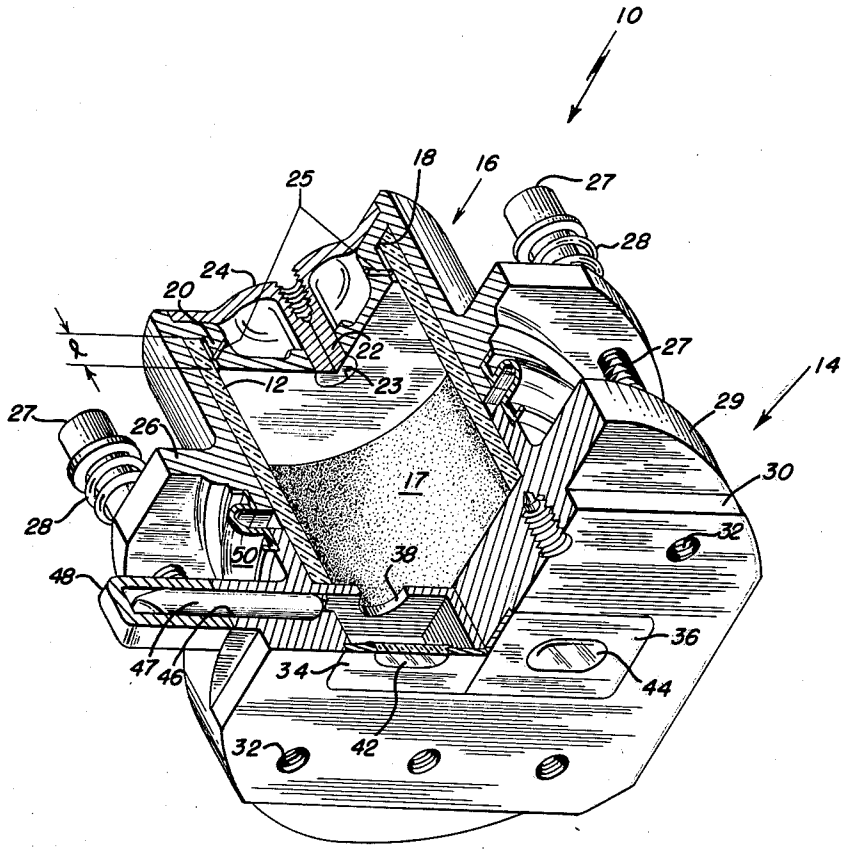
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TEMPERATURE COMPENSATED RESONANT CAVITIES

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TEMPERATURE COMPENSATED RESONANT CAVITIES

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This invention relates to resonant cavities, and more particularly, to means for compensating for the effects of thermal expansion on frequency in a resonant cavity.

It is well known that the resonant frequency of a resonant cavity fluctuates with dimensional changes caused by temperature variations. One known method employed to reduce this effect on frequency is to construct the cavity of an iron-nickel alloy, known as Invar, which has a very small coefficient of thermal expansion. Also, as is known, the cost of resonant cavities made of this material is quite expensive and, further, cavities of this type do not provide complete compensation especially where the cavity is subjected to extreme temperature variations. Another temperature compensating means which is utilized consists of a resonant cavity made with quartz as the main frequency controlling element in order to take advantage of the very low linear coefficient of expansion of quartz. However, when an attempt is made to hermetically seal a quartz cavity by normal soldering or brazing techniques, the solder has a different coefficient of expansion than the quartz and this changes the effective coefficient of expansion of the cavity in a non-linear manner which is difficult to compensate. This is particularly noticeable when the cavity is used as a reference for a source of oscillation in order to obtain a high degree of stability over extreme environmental conditions, such as wide changes in temperature, shock, humidity and atmospheric pressure. It is, therefore, desirable to provide a quartz reference cavity while is capable of uniform reproduction and at the same time is capable of being compensated by a material having a substantially linear coefficient of expansion.

