

[54] **FIXED FREQUENCY SOLID DIELECTRIC
FUSED QUARTZ CAVITY**

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333/83, 84, 73, 95, 97, 83 T; 317/247**

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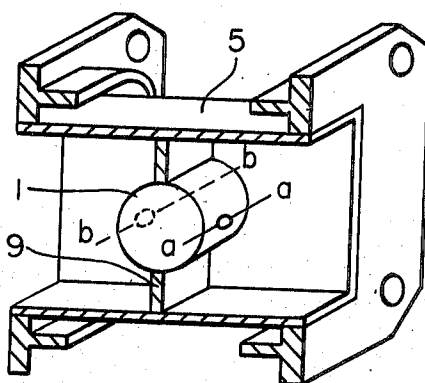
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EXEMPLARY CLAIM

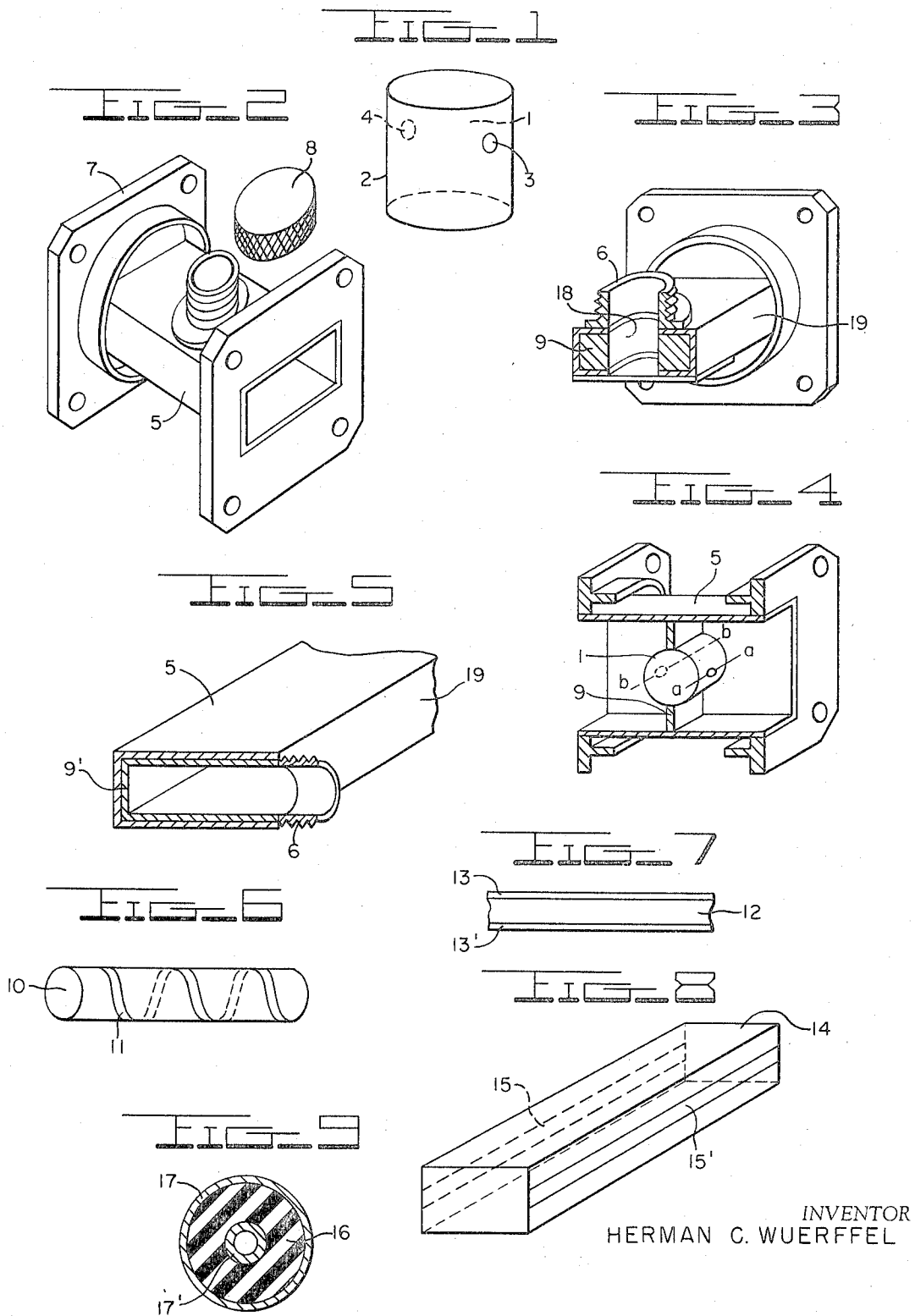
1. The combination of a hollow waveguide, a solid dielectric resonant cavity comprising a fused quartz member dimensioned to form a resonant cavity at a given frequency, the outer surface of said quartz member having a coating of a highly conductive material, said coating completely enclosing said quartz member except for a pair of openings located on opposite sides of said quartz member, means for fixedly positioning said resonant cavity in the hollow portion of said waveguide so that said openings are operative to couple electromagnetic energy in said waveguide into and out of said resonant cavity, said means including a conductive partition means bridging the gap between the conductive coating of said resonant cavity and the inner walls of said waveguide.

