Patent (Smithsonian Astrophysical Observatory) 5 p CSCL 20E Unclas
00/16 22290

United States Patent [19]

[11] 3,771,074

[45] Nov. 6, 1973

Fletcher et al.

[54] **TUNABLE CAVITY RESONATOR WITH RAMP SHAPED SUPPORTS**

[76] Inventors: **James C. Fletcher,** Administrator of the National Aeronautics and Space Administration with respect to an invention of; **Robert F.C. Vessot; Thomas E. Hoffman,** both of Marblehead, Mass. 01945; **Martin W. Levine,** Manchester, Mass.

[22] Filed: **Mar. 20, 1972**

[21] Appl. No.: **235,962**

[52] **U.S. Cl.** .... **333/83 R,** 333/97 R
[51] **Int. Cl.** **H01p 1/00,** H01p 7/06
[58] **Field of Search** .... 333/83 R, 83 T; 330/56, 4, 4.3; 331/96; 324/95, .5 AH; 250/39 TL

[56] **References Cited**

UNITED STATES PATENTS

2,383,343	8/1945	Ryan	333/83 R
2,515,280	7/1950	Varian	333/83 R
2,578,429	12/1951	Karplus	331/96 X
3,386,043	5/1968	Marcatili et al.	340/4.3
3,529,267	9/1970	Gunderson et al.	333/83 T

FOREIGN PATENTS OR APPLICATIONS

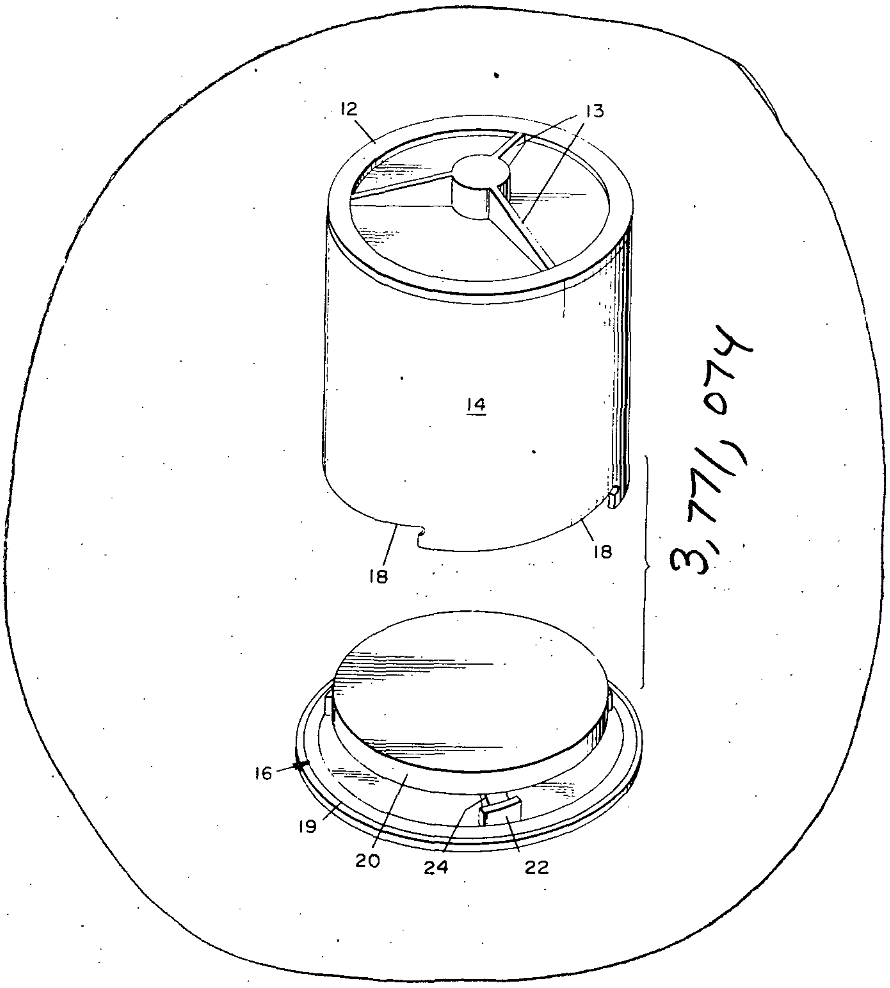
1,020,043	2/1966	Great Britain	333/83 R
967,331	10/1950	France	333/83 R

Primary Examiner—Rudolph V. Rolinec
Assistant Examiner—Wm. H. Punter
Attorney—Monte F. Mott et al.

