig. 1;

Fig. 4 is a perspective view of the coupling between the tuner and the resonator, portions of the structure being broken away to show details thereof more clearly;

Fig. 5 is a cross-sectional view taken along plane 5-5 of Fig. 1;

Fig. 6 is an end view taken along plane 6-6 of Fig. 1; and

Fig. 7 is an enlarged elevational view in section showing details of the electron gun and the cavity resonator structure included in the device illustrated in Fig. 1.

Referring now to the drawing the electron discharge device therein illustrated comprises a highly evacuated enclosing vessel housing therein a reflex oscillator, including a cavity resonator, and a thermally sensitive element for tuning the resonator and forming a part of a thermionic tuner unit. The enclosing vessel comprises a cylindrical metallic body 10 having an inwardly extending annular flange 11, a cup-shaped metallic base member 12 sealed, as by welding or brazing, to one end of the body 10 and having therein a plurality of eyelets 13 to which leading-

in conductors 14 are sealed hermetically by vitreous masses or beads 15, and a metallic, cup-shaped cap or closure 16 sealed as by welding or brazing, to the other end of the body 10.

The reflex oscillator, the principal parts of which are shown to an enlarged scale in Fig. 7, comprises a generally toroidal cavity resonator 17 bounded by a metallic disc 18 having a flexible, annularly corrugated diaphragm portion 19, a second rigid metallic disc 20 having a central frusto-conoidal portion 21 aligned with a central opening in the diaphragm portion 19 and a metallic spacer ring 22.

Opposite the frusto-conoidal portion 21 and axially aligned therewith is an electron gun which includes a cylindrical cathode member 23 having a concave end surface 24 coated with electron emissive material, a heater filament 25 within the cathode member, a heat shield 26 encompassing the cathode member and a cylindrical beam forming electrode 27. The beam forming electrode 27 and shield 26 are provided with juxtaposed flanges 28 and 29 respectively which are joined to each other and are held between insulating discs 30 and 31 seated within a flanged cup-shaped member 32. The cathode member 23 is affixed at one end to the shield 26 and the latter is connected electrically to one of the leading-in conductors 33 for the heater filament 25 by a tie wire 34. The elements of the electron gun together with the discs 19 and 20, the spacer 22 and a second spacer ring 50 are locked to the flange 11 by a C-shaped washer or clamping member 35 and a plurality of screws 36, only one of which is shown, threaded into the flange 11.

The frusto-conoidal member 21, beam forming electrode 27 and cathode are so constructed and arranged, in ways known in the art, that electrons emanating from the surface 24 are concentrated into a converging beam substantially focussed upon the gap between the smaller end of the member 21 and the portion of the diaphragm 19 opposite thereto.

Energy may be taken from the oscillating field within the resonator 17 by way of a wave guide which is of rectangular cylindrical cross-section, as shown clearly in Fig. 6, and comprises an inner portion 37 affixed to an eyelet 38 on the disc 20 adjacent a slot 86 in the ring 22, the portion 37 extending into immediate proximity to an aperture 39 in the base member 12, and an outer portion 40 affixed to the base member 12, in alignment with the inner portion 37 and sealed hermetically at its outer end by a vitreous mass 41 abutting a ceramic disc 42 fitted within the portion 40.

The inner portion 37 of the wave guide has affixed thereto a trough-shaped metallic annulus 43 which in turn mounts a metallic cylinder 44, the annulus 43 and cylinder 44 defining a choke joint with the juxtaposed portion of the base 12 to prevent loss of energy from the guide 37, 40.

Opposite the diaphragm 19 and aligned with the central aperture therein is a tubular repeller electrode 45 which is locked in a cylindrical ceramic body 46 fitted within a cylindrical metallic sleeve 47 and locked therein by a collar or band 85. The sleeve 47 is secured within a metallic coupler element 48 having a tapered end portion 49 secured to the diaphragm 19. The other end of the coupler 48 has affixed thereto a rigid metallic disc 51 to the center of which a rigid metallic drive rod 52 is secured. For reasons which will appear presently, the drive rod 52 is of a material, such as stainless steel, having a high temperature

coefficient of expansion and contraction. Extending through an insulating tubulature 53 carried by the disc 51 is a leading-in connector 54 for the repeller electrode 45.

