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I. L. STEPHAN

2,409,321

CAVITY TUNING DEVICE

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Fig. 1.

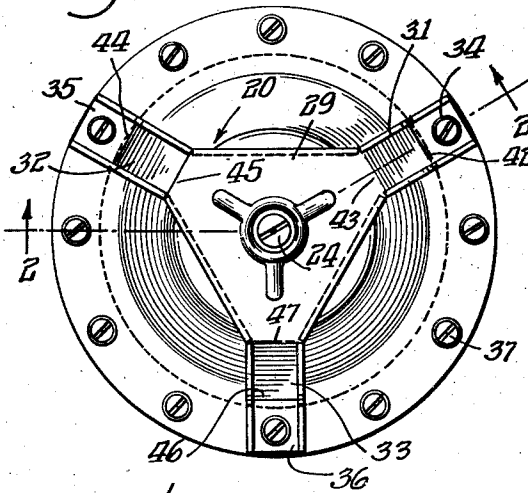


Fig. 3.

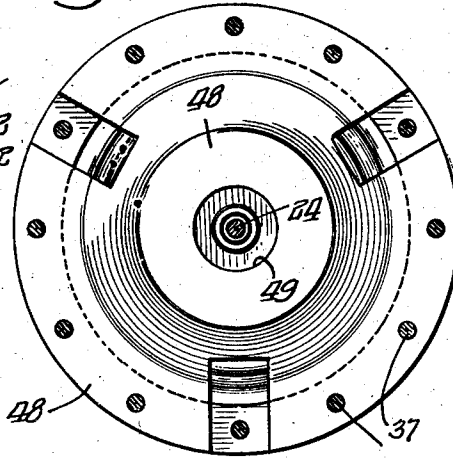


Fig. 2.

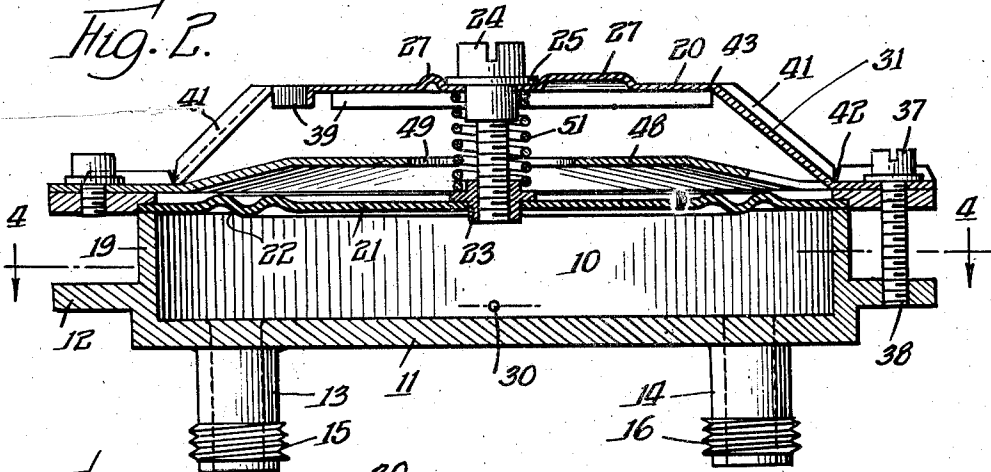


Fig. 4.

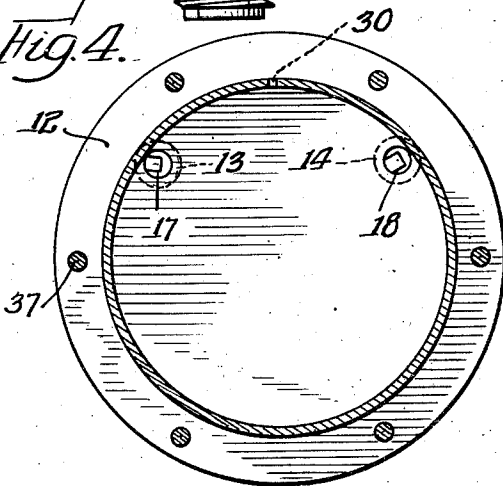
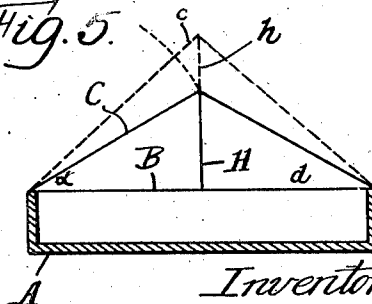


Fig. 5.



