March 23, 1948. D. L. SNOW 2,438,132

ELECTRON DISCHARGE APPARATUS

Filed Nov. 29, 1943

Fig. 1.

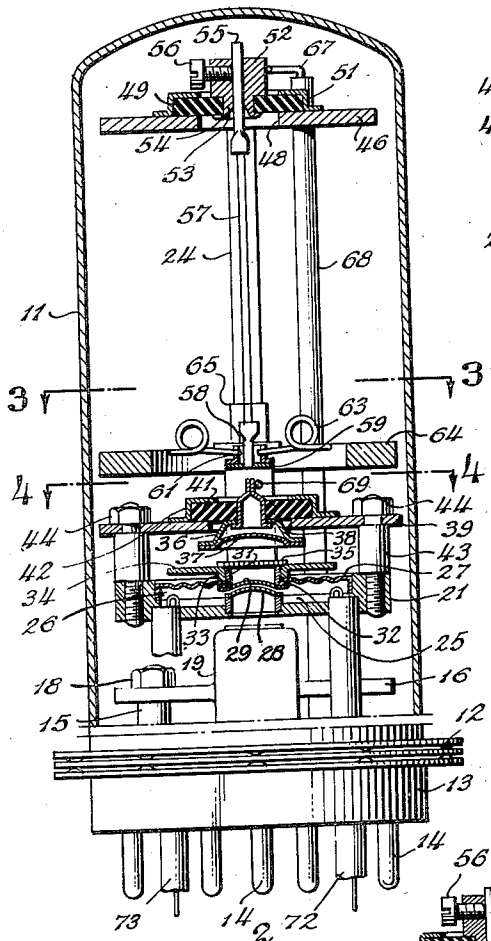


Fig. 2.

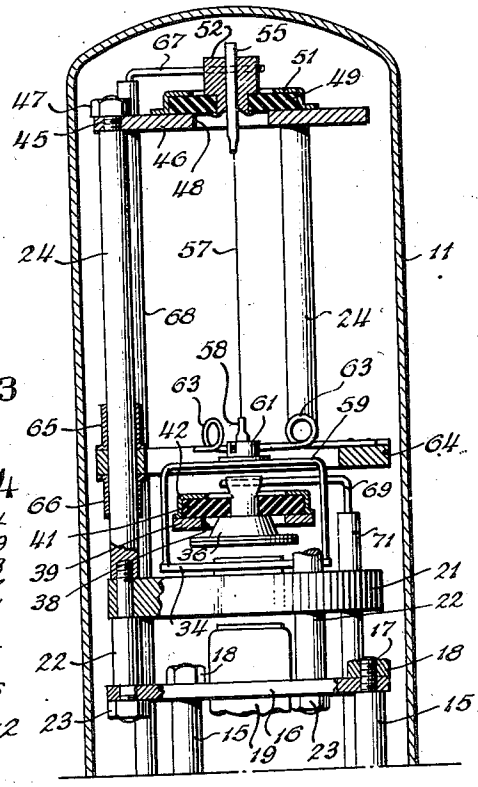


Fig. 6.

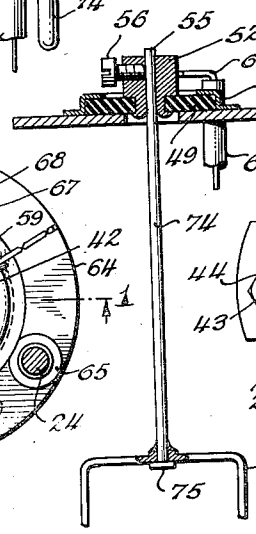


Fig. 3.

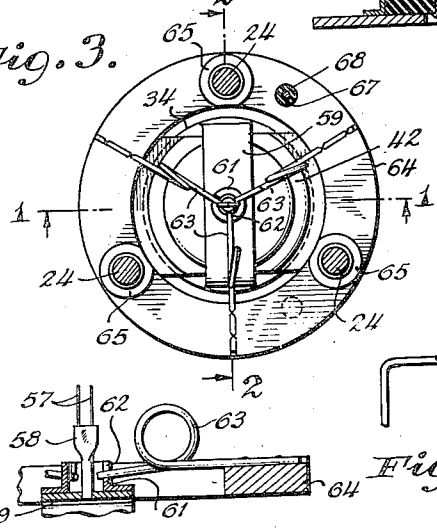


Fig. 4.

