Sept. 5, 1950 W. G. SHEPHERD 2,521,545

ELECTRON DISCHARGE DEVICE

Filed June 28, 1946

FIG. 1

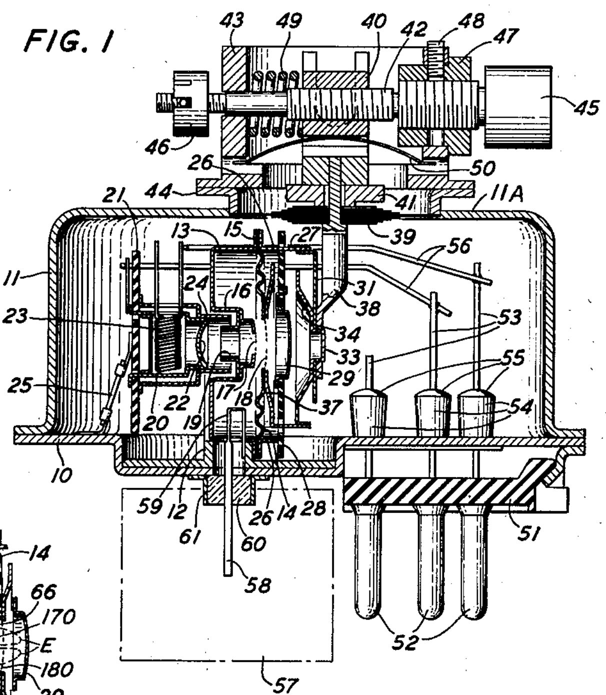


FIG. 3

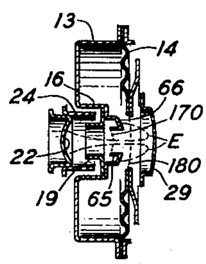
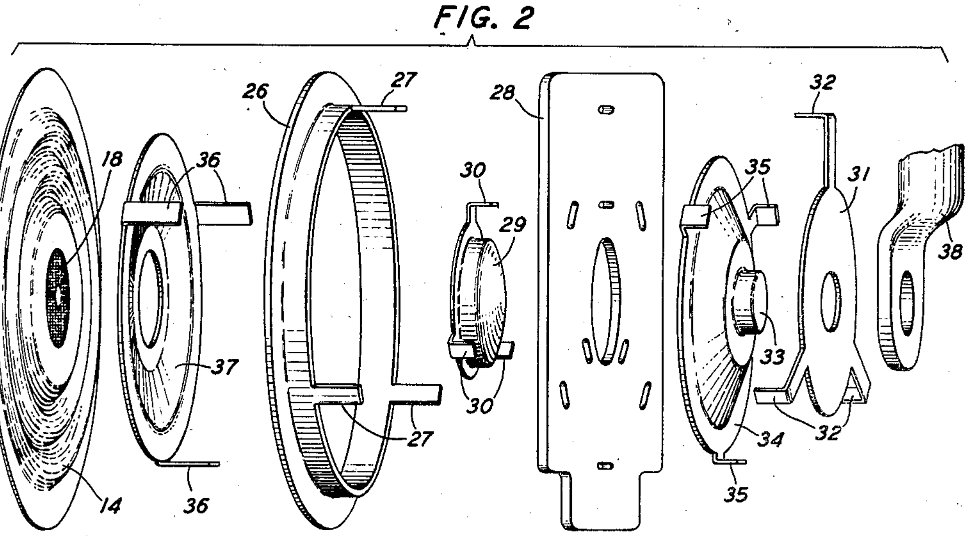


FIG. 2



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ELECTRON DISCHARGE DEVICE

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5 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge devices and more particularly to microwave oscillators of the reflex type.

In one known general construction, a reflex oscillator comprises an enclosing vessel housing a cavity resonator having a gap therein, an electron gun for projecting an electron stream across the gap in one direction and a repeller electrode for causing reversal of the direction of the electron stream after it has crossed the gap and again projecting it into the gap. In their first traversal of the gap, the electrons are velocity varied due to the field within the resonator and when they are reinjected into the gap they constitute a density varied stream and deliver energy to the field noted thereby to generate and sustain oscillations. For given electrode potentials, the oscillation frequency is determined largely by the constants of the resonator.

