

April 21, 1959

M. S. WHEELER

2,883,630

TEMPERATURE COMPENSATED ULTRA HIGH FREQUENCY REFERENCE CAVITY

Filed Nov. 21, 1952

Fig. 1.

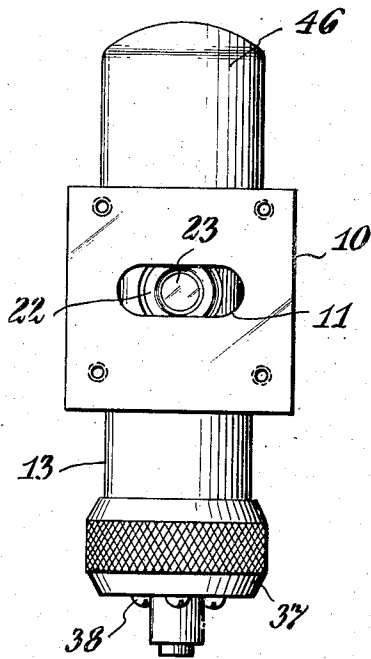


Fig. 2.

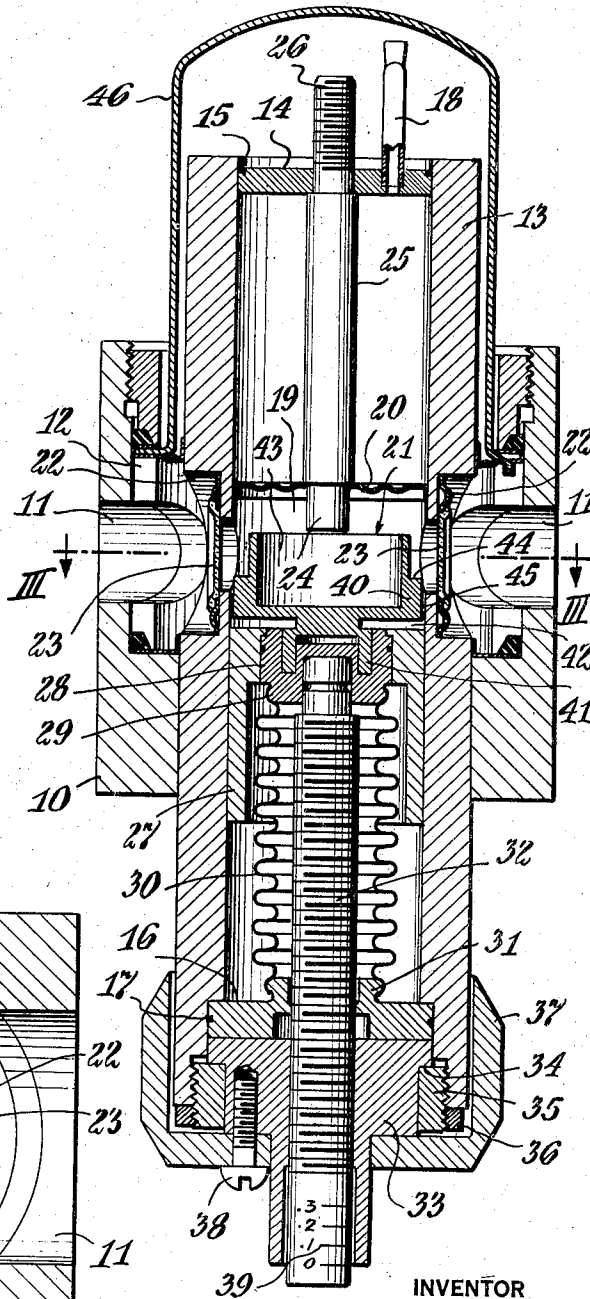
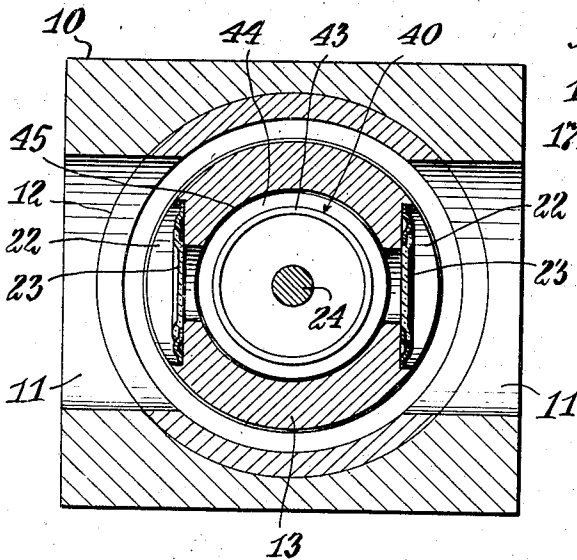


Fig. 3.



