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DEFORMABLE WALL TUNING MEANS FOR KLYSTRONS

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FIG. 1

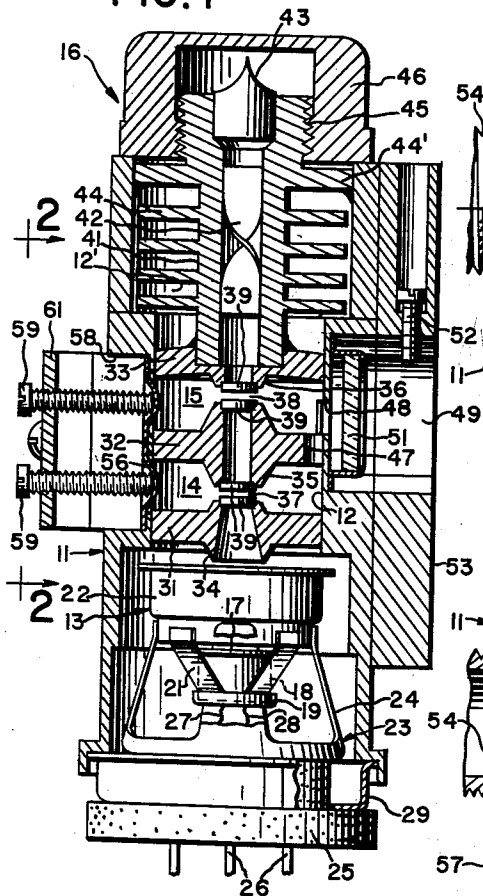


FIG. 2

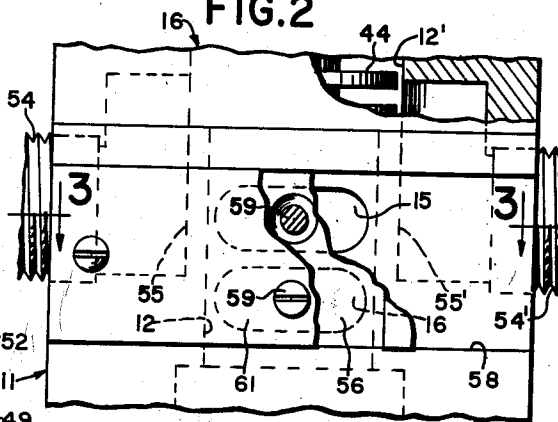


FIG. 3

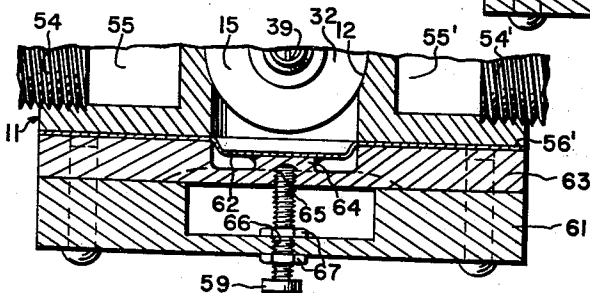
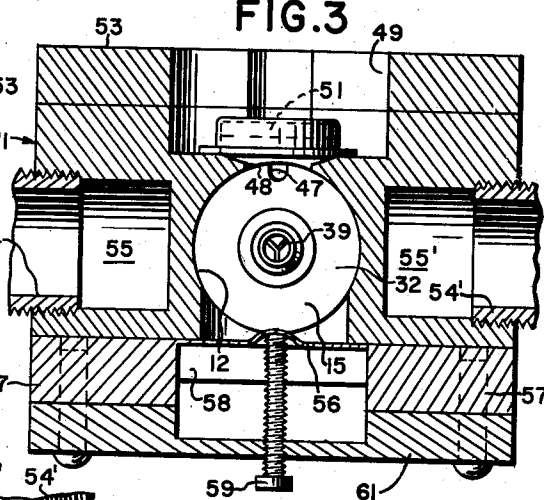


FIG. 4

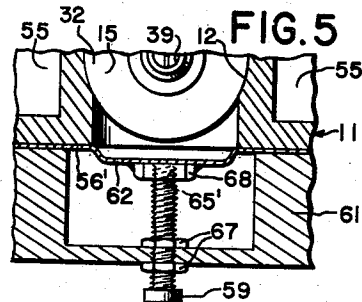


FIG. 5

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DEFORMABLE WALL TUNING MEANS FOR KLYSTRONS

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This invention relates to high frequency apparatus and more particularly to an improved, simplified structure for the apparatus.

