April 15, 1952 J. P. KINZER 2,593,155

CAVITY RESONATORS

Filed March 7, 1947 2 SHEETS--SHEET 1

FIG. 1

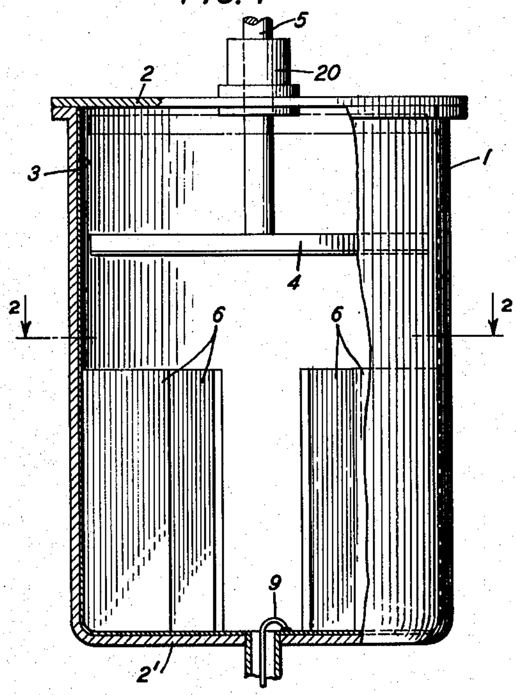

FIG. 2

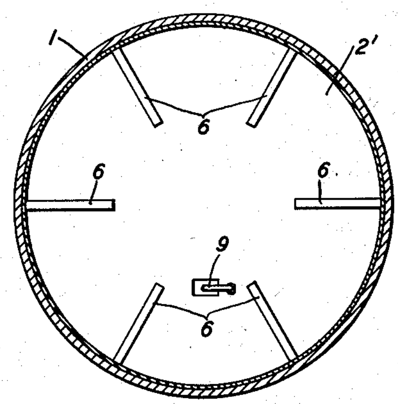

FIG. 3

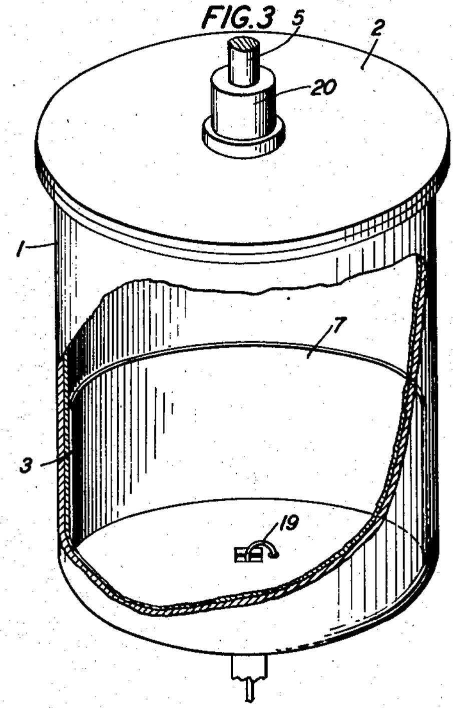

FIG. 4

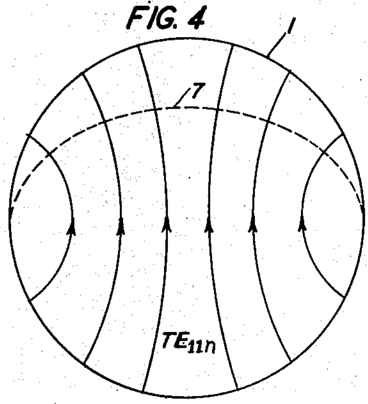

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FIG. 5

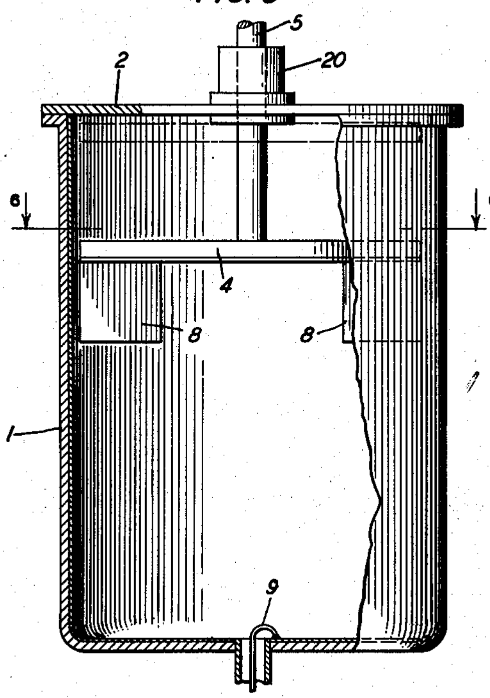
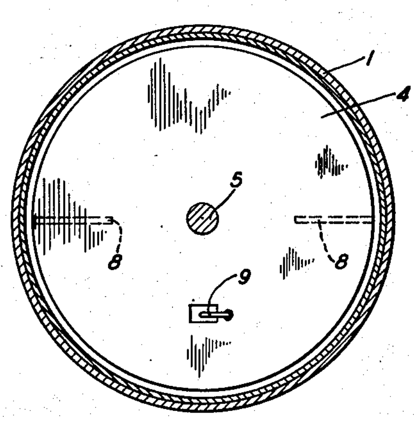