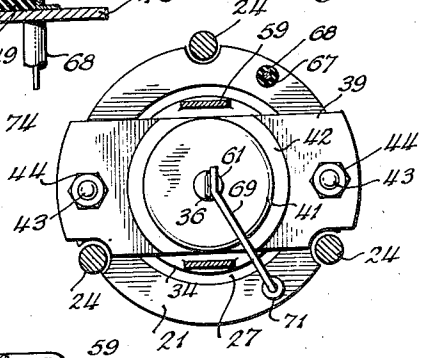


Fig. 5.

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ELECTRON DISCHARGE APPARATUS

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19 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge apparatus of the hollow resonator type and is particularly concerned with frequency control arrangements and related constructional improvements in such apparatus.

It is a major object of the invention to provide novel improvements in structure in electron discharge hollow resonator apparatus. Reflector and thermal tuning control member mountings and associated structure chiefly are improved pursuant to this object.

A further object of the invention is to provide electron discharge hollow resonator apparatus having novel electrothermal frequency control arrangements.

It is a further object of the invention to provide hollow resonator apparatus having novel non-rigid thermally responsive frequency control arrangements of relatively large radiation surface area.

A further object of the invention is to provide novel mounting and biasing means for a non-rigid thermally responsive frequency control member for hollow resonator apparatus.

Further objects of the invention will presently appear as the description proceeds in connection with the appended claims and the annexed drawings wherein:

Figure 1 is an elevation, partly in section, illustrating details of construction of a hollow resonator device according to a preferred embodiment of the invention;

Figure 2 is an elevation, partly in section, of the device of Figure 1, viewed at right angles to the direction of view of Figure 1;

Figure 3 is a plan view in section substantially along line 3—3 of Figure 1, illustrating the special spring arrangement for biasing the thermal tuning wires;

Figure 4 is a plan view in section substantially along line 4—4 of Figure 1, illustrating details of the reflector support in the device of Figure 1;

Figure 5 is an enlarged fragmentary elevation in section illustrating the slidable support for the inner end of the tuning wire biasing spring; and

Figure 6 is a fragmentary view, partly in section, illustrating a rigid frequency control strut in the structure of Figures 1–5.

The illustrated embodiment of the invention comprises a cylindrical metal envelope 11 secured, as by a suitable welded joint 12, to a base assembly 13 which is preferably of the well known vacuum tube type having a plurality of conductor prongs 14 adapted to be inserted within a suitable socket. Above joint 12, the interior of envelope 11 is vacuum tight.

All of the elements for producing and acting on the electron stream within envelope 11 are supported upon three short upstanding posts 15

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(only two shown) which are rigid with base 13 and are preferably equally spaced circumferentially. A horizontal cathode support plate 16 is suitably apertured to fit over threaded reduced upper ends 17 of posts 15 and so be seated upon posts 15. Suitable fastening means, such as nuts 18, clamp plate 16 rigidly to posts 15.

As illustrated in Figure 1, plate 16 is centrally apertured for accommodating a cathode assembly 19 which in turn is suitably rigidly mounted on plate 16.

A platform 21, preferably a metal disc, is rigidly supported parallel to plate 16, as by three short posts 22 having threaded reduced opposite end portions extending freely through suitable apertures in plate 16 and platform 21. Posts 22 are equally spaced circumferentially and are secured to plate 16 as by nuts 23. Platform 21 is clamped tightly to posts 22 by elongated upper posts 24 which are formed with tapped bores at their lower ends for fitting over the corresponding projecting threaded extensions of post 22, as illustrated in Figure 2. In this manner, posts 24 serve substantially as nuts for securing platform 21 to posts 22, and provide upstanding rigid frame elements extending to the upper end of envelope 11.

Platform 21 is formed with an upper recess 25 to provide a shallow cylindrical resonator chamber 26. A flexible wall 27 substantially bridges recess 25 and provides a substantial upper closure for chamber 26. As illustrated in Figure 1, wall 27 preferably comprises an annularly crimped disc of sheet copper or the like, having a downturned rim soldered or similarly secured within the side walls of recess 25.

Associated parallel grid structures 28 and 29 are mounted respectively in a suitable central aperture in platform 21 at the bottom of recess 25 and an aligned central aperture in wall 27. Grid 28 is mounted upon a short press-fitted sleeve insert rigid with platform 21. Grid 29 is mounted upon the lower end of a short hollow tube 31 which is flanged over at 32 against the underside of wall 27.