Cavity resonators as encountered in a high frequency apparatus such as a klystron are tuned by varying either the total inductance of the cavity or the total capacitance or both. Cavities are readily tuned by moving moveable side walls towards or away from the center of the cavity or by changing the interaction gap spacing, both processes are done usually by the aid of a mechanical mechanism. The rate-of-change of frequency per unit length of the moveable sidewall transverse is inversely proportional to the size of the cavity. This relationship is also true for the rate-of-change of frequency per unit length when the cavity is tuned by changing the gap spacing. Therefore, a klystron operating in the microwave range of more than 10,000 megacycles per second requires a very slight change in the cavity volume or gap spacing to tune the cavity over a few megacycles. Various types of mechanisms have been invented and used to accurately control the volume and gap spacing of these very small cavities in microwave tubes in order to have precise accurate tuning and up to now very accurate control of the cavity volume was difficult to obtain. This problem was further aggravated because a change in temperature effects the cavity volume and gap spacing and thus the cavity's resonant frequency.

Electron gun assemblies as used in high frequency apparatus include complex structures so that the correct spacing between the cathode and the focusing electrode is maintained during thermal cycling and so that an effective heat dam is produced to increase the efficiency of the apparatus. These complex structures are difficult to incorporate in very small tubes which operate at more than 10,000 megacycles.

A principal object of this invention is to provide an improved, simplified structure for high frequency apparatus capable of operating in the microwave range.

One feature of this invention is a deformable wall on a cavity resonator which can be readily deformed beyond its elastic limit to change the volume of cavity permanently.

Another feature of this invention is a simplified improved structure for an electron gun assembly.

Still another feature of this invention is a deformable wall on a cavity which can be deformed beyond its elastic limit either into or out of the cavity.

Still another feature of the present invention is the provision of flexing a cavity end wall by a force axially through the collector of the klystron.

Still another feature of the present invention is the provision of changing the interaction gap spacing and inductance of a cavity resonator by an axial force through a drift tube section.

These and other features and advantages of the present invention will be more apparent after a perusal of the following specification taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a cross sectional view of a novel klystron embodying the present invention;

FIG. 2 is the external view of the klystron taken from line 2-2 of FIG. 1;

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FIG. 3 is the sectional view of the klystron taken along line 3-3 of FIG. 2 showing one embodiment of the permanently deformable tuning means of the klystron;

FIG. 4 is an alternate embodiment of the permanently deformable tuning means of the klystron; and

FIG. 5 is another alternate embodiment of the permanently deformable tuning means of the klystron.

Referring to the drawings and to FIGS. 1, 2 and 3 in particular, the klystron has a metal block body 11 with a bore 12 therethrough. An electron gun assembly 13 is disposed at one end of the bore to project an electron beam through cavity resonators 14 and 15 to a collector assembly 16 disposed at the other end of the bore 12. The electron gun assembly 13 has a novel structure particularly adapted for use in small high frequency apparatus. A cathode 17 which in this embodiment is planar is supported on a cathode can 18 enclosing a heating filament (not shown). The cathode can 18 is disposed within a cup-shape stamping 19. In order to reduce the heat flow path the side wall of the stamping 19 is formed into fingers 21 which are in turn fixed by their ends to the side wall of a tubular focusing electrode 22. The focusing electrode is of course disposed concentric with the cathode 17. This sub-assembly is in turn mounted within a larger cup-shape stamping 23 which also has its side walls in forms of fingers 24 fixed by their ends to the side wall of the focusing electrode. The stamping 23 is mounted on a dish-shape insulating header 25 having electric lead-through pins 26 sealed in vacuum tight relation therethrough. Leads 27 and 28 of the filament are connected to two of the pins 26. A metal sealing ring 29 is brazed vacuum tight onto the rim of the header 25 and to the body 11 to unite the gun assembly 13 to the body 11. Another one of the pins 26 supplies the correct bias to the cathode and focusing electrode. Within the bore 12 between the collector assembly 16 and electron gun assembly 13 are disposed three apertured partitions 31, 32 and 33 which form the cavity resonators 14 and 15 within the body 11 and partition 31 also forms the anode for the electron gun. The partitions incorporate re-entrant drift tube sections 34, 35 and 36 which serve to define high frequency interaction gaps 37 and 38 between their ends. A grid 39 is placed across each end of the re-entrant drift tube sections so that better interaction is obtained between the beam and the gaps 37 and 38.