[57] **ABSTRACT**

A cavity for a hydrogen maser is disclosed consisting of three parts which provide highly stable mechanical and thermal expansion characteristics for the cavity and ease of tuning. The three parts which are made of a "glass ceramic" material having a very small thermal expansion coefficient (α of $\pm 0.5 \times 10^{-7}$ in/in/°C over 0°–38°C) include 1) a top plate, 2) a cylinder with three interrupted helical ramps at its bottom and 3) a base which includes a bottom plate and three ramp lugs on which the helical ramps of the cylinder rest when the cylinder is placed on the base with the bottom plate in the cylinder. Cavity tuning is achieved by rotating the cylinder and thereby raising or lowering it on the base, which results in changing the cylinder volume by changing the distance between the bottom and top plates.

8 Claims, 3 Drawing Figures



TUNABLE CAVITY RESONATOR WITH RAMP SHAPED SUPPORTS

ORIGIN OF INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85-568 (72 Stat. 435; 42 U.S.C. 2457).

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to a hydrogen maser and, more particularly, to an improved cavity therefor.

2. Description of the Prior Art

Atomic hydrogen masers have been developed and described in the literature. These masers have proven to be useful both as spectroscopic tools and as frequency standards. As is appreciated by those familiar with the art the accuracy and stability of the output frequency of such a maser greatly depends on the stability of various critical elements, particularly the mechanical and thermal stability of the maser's cavity. In addition, the tuning of the latter is very critical for an accurate and stable output frequency. Although to date various cavity structures have been designed none has adequately solved the stringent stability and tuning requirements.

OBJECTS AND SUMMARY OF THE INVENTION

It is a primary object of the present invention to provide an improved hydrogen maser cavity.

Another object of the present invention is to provide a hydrogen maser cavity which exhibits superior mechanical and thermal stability characteristics.

A further object of the present invention is to provide an improved hydrogen maser cavity which is easily and precisely tunable, and which exhibits superior mechanical and thermal stability characteristics.

These and other objects of the invention are achieved by providing a three-part cavity structure made of a material which exhibits extremely low thermal expansion and superior mechanical stability characteristics. The three parts of the cavity include 1) a top plate, 2) a cylinder with a plurality of interrupted helical ramps or threads at its bottom, and 3) a base which contains the bottom plate of the cavity and a plurality of ramp lugs, which engage the cylinder's interrupted helical threads. The number of ramp lugs is the same as the number of the interrupted helical ramps. Cavity tuning is achieved by rotating the cylinder and thereby raising or lowering it on the base which results in changing the volume of the cylinder between the top and bottom plates.

The novel features of the invention are set forth with particularity in the appended claims. The invention will best be understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric view of the novel cavity of the present invention;

FIG. 2 is a side view of parts of the cavity; and

FIG. 3 is a side cross-sectional view of the assembled cavity and the manner in which it is employed.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The novel features of the cavity of the present invention are shown in FIGS. **1** and **2**, wherein like elements or parts are designated by like numerals. As stated briefly herebefore the cavity, designated by numeral **10**, consists of three basic parts. These include 1) a top plate **12** with several, e.g., three, integral stiffening webs **13**, 2) a hollow cylinder **14** and 3) a base **16**. The cylinder **14** has a multifold, e.g., three-fold interrupted helical ramp or thread at its bottom. The three ramps are designated in FIG. **1** by numerals **18**. In FIG. **2** only two of the ramps are shown. The base **16** which is shown resting on a metal disc **19** includes the bottom plate **20** of the cavity and a plurality, e.g., three ramp lugs **22**, which engage the cylinder's interrupted ramps **18**. The base is strengthened by stiffening webs **24**.