The assembly comprising the coupler 48, 49 and repeller electrode 45 is supported for axial movement as a unit by a pair of resilient spider members, the arms 55 of which, as shown in Fig. 4, radiate from integral collars 56 affixed to the coupler 48, to integral annuli 57 seated against opposite ends of a cylindrical spacer 58 fitted within the body 10.

During operation of the device, electrons emanating from the cathode surface 24 are projected across the gap in the cavity resonator 17 and are velocity varied due to the oscillating field within the resonator. The velocity varied electron stream issuing from the aperture in the diaphragm 19 is subjected to a retarding field due to the repeller electrode 45, whereby the direction of motion of the electrons is reversed and the electrons are again projected into the resonator in the form of a density varied stream to deliver energy to the field within the resonator and thus to sustain oscillations. The oscillation frequency will be dependent, of course, upon the resonant frequency of the resonator and the latter, in turn, is dependent upon the configuration of the cavity. The configuration and, hence, the resonant frequency, is adjustable by deflection of the diaphragm 19. As is apparent, displacement or deflection of the diaphragm may be effected by longitudinal motion of the drive rod 52. Such motion of the rod 52 is realized and controlled accurately by varying the temperature of the rod to cause it to expand or contract to tune the cavity resonator to the desired frequency. The control of the rod is effected by a thermionic unit, of which a portion of the rod constitutes the anode.

The thermionic tuning unit is fabricated as a unitary assembly which comprises, as shown clearly in Figs. 1 and 3, an annular foundation member or platform 59 provided with integral ears 60 and a dished plate 61, the member 59 and plate 61 being coupled together by rigid posts 62 abutting the plate 61 and the ears 60. Supported in parallel relation by the posts 62 are a pair of insulating discs 63 and 64 which mount, in turn, a cathode and a control electrode cooperatively associated with the drive rod 52. The latter extends through oversized apertures in the discs 61, 63 and 64 and has its upper end secured to a rigid bridge defined by a bracket 76 and a bent strap or lever 65 affixed to the disc 61.

The cathode of the tuner unit comprises a cylindrical metallic tube 67 parallel to the rod 52 and having a coating of electron emissive material upon its outer surface, and a folded heater filament 68 within the cathode tube 67. The control electrode 69 is of rectangular form, encompasses the cathode 67 and rod 52 and is locked to the insulating discs 63 and 64 by integral bent-over tabs 71.

In the fabrication of the device, after the tuner assembly has been mounted as described herein-after, the strip or lever 65 is flexed to move the drive rod 52 longitudinally, and thus to move the coupler-repeller electrode assembly and displace the diaphragm 19, to tune the cavity resonator to a prescribed frequency. The end of this strip is then affixed, as by welding, to the bracket 70. Thereafter, as will be apparent, the natural frequency of the resonator will vary in accordance with longitudinal expansion and contraction of the drive rod 52, one end of the rod be-

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ing fixed against displacement by the bridge 65, 70. The length of this rod at any time will be dependent upon the temperature thereof and the temperature, in turn, will be determined by the bombardment of the rod by electrons emanating from the cathode 67, the rod, as noted heretofore, serving as an anode. The electron current to the rod is controllable by the control electrode 69. Thus, by adjusting the potential of the electrode 69, the resonant frequency of the cavity resonator may be altered or maintained fixed despite variations in the configuration of the cavity resonator due to temperature effects in the operation of the device.

It is evident that extremely fine tuning of the cavity resonator is attainable. Also, inasmuch as the repeller electrode 45 is coupled mechanically to the diaphragm 19 and moves therewith, the spacing of the repeller electrode relative to the diaphragm is fixed, whereby, for the any given potentials upon the elements of the oscillator, the transit times for electrons leaving the cavity resonator and returning thereto likewise is fixed. Further, because of the mounting of the coupler 48 by the spiders, displacement of the coupler is linear whereby a predeterminable relation between resonator frequency and control electrode potential is achieved.