The collector assembly 16 includes a collector tube 41 disposed coaxially with the drift tube section 36 and supported by partition or end wall 33. The electrons of the beam are collected on a baffle 42 disposed within the tube 41 to protect the end of a pinched-off exhaust tubulation 43 which is brazed coaxially at the exterior end of tube 41. The collector tube 41 is cooled by a liquid flowing across a plurality of cooling fins 44 which are disposed within an enlarged end portion 12' of the bore 12. The cooling fin 44' disposed on the external end of the collector 41 is brazed at its periphery within the end portion 12' leaving the end of the body 11 protruding axially beyond fin 44'. The exterior end of the collector 41 has an external screw thread 45 on which is disposed a nut 46 which can bear down on the protruding end of the body 11 when the nut 46 is tightened. Since end fin 44' and partition 33 are thin they can be flexed by an axially aligned force readily imposed by tightening the nut 46 to increase the spacing gap 38 slightly for tuning purposes. When the nut 46 is loosened the fin 44' and partition 33 spring back since they are stressed within their elastic limits and the gap spacing thus decreases. The temperature compensation techniques described hereinafter are described and claimed in copending continuation-in-part application U.S. Serial No. 294,558, filed July 12, 1963, by James M. De Pue,

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Jr., and Norman E. Oaks which application is assigned to the same assignee as the subject parent application. If the collector tube 41 is made of a material having a different thermal expansion coefficient than that of the material of which the wall of the end portion 12' one can control, with temperature, the spacing of the gap 38 by choosing various material; for example if tube 41 is made of steel and the wall of the portion 12' is made of copper the length or spacing of the gap will increase with temperature as the volume of cavity 15 increases thereby stabilizing the resonant frequency over a broad temperature range.

Inherently, the tube 41, when made of a material having a lower temperature coefficient of expansion than the body 12', as mentioned directly above, will function as a built in temperature compensation device. The gap spacing 38 will tend to decrease as the partitions 32, 33 are heated under operating conditions. The tube 41 accomplishes this stabilization by counteracting the decrease in gap spacing due to the expansion of partitions 32, 33. Tube 41 is flexibly mounted on body 12' by means of end fin 44' and partition 33 and is made of a material having a lower temperature coefficient of expansion than the body and thus will increase the gap spacing 38 upon heating under operating conditions and thereby counteract the decrease in gap spacing due to the expansion of members 32, 33. This action results in a minimal change in gap spacing and thus minimal frequency drift.

The novel features of the klystron may be incorporated in an amplifier although the klystron shown is an oscillator in that the cavities 14 and 15 are closely coupled through a coupling aperture 47 formed in the partition 32. High frequency energy is coupled from the oscillator through an aperture 48 formed transversely through a wall of body 11 and communicating between the cavity 15 and a waveguide section 49. A window 51 which forms the vacuum wall between the cavity 15 and the waveguide is disposed across aperture 48. Protruding into the waveguide 49 is a matching screw 52 which aids in matching the waveguide circuit (not shown) to the coupling through the aperture 48. A surface 53 on body 11 forms a means for mounting more waveguide sections to form the waveguide circuit to the klystron.

The klystron shown is liquid cooled whereby the liquid enters the body 11 through a port 54, along a channel 55 in body 11 parallel to the beam axis, transversely across the collector cooling fins 44, along a channel 55', and exits through port 54'.

Normally in a small, high frequency apparatus of the type described, the dimensions of the cavity resonators must be held to close tolerance so that they will resonate at the prescribed frequencies. Close tolerances are difficult and expensive to maintain in mass production and therefore the cavities must be tuned to the prescribed frequency after assembly by deforming a thin wall 56 which is disposed on body 11 parallel to the beam axis. In the embodiment shown in FIG. 3 the thin wall 56 has thicker end portions 57 and is brazed within a transverse cut 58 on the body 11 but the thin wall 56 may be machined as an integral part of the body 11 if desired. The wall 56 is deformable inwardly of the cavities 14 and 15 by screws 59 threaded on a tuning bridge 61 which is in turn mounted on end portions 57. When the screws 59 are screwed into the bridge 61 the wall 56 is stressed beyond its elastic limit and permanently deformed.

An alternate embodiment of the permanently deformable means is shown in FIG. 4. The deformable wall 56' in FIG. 4 can be moved towards or away from the beam axis thereby increasing or decreasing the resonant frequency of the cavities. The wall 56' is, in this embodiment, preferably of uniform cross-section with a dimple 62 disposed in the wall 56' where it forms the cavity 15. The legs of a U-shaped member 63 are brazed onto the exterior of wall 56' and a lug 64 depending from the center of the member 63 is brazed onto the dimple 62.

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A tapped-well 65 is formed in member 63 into which the screw 59 is threaded but in this embodiment the screw 59 cannot be threaded in the tuning bridge 61 but is disposed in an aperture 66. Therefore nuts 67 are disposed on both sides of the bridge to control the location of the tuning screw 59. Thus by moving the screw towards or away from the beam axis the wall 56' along with U-shape member 63 are stressed beyond their elastic limit and permanently deformed.