In practice the cylinder **14** rests on the base with the lugs **22** engaging the ramps **18**, so that the bottom plate **20** is inside the cylinder, and the top plate **12** is placed at the top of the cylinder. Thus the volume of the cavity is defined by the cylinder's inner diameter and the distance between the top and bottom plates. Cavity tuning is easily and precisely achieved by rotating the cylinder and thereby raising or lowering it on the base which in turn controls the distance of the top plate from the bottom plate, which is fixedly connected and is a part of the base.

The material from which the top plate **12**, the cylinder **14** and the base **16** are manufactured is chosen on the basis of its mechanical and thermal stability characteristics. At present materials are available which exhibit excellent mechanical and thermal stability characteristics. These materials are generally known in the art as "glass ceramics." Some of these materials have a thermal expansion coefficient, known as α, with $|\alpha| \leq 0.5\times10^{-7}$ in/in/°C over a temperature range of 0°–38°C. Thus they are particularly adapted for fabricating the cavity's parts. In one embodiment actually reduced to practice a material sold by Owens-Illinois and known as CER-VIT C-101 was used with excellent results. This material is mentioned herein merely to recite one type of material which may be used, rather than to limit the invention thereto.

In practice the cavity is supported and secured within a metallic hold-down cylinder **25**, shown in FIG. **3**. Cylinder **25** is fastened at the bottom to the disc **19**. A Belleville spring assembly **26** is used to provide uniform downward pressure at the outer circumference of the top plate **12**. The tension of the spring assembly is set by means of adjusting screws **28** and a force distributing ring **29** so that thermal movement of the cylinder **25** relative to that of the cavity material does not cause any appreciable change in the compressive force on the top plate **12** of the cavity. In FIG. **3** the entire assembly is shown supported within a bell jar **30** is also secured to the bottom disc **19**.

Although particular embodiments of the invention have been described and illustrated herein, it is recognized that modifications and variations may readily occur to those skilled in the art and consequently it is intended that the claims be interpreted to cover such modifications and equivalents.

What is claimed is:

1. In a tunable cavity the arrangement comprising:

a hollow cylinder having first and second opposite ends;

a top plate closing said first end; and

a base member including a bottom plate insertable in said cylinder through said second end and support means for engaging the cylinder at said second end so that the distance between said top and bottom plates varies as said cylinder is rotated about its longitudinal axis while the cylinder is supported and engaged by said support means, said support means comprising *n* ramp lugs extending upwardly from said base member, *n* being an integer, and said cylinder forms n interrupted ramps at said second end, with each interrupted ramp resting on one of said lugs whereby as said cylinder is rotated in a first direction the cylinder is lowered on the base and is raised therefrom when the cylinder is rotated in a second direction opposite said first direction, to thereby control the distance between said top and bottom plates, within said cylinder.

2. The arrangement as recited in claim **1** further including means for providing a uniform compressive force to the outer circumference of said top plate.

3. The arrangement as recited in claim **1** wherein each of said top plate, said cylinder and said base member is of a material which has a thermal coefficient of expansion definable as α which is not more than $\pm 0.5 \times 10^{-7}$ in/in/°C over a preselected temperature range.