5 Claims, 9 Drawing Figures



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FIXED FREQUENCY SOLID DIELECTRIC FUSED QUARTZ CAVITY

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to a novel structure for inductors, condensers and other frequency determining elements such as resonant cavities and the like.

Where inductors, capacitors, or resonant cavities and the like are used as frequency determining elements in such circuits as oscillators and bandpass filters, it is generally of utmost importance that the impedance of these frequency determining elements be substantially constant with change in temperature.

A change in temperature generally causes some change in physical dimension of an impedance element or resonant cavity with accompanying change in electrical characteristics. Also, it has been noticed that when the temperature of most impedance elements is varied between given temperature limits that the impedance values of the resonant cavity or impedance element for a given frequency does not remain constant for the same given temperature. The cyclic reversal of temperature thus has a strange effect on the physical and electrical properties of these resonant cavity or impedance elements.

At low frequency the change of dimensions or impedance with temperature variations is rarely considered sufficiently important to cause much concern. At extremely high frequencies, however, a small change in impedance value may have an appreciable effect, for example, with a resonant cavity used as a bandpass filter or as a frequency determining circuit in an oscillator. If a cyclic variation of temperature caused a resonant cavity to be only 0.03 of a percent off in resonant frequency for a given temperature, this would amount to an error of 3 megacycles for a resonant frequency of 10,000 megacycles. This is an appreciable error for many applications.

One object of the present invention is therefore to construct a new type of impedance element, such as inductors, capacitors, or resonant cavities and the like which provide a relatively small and consistent temperature-impedance characteristic as the temperature is varied over wide limits.

Another object of the invention is to provide a solid dielectric resonant cavity having a high Q and a substantially constant temperature-impedance characteristic as the temperature is periodically varied over wide limits.

Another object of the present invention is to provide a novel waveguide structure for holding the resonant cavity.

Still another object of the present invention is to provide resistance, inductance and capacitance impedance elements whose temperature-impedance characteristics are substantially constant as the temperature is varied over wide limits.

These and other objects of the where the will become apparent to those skilled in the art from the specification and attached drawings wherein:

FIG. 1 is a perspective view of a solid dielectric resonant cavity forming one embodiment of the present invention.

FIG. 2 shows the cavity holder where the cavity is to be used as a bandpass filter in a waveguide system.

FIG. 3 is a cross-sectional view of the resonant cavity holder when a TM mode is to be excited in the cavity.

FIG. 4 is a cross-sectional view of the waveguide showing the holder and cavity.

FIG. 5 is a cross-sectional view of the resonant cavity holder when the TE mode is to be excited in the resonant cavity.

FIG. 6 is a resistance or inductance impedance element incorporating the present invention.

FIG. 7 is a cross-sectional view of a condenser incorporating the present invention.

FIG. 8 is a parallel wire transmission line incorporating the present invention.

FIG. 9 is a coaxial cable incorporating the present invention.