Referring to FIG. 5 another embodiment of the permanently deformable tuning means is shown. In this embodiment the wall 56' with its dimple 62 is also brazed to body 11 similar to the embodiment shown in FIG. 4. At the center of the dimple 62 is disposed a small block of metal 68 having a tapped-well 65'. The block of metal 68 is smaller than the cavity opening which the thin wall closes. Screw 59 is threaded into the tapped well 65' in the block 68 and by adjusting nuts 67 the wall 56' is pushed either towards or away from the beam axis. If the mass of the block 68 is sufficiently small the wall 56' is permanently deformed and thereby "oil-canning" of the wall 56' is prevented.

Preferably after the apparatus is pretuned the tuning bridge 61 in all embodiments is removed and a protective cover plate (not shown) is placed where the bridge 61 was, thereby protecting the thin wall 56 from being damaged or deformed.

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 is:

1. A high frequency apparatus comprising an electron gun assembly for projecting an electron beam along an axis through at least one cavity resonator having an interaction gap therein to a collector assembly, said cavity resonator having a deformable wall adapted and arranged to be deformed beyond its elastic limit and a flexible end-wall adapted and arranged to be flexed within its elastic limit, said collector assembly comprising a cylindrical member mounted coaxially on said flexible end-wall, a flexible fin protruding substantially radially and mounted on said cylindrical member, said flexible fin being fixed at its periphery in relation to the side walls of said cavity resonator, and means for applying an axial force for flexing both said flexible end-wall and said flexible fin.

2. A high frequency apparatus comprising, a cavity resonator having an interaction gap formed therein, an electron gun assembly for projecting an electron beam along an axis through the interaction gap of the cavity resonator, a collector assembly for collecting said beam after it has passed through the cavity resonator, said cavity resonator having a side wall which is deformed beyond its elastic limit to thereby fix tune said cavity resonator, said side wall being disposed substantially parallel to said axis, said side wall including a thin metallic member and a U-shape metallic member with its legs bonded to the outer edges of said thin member, and the center portion of the U-shape member bonded to the center of said thin member.

3. A high frequency apparatus comprising, a cavity resonator having an interaction gap formed therein, an electron gun assembly for projecting an electron beam along an axis through the interaction gap of the cavity resonator, a collector assembly for collecting said beam after it has passed through the cavity resonator, said cavity resonator having a side wall which is deformed beyond its elastic limit to thereby fix tune said cavity resonator, said side wall being disposed substantially parallel to said axis, said side wall including a thin metallic member and a metal block disposed on the center of said thin metallic member.

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4. The apparatus of claim 3 where said metal block is disposed on the exterior surface of said thin metallic member.

5. A high frequency apparatus comprising an electron gun assembly for projecting an electron beam along an axis through at least one cavity resonator having an interaction gap therein to a collector assembly, said cavity resonator having a transverse flexible end-wall adapted and arranged to be flexed within its elastic limit, said collector assembly comprising a cylindrical member axially mounted on said transverse flexible end-wall of said cavity resonator, a flexible fin protruding substantially radially and mounted on said cylindrical member, said flexible fin being fixed at its periphery in relation to the side walls of said cavity resonator, and means for applying an axial force for flexing both said transverse flexible end-wall and said flexible fin.

6. The high frequency apparatus of claim 5 wherein said means comprises a screw-thread portion disposed on the end of said cylindrical member, a body supporting said cavity resonator and said cylindrical member therein, said flexible fin being fixed to said body by its periphery, and a nut threaded on said screw-thread portion, said nut being of a size to engage said body as said nut is threaded onto said screw-threads.

7. A high frequency apparatus comprising an electron gun assembly for projecting an electron beam along an axis through at least one cavity resonator having an interaction gap therein to a collector assembly, said cavity resonator having a deformable side wall, a tuning bridge disposed on the exterior of said deformable side wall, a screw operatively attached to said tuning bridge and adapted and arranged to stress said deformable wall beyond its elastic limit, a U-shape metallic member with its legs bonded to the outer edges of said deformable side wall, and the center portion of the U-shaped member bonded to the center of said deformable side wall, said screw protruding through said tuning bridge and threaded into a tapped-well formed in said U-shaped member, and means co-operating with said tuning bridge for urging said screw and said deformable side wall into or out of said cavity resonator to be permanently deformed.