Supported from the discs 63 and 64 by bent wires 72 locked to these discs are a pair of filaments 73 which are coated with a getter material and are connected electrically at one end by a fuse wire 74. A protective shield 75, mounted upon two of the posts 62, is interposed between the control electrode 69 and the getter coated filaments. During the evacuation treatment of the device, a suitable current is passed through the filaments 73 by way of the leading-in conductors for two of the electrodes of the device, to flash the getter material. An increased current pulse is then applied to melt the fuse wire 74 and, thus, break the electrical connection between the two conductors mentioned.

Electrical connection between the leading-in conductors 14 and the electrodes of the oscillator and thermionic tuner unit may be established by way of conductors, for example wires 76 encased in insulating sleeves 77, to which the conductors 14 and electrodes are connected by tie wires or strips 78. One suitable arrangement of the various tie wires is indicated in Figs. 2, 5 and 6. The specific connections may be varied, of course, and will be apparent without further description.

The device described is designed especially for fabrication from several subassemblies which are readily associated to constitute the complete device wherein all the parts are held securely in place and wherein the parts of the oscillator unit are aligned very accurately, for example coaxial within less than .001 inch. The general method of assembly and fabrication is, briefly, as follows: The disc 13, 19 is brazed to the flange 11 on the body 10. The spiders are secured to the coupler 48 by welding the collars 56 thereto and this assembly together with the spacer 58 is inserted into the body 10 and the spiders are brazed to the spacer 58, the latter is brazed to the body 10 and the smaller end of the frusto-conical portion 49 is brazed to the diaphragm 19. During this operation, the coupler 48 is centered accurately, as by a suitable jig, with respect to the body 10 and thus, is aligned accurately with the diaphragm. In order to prevent damage to the diaphragm during subsequent operations, a lock

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member 80 having a slotted end 81 for accommodating the flange on the coupler 48 is secured to the spacer 58, the slot being of such width as to limit axial motion of the coupler and, hence, displacement of the diaphragm to, for example, of the order of a few thousandths of an inch.

A subassembly comprising the repeller electrode 45, insulator 46 and sleeve 47, constructed so that the repeller electrode is accurately coaxial with the outer surface of the sleeve 47, is inserted within the coupler 48 until the electrode 45 rests upon the frusto-conical portion 49 and then is withdrawn a distance requisite to establish the prescribed spacing between the repeller electrode and the diaphragm 19, whereupon the sleeve 47 is welded to the coupler 48. Thus, the repeller electrode 45 is aligned coaxially with the diaphragm 19. Using the repeller electrode as a guide, a suitable tool closely fitted thereto, is inserted through the repeller electrode to punch an aperture in the diaphragm 19. As is evident, the aperture thus produced is accurately aligned with the repeller electrode.

The disc 20, ring 22 and inner portion 37 of the wave guide are fabricated as a subassembly, with the ring 22 accurately coaxial with the frusto-conical portion 21 and the ring 22 is then affixed, as by brazing, to the disc 13. During this operation, the apertures in the diaphragm 19 and frusto-conical portion are aligned accurately while viewing with a microscope.

Another subassembly comprising the cathode 23, 24, shield 26, insulators 30 and 31 and cup-shaped member 32, but not the heater 25, is then fabricated, aligned with the apertures in the portion 21 and diaphragm 19 while viewing with a microscope through the central aperture in the dish portion 24 of the cathode, and is then secured to the flange 11 by the screws 36.

The cap or closure 51 with the drive rod 52 fixed thereto, is affixed, as by welding, to the coupler member 48, a portion of the flange of the cap 51 being cut away, as shown in Fig. 4, to clear the slotted end portion 81 of the lock member 80. This portion is then bent away from the coupler member 48 and severed.

