DOUBLY COMPENSATED TUNABLE CAVITY

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INTRODUCTION

The problem of temperature compensation of microwave cavities is one that has received considerable attention. This paper will attempt to describe a method of compensation which has been used by the Microwave Development Laboratories with some degree of success. It is well to point out at this time that all the cavities described here will be assumed to be filled with a dry inert gas and hermetically sealed. This will elminate for the purposes of this paper the question of himidity effects.

DESCRIPTION

Let us first consider the equation for the resonant frequencies of a right circular cylinder.

$$f^2 = \frac{A}{D^2} - \frac{Bn^2}{L^2} \qquad (1)$$

where f is the frequency in megacycles.

D is the diameter of the cavity in inches.

L is the length of the cavity in inches.

and A,B and n are constants depending on the mode and velocity of electromagnetic waves in the dielectric.

Differentiating with respect to temperature we have:

$$f\left(\frac{\partial f}{\partial t}\right) = -\frac{A}{D^3}\frac{\partial D}{\partial t} - \frac{Bn^2}{L^3}\frac{\partial L}{\partial t} \qquad (2)$$

By setting $\frac{\partial f}{\partial t} = 0$ we have the equation for perfect compensation

$$\frac{\partial L}{\partial t} = -\frac{L^3}{D^3}\frac{A}{Bn^2}\frac{\partial D}{\partial t} \qquad (3)$$

Here $\frac{\partial L}{\partial t} = \alpha LT$

$$\frac{\partial D}{\partial t} = \alpha DT$$

α is the coefficient of thermal expansion of the material used in the cavity.

and T is the change in temperature.

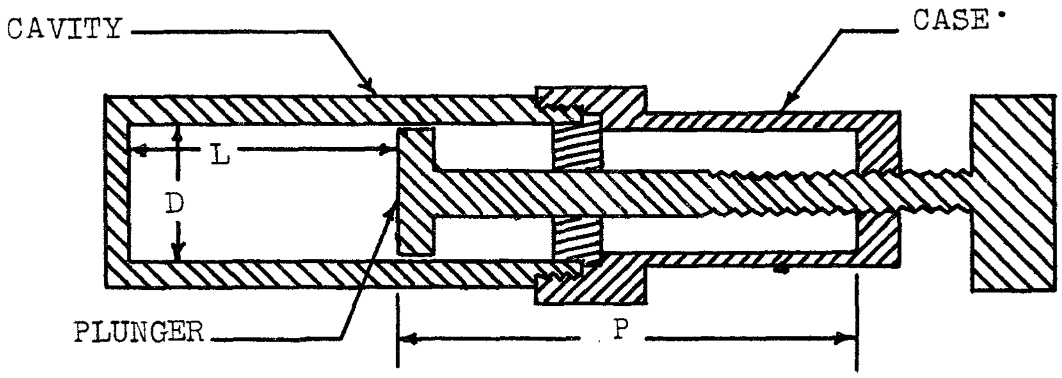

FIGURE 1

Figure 1 is a sketch of a simple cavity. The equation for perfect compensation for this type of cavity is

$$\alpha LT - (\alpha' - \alpha) PT = - \frac{L^3}{D^3} \frac{A}{Bn^2} \alpha DT \qquad (4)$$

If the cavity, case and plunger are all made of the same material, then $\alpha' = \alpha$ and the limiting factor on the compensation of the cavity is the value of the coefficient of expansion of the material used.

If, on the other hand, we make the plunger, or a section of it of some material with a higher coefficient of expansion than the rest of the unit, the cavity can be designed to have perfect compensation at one frequency. For many applications this is adequate.