An impedance element incorporating the present invention comprises a fused quartz base or form member on the outer surface of which is rigidly attached, as by plating, a thin layer of conductive material conforming to the conventional shape of a condenser plate, inductor winding, or cavity wall as the case may be.

The shape of the fused quartz member varies, of course, with the particular electrical circuit element being considered but, in any event, the thickness of the quartz member is made substantially greater than that of the conductive member deposited thereon so that the overall dimensions of the continuation are determined mainly by the expansion temperature characteristics of the quartz member.

Fused quartz is made by pulverizing a piece of natural quartz and then fusing the tiny particles by heating the quartz mixture to its melting temperature.

It has been discovered that fused quartz has both a relatively small change of dimension with temperature, and also has the unusual characteristic of having substantially constant physical and electrical characteristics even though it has been subjected to wide temperature variations.

A resonant cavity of the well known variety resonant to a frequency of 10,000 megacycles of an operating temperature of 100°C, was subjected to repeated temperature variations over appreciable temperature limits (due for example to repeated on-off intervals as is present in most applications of resonant cavities) and it was discovered that the resonant frequency of the cavity varied considerably from 10,000 megacycles when the temperature of the cavity was again held at 100°C. This was due in all probability to the change of physical dimension.

It was also discovered that when a resonant cavity comprising a solid dielectric made of fused quartz on the outside of which was deposited a thin layer of conductive material such as silver, etc., and of such size as to be resonant to 10,000 megacycles at 100°C, that subjecting the same cavity to the same temperature variations as before, resulted in practically no change in resonant frequency at 100°C. (In one instance the change was less than 1.6 parts in 10⁹ per degree centigrade of temperature cycle for a repeated temperature between the range of 0°C and 60°C.)

Another advantage of using fused quartz as the dielectric of a resonant cavity is that it was much smaller in size than conventional type air dielectric resonant cavities and could be manufactured more economically

than any cavity operating on an equivalent mode of oscillation now in use.

The characteristics of fused quartz make it very desirable as a dielectric for capacitors since besides having a low but consistent temperature-expansion characteristic, it also has a low hysteresis loss. Fused quartz, however, has a low dielectric constant and can therefore be used as a substitute for an air dielectric having the aforesaid advantages.

For reasons previously given, fused quartz has utility as coil and resistance forms, and as the insulation, or dielectric of a parallel-wire transmission line or coaxial tube where very small impedance changes are found to be undesirable.

The most practical use for the present invention has been the resonant cavity embodiment since it is used as a frequency determining element at the higher frequencies where even small percentage variations in dimensions and electrical properties are not undesirable.

Referring now to FIG. 1 where the resonant cavity embodiment is shown, a cylindrically shaped fused quartz member 1 is thinly coated with a layer of a high conductivity material 2 which rigidly adheres to and covers quartz member 1 except for two small openings 3-4 formed in the wall of the cavity and through which electromagnetic energy is to be coupled. The solid dielectric cavity is preferably cylindrical in shape because of the higher Q obtained thereby but if desired it could have other forms such as a cubical shape.

Referring now to FIGS. 2-4 where the solid dielectric resonant cavity 1 is shown used as a filter in a waveguide system, a metallic partition member 9 is placed in a waveguide 5 to form a conductive seat for the resonant cavity member. For the TM modes the axis of the cylindrically shaped resonant cavity member 1 is placed parallel to the short dimension (i.e., perpendicular to the direction of the magnetic field lines of the rectangular waveguide there shown). A cavity retainer portion 6 is placed about the circular opening 18 cut in the walls of the waveguide adjacent to partition seat 9 so as to form a cylindrical opening of the size of the resonant cavity 1. The cavity 1 is placed into the opening of cavity retainer 6 and the cavity retained cap 8 is then screwed or otherwise held fast to the cavity retainer portion 6 thus holding cavity portion 1 solidly in its seat.

The edges of partition 9 must of course make good electrical contact with the metallic coating on the surface of the fused quartz solid dielectric cavity 1.