INVENTOR
MYRON S. WHEELER
BY *John. Kelly*
ATTORNEY

1

2,883,630

TEMPERATURE COMPENSATED ULTRA HIGH FREQUENCY REFERENCE CAVITY

Myron S. Wheeler, Cedar Grove, N.J., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application November 21, 1952, Serial No. 321,901

4 Claims. (Cl. 333—83)

This invention relates to an ultra high frequency cavity, which is a type of tube constructed with a cavity resonator with opposed windows, and in which resonance occurs only for a wave length of predetermined length for which the resonator is set. Inasmuch as change of temperature changes the internal dimensions of the resonator, there have been attempts heretofore to provide some approximation of temperature compensation and thus maintain the device resonant to as near the same frequency as possible under the varying temperature conditions.

According to the present invention, a reference cavity is provided wherein setting may be made more precisely to the frequency standard and one wherein the frequency may be changed over a wide band of frequencies.

In addition to the broad concept of the invention as above expressed, it has objectives of improved structural features for simplicity of manufacture, assembly and use, sturdiness, accuracy, visible setting and compactness.

Other objects of the invention will appear to persons skilled in the art to which it appertains as the description proceeds, both by direct recitation thereof and by implication from the context.

Referring to the accompanying drawing, in which like numerals of reference indicate similar parts throughout the several views:

Fig. 1 is an elevational of a reference cavity of the present invention;

Fig. 2 is a longitudinal central section thereof; and

Fig. 3 is a cross-section on line III—III of Fig. 2.

In the specific embodiment of the invention illustrated in said drawing, the reference numeral 10 designates a mounting block by which the reference cavity tube of the present disclosure is carried and located in its proper position in cascade in a wave guide (not shown). Said block has opposed orifices 11, 11 therein for passage of the wave energy therethrough from one wave guide section to another secured at opposite sides of the block in use. Furthermore, said block has a hollow 12 from top to bottom transverse to the passageway from one said orifice to the other, said hollow being of appropriate size and shape, preferably cylindrical, for reception and retention of the reference cavity tube, part of which protrudes from the top of the block and part from the bottom thereof.

The reference cavity tube comprises a cylindrical hollow housing 13 of suitable metal, such as copper. Said housing has a top closure disc or header 14 sealed thereto as by a solder ring 15 and a bottom closure disc or header 16 similarly sealed as by a solder ring 17 so that the interior of the tube may be evacuated, for which purpose an exhaust tubulation 18 is shown projecting upwardly from the top header.

The medial portion of the hollow of housing 13 is constituted as a resonator 19 with a deformable diaphragm 20 constituting the upper end wall thereof, and a piston-type movable unit 21 providing the bottom wall

2

thereof. The resonator is at a location between the orifices 11, 11 of the block 10 and constitutes the major portion of the passageway from one orifice to the other within the tube. The cylindrical housing 13 is provided with diametrically opposite window openings 22 into the resonator in aligned opposition to the orifices of the block, and said window openings have windows 23 of glass or other suitable material sealed vacuum-tight to the housing.

The deformable diaphragm 20 is secured at its peripheral margin to the cylindrical wall of the housing and by virtue of deformation will effect a change of volume, inductance and capacitance of the resonator thereby resulting in a change of resonant frequency to which the resonator will respond. The change of inductance and capacitance is augmented by provision of a nose 24 at the center of the diaphragm, said nose protruding into the resonator toward the bottom wall thereof. In manufacture, the bottom wall is set initially at a predetermined position and the top wall or diaphragm is deformed and the nose correctly positioned to make the resonator responsive to the desired frequency standard. A temperature compensator, such as rod 25, extends from nose 24 to the top header 14 and the afore-mentioned initial setting of the nose may be accomplished with exactitude by a slight deformation of said upper header after the diaphragm and header have been secured in substantially proper position in the housing. This final adjustment by deformation of the said header is performed by the agency of a suitable tool (not shown) which can make threaded engagement with an upwardly protruding and threaded stem end 26 of said rod. It will be understood, of course, that the rod makes a vacuum-tight seal with the header. The said rod is a different material from that comprising the housing, molybdenum being one example, so as to provide an acceptable differential of heat expansion between the rod and housing and making desired compensation to maintain substantially constant resonant frequency of the resonator at varying temperatures. This results from the different coefficients of expansion of the cylindrical housing and its coaxially extending rod.