FIG. 6



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UNITED STATES PATENT OFFICE

2,593,155

CAVITY RESONATOR

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Application March 7, 1947, Serial No. 733,224

1 Claim. (Cl. 178—44)

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This invention relates to cavity resonators and more particularly to the suppression of undesired modes of oscillation in such resonators.

An object of the invention is to achieve high Q in a cavity resonator by discriminating against unwanted modes of oscillation without concomitantly affecting the frequency or field pattern of the desired mode.

Another object of the invention is to degrade unwanted modes without affecting appreciably the desired mode in a high Q resonator.

Another object of the invention is to split appreciably the frequencies of degenerate modes in a cavity resonator.

Still another object of the invention is to relegate undesired modes to frequencies outside the operating range without concomitantly affecting the frequency of the desired mode.

In accordance with an embodiment of the invention, a thin metallic fin or septum is introduced into a cavity resonator in a manner such that it is everywhere perpendicular to the E-lines of one of the normal desired modes, for example, TE_{01n}. Because of its position relative to the field patterns of other existing modes, such a fin will tend to absorb these latter, extraneous modes, and will perturb their frequencies. In highly symmetrical cavities, it will split extraneous modes, which are degenerate, without concomitantly affecting the frequency or electric field pattern of the desired mode. The conformation of such fins may be annular, crescent, diametral, longitudinal, radial, depending on which mode is selected as a desired mode and their penetration into the cavity may be partial or complete. In practice, it may be found desirable to extend the fin from the wall into the cavity space to a compromise penetration for establishing maximum absorption of extraneous modes consistent with minimum effect on the desired mode.

Fig. 1 shows a resonant cavity operating in a TE_{01n} mode in accordance with the invention.

Fig. 2 is a sectional view of the cavity of Fig. 1.

Fig. 3 shows a modification operating in a TE_{11n} mode.

Fig. 4 is an explanatory diagram for Fig. 3.

Fig. 5 is a modification showing the mode suppressing fins on the moving piston of the cavity.

Fig. 6 is a sectional view of the cavity shown in Fig. 5.

Referring to Fig. 1, there is shown in longitudinal section a cavity resonator 1 in the form of a cylinder having a closed lower end 2′ and a cover plate 2.

The cavity resonator and cover plate 2 may consist of electrically conducting material such

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as aluminum or copper, preferably with an interior coating or deposit of highly conductive material, such as silver or gold 3.

The resonator may be provided with a single feed as shown at 9 in Figs. 1 and 2 or with the input and output connections, disclosed in the United States application of H. B. Brehm and W. F. Kannenberg, Serial No. 687,549, filed August 1, 1946 now United States Patent Number 2,527,619, issued October 31, 1950. In either feed, the coupling loops pass through the end plate 2′, and are tangential to a circle in the region of strong electric field for oscillation of the TE_{01n} mode. The loops are located preferably half-way between the center and circumference of the end plate 2′. A tuning piston 4 supported by a plunger 5 passing through a guiding sleeve 20 is moved in the interior space to tune the cavity resonator 1, whereby it may have a natural resonance frequency at a normal TE_{01n} desired mode, within a predetermined tuning range. A peripheral gap or clearance exists between the piston 5 and the side wall of the cavity for suppressing TM modes as disclosed in the United States application of I. G. Wilson Serial No. 593,508, filed May 12, 1945.

Oscillations of the desired mode TE_{01n} will have an electric field pattern of concentric lines of force with respect to the cylindrical side wall of the resonator 1. Oscillations of extraneous and undesired modes, such as TE_{11n}, TE_{21n}, etc. may be concomitantly excited with their characteristic electric field patterns. In order to effectively suppress these extraneous modes, a thin metallic fin or fins 6 is longitudinally disposed on the periphery of the cylinder 1 to extend radially inward into the cavity space as illustrated in Fig. 2. Since the fins 6 are everywhere perpendicular to the electric field lines of the desired mode TE_{01n}, such mode will be undisturbed in its field pattern and frequency. However, other modes will be strongly suppressed to a greater or lesser extent by the fin 6, and their field patterns disturbed.

Except for isolated cases, all the other modes of the original cylinder 1 will be perturbed in frequency since the fields in the empty cylinder no longer satisfy the new boundary conditions of the altered surface with fins. Furthermore, if the original cylinder was circular, its inherent double degeneracy will be lost.

Although the frequency and fields of the TE_{01n} mode in Fig. 2 are unchanged, the Q of the cavity 1 may be affected depending on the radial penetration of the longitudinal fin 6.