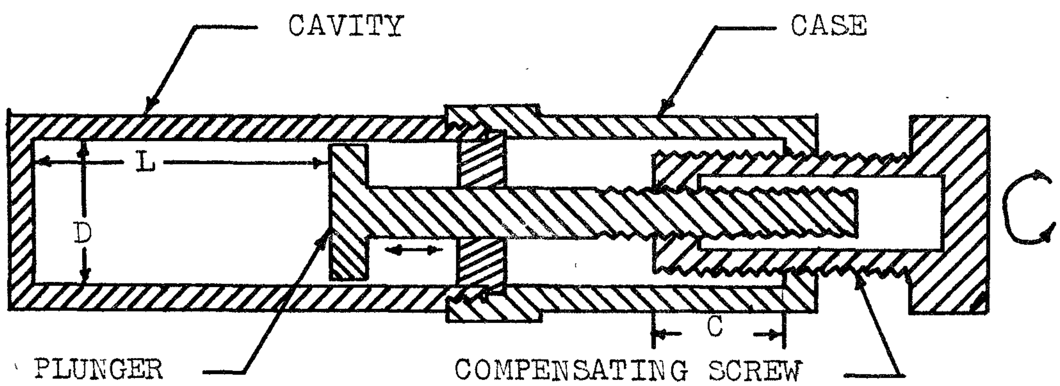

FIGURE 2

To obtain compensation at more than one frequency we have devised the method shown in Figure 2. Here, the cavity, case and plunger are made of a low expansion material such as invar. The compensating screw is made of a material with a substantially higher coefficient of expansion.

The equation for perfect compensation for this type of cavity is

$$\alpha LT - (\alpha' - \alpha) CT = - \frac{L^3}{D^3} \frac{A}{Bn^2} \alpha DT \qquad (5)$$

Equation 5 is solved for C at the two edges of the band. From the two values of C and L, a thread ratio can be determined which will allow us to maintain the theoretical values of L and C within a few thousandths of an inch over the frequency band. In actual practice, the value of C will be very close to theoretical over the entire range of the screw.

RESULTS

Figure 3 shows curves of calculated performance for the three types of cavities described. In all the calculations, the coefficient expansion for invar was assumed to be 2.7×10^{-6} inches per inch per C. The cavities are identical in size.

Several of these doubly compensated cavities have been made with good results. Figure 4 shows a typical performance curve of one of these cavities.

CALCULATED TEMPERATURE COMPENSATION

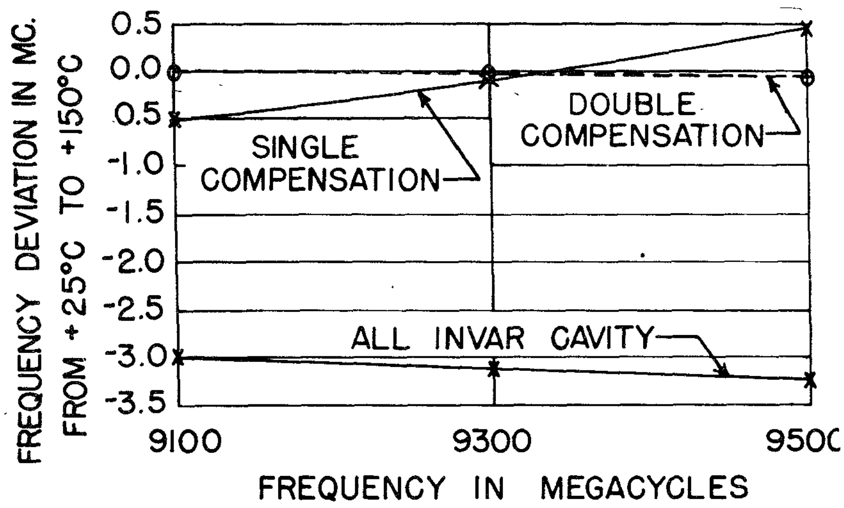

Fig. 3

TYPICAL PERFORMANCE OF DOUBLY COMPENSATED CAVITY

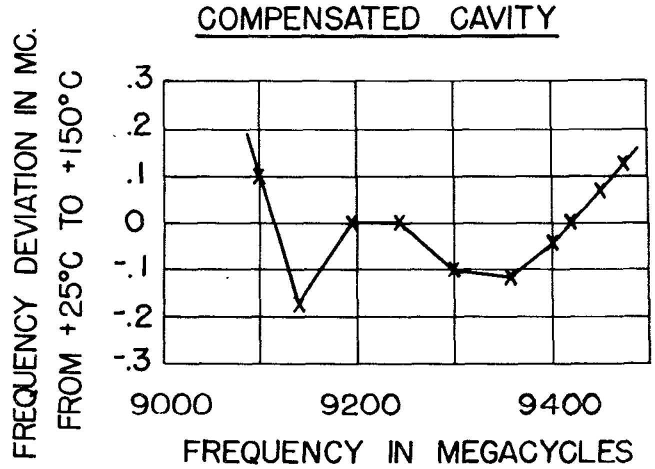

Fig. 4