Subsequently, the thermionic tuner assembly is threaded over the rod 52 and the platform 59 is seated upon the upper spider member (in Fig. 1) and locked in place by forcing a portion of the body 10 thereagainst as indicated at 82 in Fig. 1. The drive rod 52 then is welded to the bridge piece 65 and the latter is flexed to tune the cavity resonator and welded to the bracket 76, as noted heretofore.

It is to be noted particularly that the construction above described enables very exact coaxial alignment of the elements of the oscillator whereby predeterminable and stable operating characteristics are obtained. Further, it will be noted that in the completed device the internal elements are mounted securely in fixed relation whereby the device may be subjected to relatively strong shocks without disturbance of the desired space relation of the parts.

Although a specific embodiment of the invention has been shown and described, it will be understood that it is but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. An electronic device comprising means including a diaphragm defining a cavity resonator,

means opposite said resonator for exciting it, a repeller electrode opposite said diaphragm, a cylindrical coupling member extending normal to said diaphragm and having one end affixed thereto, means mounting said repeller electrode from said coupling member, means mounting said coupling member for motion in the direction of its longitudinal axis, said mounting means comprising a pair of spaced spider members having resilient arms secured to said coupling member and extending outwardly therefrom, and means coupled thereto for driving said coupling member in said direction to flex said diaphragm.

2. An electronic device comprising a cylindrical body, a cavity resonator supported within said body and having a flexible wall portion substantially normal to the longitudinal axis of said body, means opposite said resonator for exciting it, a repeller electrode opposite said wall portion, a coupling member secured to said wall portion, means mounting said repeller electrode from said coupling member, a pair of resilient spider members disposed in parallel planes normal to said axis, said spider members being supported by said body and mounting said coupling member, and tuner means coupled thereto for displacing said coupling member parallel to said axis.

3. An electron discharge device comprising a hollow body member having an inwardly extending flange, a cavity resonator supported by said flange and having juxtaposed wall portions provided with aligned apertures, one of said wall portions being flexible, a unitary electron gun assembly opposite the other of said wall portions and supported by said flange, a repeller electrode opposite said one wall portion, a coupler member affixed to said one wall portion, resilient means supporting said coupler member from said body member, and a thermionic tuner assembly supported by said body member, said tuner assembly including an electrode member coupled to said coupler member and mounted for longitudinal expansion and contraction.

4. An electron discharge device comprising a cylindrical body member having an inwardly extending flange and a seating surface adjacent said flange, a cavity resonator supported by said flange and having juxtaposed wall portions provided with central apertures and extending transversely with respect to said body, one of said wall portions being flexible, an electron gun opposite the other of said wall portions, a repeller electrode opposite said one wall portion, a coupler member affixed to said one wall portion, means mounting said repeller electrode from said coupler member, a first spider member seated on

said seating surface and connected to said coupler member, a spacer seated upon said spider member, a second spider member seated on said spacer and connected to said coupler member, and a thermionic tuner unit mounted by said body and including a longitudinally expandable and contractile electrode having one end fixed and the other end connected to said coupler member.

5. An electron discharge device comprising an enclosing vessel, means within said vessel and separate therefrom defining a cavity resonator having a displaceable wall portion provided with an aperture, means opposite said resonator for exciting it, a coupling member affixed to said wall portion, an electrode outside said resonator and positioned opposite said aperture, rigid means mounting said electrode from said coupling member, flexible means separate from said wall portion mounting said coupling member, and actuating means within said vessel coupled to said coupling member for flexing said wall portion, thereby to tune said resonator.

6. An electron discharge device comprising a cavity resonator having opposed walls provided with aligned apertures, one of said walls being flexible, an electron gun opposite the other of said walls and the aperture therein, a cylindrical coupling member joined to said one wall, a cylindrical insulating member fixedly mounted by and within said coupling member, an electrode fitted within said insulating member and opposite the aperture in said one wall, and driving means connected to said coupling member for displacing it axially thereby to flex said flexible wall and tune said resonator.

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