In the case of a single fin 6 projecting from the rim or periphery of the cylinder 1 part way into the interior, it was determined that the change in Q was as indicated below:

Desired mode $TE_{0,1,12}$ $\frac{\text{Diameter}}{\text{Length}}=0.4$

Fin Penetration	$Q\frac{\delta}{\lambda}$	Per Cent Change in Q
Percent		
0	2.573	0
10	2.536	1.5
20	2.479	3.5
50	2.04	21.0
100	1.471	57.0

wherein

$$Q\frac{\delta}{\lambda}$$

is a convenient parameter, involving wavelength λ, and skin depth δ as disclosed in the United States application of J. P. Kinzer, Serial No. 588,201, filed April 13, 1945, now Patent No. 2,541,925, issued February 13, 1951.

Thus, for example, a 20 per cent penetration of the longitudinal fin 6 involves only a 3.5 per cent degradation in Q for the desired TE_{01n} mode. As the above table indicates, narrow fins are preferable.

The extraneous and undesired modes will be concomitantly affected by a single fin 6. Thus, all modes $TE_{\tau mn}$ with $\tau>0$ will be split to some extent into two modes of different frequencies. For example, the $TE_{1,2,n}$ mode will be replaced by two new modes. One thereof will be same frequency as the original, with field orientation such that the electric force (E) lines are perpendicular to the fin. There will be a second mode resulting from the splitting, which will be oriented generally 90 degrees from the first, and whose E lines will be badly distorted in the vicinity of the fin, and its frequency thereby lowered.

When two fins are located circumferentially 90 degrees apart in the cavity, both new modes resulting from the splitting of the TE_{12n} mode are perturbed in frequency from the original value. There will be no orientation of the original TE_{12n} mode which will satisfy the new boundary conditions introduced by the two fins. If both fins are identical, the frequency perturbations would be equal and a double degeneracy would ensue.

In some applications, where maximum Q is not essential, larger fins may be used, for example, in a wave guide feeding a resonant cavity where it is desired to establish only a TE_{0m} wave in the guide.

Here the fins may extend virtually to the center of the guide and χ of them may be present with uniform angular spacing. In this instance, all modes $TE_{\tau mn}$ and types of wave transmission having

$$\tau<\frac{\chi}{2}$$

when χ is even or having $\tau<\chi$ when χ is odd, would be suppressed.

If the normal operating mode were required to be the TE_{11n}, then instead of fins as described previously in Fig. 1 for the TE_{01n} mode, it would be expedient to insert crescent-like fins in the interior of the cylinder, as illustrated in Figs. 3 and 4. Such fins would be arranged as shown at 7, being attached to the end plate at its periphery and extending longitudinally into the cavity space. The feed loop 19 would be centrally located on the end plate and extend along a longitudinal plane of the cavity. However, it may for some purposes be desirable to develop the fin into a surface extending the entire length of the cavity. In this event, the resonant cavity would still be cylindrical but no longer circular. The tuning piston must be correspondingly shaped. As shown in Fig. 4, the electric field pattern of the operating TE_{11n} mode will everywhere be perpendicular to the crescent fin or to the crescent surface aforementioned. With the fin or superficies 7 crescent-like in cross-section present, the field pattern and frequency of the operating TE_{11n} mode for the resulting cavity resonator will be the same as for the original cylinder 1. However, all other extraneous modes (including the companion or degenerate TE_{11n} mode whose E lines were originally everywhere perpendicular to the operating TE_{11n} mode) are absorbed to a considerable extent, and their frequencies perturbed by the new interior surface of the resonator, due to the newly established boundary conditions for their electric field patterns.

Referring to Fig. 5, the cavity resonator or ring box 1 is provided with diametral metallic fins 8—8 fastened to the moving, tuning piston 4 and perpendicular to the face thereof. The fins 8—8 are arranged to be perpendicular to the electric force lines of the main TE_{01n} mode and parallel to the E lines of the TE_{122} mode, for which it will introduce large loss. A single coupling loop 9 is shown, for introducing the microwave energy into the cavity. It should be understood that two loops may be used in the manner disclosed in the aforementioned United States application of H. B. Brehm et al., Serial No. 687,549, filed August 1, 1946, now Patent No. 2,527,619, issued October 31, 1950. In the latter case, the fins 8—8 are disposed so as to be perpendicular to the line joining the coupling loops.

What is claimed is:

In combination, a tunable cavity resonator of high Q having a cylindrical side wall and parallel end walls, the upper end wall being a movable reflecting piston forming a peripheral gap with said side wall, a conductive coupling loop passing through the other end wall for exciting a TE_{01n} mode at a position of high field intensity therefor, a plurality of thin, equiangularly spaced conducting fins connected longitudinally to the side wall, said fins extending radially into said resonator to split degenerate modes and shift the frequency of extraneous $TE_{\tau mn}$ modes, where $\tau>0$ to frequencies outside the tuning range of said resonator.

JOHN P. KINZER.

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