In accordance with the reference cavity of the invention, a cylindrical resonant structure or cavity is made of clear fuzed quartz having a low resistance metallic coated inner surface. A waveguide coupling member or flange is urged against one end of the quartz cylinder by a plurality of coupling springs mounted outside the wall of the cavity. Surrounding the opposite end of the quartz cylinder is a cavity housing having a metallic re-entrant cylinder or cap which is adapted to expand within the quartz cavity in response to a change in temperature. This cap is compressed against the end of the quartz cylinder and is spring loaded to the waveguide coupling flange in order to provide a tightly sealed expandable cavity without soldering directly to the quartz. A single fluted bellows is soldered between the housing and waveguide flange to complete the hermetic seal of the cavity and to permit the housing and the waveguide flange to expand or contract with respect to each other. In addition, the center of the cavity housing is deformable by application of pressure to provide a fixed tuning mechanism. As the length and diameter of the quartz cylinder increases in response to heat or other environmental changes, the re-entrant cap, being spring anchored to the end of the quartz cylinder, expands at a different rate into the cavity to compensate for the increase in volume of the cylinder, resulting in substantially no change in the resonant frequency of the cavity. With this arrangement, the desirable linear expansion properties of the quartz are obtained, and, at the same time, no solder joints or similar sealing materials are bonded directly

to the quartz to adversely affect its linear coefficient of expansion or mechanical dimensions.

Further objects and many of the attendant advantages of this invention will be readily appreciated as the description thereof progresses. In the accompanying drawing there is shown an isometric view of a resonant cavity **10** which can be used as an automatic frequency control of a microwave oscillator or as a tuned filter or like component for radio or other electrical circuits. Resonant cavity **10** comprises a cylindrical quartz structure **12** which is securely disposed between a waveguide coupling member or flange **14** and a cavity housing **16**.

The inner surface of the quartz structure **12** is coated with silver **17** or with a similar highly conductive material. The cavity housing **16** is formed of material having a higher coefficient of thermal expansion than the quartz cavity and, in the present embodiment, is constructed of aluminum. The cavity housing extends around the outer portion of the quartz cavity and is compressed against the end of the quartz cylinder at **18**. The re-entrant portion **20** of the cavity housing extends within the quartz cylinder a distance, *l*, and expands into the cavity at a rate of expansion determined by this distance. Thus, to compensate for the coefficient of linear expansion of quartz, the re-entrant material expands at a faster rate than the quartz. The distance which the compensating material projects into the cavity is a function of the ratio of the coefficient of expansion of the cavity and of the compensating material and is calculated in a well-known manner. Since the cavity housing **16** is compressed only against the end portion of the quartz cylinder, the expansion of the housing occurs into the cavity. In the center of the cavity housing is a cylindrical probe **22** which is slidably inserted into an aperture **23** in the cavity housing. A deformable metallic tuning cap **24** is integral with probe **22** and fits into the cavity housing. The metal tuning cap is deformable by application of pressure at its tapped portion to provide a fixed tuning mechanism which is permanently set to a desired resonant frequency and which expands with the re-entrant portion of the cavity housing into the cavity during temperature changes. Thus, for example, a 10,000 megacycle-per-second cavity can be tuned to any frequency within a forty megacycle-per-second band by deforming the metal of the tuning cap. For example, at a given temperature, the cavity can be tuned within ±50 kilocycles per second of a preselected frequency.

Extending from the outer portion of the cavity housing **16** and integral therewith is an external mounting flange **26** which contains four equally spaced apertures to receive four mounting bolts **27** with steel springs **28**. The mounting bolts **27** are inserted through the springs and then into the apertures of flange **26**. Each spring is compressed between the head of the bolt **27** and the face of flange **26**. The bolts are received by tapped apertures in the flange portion **29** of waveguide coupling **14**. In this manner, the four springs **28** urge the cavity housing toward the waveguide coupling member and support the quartz cylinder in a manner which permits the cavity to expand in both length and diameter. In order to prevent air drafts on the compensator end of the cavity, a cover, not shown, preferably surrounds the entire cavity assembly and is bolted to an outer flange **29** on the waveguide coupling member **14**. By means of this cover, the cavity parts are maintained in thermal equilibrium during rapid temperature changes.

In order that high frequency energy can be introduced and extracted from the cavity, the waveguide coupling member **14** is provided with an input section **34** and an oppositely disposed output section **36**. Each section consists of a waveguide cavity having a resonant iris **38** coupling into the quartz structure **12** and a pair of glass wave-

guide windows **42** and **44** to permit sealing of the cavity structure. These windows form part of the coupling flange portion **30** of the waveguide coupling member which is integral with flange portion **29** and provided with threaded tubes **32** to couple to input and output rectangular waveguide, not shown. The windows are located in the waveguide coupling member remote from the cavity walls so that their physical variations with temperature and atmospheric changes have no effect upon the resonant frequency of the cavity.

