Aug. 15, 1961 M. W. ST. CLAIR 2,996,690

TEMPERATURE COMPENSATED CAVITY RESONATOR

Filed April 24, 1958

Fig. 1

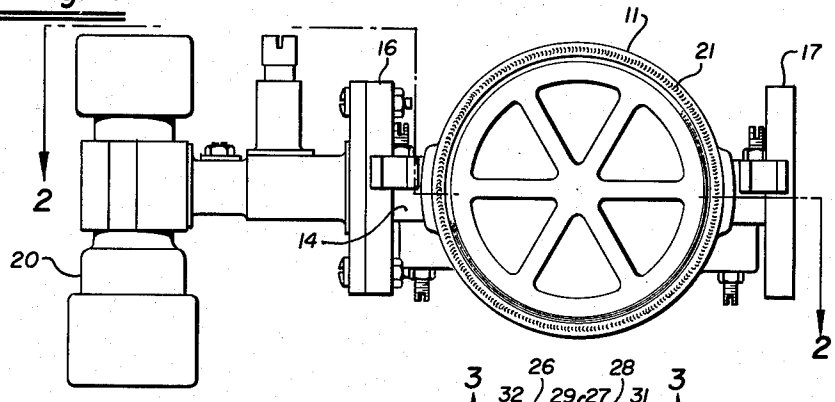


Fig. 2

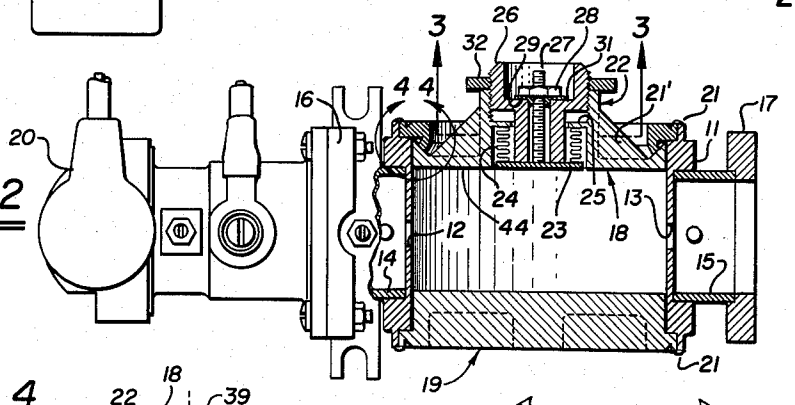
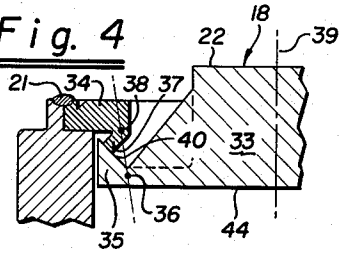


Fig. 4



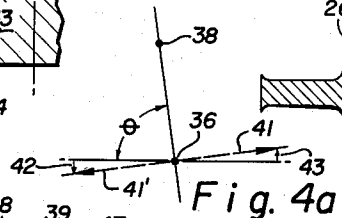
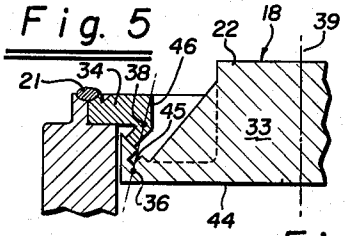


Fig. 4a

Fig. 5



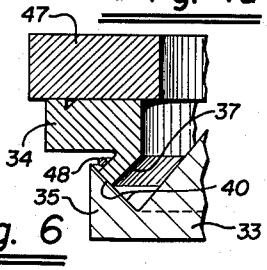


Fig. 6

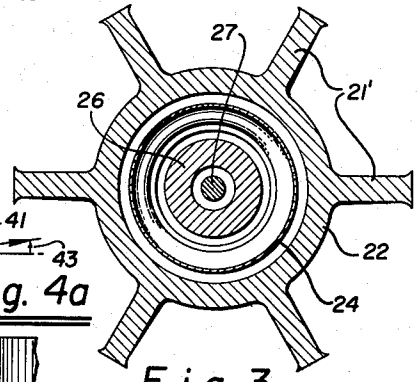


Fig. 3

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TEMPERATURE COMPENSATED CAVITY RESONATOR

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This invention relates in general to ultra high frequency apparatus and more particularly to cavity resonators for use, for example, as filters or as stalos in stabilizing the frequency of local oscillator sources such as reflex klystrons and the like.