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UNITED STATES PATENT OFFICE

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CAVITY TUNING DEVICE

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12 Claims. (Cl. 178-44)

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The present invention relates to cavity tuning devices for ultra-high radio frequency apparatus, and more particularly to a novel apparatus for compensating for temperature variations in a cavity tuning device.

In ultra-high frequency radio systems it is common to utilize resonant cavities. Such resonant cavities may be tuned by various different arrangements, but one of the most satisfactory methods is to utilize an adjustable diaphragm, the position of which may be varied, for example, by means of an adjustable screw. Such adjustment, however, is correct only for a particular temperature and consequently there may be subsequent expansion or contraction of the resonant cavity which will change the resonant frequency thereof. In order to keep the resonant frequency constant, it is therefore desirable to provide some arrangement for compensating for the expansion or contraction resulting from differences of temperature. It is further desirable that the compensating arrangement shall be simple and compact in the interests of space conservation and facility of manufacture.

With the foregoing in mind, it is an object of the present invention to provide a novel arrangement for the temperature compensation of a cavity tuning device.

It is another object of the invention to provide a simple and compact device for compensating the effects of temperature on a resonant cavity.

Other and further objects will become apparent by reference to the following description taken in connection with the accompanying drawing, wherein:

Fig. 1 is a plan view of a tuning cavity provided with an arrangement for introducing compensation for temperature variations, according to the present invention;

Fig. 2 is an enlarged cross-sectional view of the apparatus taken along obtuse angularly displaced lines 2-2 of Fig. 1;

Fig. 3 is a plan view of the device with the upper spider or bridge-work removed;

Fig. 4 is a sectional view taken along the lines 4-4 of Fig. 2; and

Fig. 5 is a diagram explanatory of the principles involved in the temperature compensation arrangement.

Referring to Figs. 1 to 4, it will become apparent that there has been shown a resonant cavity 10 having a body 11 which is generally of cup-shaped or shallow cylindrical configuration,

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The body 11 is provided with a surrounding flange 12 having suitable threaded apertures therein for receiving a number of fastening screws or bolts for retaining other cooperating members in position on the top of the cup-shaped portion of the cavity. Underneath the body 11 of the cavity 10 there may be provided one or more coupling stems 13 and 14 each of which has threaded portions, such as 15 and 16, so that a coaxial cable may be coupled thereto. Within the hollow opening in the members 13 and 14 there may be provided probes or coupling loops 17 and 18 as seen in Fig. 4. Thus, where desired, energy may be coupled to the resonant cavity or extracted therefrom in order to indicate the frequency at which the cavity operates.

Immediately above the vertical wall portion 19 of the cavity 10 there is positioned a movable diaphragm 21 which may be provided with a plurality of concentric corrugations 22 to permit the central portion thereof to be moved in the manner of a piston. The outer edge of the diaphragm 21 rests upon the vertical walls 19 of the cavity 10. In order to avoid detuning of the cavity by changes in barometric pressure, the "breather-hole" 30 is provided to insure equality of air pressures inside and outside the cavity. The "breather-hole" also serves as a drain in the event that water should accumulate in the cavity due to condensation of vapors present in the atmosphere. At the center the diaphragm 21 is provided with a hollow stud 23 secured thereto and provided internally with threads for cooperation with an adjusting screw 24. The adjusting screw 24 has a collar portion 25 which engages a flat circular area within a corrugated reinforced portion 27 in a supporting spider or bridge-work member 20.