Tube 31 snugly fits within a hollow boss 33 depending from a bracket plate 34, and the adjacent annular region of wall 27 is tightly clamped between flange 32 and boss 33. The upper end of tube 31 is radially flared over the upper side of plate 34, and an electron stream smoothing grid 35 is mounted thereacross.

Grids 28, 29 and 35 may be of any suitable type, but are preferably of the wire mesh type. As illustrated in Figure 1, grids 28 and 29 are preferably bowed in the direction of passage of the electron stream from cathode 19 to prevent their buckling and undesired distortion when heated by impact of electrons.

The above described arrangement provides on

platform 21 a hollow resonator having opposed electron permeable wall portions comprising parallel grids 28 and 29, and these grids are flexibly interconnected because of the flexibility of wall 27. Wall 27 is preferably of such properties and is sufficiently resilient as to tend to maintain a preformed shape and given position such as that of Figure 1.

A metal reflector holder 36 supports a metal reflector 37 having a downwardly facing arcuate surface in alignment with cathode 19 and the grids. The upper end of holder 36 projects freely through a central aperture 38 formed in a reflector support plate 39 parallel to platform 21, and is secured to a block 41 of insulating material which is immovably mounted across aperture 38, as by a continuous flanged metal rim strip 42 welded to the upper side of plate 39.

Plate 39 bridges the upper ends of a pair of short studs 43 which have their lower ends threaded into platform 21 and their upper ends rigidly secured to plate 39 as by nuts 44, as illustrated in Figures 1 and 4.

In the above described manner reflector 37 is insulated from the frame parts, and is fixedly mounted in axial alignment with the electron stream from cathode 19. The frame and envelope 11 serve as an electrical ground and are connected to a suitable one of the prongs 14 for the purpose.

The upper ends of posts 24 are formed with reduced threaded extensions 45 (see Figure 2), for mounting a tuning control support plate or bridge 46 parallel to platform 21. Plate 46 is clamped to posts 24 as by nuts 47.

Plate 46 is centrally apertured at 48, and a block 49 of insulating material is immovably supported across aperture 48, as by a continuous sheet metal rim strip 51 welded upon the upper side of plate 46. A terminal member 52 preferably comprising a metal block is formed with a depending boss 53 extending through a central aperture in block 49, and boss 53 is flanged over as at 54 to rigidly secure terminal 52 to block 49.

Terminal 52 is formed with a central bore through which extends a rigid conductor rod 55. A set screw 56 locks rod 55 in any desired position of axial displacement on terminal 52.

A plurality of spaced parallel conductor wires 57 of tungsten or some high-tensile-strength ductile material are fixed at their upper ends to the lower end of rod 55, and at their lower ends to a short conductor rod 58 axially aligned with rod 55. Wires 57 are therefore substantially coaxial with the electron beam. Wires 57 may be of round, flat, oval or any desired cross-section for obtaining an efficiently large radiation surface area. Rod 58 is rigidly secured to the bridge of an inverted U-shaped bracket 59 which has the ends of its depending legs secured as by soldering to plate 34.

A short hollow collar 61 concentric with rod 58 is rigid with bracket 59. Collar 61 is formed with three equally spaced radial slots 62 (see Figures 3 and 5), for slidably supporting the inner ends of radially extending spring levers 63. The outer ends of springs 63 are fixed as by welding to a rigid annular ring 64 which is parallel to platform 21. As illustrated, each spring lever 63 is formed with an intermediate coil for increasing its effective length and resiliency.

Spring levers 63 comprise resilient lever means for maintaining the wires 57 under tension. The term "resilient lever" means as used herein denotes both spring levers such as 63 and spring

biased rigid levers. For example, levers 63 could be replaced by rigid levers hinged to ring 64 and downwardly biased by coil or leaf springs reacting on the frame, without departing from the spirit of the invention.

As illustrated in Figure 2, each post 24 passes through suitable apertures in ring 64, and flanged sleeves 65, 66 are provided for securing ring 64 rigidly to posts 24.

Ring 64 is thus rigid with the element supporting frame within envelope 11 and serves to anchor one end of each of springs 63. Springs 63 are so biased as to oppose vertical upward displacement of bracket 59, the slidable substantially lost motion connections between the inner ends of springs 63 and collar 61 permitting the required displacement for frequency control.