It is desirable that cavity resonators or stalos of the present type be tunable over a range of resonant frequencies and, once tuned, that they remain fixed in dimension during use so that their resonance frequency will not change. However, these cavity resonators undergo a wide range of operating temperatures and are constantly changing in dimensions due to expansion and contraction of their structural parts. Various temperature compensating schemes have been utilized in the past to maintain the cavity resonator frequency constant over a range of operating temperatures. It is the main object of the present invention to provide a cavity resonator incorporating novel, improved tuning apparatus and temperature compensation features.

One feature of the present invention is the provision of a novel cavity resonator constructed of parts made of materials having different coefficients of expansion and so interrelated that at least one of the main structural walls of the cavity resonator will move in variable accordance with the temperature changes of the cavity resonator to maintain a fixed operating frequency; or some predetermined fixed temperature coefficient of frequency different from zero, if desired.

An other feature of the present invention is the provision of a novel cavity resonator construction of the above featured type wherein the one end wall of the cavity resonator is circular and is mounted at its periphery on a rim made of a metal of different coefficient of expansion, the end wall and rim being so formed and dimensioned that radial expansion of the wall results in an axial movement of the wall due to its interaction with the rim material.

Still another feature of the present invention is the provision of a cavity resonator incorporating a novel tuning plate construction for selectively changing the dimensions of the cavity resonator.

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

FIG. 1 is an elevation view of a cavity resonator which embodies the present invention mounted on a klystron oscillator for stabilization purposes,

FIG. 2 is a longitudinal cross-section view of the cavity resonator taken along section line 2—2 of FIG. 1,

FIG. 3 is a cross-section view of the tuner mechanism taken along section line 3—3 in FIG. 2,

FIG. 4 is an enlarged cross-section view of a portion of one side wall taken along section line 4—4 in FIG. 2

showing the construction utilized for temperature compensation,

FIG. 4*a* is a vector diagram illustrating the direction of movements of the temperature compensation plate,

FIG. 5 is a modification of the structure shown in FIG. 4, and

FIG. 6 shows the manner in which the ring 34 is assembled to the center portion 33.

Referring now to the drawings, the cavity resonator utilized to describe the present invention comprises a hollow cylindrical main body member 11 made, for example, of Invar which has a low thermal coefficient of expansion. A pair of coupling holes 12 and 13 which may be sealed with dielectric windows to permit hermetic sealing of the cavity, if desired, are provided in the sides of the main body cylinder. Input and output waveguides 14 and 15, also of Invar, are brazed to the main body over these coupling holes. Flanges 16 and 17 of, for example, steel or brass, are brazed to the outer ends of the waveguides and serve to couple the cavity resonator to the input and output circuit members such as the reflex klystron 20. End plates 18 and 19 are mounted over the open ends of the hollow cylinder 11 by welding at junctions 21, it being understood that these end plates may be screwed to body 11 or secured in any other effective manner. The end plates are provided with stiffening ribs 21'. End plate 19 is of the same material as the main body 11, the construction of end plate 18 being described in more detail below.