The coupling openings 3-4 are located along respective lines $a-a$ and $b-b$ which are parallel to the electric field lines and are midway between the short sides of waveguide 5. The position of holes 3-4 along these lines $a-a$ and $b-b$ depend upon the mode to be excited in the resonant cavity 1. For example, for the TM_{01} mode, the openings 3-4 are located in the center of waveguide 5.

One resonant cavity used with the TM_{01} mode had a ratio of base width (diameter of circular cross-sectional) to length (height of the cylinder) of one. The diameter of the base was about 0.424 of an air wavelength and the hole openings 3-4 were 0.118 of a wavelength in diameter. The conductive layer forming the cavity wall was made of silver finely plated on the quartz form. The coating thickness is preferably made no greater than is necessary to provide good conductive path.

Where the TE modes are to be excited, the cylindrical cavity portion 1 is placed so that its axis is perpendicular to the electric field lines in waveguide 5 (i.e., the axis of the cylinder would be parallel to the long cross sectional dimension of the waveguide 5). For this embodiment the cavity retainer portion would be placed in one of the narrow walls 19 of waveguide 5 as shown in FIG. 5.

In this embodiment, the openings 3-4 are placed so that they are located along respective lines which are midway between the long dimension of waveguide 5. For the TE_{01} mode the openings 3-4 are not located in the center of waveguide 5 but are near the ends of the waveguide 5.

For this latter embodiment the size of the dielectric cavity is about one-third larger than for the embodiment of FIGS. 2-4 and has a much higher Q.

The present invention when applied to a coil or resistance is shown in FIG. 6. Here a helical conductive portion 11 is coated or otherwise rigidly attached to a form 10 made of fused quartz.

FIG. 7 shows a condenser wherein relatively thin conductive plates 13-13' are rigidly attached or coated to the fused quartz dielectric portion 12.

FIG. 8 shows the present invention applied to a parallel wire transmission line section 15-15'. The conductive portions 15-15' are coated or otherwise firmly placed on fused quartz portion 14.

FIG. 9 is a coaxial cable where the relatively thin inner and outer conductors 17-17' are coated or firmly attached to the surface of a hollow fused quartz portion 16.

Many other modifications may be made without deviating from the scope of the present invention.

What is claimed is:

1. The combination of a hollow waveguide, a solid dielectric resonant cavity comprising a fused quartz member dimensioned to form a resonant cavity at a given frequency, the outer surface of said quartz member having a coating of a highly conductive material, said coating completely enclosing said quartz member except for a pair of openings located on opposite sides of said quartz member, means for fixedly positioning said resonant cavity in the hollow portion of said waveguide so that said openings are operative to couple electromagnetic energy in said waveguide into and out of said resonant cavity, said means including a conductive partition means bridging the gap between the conductive coating of said resonant cavity and the inner walls of said waveguide.

2. The combination of a hollow waveguide, a solid dielectric resonant cavity comprising a fused quartz member dimensioned to form a resonant cavity at a given frequency, the outer surface of said quartz member having a coating of a highly conductive material, said coating completely enclosing said quartz member except for a pair of openings located on opposite sides of said quartz member, means for fixedly positioning said resonant cavity in the hollow portion of said waveguide, said openings located along respective lines which bisect respective right cross-sections of said waveguide.

3. A waveguide component comprising a hollow metallic waveguide section of predetermined cross-sectional area, a nonconductive element of selected configuration and having a cross-sectional area less than said predetermined cross-sectional area such that

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said element may be confined within said waveguide section, said element having a conductive coating thereon such that a resonant cavity of selected volume is formed, said conductive coating having at least first and second spaced apertures therein forming input and output ports respectively for said resonant cavity, metallic partition means transversely disposed within said waveguide section in conductive relation to the walls thereof, said partition means having a seat therein adapted to receive said element such that said first and second apertures are on opposite sides of said partition

6

means and said coating is in conductive relation to the walls of said waveguide section, and access means for inserting and removing said element from said waveguide section.

4. The component as described in claim 3 wherein said element is fused quartz.

5. The component as described in claim 4 wherein said element has a cylindrical configuration and said first and second apertures in the coating thereon are on the side wall of the cylindrical element.

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