The bridge-work member 20 has a flat upper portion 29 which is supported some distance above the diaphragm 21 by a plurality of legs, such as 31, 32 and 33, each of which terminates in flat portions 34, 35 and 36 provided with suitable apertures through which screw fastening means 37 may be placed so as to engage threaded openings 38 in the lower flange 12 on the resonant cavity body 11. In order to increase the rigidity of the central area 29 of the spider 20, the sides thereof may be turned downwardly as may be seen at 39 in Fig. 2. The angularly disposed legs 31 to 33 are made relatively rigid by turning up the sides thereof as at 41 to form channeled members. Due to this arrangement of turning down the edges of the central portion 29 to form the sides 39, and turning upwardly the sides 41

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on the three angularly arranged legs, it becomes apparent that at each of the junctures of the legs 31 to 33 with the flat portions 34 to 36 and with the central portion 29 there is provided a less rigid "hinge" portion. Such portions are designated by reference characters 42 to 47 in Figs. 1 and 2. The purpose of this structure will appear presently. Since the spider 20 will afford little protection to the diaphragm 21, there may be provided a diaphragm cover 48 having a dished configuration, as shown most clearly in Fig. 2. At the center the member 48 is provided with an aperture 49 to accommodate the screw 24 and its associated spring 51, the purpose of the latter being to retain the diaphragm in proper adjusted position. Spring 51 bears against a flange or collar-like area on the stud 23 and against the bottom side of the spider 20. The body structure 11 together with the diaphragm 21 form the resonant cavity 10 which may be tuned to a desired frequency by adjustment of the diaphragm through manipulation of the adjusting screw 24.

In a resonant cavity system such as disclosed, radial expansion or contraction of the body structure 11 tends to cause a change in the resonant frequency due to the effect of such expansion or contraction upon the magnetic field which predominates in the areas adjacent the cavity wall. Thus expansion of the structure 11 tends to cause a decrease in resonant frequency, while contraction of structure 11 tends to cause an increase in resonant frequency. In accordance with the present invention this tendency is counteracted, firstly, by constructing the main body 11 of the cavity of a material having a low coefficient of expansion, and, secondly, by causing the central portion of the diaphragm, in the region where the electric field predominates, to move so as to affect the electric field in a manner to prevent or minimize any change in resonant frequency due to expansion or contraction of body 11. Since the electric field is a maximum in the central area of the cavity, upward movement of the central portion of the diaphragm tends to increase the resonant frequency, while downward movement of said portion tends to decrease the resonant frequency. The movement of the diaphragm is effected by the above-described bridge structure through the medium of the connecting screw and its associated spring. To this end the spider member 20 is constructed of a material having a relatively high coefficient of linear expansion. The screw 24 and spring 51 should have a negligible coefficient of expansion so as not to interfere with the desired operation.

In order to explain the manner in which the spider structure 20 produces the desired movement of the diaphragm, reference is made to the simplified explanatory diagram of Fig. 5. In this figure, it may be assumed that the U-shaped member A represents a cross-section through the cavity body 11 and that the line B joining the upper ends of the U-shaped member represents the diaphragm 21. Since only the expansion or contraction of spider legs will produce movement of the diaphragm, the spider structure may be simplified in the manner shown. The apex of the triangle formed by the sides C may be said to be a distance H above the diaphragm B. Now if the dimensions of the member A remain fixed, or relatively fixed, then any expansion of the sides C by an amount c will produce a much greater increase in the distance H by an amount

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h which represents movement of the diaphragm. The amount h which the distance H is increased is larger than c by an approximate factor of

$$\frac{1}{\sin \alpha}$$

where α is the angle between the side C and the diaphragm or base B. By selecting a material of the appropriate coefficients of expansion for the angular member C, different amounts of compensating movement of the diaphragm can be obtained. Moreover, it will be apparent that if the angle α is small the amount of movement of the diaphragm will be large, and such movement will decrease if the angle is increased. Thus the amount of compensation may be varied by varying the angle α .

The reason for the "hinge" portions 42 to 47, hereinbefore referred to, will now be apparent. These portions permit the desired expansion or contraction of the spider legs without causing distortion of the spider structure. If desired, these portions may be rendered better capable of the required hinge action by weakening the metal of said portions.