Two or more wires 57 are preferably employed because they provide high tensile strength with a maximum of radiation surface area for quick cooling. Where two or any even number of wires are used, each pair may comprise a continuous wire having its opposite ends secured in one conductor rod and its looped mid-portion secured in the other.

Electric current for heating wires 57 is conducted along a lead 67, which extends from another one of the prongs 14 through an insulating glass tube 68, and is soldered or similarly fixed to terminal 52 as illustrated. The lower ends of wires 57 are grounded to the frame. Reflector 37 has a desired potential applied to it by a lead 69 which extends through a glass sleeve 71 from still another prong 14. Similarly the cathode and other elements within envelope 11 are energized by suitable connections to further ones of prongs 14.

During assembly of the above described structure, conductor rod 55 is locked by set screw 56 in a position for maintaining wires 57 taut and for tensioning springs 63. The values of tensioned springs 63 are so chosen that the downward force they exert on bracket 59 is sufficient to overcome any resistance offered by flexible wall 27, and so that they yield readily to the pull of cooling wires 57.

Energy, at ultra high frequencies in the neighborhood of 3×10^8 cycles per second and higher, is extracted from resonator chamber 26, as by concentric line sections 72 and 73 which extend in vacuum tight relation through the base. Each line section is provided at its inner end with a conductive loop extending between the inner and outer conductors and disposed within the resonator field as illustrated.

In operation of the above described device, an electron stream from cathode 19 is projected through resonator grids 28, 29 and is then returned into the resonator by the repelling action of charged reflector 37. The electron stream excites and maintains an ultra high frequency field within resonator chamber 26. Accepted theories of electron velocity modulation operation of such devices are known and disclosed in United States Letters Patent No. 2,250,511 to which reference is made for further detail.

The frequency of the output from resonator chamber 26 may be varied by changing the resonant frequency of resonator 26, as by adjusting the spacing between grids 28 and 29. For this purpose electric current is supplied to wires 57 by way of lead 67. This current serves to heat the wires 57, which thereupon change length, permitting springs 63 to move bridge 59 and plate 34 connected to grid 29. In this way, by suitable

control of this current exteriorly of the device, the output frequency may be correspondingly adjusted or varied.

In the invention, the frame structure and the parts supported thereby are substantially all symmetrically arranged about the indicated longitudinal center line of the electron stream. The frame structure is sturdy and non-microphonic, and the cathode is mounted in longitudinal alignment with grids 28, 29 and reflector 37. Posts 24 are sufficiently long to enable wires 57 of considerable length to be employed, thereby enabling large relative grid displacements. Since wires 57 are also substantially aligned with the electron stream and on the longitudinal center line of the device, the forces exerted during frequency control are symmetrically distributed, a function which is aided by the special resilient bias arrangement for wires 57.

Bracket 59 and the parts to be moved by wires 57 are lightweight. This requires a relatively low power supply to wires 57 and increases frequency control speed.

As illustrated in Figure 6, the invention also contemplates a rigid bidirectional tuning control arrangement for varying the grid spacing. Bracket 59 is connected to block 52 by a longitudinally rigid rod 74 of Duralumin or some other high coefficient of thermal expansion material. Rod 74 preferably has its upper end secured within block 52 by set screw 56, and has its lower end staked over or similarly rigidly fixed to bracket 59 as indicated at 75.

Rod 74 is electrically energized from lead 67 and, being thermally responsive to change its length with variations in its temperature, effectively replaces rods 55, 58 and wires 57 in the assemblage of Figures 1 through 5. Also, where bidirectional frequency control rod 74 is employed, ring 64 and its connecting sleeves 65 and 66, biasing springs 63 and collar 61 are omitted.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed and desired to be secured by United States Letters Patent is:

1. High frequency apparatus comprising a hollow resonator having a movable portion for varying the frequency of said resonator, and means for controllably moving said portion comprising an expansible and contractible substantially non-rigid frequency control member coupled to said movable portion, and means for maintaining said member under tension comprising resilient lever means coupled thereto.

2. The apparatus defined in claim 1, wherein said resilient lever means comprises a spring lever anchored substantially at one end in said apparatus and having its other end connected to said portion.

3. The apparatus defined in claim 1, wherein said resilient lever means comprises a spring lever anchored substantially at one end in said apparatus and having a slidable connection between its other end and said portion.

4. The apparatus defined in claim 1, wherein said resilient lever means comprises a plurality of radially disposed spring levers mounted substantially symmetrically with respect to said member.

