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CAVITY RESONATOR

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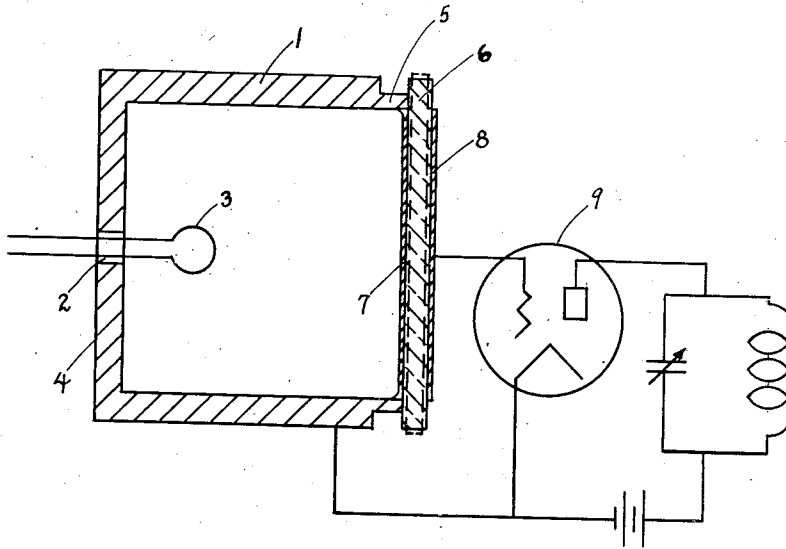


FIG. 1

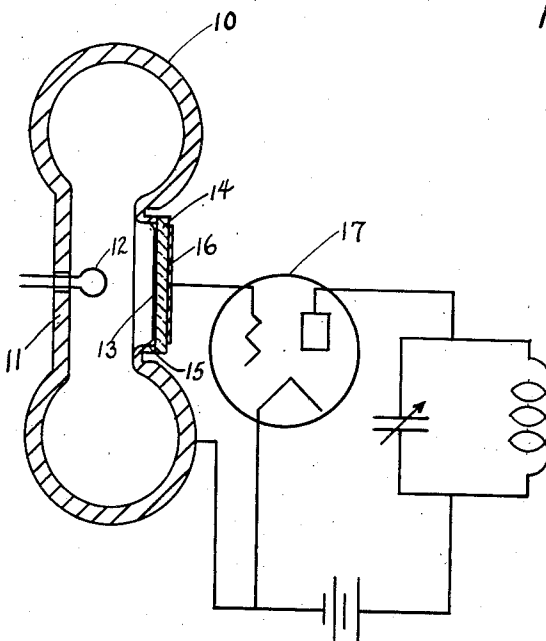


FIG. 2

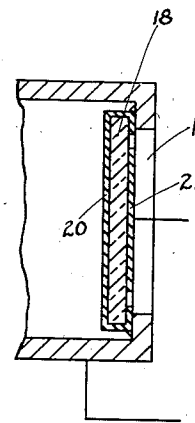


FIG. 3

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CAVITY RESONATOR

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3 Claims. (Cl. 178—44)

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This invention relates to cavity resonators, and more particularly, to mechanically modulated cavity resonators.

A main object of this invention is to provide a cavity resonator adapted to be employed in ultra high frequency radio equipment as a tank circuit element for generating a frequency-modulated ultra high frequency wave in a transmitter or as a resonator for tuning a receiver to an ultra high frequency wave.

A further object of the invention is to provide a resonator device for an ultra high frequency receiver which is adapted to provide substantially panoramic tuning for the receiver whereby all signals in a desired band of frequencies in the microwave region may be simultaneously detected.

Further objects and advantages of the invention will appear from the following description and claims, and from the accompanying drawings, wherein:

Figure 1 is a diagrammatic view of a cavity resonator of the square prism type provided with a frequency-modulating means in accordance with this invention.

Figure 2 is a diagrammatic view of a cavity resonator of the toroidal type provided with frequency-modulating means in accordance with this invention.

Figure 3 is a diagrammatic view illustrating a modification of a cavity resonator frequency-modulating structure in accordance with this invention.

Cavity resonators as ordinarily used in ultra high frequency wave technique are employed as tank circuit elements for generating high frequency waves in combination with appropriate electron tubes, as tuned filter elements in amplifiers, as selective circuits in receivers, in electromagnetic horns, and in other devices requiring sharp resonance characteristics at a predetermined frequency or frequencies.