From the foregoing description it will be seen that by selecting suitable materials for the component parts and by designing the spider structure accordingly, the desired compensation may readily be obtained. For a given material of the cavity body 11, the spider structure should be designed and constructed so to move the diaphragm in a manner to counteract any change in resonant frequency which would otherwise be caused by expansion or contraction of body 11.

In one satisfactory embodiment of the device, the adjusting screw 24 was made of Invar, an alloy which undergoes negligible expansion with temperature. With an Invar adjusting screw, the length of the screw may be regarded, for all practical purposes, as substantially fixed at all temperatures normally encountered. In this particular embodiment the main cavity structure 11 was of steel. Ideally this structure would also have a negligible coefficient of linear expansion, but since Invar is expensive, steel was selected in its place as having a coefficient sufficiently low for the purpose. The spider element 20 was constructed of aluminum, a metal having a coefficient of expansion almost twice that of steel.

While a preferred embodiment of the invention has been shown and described in order to explain the present invention, it of course, will be understood that I do not wish to be limited thereto since obviously modifications and alterations may be made in the instrumentalities employed and in their general arrangement without departing from the spirit and scope of the invention as set forth in the appended claims.

I claim:

1. In combination with an ultra-high frequency tuning cavity having a movable diaphragm, means for compensating for temperature variations so as to maintain the resonant frequency of said cavity substantially constant, comprising a temperature-responsive expansible and contractible member mounted on the cavity structure externally thereof, and a connecting element between said member and the movable diaphragm, whereby the latter is moved in response to expansion or contraction of said member.

2. In combination with an ultra-high frequency tuning cavity having a movable diaphragm, means for compensating for temperature variations so as to maintain the resonant frequency of said

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cavity substantially constant, comprising a bridge-like member mounted on the cavity structure externally adjacent said movable diaphragm, said member being formed of material having a high coefficient of expansion, and a connecting element between said member and the movable diaphragm, whereby the latter is moved in response to expansion or contraction of said member.

3. An ultra-high frequency tuning cavity, comprising a cup-shaped member having a low coefficient of expansion, a flexible diaphragm forming a closure member for said cavity, a bridge-like member spanning said diaphragm exteriorly of said cavity and secured to the cavity structure, said bridge-like member being formed of material having a high coefficient of expansion, and connecting means between the central portions of said bridge-like member and said diaphragm, whereby the diaphragm is moved in response to expansion of said bridge-like member.

4. An ultra-high frequency tuning cavity, comprising a cup-shaped member having a low coefficient of expansion, a flexible diaphragm forming a closure member for said cavity, a spider member spanning said diaphragm exteriorly of said cavity and having legs extending at acute angles to the plane of said diaphragm and secured to the cavity structure, said spider member being formed of material having a high coefficient of expansion, and connecting means between the central portions of said spider member and said diaphragm, whereby the diaphragm is moved in response to expansion of the legs of said spider member.

5. An ultra-high frequency tuning cavity comprising a cup-shaped base member, a flexible diaphragm cover for said cup-shaped member, a bridge-like frame supported above said diaphragm, said frame having a rigid central area supported by a plurality of angularly disposed legs, said legs being adapted to expand and contract with temperature changes thereby to move said rigid central area from one plane to another, and means interconnecting said diaphragm with said central area.

6. An ultra-high frequency resonant device having a flexible diaphragm wall, a temperature-expansible framework having a relatively rigid central area adapted to be supported parallel to said diaphragm, said rigid central area being supported by a plurality of legs, the extremities of which are fixed in position, said legs having intermediate portions arranged at acute angles to said diaphragm and having relatively flexible portions interconnecting said intermediate portions with said rigid central area and with the remaining portions of said legs, and means interconnecting said central area of said framework with said diaphragm.