Piston unit 21 is fabricated from several parts and includes a skirt member 27 the outer peripheral surface whereof makes sliding contact with the interior wall of the cylindrical housing 13. In this connection it may be noted that since there obviously will be sufficient clearance to permit reciprocation or adjustment of the piston, the region below the skirt member within the housing will be evacuated while the vacuum pump is functioning to exhaust the device through tabulation 18. According to the present showing, said skirt member is hollow and has its upper end closed by a plug 28 soldered or otherwise made fast in said member. This plug has a lower peripheral bead 29 to which is secured, vacuum-tight, the upper rim of a bellows 30 which depends therefrom longitudinally of the skirt and housing coaxial therewith. The lower end of the bellows extends to the bottom housing header 16 which has a similar bead 31 to which said bellows is also attached with a vacuum-tight engagement. Since the bellows is secured both to the bottom header and to the piston unit, said unit is prevented from rotating and has only a controlled longitudinal movement.

Longitudinal movement of the piston unit 21 is obtained by means of an adjusting screw 32 the upper end of which is soldered to or otherwise fixed with respect to said plug 28, being shown coaxially embedded in said plug for mechanical strength and union therewith. Said screw is shown coaxial to the housing and extends downwardly through the bottom header 16 and protrudes from the lower end of the device, passing in threaded engagement through a nut 33 rotatably mounted in the lower end of

the housing and seating against the under face of bottom header 16. Said nut has a peripheral downwardly facing shoulder 34 engaged by a retaining ring 35 having threaded engagement with the interior end margin of the housing and fixed in proper position by a locking ring 36 5 screwed onto said retaining ring and screwed home against the end of the housing.

Adjustable rotation means is provided for said nut 33, and here shown as a barrel 37 overlapping the lower margin of the housing and underlying the underface of the nut and secured thereto as by screws 38. The outer peripheral face of the barrel may be knurled, if so desired, to render it readily rotatable by the operator. As a further convenience, the lower end of the adjusting screw is preferably arranged to protrude from the bottom of the nut and provided with a scale 39 on a smoothed terminal portion of the screw so the operator may conveniently note the adjusted relation of the screw in the nut and housing.

The piston unit further includes a piston 40 constituting an essential feature of the present invention. For the most part, said piston is above the skirt member 27 but is provided with a hollow stem 41 depending coaxially into the skirt member and secured to the plug 28 thereof. The body of the piston is spaced at its bottom from the top surface of the skirt member and plug to provide a transverse slot 42 having substantially a quarter wavelength depth radially of the piston. Furthermore, the cylindrical exterior of the piston has a smaller diameter tubular portion 43 next to its upper end and a larger diameter portion next to its lower end with a radially extending and upwardly facing shelf 44 about half way of the length of the piston forming the step between the two different diameters of peripheral surfaces. There is clearance between the larger diameter surface of the piston and the housing, thus forming an annular slot 45 having a length in an axial direction of substantially a quarter wave length. The combined axial depth of annular slot 45 with the radial depth of the radial slot 42 gives a total of substantially half of a wave length which results in presence of low impedance at the level of the step or shelf 44 and consequently the effect thereof of short circuit between the shelf and housing. Said step is essentially the bottom of the resonator, and it will be observed from Figure 2 wherein the piston is at its most upward position of adjustment that said shelf is almost at the bottom of the windows so that incoming wave energy has substantially unobstructed entry to the resonator. From the position shown in Fig. 2, the piston has an adjustment of about half an inch downward enabling the frequency to which the resonator is responsive adjustable over a wide range.

It may now be pointed out that the piston is hollow or cupped as at 43 with the opening thereof upward and deep enough so that substantially no energy reaches the bottom of the hollow. An upper part of the tubular portion 43 of the piston, in any adjusted position of the piston is always closer to the nose 24 than the bottom of the hollow, and therefore the capacitance is essentially, and for practical considerations, only between the upper tubular portion 43 of the piston and said nose rather than between the bottom wall of the hollow and the nose.