In some applications, it is desirable that the oscillation frequency be variable over a fairly wide range and to be accurately adjustable to any desired frequency in this range conveniently. Such frequency adjustment may be effected by alteration of the configuration of the cavity resonator, for example by displacement of a flexible wall portion thereof. In devices intended for operation at extremely high frequencies, specifically frequencies corresponding to wavelengths of the order of 5 centimeters or less, necessarily the resonator dimensions must be small. Hence, even slight changes in a dimension of the resonator may cause a large variation in the resonant frequency thereof.

In accordance with one feature of this invention, the cavity resonator, the tuning mechanism therefor and the enclosing vessel of the device are constructed and arranged so that physical changes in the tuning mechanism and the enclosing vessel with variations in temperature have substantially no effect upon the characteristics of the cavity resonator, whereby frequency drift with temperature variations is minimized.

More specifically, in accordance with one feature of this invention, the cavity resonator is provided with a disc-like flexible wall to which a tuning lever is coupled and the lever is constructed and arranged so that its direction of major thermal expansion and contraction is substantially normal to the direction in which the wall is displaced by flexure to tune the resonator.

In accordance with another feature of this invention, the resonator and the support or fulcrum of the lever are mounted on the enclosing vessel of the device so that dimensional changes of the vessel with temperature variations do not affect the relative positions of the resonator and lever and, hence, do not alter the frequency to which the resonator has been tuned.

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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 in section of an electron discharge device illustrative of one embodiment of this invention;

Fig. 2 is an exploded perspective view showing details of the tuning mechanism for the cavity resonator, included in the device illustrated in Fig. 1; and

Fig. 3 is a view in section and partly diagrammatic of a portion of an electron discharge device illustrative of another embodiment of this invention.

Referring now to the drawing, the device therein illustrated comprises a highly evacuated metallic enclosing vessel including a base portion or member 10 and a flanged cup-shaped portion 11 seated upon the base member 10 and joined hermetically thereto as by welding or brazing the portion 11 having a wall 11A parallel to the base portion 10. Seated on a recess in the base member 10 is a mounting or saddle member 12 upon which a unitary electrode and resonator assembly is supported.

This unitary assembly comprises a toroidal metallic cavity resonator, designated 13 as a whole, secured to the mounting or saddle member 12 and having a corrugated flexible metallic wall 14 and an exterior annular flange 15. The resonator includes also an inwardly extending, stepped cylindrical member 16 to the inner end of which a centrally apertured, dished grid 17 is affixed. Opposite and in alignment with the grid 17 is a second, centrally apertured dished grid 18, which is supported by the corrugated wall 14. A cylindrical insert 19 is secured within the member 16 and constitutes the end electrode of an electron gun.

The electron gun comprises a cathode member 20 which is mounted on an insulating plate 21 and is provided with a circular, concavo-convex end portion 22, the concave face of which is coated with a thermionic material. The cathode member 20 is provided in one wall with a suitable aperture through which a heater element 23 is inserted. Encompassing the cathode member is a beam forming electrode which is secured at one end to the insulating plate 21 and includes a cylindrical portion 24 fitted upon the cathode member 20 and encompassing a portion of the insert or electrode 19. The end portion 22 of the cathode, the beam forming electrode and electrode 19 are constructed and arranged so that electrons emanating from the cathode are concentrated into a converging beam focussed upon the gap between the grids 17 and 18.

The insulating plate 21 may be seated upon the base member 10 and fixed in position by a pair of braces or struts 25, only one of which is shown in the drawing.

Secured to the flange 15 on the resonator is a ring 26 which is provided with a plurality of fingers 27 and mounts a second insulating plate 28. The plate 28, in turn, mounts a dished repeller electrode 29, opposite and axially aligned with the grids 17 and 18 and having locking tabs 30 which extend through slots in the plate 28 and are bent over against this plate. A centrally apertured spider member 31 is provided with fingers 32 each of which is secured to a respective finger 27 of the mounting ring 26, and has locked in the central aperture therein a protuberance 33 on a dished disc 34. The disc 34 is provided with tabs 35 each of which is affixed, as by welding, to a respective finger 36 of an annulus 37, the fingers 36 extending through oversize apertures in the insulating plate 28. The annulus 37 is dished as illustrated and has its central portion secured to the flexible wall 14 of the cavity resonator.