In the conventional cavity resonator the dimensions of the cavity are fixed so that the resonance effect occurs at a substantially distinct frequency, or provision may be made for adjusting one or more dimensions or by adjusting a tuning element within the cavity to vary the resonance frequency. After adjustment is made the resonator is still characterized by a substantially

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distinct single-frequency response, as a general rule.

In certain applications of ultra high frequency waves it is desirable to frequency-modulate the cavity resonator at a relatively rapid and constantly maintained rate, such as in certain types of signalling between aircraft, or between aircraft and ground stations; for determining range distances by measurement of phase differences between transmitted and reflected waves; for calibrating range oscillators; and for a large number of other radio navigational applications. In certain instances it may be desirable to amplitude-modulate the frequency-modulated wave, such as in certain types of television transmissions.

In the reception of frequency-modulated ultra high frequency waves as above generated, it is necessary to frequency modulate the selective cavity resonator tuning elements of the receiver at the same modulation rate as the transmitter for proper reception. However, under certain circumstances it is desirable to provide for panoramic reception of all distinct waves (not frequency-modulated) in a given band in the ultra high frequency region, where provision is made for separating and indicating the respective waves as they exist over the band. Without reference to the specific details of the equipment for separating and indicating the respective waves present in the band, it will be clear that a receiver having frequency-modulated cavity resonator tuning elements which are frequency-modulated over the desired band will at certain periodically related instants be in resonance with each of the respective waves (not frequency-modulated) which exist over the band.

It is therefore a prime purpose of this invention to provide a frequency-modulated cavity resonator adapted for use in equipment similar to that above mentioned.

Referring to the drawings, Figure 1 discloses a cavity resonator of the square prism type wherein 1 designates the body portion thereof which may be of copper or other highly conductive material of substantial thickness. At one end wall 4 of the cavity an opening 2 is provided for the insertion of a coupling loop 3. Adjacent the other end wall of the cavity the body portion 1 is formed with a rim portion 5 of substantially reduced

thickness which is in abutment with a square piezo-electric crystal plate 6, secured to rim 5 by soldering the edge portions of its inner electrode 7 to the adjacent inner wall surfaces of the cavity. Electrode 7 is of the plated type and is sufficiently thick to adequately rigidly hold and support crystal plate 6 against rim 5, the soldered joints providing a substantially rigid connection between said rim and the crystal.

The outer electrode 8 of the crystal is also of the plated type. Electrode 8 is connected to the grid of an appropriate oscillator tube 9, the cathode of said tube being connected to body portion 1 of the cavity resonator, which is conductively connected to electrode 7 by the soldered joint at rim 5. An appropriate plate tuning circuit is provided for oscillator tube 9 for oscillating crystal 6 in an extensional mode, as indicated by the dotted lines in Figure 1, whereby the thickness of the crystal as well as the length thereof alternates in accordance with the period of oscillation of the crystal. Rim 5 is dimensioned to be of an appropriate length and thickness so as to vibrate in phase with crystal 6 so that there is no relative motion between rim 5 and crystal 6 at the soldered joint connecting them. The resultant motion of crystal 6 with respect to body portion 1 of the cavity resonator is such that electrode 7 oscillates laterally and periodically changes its distance from end wall 4 at a rate equal to the frequency of oscillation of crystal 6. The periodic change in the dimension between wall 4 and electrode 7 frequency-modulates the cavity resonator at a frequency of modulation substantially equal to the crystal oscillation frequency. The degree of modulation depends upon the specific dimensions of the resonator.

In the embodiment of Figure 2 a metal toroidal cavity resonator 10 is employed having a first reentrant wall 11 through which the coupling loop 12 is introduced and a second reentrant surface element 13 opposite wall 11 comprising the inner plated electrode of a circular piezo-electric crystal plate 14. Crystal plate 14 is mounted on an appropriately formed annular rim structure 15 provided on the toroid, and surface element 13 is peripherally soldered to the inner surface of annular rim 15. An outer plated electrode 16 is provided for crystal 14, said outer electrode being connected to the grid of an oscillator tube 17. The cathode of tube 17 is connected to toroid 10 and an appropriate plate tuning circuit is provided for tube 17 for oscillating crystal 14 in an extensional mode. As in the embodiment of Figure 1, rim 15 is dimensioned to vibrate freely in phase with crystal 14 so that no relative motion occurs between the crystal and said rim at the peripheral soldered joint. The resultant oscillatory motion of surface element 13 with respect to wall 11 frequency-modulates the cavity resonator substantially at the oscillation frequency of the crystal, the degree of modulation being somewhat greater than in the embodiment of Figure 1 for a given amplitude of crystal oscillation due to the closer normal spacing between the wall 11 and surface element 13 of the toroid cavity resonator.