8. A high frequency apparatus comprising an electron gun assembly for projecting an electron beam along an axis through at least one cavity resonator having an interaction gap therein to a collector assembly, said cavity resonator having a deformable side wall, a tuning bridge disposed on the exterior of said deformable side wall, a screw operatively attached to said tuning bridge and adapted and arranged to stress said deformable wall beyond its elastic limit, a metal block disposed on the center of said deformable side wall, said screw protruding through said tuning bridge and threaded into a tapped-well formed in said metal block and means co-operating with said tuning bridge for urging said screw and said deformable side wall into or out of said cavity resonator.

9. A high frequency apparatus comprising an electron gun assembly for projecting an electron beam along an axis through at least one cavity resonator having an interaction gap therein to a collector assembly, said cavity resonator having a deformable wall adapted and arranged to be deformed beyond its elastic limit and having a flexible end-wall adapted and arranged to be flexed within its elastic limit, said collector assembly comprising a cylindrical member mounted on said flexible end-wall, a flexible fin protruding substantially radially and mounted on said cylindrical member and spaced from said transverse end-wall, a body having a bore therethrough supporting said cavity resonator and said cylindrical member therein, said flexible fin being fixed to said body by its protruding end, a screw-threaded portion disposed on the end of said cylindrical member, a nut threaded on said screw-thread portion, said nut being of a size to engage said body as said nut is threaded onto said screw thread.

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10. A high frequency apparatus comprising an electron gun assembly for projecting an electron beam along an axis through at least one cavity resonator having an interaction gap therein to a collector assembly, said cavity resonator having a flexible end-wall, said collector assembly comprising a cylindrical member mounted coaxial on said flexible end-wall, and means for applying an axial force for flexing said flexible end-wall, said means comprising a body supporting said cavity resonator and said cylindrical member therein and projecting from said flexible end wall, and a nut threadably engaging said collector assembly, said nut being of sufficient size to engage said body as said nut is threaded onto said collector assembly.

11. A high frequency apparatus comprising a body section having a bore therethrough, an electron gun assembly disposed at one end of said bore for projecting an electron beam through said bore, a collector assembly disposed at the other end of said bore, at least two aperture partitions disposed within said bore forming a cavity resonator and an interaction gap therein, said collector assembly comprising a cylindrical member mounted coaxially on one of said aperture partitions and having one end protruding from said bore, an annular fin disposed on said cylindrical member and having its periphery fixed to the inner wall of said body forming a cooling cavity around said cylindrical member, two opposite transverse bores in said body communicating with said cooling cavity, said body having a deformable wall forming a side wall of said cavity.

12. A high frequency apparatus comprising an electron gun assembly for projecting an electron beam along an axis through at least one cavity resonator having an interaction gap therein to a collector assembly, said electron gun assembly including a cathode, a focusing electrode concentric with said cathode, a first cup-shape member fixed at its periphery to said focusing electrode, a second cup-shape member disposed within said first member, said second cup-shape member being also fixed at its periphery to said focusing electrode, and support means supporting said cathode within said second member, said cavity resonator having a deformable wall adapted and arranged to be deformed beyond its elastic limit and a flexible end-wall adapted and arranged to be flexed within its elastic limit, said collector assembly comprising a cylindrical member mounted coaxially on said flexible end-wall, a flexible fin protruding substantially radially and mounted on said cylindrical member and spaced from said transverse end-wall, said flexible fin being fixed at its periphery in relation to the side walls of said cavity resonator, and means for applying an axial force for flexing both said flexible end-wall and said flexible fin.

13. A high frequency apparatus comprising an electron gun assembly for projecting an electron beam along an axis through interaction means to a collector assembly, said electron gun assembly including a cathode, a focusing electrode concentric with said cathode, a first cup-shape member fixed at its periphery to said focusing electrode, a second cup-shape member disposed within said first member, said second cup-shape member being also fixed at its periphery to said focusing electrode, and support means supporting said cathode to said second member.

14. The apparatus of claim 13 wherein said first and second cup-shape members are further defined as having their side walls in the form of fingers and the ends of said fingers are fixed to said focusing electrode.

15. A high frequency apparatus comprising a body section having a bore therethrough, an electron gun assembly disposed at one end of said bore for projecting an electron beam through said bore, a collector assembly disposed at the other end of said bore, at least two apertured partitions disposed within said bore forming a cavity resonator and an interaction gap therein, said collector assembly comprising a cylindrical member mounted

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coaxially on one of said apertured partitions and having one end protruding from said bore, an annular fin disposed on said cylindrical member and having its periphery fixed to the inner wall of said body forming a cooling cavity around said cylindrical member, and two opposite transverse bores in said body communicating with said cooling cavity.

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