The disc 34 and annulus 37, because of their form, are relatively rigid. The spider member 31 constitutes a flexible coupling between the ring 26, which is fixed in position, and the unit composed of the disc 34 and annulus 37 so that motion of the unit mentioned results in flexure of the wall 14 and, hence, in alteration of the resonant frequency of the cavity resonator. Controlled motion is imparted to the unit by way of a lever arm 38 which has one end portion fitted on the protuberance 33 and is pivoted upon and hermetically sealed to a laminated metallic diaphragm 39 in turn sealed hermetically to the cup-shaped portion 11A of the enclosing vessel.

The lever 38 is subject to actuation by a differential screw arrangement whereby accurate adjustment of its position and, hence, accurate tuning of the cavity resonator may be realized. Specifically, the outer end of the lever extends into and is fixed to a nut member 40 slidable upon a seat 41 seated upon the diaphragm 39, the member 40 being provided with a trapped portion for accommodating the tuning screw 42. The tuning screw is supported upon a frame 43 secured to a support 44 in turn affixed to the portion 11A of the enclosing vessel, and is provided with a head 45 for facilitating manipulation thereof and a stop nut 46 for limiting displacement thereof in one direction. As shown clearly in Fig. 1, an enlarged portion of the tuning screw is threaded into a tapped insert 47 fixed on the frame 43 by one or more set screws 48, which may be utilized also to lock the tuning screw 42 in any desired position. In order to eliminate back lash a helical spring 49 may be provided in engagement with the frame 43 and nut member 40. Also a bowed thrust spring 50 extending through a slot in the nut member 40 and having its ends locked in slots in the frame 43 may be provided to maintain a substantially constant contact force between the nut member 40 and the tuning screw.

As is apparent, rotation of the tuning screw 42 results in displacement of the nut member 40 and consequent rocking of the lever 38. Rocking of the latter is translated into displacement of the flexible wall 14 to tune the cavity resonator. It will be noted that the direction of displacement of the flexible wall portion 14 is at substantially right angles to the length of the lever 38 so that expansion and contraction of the lever with temperature variations has substantially no effect upon the flexible wall portion 14 and, consequently, substantially complete thermal segregation, in effect, is attained between the tuner mechanism and the cavity resonator whereby drift in the resonant frequency of the resonator with variations in ambient temperature is minimized. Moreover, it will be noted that substantial segregation thermally, in so far as the effect of expansion and contraction of the portion 11 of the enclosing vessel upon the resonant frequency of the resonator is concerned, is realized due to the fact that the direction in which the major dimensional variation with temperature of the portion 11 occurs is at right angles to the direction of displacement of the flexible portion 14 requisite to cause a change in the tuning of the cavity resonator. Such expansion and contraction of the vessel 10, 11, 11A as may occur in the direction parallel to the base portion 10 has little effect upon the tuning cavity because, for such conditions, the fulcrum point for the lever and the support point for the resonator will be displaced in the same direction and to substantially equal extents with, therefore, substantially no change in the relative location of these points.

Thus, not only is accurate tuning of the resonator enabled but variation in the resonant frequency with temperature changes is substantially minimized.

The base 10 has secured thereto an insulating plate 51 which carries terminal prongs 52 to which leading-in conductors 53 are connected. These conductors extend through eyelets 54 in the base 10 and are sealed hermetically to the eyelets by vitreous beads 55. Connection between the cathode 20, 22, heater 23 and repeller electrode 29 and the conductors 53 is established by suitable wires 56 only two of which are shown on the drawing.

In order to achieve highly stable operation of the device, it is desirable that the cavity resonator have a high Q, that is, a large ratio of inductive reactance to resistance. On the other hand, operation at high frequencies, e. g. in the microwave range, restricts the size of resonator that may be employed. The desideratum of both high frequency operation and stable operation may be achieved by coupling an external cavity resonator of high Q to the cavity resonator 13. Such an external resonator is indicated in broken outline at 57 in Fig. 1. The coupling is effected by a conductor 58 which has an inner end loop portion 59 and is sealed in a vitreous bead 60 in turn sealed to an eyelet 61 affixed to the base 10. Because of the manner of mounting the resonator 13, i. e., upon the base 10 and with its axis parallel thereto, it will be noted that the coupling conductor 58 may be made very short, of the order of one-half wavelength of the operating frequency of the device, whereby a close and efficient coupling of the external resonator or guide 57 to the internal resonator 13 is realized.