Mounted in a hollow cylindrical extension 22 in the axial center of one of the end plates 18 is a screw tuner mechanism comprising a circular tuner plate 23 welded to one end of a cylindrical flexible bellows 24, the other end of which is welded to an annular lip 25 in the extension 22. The bellows 24 permits hermetic seal of the cavity resonator if desired. The upper portion of the bore in the cylindrical extension 22 is threaded and carries a hollow cylindrical tuner screw member 26, the inner end of the tuner screw member 26 being adapted to engage the tuner plate 23. One end of a locking screw 27 is welded to the tuner plate 23 and extends up within the hollow tuner screw member 26, the screw 27 being provided with a lock nut 28 and washer 29 adapted to engage a ledge 31 on the tuner screw member 26. The plate 23 may be moved inwardly into the cavity resonator by screwing the tuner member 26 into the extension 22. When the plate 23 has reached its desired position, the screw 26 is locked by means of lock nut 32. The plate 23 is pulled up firmly against the inner end of the tuner screw 26 by tightening lock nut 28 down on screw 27. Thus the position of the plate 23 within the cavity resonator is determined by the positioning of the tuner screw 26 and the locking screw 27 is utilized to lock the plate firmly against the tuner screw 26. The lip 25 serves to limit the distance that tuner screw 26 can be moved into the cavity resonator to therefore prevent overstretching the bellows 24.

The same end plate 18 is constructed in a novel manner to provide temperature compensation for this cavity resonator. The large central portion 33 of this end plate (including the above described tuner mechanism) is made of steel or other high expansion material and is brazed to an outer rim or ring portion 34 which is of a material such as Invar having a very low thermal coefficient of

expansion relative to the material of the central portion 33. The central portion 33 is provided with a peripheral section 35 joined to the central or main section 33 at a relatively thin annular junction point 36 (FIG. 4). It is noted that the tuner structure shown in the plate 18 in FIG. 2 has been omitted in FIGS. 4 and 5 for the purpose of giving a clearer picture of the temperature compensation feature. The annular Invar ring 34 also has an inner circumferal section 37 which is joined to the main section of the Invar ring at a relatively thin junction point 38. The upper surface 40 of the peripheral section 35 is directed at an angle relative to the axis line 39 and mates with the end surface of the circumferal section 37 which extends at the same angle, these two surfaces being securely brazed together. The reason for this angular mating surface 40 will be described in more detail below.

The Invar ring 34 and main body 11 to which the ring 34 is secured have a relatively slight expansion over the temperature range of operation of the cavity resonator due to the low coefficient of expansion of Invar. Therefore the junction point 38 remains substantially stationary in the radial direction and in the axial direction relative to the axis 39 during all temperatures of operation. The steel central portion 33, however, has a relatively high thermal coefficient of expansion and it expands radially from the central axis 39 a relatively large distance as well as inwardly into the cavity resonator. Thus the junction point 36 moves radially outward from the axis 39 and axially inward into the cavity resonator with temperature expansion and vice versa with temperature contraction. The flexibility at points 36 and 38 allows considerable bending and flexing of the Invar ring 34 and steel center 33 during the relative expansion and contraction between the two. The junction point 36 of the center portion 33 therefore swings arcuately about the junction point 38 in the inner ring 34 as indicated by the vectors 41 and 41' (see FIG. 4*a*). It is noted that the motion indicated by the vector 41' has a downward vertical component 42 when the center portion 33 is expanding and vector 41 has an upward vertical component 43 during contraction. Thus the inner surface 44 of the steel center portion 33 tends to move in a direction inwardly of the cavity resonator as center portion 33 expands. This inward motion results from the component 42 increased by the expansion of the metal in the space between surface 44 and the mating surface 40. Conversely, during contraction the center portion 33 moves outwardly of the cavity resonator.