4. The arrangement as recited in claim **1** wherein *n* is not less than 3.

5. The arrangement as recited in claim **4** wherein each of said ramps is helically shaped.

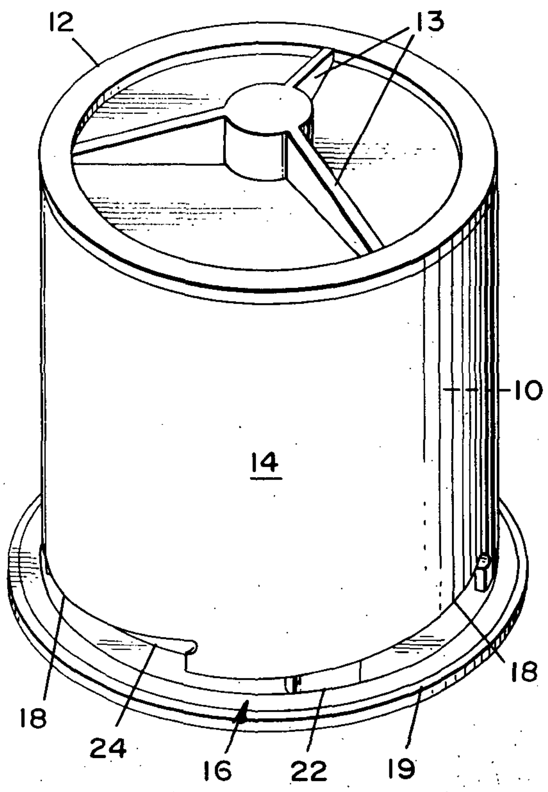
6. The arrangement as recited in claim **4** wherein each of said top plate, said cylinder and said base member is of a material which has a thermal coefficient of expansion definable as α which is not more than $\pm 0.5 \times 10^{-7}$ in/in/°C over a preselected temperature range.

7. The arrangement as recited in claim **5** further including means for providing a uniform compressive force to the outer circumference of said top plate.

8. The arrangement as recited in claim **7** wherein each of said top plate, said cylinder and said base member is of a material which has a thermal coefficient of expansion definable as α which is not more than $\pm 0.5 \times 10^{-7}$ in/in/°C over a preselected temperature range.

* * * * *

FIG. 1



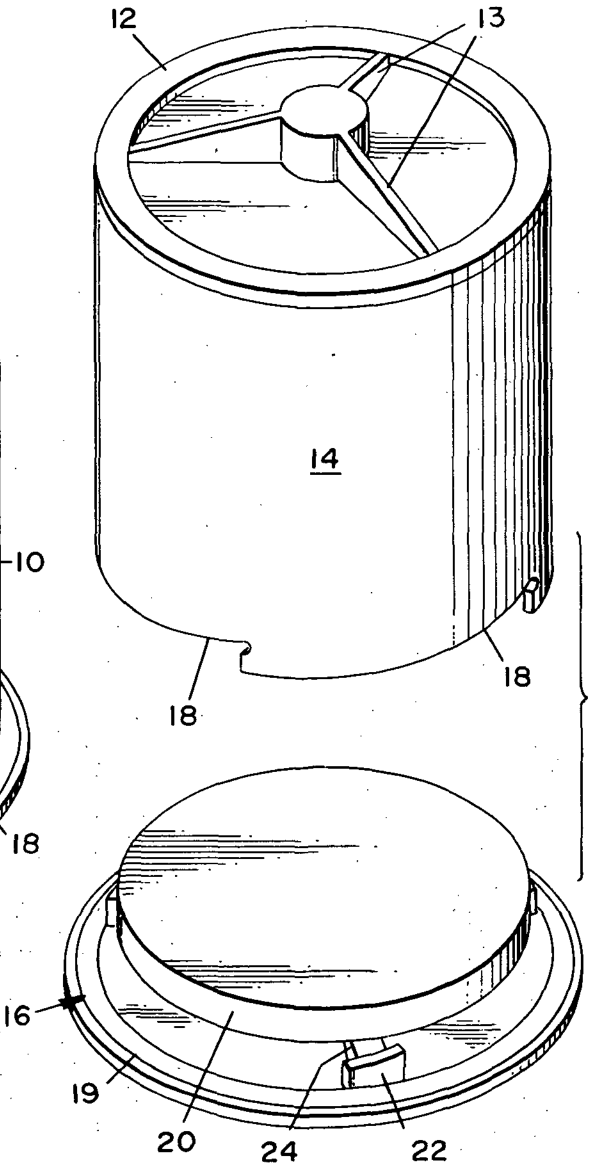


FIG. 2

FIG. 3