In Figure 3 a modification is disclosed wherein the crystal 18 is supported within the cavity resonator. The cavity resonator is formed with an opening 19 in a wall thereof. The crystal is of a size and shape such as to slightly overlap the edges of opening 19 when positioned over said opening at the inner surface of said wall. A first electrode 20 is provided on crystal 18 which

provides a continuous conductive surface for that portion of the crystal exposed to the inside of the cavity resonator, said electrode being rigidly secured to the apertured cavity wall by an appropriate peripheral soldered joint. A second electrode 21 is provided on that portion of the crystal 18 exposed to the exterior, electrode 21 being insulated from electrode 20 by an appropriate gap between the electrodes.

The rim portion of the resonator need not be designed to oscillate in mechanical resonance with the crystal, inasmuch as the crystal may be appropriately oriented and shaped so as to be substantially stationary at its peripheral edge portions while expanding and contracting in thickness to thus produce the frequency-modulating effect in the cavity resonator.

Other suitable electrical means for oscillating the crystal than the specific circuit herein described may be employed within the contemplation of this invention. Thus, a grid-plate crystal oscillator circuit or any other crystal oscillator circuit known in the art may be employed, or any other known electrical means for driving the crystal.

It is also contemplated that the vibrating surface element may be driven by mechanical vibrators such as tuning fork devices or by magnetostriction oscillator devices.

It is further contemplated that the vibratory element may be mounted at other points within the cavity than at a wall portion thereof, since the frequency-modulation effect may be achieved wherever the vibratory element can be coupled in any manner to the electromagnetic field existing within the cavity.

While certain specific embodiments of mechanically modulated cavity resonators have been disclosed in the foregoing description, it will be understood that various modifications within the spirit of the invention may occur to those skilled in the art.

What is claimed is:

1. A cavity resonator having as a wall element a piezo-electric crystal unit having plated electrodes on the opposite faces thereof, one electrode facing inwardly of the cavity resonator and the other electrode facing outwardly, the inwardly facing electrode being connected to the cavity resonator body at its peripheral edges, whereby oscillation of the piezo-electric crystal unit periodically varies the resonance frequency of the cavity resonator.

2. A cavity resonator having as a wall element a piezo-electric crystal unit having plated electrodes on the opposite faces thereof, one electrode facing inwardly of the cavity resonator and the other electrode facing outwardly, the inwardly facing electrode being connected to the cavity resonator body at its peripheral edges and said resonator body being substantially reduced in wall thickness immediately adjacent to its connection to the peripheral edges of said inwardly facing electrode, whereby oscillation of the piezo-electric unit periodically varies the resonance frequency of the cavity resonator.

3. A cavity resonator having as a wall element thereof a piezo-electric crystal unit comprising a piezo-electric crystal plate oriented and shaped so as to be substantially stationary at its peripheral edge portions while expanding and contracting in thickness during oscillation, and having plated electrodes on the opposite faces thereof, one electrode facing inwardly of the cavity resonator and the other electrode facing outwardly,

the inwardly facing electrode being connected at its peripheral edges to the cavity resonator body, whereby expansion and contraction in thickness of the crystal plate during oscillation periodically varies the resonance frequency of the cavity resonator.

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REFERENCES CITED

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

Number
2,106,769
2,174,701
2,233,263
2,241,976
2,306,282
2,323,201
2,374,810
2,405,277
2,408,425

UNITED STATES PATENTS

Name	Date
Southworth -----	Feb. 1, 1938
Koch -----	Oct. 3, 1939
Linder -----	Feb. 25, 1941
Blewett -----	May 13, 1941
Samuel -----	Dec. 22, 1942
Carter -----	June 29, 1943
Fremlin -----	May 1, 1945
Thompson -----	Aug. 6, 1946
Jenks -----	Oct. 1, 1946