7. An ultra-high frequency tuning device having a diaphragm adapted to be positioned to determine the resonant frequency of said device, a diaphragm positioning apparatus comprising a temperature-expansible framework having a body supported on a plurality of legs angularly disposed with respect to said diaphragm and said body, said legs being joined to said body with portions less rigid than the remaining portions of said framework whereby said legs may expand and contract with temperature changes thereby to move said body from one parallel plane to another, and means interconnecting said diaphragm with said body.

8. An ultra-high frequency tuning device having a movable wall member, a temperature-ex-

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pansible framework comprising a body portion arranged in a plane parallel to said wall member, said body portion being supported by a plurality of angularly disposed legs interconnected with said body portion by relatively flexible portions, the extremities of said leg being secured in fixed position, an adjustable means interconnecting said body portion with said movable wall member whereby said movable wall member may be initially adjusted to determine the frequency of said tuning device, and means for introducing ultra-high frequency energy into said tuning device.

9. An ultra-high frequency tuning cavity having two spaced apart parallel walls, one of said walls being formed of a relatively thin flexible member, means for adjustably positioning said flexible wall with respect to the other wall comprising a temperature-expansible framework having a central body portion supported on a plurality of legs each angularly disposed with respect to said body portion, said legs terminating in portions rigidly secured in position with respect to said other wall of said cavity, said angularly disposed portions of said legs being interconnected with the fixed portions of said legs and with said central body portion by relatively flexible portions whereby in response to temperature changes the expansion or contraction of said angularly disposed leg portions will cause said body portion to be moved from one plane to another, an adjustable screw member interconnecting said body portion of said framework with said flexible cavity wall whereby said wall may be adjusted to initially determine the resonant frequency of said cavity, means for frictionally retaining said adjusting screw in adjusted position, and means for introducing ultra-high frequency energy into said cavity.

10. An ultra-high frequency tuning cavity comprising a relatively shallow cylinder having one end formed of a flexible diaphragm, an annular supporting ring mounted on said cavity, a temperature-expansible framework supported from said annular ring comprising a relatively rigid central body portion, at least three legs flexibly interconnected with said central body portion, each of said legs being provided with flexibly interconnected portions adapted to be secured in position on said mounting ring, diaphragm adjusting means interconnecting said diaphragm and the central body portion of said framework for initially determining the position of said diaphragm, and means for coupling ultra-high frequency radio energy to said cavity.

11. An ultra-high frequency tuning cavity comprising a circular frame member having an annular supporting flange on the exterior thereof, a circular flexible diaphragm cover arranged to constitute one wall of said cavity, an annular ring for securing said diaphragm in position, said ring being secured to said annular flange, an apertured protective cover for said diaphragm secured to said annular ring, a temperature-expansible framework having a relatively rigid central portion provided with an aperture therein, a plurality of fastening legs arranged to be secured to said annular ring, and a plurality of interconnecting legs flexibly secured to said fastening legs and to said central body portion, an adjusting screw mounted in the aperture of said central body portion and extending through the aperture in said cover and engaging cooperating means mounted at the center of said diaphragm whereby said diaphragm may be adjusted to a predetermined selected position, spring means in-

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terposed between said framework and said diaphragm for securing said diaphragm in adjusted position, and means for introducing ultra-high frequency energy in said tuning cavity.

12. An ultra-high frequency cavity structure, 5 comprising a cup-shaped member and a flexible diaphragm secured thereto, said member and said diaphragm cooperatively forming a resonant cavity in which the magnetic field of the contained energy predominates in the areas adjacent 10 the cavity wall while the electric field of said

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energy predominates in the central area of the cavity, the resonant frequency of said cavity being subject to change by the effect on the magnetic field of expansion or contraction of said cup-shaped member due to temperature changes, and temperature-responsive means for moving the central portion of said diaphragm so as to produce a compensating effect on the electric field and thereby maintain the resonant frequency substantially constant.

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Disclaimer

2,409,321.—*Ingo L. Stephan*, Delanco, N. J. CAVITY TUNING DEVICE. Patent dated Oct. 15, 1946. Disclaimer filed Dec. 10, 1947, by the assignee, *Philco Corporation*.

Hereby enters this disclaimer to claim 1 of said Letters Patent.

[*Official Gazette January 13, 1948.*]