5. High frequency apparatus comprising a hollow resonator having relatively movable portions determining electrical characteristics of the electromagnetic field of said resonator, means for controlling relative movement of said portions for varying the resonator frequency comprising a substantially non-rigid frequency control member which is exansible and contractible in response to temperature changes connected between said relatively movable portions and means for maintaining said member under tension comprising resilient lever means interconnecting said portions.

6. High frequency apparatus comprising a hollow resonator having a movable portion for varying the frequency of said resonator, means coupled thereto for moving said portion in one direction, and resilient lever means for opposing movement of said portion in said one direction, said resilient lever means comprising a spring lever having one end anchored in said apparatus and having a slidable connection between its other end and said movable portion.

7. High frequency apparatus comprising a hollow resonator having electron permeable regions, means aligned with said regions for passing an electron stream through said regions, a thermally responsive non-rigid frequency control member connected to said resonator and disposed substantially axially of the path of said electron stream, and resilient means coupled to said member maintaining said member under tension.

8. Electron discharge apparatus comprising a hollow resonator having a movable portion for changing the frequency of said resonator, means in said apparatus for passing a stream of electrons through said resonator and for returning said electron stream into said resonator, a flexible wire connected at one end to said portion and anchored at its other end in said apparatus, said wire being expansible and contractible in response to temperature changes and extending in substantial axial alignment with the path of said electron stream, and means coupled to said wire and biasing said wire to maintain it under tension.

9. The apparatus defined in claim 8, wherein said biasing means comprises symmetrically disposed resilient lever means.

10. High frequency apparatus comprising a hollow resonator, means coupled to said resonator and movable for varying the frequency of said resonator, a substantially non-rigid expansible and contractible thermally responsive frequency control member connected to said movable means, resilent means maintaining said member under tension, and a slidable connection between said resilient means and said member.

11. High frequency apparatus comprising a hollow resonator having a movable portion for varying the frequency of said resonator, a substantially non-rigid frequency control member secured to said portion, and a resiliently urged lever connected adjacent opposite ends to said portion and a stationary part of said apparatus, one of said connections being an anchor for one end of said lever and the other connection being a slidable bearing connection.

12. High frequency apparatus comprising a stationary support, a hollow resonator mounted on said support and having a movable wall portion, thermally responsive means coupled to said wall portion for moving said wall portion, and a plurality of substantially radially disposed spring levers each having their outer ends fixed to said support and their inner ends operably connected to said wall portion.

13. High frequency apparatus comprising a hollow resonator having aligned flexibly interconnected spaced grids, a non-rigid frequency control member which varies in length with changes in temperature coupled between said grids, and resilient lever means coupled between said grids and maintaining said member under tension.

14. High frequency apparatus comprising a hollow resonator having a movable electron permeable wall portion, a bracket connected to said wall portion, a substantially non-rigid thermally responsive expansible and contractible frequency control member extending between said bracket and a relatively stationary part of said apparatus, and means in said apparatus resiliently maintaining said member under tension comprising a radial lever anchored at one end in said apparatus and slidably bearing at its inner end on said bracket.

15. High frequency apparatus comprising a hollow resonator having a movable wall portion for varying the frequency of said resonator, a relatively stationary platform supporting said resonator, means for moving said wall portion in one direction, a substantially annular support rigid with said platform, and a plurality of substantially radial resilient levers having their outer ends fixed to said support and their inner ends having a slidable bearing connection with said means for moving said wall portion, said levers opposing said movement in said one direction.

16. An electron discharge device comprising an envelope, a base closing one end of said envelope, a cathode support rigid with said base and disposed within said envelope, a platform rigid with said cathode support, a hollow resonator having a movable wall portion and mounted

on said platform, an electron reflector support rigid with said platform, a frequency control member supporting bridge rigid with said platform and disposed adjacent the other end of said envelope, and an electrically actuated expansible and contractible frequency control member coupled between said bridge and said movable resonator wall portion.

17. The device defined in claim 16, wherein said frequency control member comprises a flexible wire, and including resilient means maintaining said wire under tension.

18. The device defined in claim 16, wherein said frequency control member comprises a plurality of non-rigid wire elements, and means resiliently biasing said elements.

19. The device defined in claim 16, wherein said frequency control member comprises a longitudinally rigid strut of a material having a high coefficient of thermal expansion.

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