From the above description it will now be seen that the resonator is constituted by two closed-end coaxial transmission lines, the upper one of which is nose 24 coaxially within housing 13 closed at the upper end by diaphragm 20, whereas the lower one is tubular portion 43 of the piston and surrounding portion of housing 13 closed at its lower end by step or shelf 44. By adjusting the piston, the capacitance between the two transmission lines is varied and thus the resonator is tuned to different frequencies.

By utilization of proportions in accordance with the illustration of Fig. 2, there is a frequency sensitivity, R , upon moving the nose and diaphragm which does the

temperature compensation, of about ten megacycles per mil of movement, while, upon moving the piston unit there is an average sensitivity of about two megacycles per mil, for effecting mechanical tuning. With a device having only the temperature compensation means and not the opposed mechanical tuning means, the proportions or relation of the various factors and parameters are reasonably simple, since the device is set for a fixed frequency. For such a type of reference cavity it can be shown mathematically that for a given frequency sensitivity R of the resonator to motion of the compensating nose at a frequency f where the coefficient of expansion of the rod is α_i and the coefficient of expansion of the housing is α_e the required length of rod h is expressed by the equation:

$$R = \frac{\alpha_e}{h(\alpha_e - \alpha_i)} f = \text{constant } x f$$

The only variable then would be length h of the rod, which is adjusted to satisfy the above equation.

But difficulties are encountered when the construction includes the tunable bottom wall of the resonator, as R , a function of cavity dimensions, is in general not a linear function of f as required by the above equation. I have found that, by the use of a piston having the construction and attributes herein shown and described, R may be made to vary approximately linearly with f . Thus the above equation is approximately satisfied over a wide band of frequencies. In practice, the device is set for the ideal proportionality expressed by the formula at about the middle of the frequency band, referred to herein as the standard frequency, and then tuning to a higher or lower frequency deviates frequency sensitivity somewhat to one side or the other of the theoretical linear value. However, the ideal of proportionality is closely approached by the construction shown and is within plus or minus five percent which will give a frequency stability of plus or minus five tenths of a megacycle for one hundred degrees of temperature change, with a ten centimeter wave length and over a tuning range of a thousand megacycles, and these comparatively small deviations support the statement that the construction obtains substantially proportionate frequency sensitivity within a wide band of frequencies.

It may be added that, for protective purposes a cap 46 is carried by the block and overlies the upper end of the housing, tubulation and rod. Also, for electrical purposes, the cap and block are grounded to each other and to the tube housing.

I claim:

1. In a tunable cavity resonator including a hollow housing member having an axis, a top closure means and a bottom closure means, the combination of (1) a temperature compensating means, said temperature compensating means including a deformable diaphragm having a central portion, a nose member attached to said central portion of said deformable diaphragm, said deformable diaphragm being secured at its peripheral margin to said hollow housing member, a rod member extending from said central portion of said deformable diaphragm to said top closure means, said rod member being positioned on the opposite side of said deformable diaphragm from said nose member, said rod member being composed of a material having a different coefficient of expansion from the material composing said housing member, and (2) tuning means, said tuning means including an axially movable piston unit located on the same side of said deformable diaphragm as said nose member thereby forming a resonant cavity between said deformable diaphragm and said piston unit, said piston unit including a piston member, said piston member including a tubular portion being coaxial with said housing member, said tubular portion including an upper portion having a first outer diameter and a lower portion having a second outer diameter with said first outer

diameter being smaller than said second outer diameter, said housing member substantially enclosing said temperature compensating means and said tuning means, said housing member having window openings to said resonant cavity, and windows sealing said window openings, said windows being capable of transmitting electrical energy.

2. In a tunable cavity resonator including a hollow housing member having an axis and a top closure means and a bottom closure means, the combination of (1) temperature compensating means, said temperature compensating means including a deformable diaphragm having a central portion, a nose member attached to said deformable diaphragm at said central portion, said deformable diaphragm being secured at its peripheral margin to said hollow housing member, a rod member extending from said central portion to said top closure means, said rod member being composed of a material having a different coefficient of expansion than the material composing said housing member, and (2) tuning means, and tuning means including an axially movable piston unit located on the same side of said deformable diaphragm as said nose member thereby forming a resonant cavity between said deformable diaphragm and said piston unit, said piston unit including a piston member, said piston member including a tubular portion having an open end and an upper portion adjacent to said open end, a closed end and a lower portion positioned between said upper portion and said closed portion, said open end being directed toward said nose member, said piston member being positioned so that said nose member is closer to said upper portion than to said closed end said housing member substantially enclosing said temperature compensating means and said tuning means.