In order to maintain a constant dielectric medium within the quartz cavity, evacuation of the cavity is achieved by means of an aperture **46** in the waveguide coupling member **14**. This tubular portion extends radially outward from the waveguide coupling member and contains a metal exhaust tube **47** which is hermetically sealed to the waveguide coupling member **14** and pinched off after the cavity has been evacuated. An exhaust tube guard member **48** is attached to the waveguide coupling flange in order to protect the end portion of the exhaust tube. A single fluted copper bellows **50** is soldered between the cavity housing **16** and the waveguide flange **14** to complete the hermetic seal of the cavity. This bellows permits expansion and contraction of the cavity housing and waveguide flange with respect to each other during temperature variations of the cavity. As noted, the cavity is tuned by deforming the annealed copper end cap **24** which is shaped in a manner to reduce microphonics and is hermetically sealed to cavity housing **16**. In addition, apertures **25** permit the evacuation of the enclosed area formed by the copper end cap **24** and the cavity housing.

While the present embodiment of the invention utilizes a TE_{011} mode cylindrical quartz cavity as its frequency controlling element, other materials such as plastics, ceramics or other metals can be substituted for quartz providing that a high conductive coating is applied to the inner surface of the cavity material. In each case, however, the distance, *l*, which the re-entrant compensating material protrudes within the cavity can be changed to compensate for the linear coefficient of expansion of the substitute cavity material. In addition, the re-entrant portion of the cavity housing **16** can be constructed of materials other than aluminum and the required linear coefficient of expansion of the substituted material can be calculated in a well-known manner.

For the foregoing reasons, it is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention. Accordingly, it is desired that the invention not be limited to the particular details of the embodiments disclosed herein except as defined in the appended claims.

What is claimed is:

1. A temperature compensated resonant cavity comprising a hollow cylindrical quartz structure having a substantially linear coefficient of expansion in response to changes in temperature, a waveguide coupling member in register with one end of said cylindrical structure to form a first solder-free joint therewith, a re-entrant metallic cap extending into said cylindrical structure and enclosing the other end of said cylindrical structure to form a second solder-free joint therewith and adapted to expand into said resonant cavity at a different rate of expansion than that of said cylindrical structure, thereby to compensate for a change in volume of said resonant cavity in response to a change in temperature, and tension means extending outside said cylindrical structure urging said waveguide coupling member and said reentrant metallic cap toward each other, thereby to provide a microwave seal for said resonant cavity.

2. A temperature compensated resonant cavity comprising a hollow cylindrical quartz structure having a substantially linear coefficient of expansion in response to changes in temperature, a waveguide coupling member in register with one end of said cylindrical structure to form a first solder-free joint therewith, a reentrant metallic cap extending into said cylindrical structure and enclosing the other end of said cylindrical structure to form a second solder-free joint therewith and adapted to expand into said resonant cavity at a different rate of expansion than that of said cylindrical structure, thereby to compensate for a change in volume of said resonant cavity in response to a change in temperature, the inner surface of said cylindrical structure having a metallic coating thereon, and tension means extending outside said cylindrical structure urging said waveguide coupling member and said reentrant metallic cap toward each other, thereby to provide a microwave seal for said resonant cavity.

3. A temperature compensating cavity resonator comprising a hollow cylindrical quartz structure having a substantially linear coefficient of expansion in response to changes in temperature, a waveguide coupling member positioned at one end of said cylindrical structure and adapted to couple energy to said cavity resonator to form a first solder-free joint therewith, a reentrant metallic cap extending into said cylindrical structure and enclosing the other end of said cylindrical structure to form a second solder-free joint therewith and adapted to expand into said resonant cavity at a different rate of expansion than that of said cylindrical structure, thereby to compensate for a change in volume of said resonant cavity in response to a change in temperature, and tension means extending outside said cylindrical structure urging said waveguide coupling member and said reentrant metallic cap toward each other, thereby to provide a microwave seal for said resonant cavity.

4. A temperature compensated resonant cavity comprising a hollow cylindrical quartz structure having a substantially linear coefficient of expansion in response to changes in temperature, a waveguide coupling member in register with one end of said cylindrical structure to form a first solder-free joint therewith, a reentrant metallic cap extending into said cylindrical structure and enclosing the other end of said cylindrical structure to form a second solder-free joint therewith and adapted to expand into said resonant cavity at a different rate than that of said cylindrical structure, thereby to compensate for a change in volume of said resonant cavity in response to a change in temperature, an expandable bellows member connected between said waveguide coupling member and said reentrant metallic cap, and tension means extending outside said cylindrical structure urging said waveguide coupling member and said reentrant metallic cap toward each other, thereby to provide a microwave seal for said resonant cavity.

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