The amplitude of the vertical components 42 and 43 of the movement vector between junction point 38 and junction point 36 may be adjusted by changing the angle θ between the line drawn through the points 36 and 38 and the horizontal and thus the ratio of distance of movement to degree of temperature change may be varied. Since such motion changes the resonant frequency of the cavity the resulting effect is to produce any desired rate of change of cavity frequency with temperature; and, if desired, to exactly compensate for all other temperature dependent frequency changes in the cavity, such as the frequency changes due to the small residual coefficient of the Invar body material. Changes in angle θ may be made by properly dimensioning ring 34 and center portion 33 including their extensions 35 and 37 before assembly. The angle θ may also be changed or adjusted by a simple expedient after complete assembly of the cavity resonator if a change or correction in temperature compensation is desired. This variation may be accomplished by making a cut 45 in the plate 33 near the junction 36 as shown in FIG. 5. This cut shifts the most flexible point 36 of the center portion 33 to the left relative to the position shown in FIG. 4 and thus results in an increase in angle θ.

It is noted that the configuration in FIG. 5 in which θ has been made larger than 90° results in an outwardly directed vertical component of movement during temperature expansion and an inwardly directed component during contraction. This is opposite to the movements of the configuration of FIG. 4.

Also, the point 38 may be shifted relative to the point 36 by shaving the surface 46 (see FIG. 5) and thus decreasing the angle θ.

The slant in the surface 40 of section 35 and in the mating surface of section 37 aids in assembling the central portion 33 to the ring 34. To assemble, the ring 34 is placed on the surface 40 and a weight 47 placed on top of the ring to urge it into close contact with this surface (see FIG. 6). A ring of silver solder 48 is placed at the V junction of the section 35 and the section 37 and the assembly placed in a brazing furnace. As the materials heat up the central portion 33 and section 35 radially expand and the ring 34 having a low coefficient of expansion, slides down on the surface of section 35. The silver solder flows between the mating surfaces. On cooling of the assembly, the solder solidifies and, although the central portion 33 contracts, friction and the downward pressure on ring 34 prevent the section 37 from sliding up the surface of section 35 and weakening or breaking the brazed joint.

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 temperature compensated high frequency cavity resonator comprising a main body forming the cavity resonator and a movable wall in said main body for temperature compensation of said cavity resonator, said wall including an outer annular rim portion made of material of one thermal coefficient of expansion, said rim portion comprising a main section secured to said main body and an inner circumferal section with an annular junction between the sections, said wall also including a circular central portion made of a material of a different thermal coefficient of expansion comprising a main central section and a peripheral section with an annular junction therebetween, the peripheral section of said central portion being securely affixed to the inner circumferal section of said rim portion, relative movement between said rim portion and said central portion during the expansion and contraction of said cavity resonator during temperature changes producing a flexing of said portions at said junctions with a resultant movement of the wall section within the cavity resonator.

2. A temperature compensated high frequency cavity resonator as claimed in claim 1 wherein the mating surfaces at which said peripheral section and said inner circumferal section are joined are directed at an obtuse angle relative to the plane of said wall.

3. A temperature compensated high frequency cavity resonator comprising a main body forming the cavity resonator and a wall in said main body adapted for movement in the body for temperature compensation of said cavity resonator, said wall comprising a rim section affixed to said main body made of material having one thermal coefficient of expansion and a central section securely affixed to said rim section and made of a material having a different thermal coefficient of expansion, said wall having a relatively flexible portion at the junction of said rim section and central section, the flexible portion bending during radial expansion and contraction of said central section during temperature changes and being arranged to move the central section of said wall within said cavity resonator to effect temperature compensation of the cavity resonator.

4. A temperature compensated high frequency cavity resonator as claimed in claim 3 wherein said central section of the wall is positioned more inwardly of the main body than said rim section such that said flexible portion

extends in a direction which forms a substantial angle relative to the plane surface of said wall.

5. A cavity resonator apparatus as claimed in claim 1 wherein said rim portion and said main body are made of material having substantially the same thermal coefficient of expansion.

6. A cavity resonator apparatus as claimed in claim 5 wherein said rim and main body material is Invar.

7. A cavity resonator apparatus as claimed in claim 3 wherein said rim section and said main body are made of material having substantially the same thermal coefficient of expansion.

8. A cavity resonator apparatus as claimed in claim 7 wherein said rim and main body material is Invar.

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