3. In a tunable cavity resonator including a hollow housing member having an axis, a top closure means and a bottom closure means, a resonant cavity confined at one end by temperature compensating means including a deformable diaphragm, a nose member and a rod member, said deformable diaphragm being secured at its peripheral margin to said hollow housing member, said deformable diaphragm having a central portion with said nose member being attached to said deformable diaphragm at said central portion, said nose member extending into said resonant cavity, said rod member connecting the central portion of said deformable diaphragm and said top closure means, said rod member being composed of a material having a different coefficient of expansion from the material composing said housing member, said resonant cavity being confined at the other end by a movable piston tuning unit, said piston tuning unit including a cupped piston member and a support assembly for said piston member, said support assembly connecting said piston member and said bottom closure means, said piston member including a bottom portion and a tubular portion, said bottom portion being partially spaced from said support assembly to form thereby a transverse slot between said bottom portion and said support assembly, said transverse slot having a radial depth of substantially one-quarter wave length, said tubular portion being coaxial with said housing member and including an upper portion having a first outer diameter and a lower portion having a second outer diameter with said first outer diameter being smaller than said second outer diameter with said lower portion being spaced from said housing member to provide an annular slot between said lower portion and said housing member, said annular slot having an axial length of substantially one-quarter wave length, said transverse slot radial depth and said annular

slot axial length having a total of substantially one-half wave length, thereby providing in effect a short circuit, said housing member substantially enclosing said temperature compensating means and said tuning unit, said hollow housing member having window openings into said resonant cavity, and windows sealing said window openings with said windows being capable of transmitting electrical energy.

4. In a tunable cavity resonator including a hollow housing member having an axis, a top closure means and a bottom closure means, a resonant cavity confined at one end by temperature compensating means including a deformable diaphragm, a nose member and a rod member, said deformable diaphragm being secured at its peripheral margin to said hollow housing member, said deformable diaphragm having a central portion with said nose member being attached to said deformable diaphragm at said central portion, said nose member extending into said resonant cavity, said rod member connecting the central portion of said deformable diaphragm and said top closure means, said rod member being composed of a material having a different coefficient of expansion from the material composing said housing member, said resonant cavity being confined at the other end by a movable piston tuning unit, said piston tuning unit including a cupped piston member and a support assembly for said piston member, said support assembly connecting said piston member and said bottom closure means, said piston member including a bottom portion and a tubular portion, said bottom portion being partially spaced from said support assembly to form thereby a transverse slot between said bottom portion and said support assembly, said transverse slot having a radial depth of substantially one-quarter wave length, said tubular portion being coaxial with said housing member and including an open end, an upper portion adjacent to said open end, a closed end and a lower portion between said upper portion and said closed end, said open end being directed toward said nose member, said piston member being positioned so that said nose member is closer to said upper portion than to said closed end, said upper portion having a first outer diameter and said lower portion having a second outer diameter with said first outer diameter being smaller than said second outer diameter, with said lower portion being spaced from said housing member to provide an annular slot between said lower portion and said housing member, said annular slot having an axial length of substantially one-quarter wave length, said transverse slot radial depth and said annular slot axial length having a total of substantially one-half wave length, thereby providing in effect a short circuit, said housing member substantially enclosing said temperature compensating means and said tuning unit, said hollow housing member having window openings into said resonant cavity, and windows sealing said window openings with said windows being capable of transmitting electrical energy.

References Cited in the file of this patent

UNITED STATES PATENTS

2,106,769	Southworth	Feb. 1, 1938
2,181,871	Conklin	Dec. 5, 1939
2,468,145	Varian	Apr. 26, 1949
2,525,468	Alpert	Oct. 10, 1950
2,530,089	Smith	Nov. 14, 1950
2,543,246	Landon	Feb. 27, 1951
2,584,717	Alpert	Feb. 5, 1952
2,597,149	Kahan	May 20, 1952