In the operation of the device, electrons emanating from the coated cathode portion 22 are concentrated into a converging beam focussed upon the gap between the grids 17 and 18 and pass through the central openings in the grids 17 and 18. In crossing the gap, the direct current beam is converted into a velocity varied beam. The latter enters the region between the grid 18 and repeller electrode 29 and because of the low potential upon the latter electrode the direction of electron motion is reversed and the electrons are again projected into the gap in the form of a density varied beam and deliver energy to the field within the resonator whereby oscillations are sustained. The grids and the repeller electrode are so constructed and arranged, for example in accordance with the principles set forth in Patent 2,411,913 of December 3, 1946 of John R. Pierce and William G. Shepherd, that the reversed electrons enter the gap in the form of a diverging beam and after crossing the gap are collected by the member 16, whereby, as pointed out in the application noted, electronic hysteresis effects are minimized.

It will be noted that in crossing the gap in the forward direction, the electrons pass through the central apertures in the grids 17 and 18 and, hence, cross the gap at a region where the field is relatively weak. In crossing the gap in the reverse direction, however, the electrons pass through the grid 18 and, thus, traverse regions where the field is relatively strong. Thus, the modulation coefficients for the two directions of electron motion across the gap are different, that for the reversed electron stream being greater than that for the forwardly moving stream. This construction is favorable to the realization of high operating efficiencies.

Different modulation coefficients for the two directions of electron motion across the gap in the cavity resonator may be realized advantageously also in the construction illustrated in Fig. 3. As shown in this figure, the cylindrical member 16 is provided with an inwardly extending cylindrical portion 65 across the inner end of which an electron permeable member such as a grid 170 extends. The electron trajectories are illustrated by the broken lines E. It will be noted that in their forward motion, that is from left to right in Fig. 3, the electrons in crossing the gap between the electron permeable members or grids 170 and 180 traverse a gap of length greater than the length traversed in the reverse direction, i. e., from the grid 180 to the electron receiving member 66, which is the dished end 66 upon the member 16. Consequently, a weaker modulation coefficient exists for the forward transit of the electrons across the gap than for the reverse transit.

The resonator in the device illustrated in Fig. 3 may be tuned in the same manner as that in the device shown in Fig. 1 and described heretofore. In order to simplify the drawing, the tuning mechanism has been omitted from Fig. 3.

Although specific embodiments of this invention have 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.

Reference is made of Patent 2,466,062, issued April 15, 1949 to William D. Stratton wherein a related invention is disclosed.

What is claimed is:

1. An electron discharge device comprising an enclosing vessel having a pair of opposed wall portions, a cavity resonator mounted upon one of said wall portions and having a wall displaceable in the direction substantially parallel to said one wall portion, and a tuning lever coupled to said displaceable wall, mounted from the other of said wall portions and extending substantially normal to said direction.

2. An electron discharge device comprising an enclosing vessel having a pair of substantially parallel wall portions, a cavity resonator mounted by one of said wall portions and having a wall flexible in the direction parallel to said one wall portion, and a tuning lever fulcrumed upon the other of said wall portions, connected to said flexible wall and extending substantially normal to said parallel wall portions.

3. An electron discharge device comprising a metallic enclosing vessel having a base and a wall portion opposite said base, a cavity resonator mounted upon said base and having a flexible disc wall portion substantially normal to said base, a flexible member mounted on said wall portion of said vessel, and a tuning lever mounted on said flexible member, extending substantially parallel to said flexible disc wall and connected to said flexible wall.

4. An electron discharge device comprising a metallic enclosing vessel having a base and a wall opposite said base and substantially parallel thereto, a substantially toroidal cavity resonator affixed to said base and having its axis substantially parallel thereto, said resonator having a wall portion movable in the direction parallel to said base, a flexible member affixed to said wall, and a tuning lever fulcrumed on said flexible member, extending substantially normal to said axis and connected to said movable wall portion.

5. In combination, an enclosing vessel having a flexible wall portion, a cavity resonator within said vessel and having a flexible wall, and means for tuning said resonator comprising a lever fulcrumed on said wall portion, extending substantially parallel to said flexible wall and having one end connected thereto.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
Re. 22,506	Hahn	June 27, 1944
2,304,186	Litton	Dec. 8, 1942
2,309,966	Litton	Feb. 2, 1943
2,396,802	Mouromtseff et al.	Mar. 19, 1946
2,402,119	Beggs	June 18, 1946