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ELECTRICAL RESONATOR AND MODE SUPPRESSOR THEREFOR

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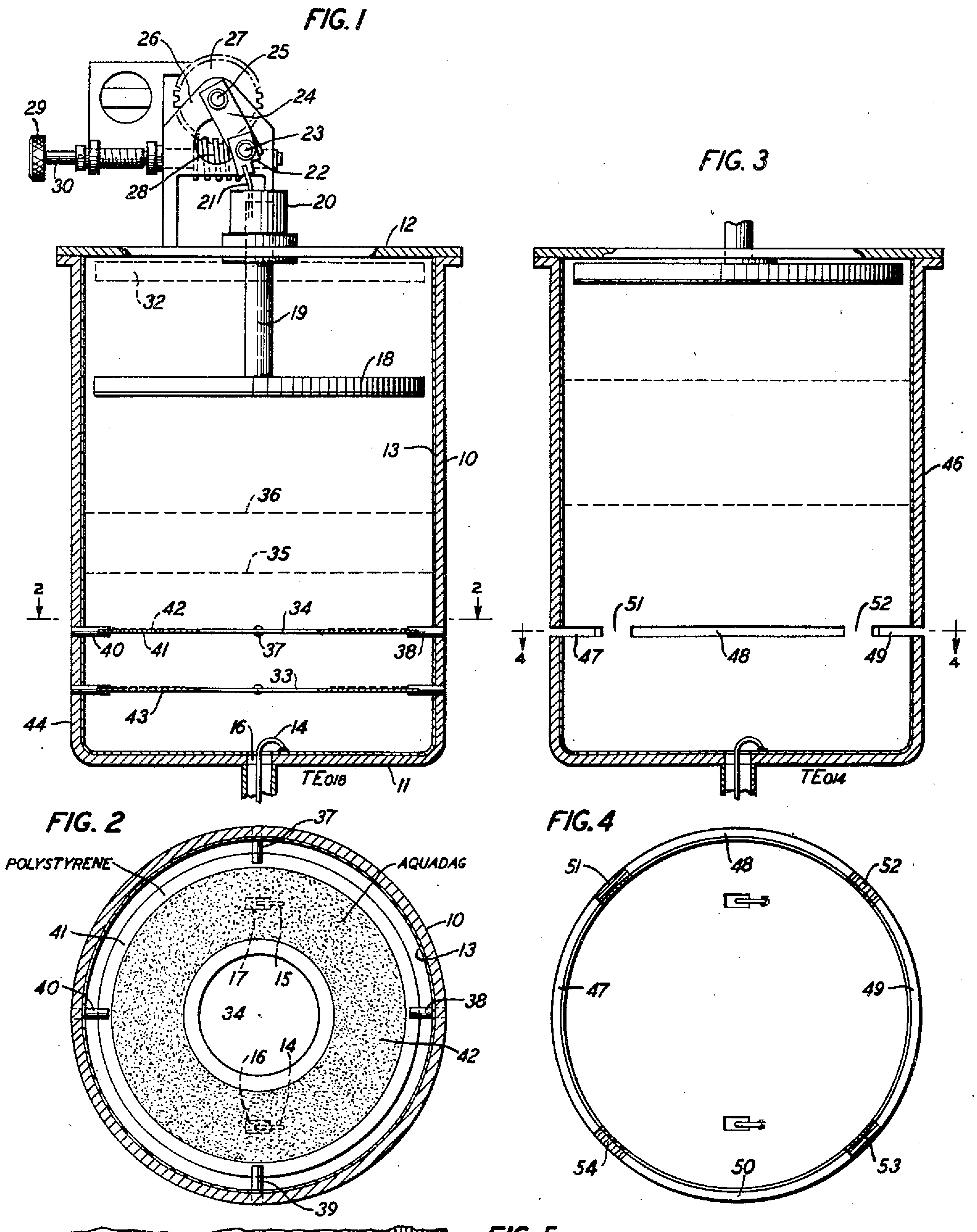

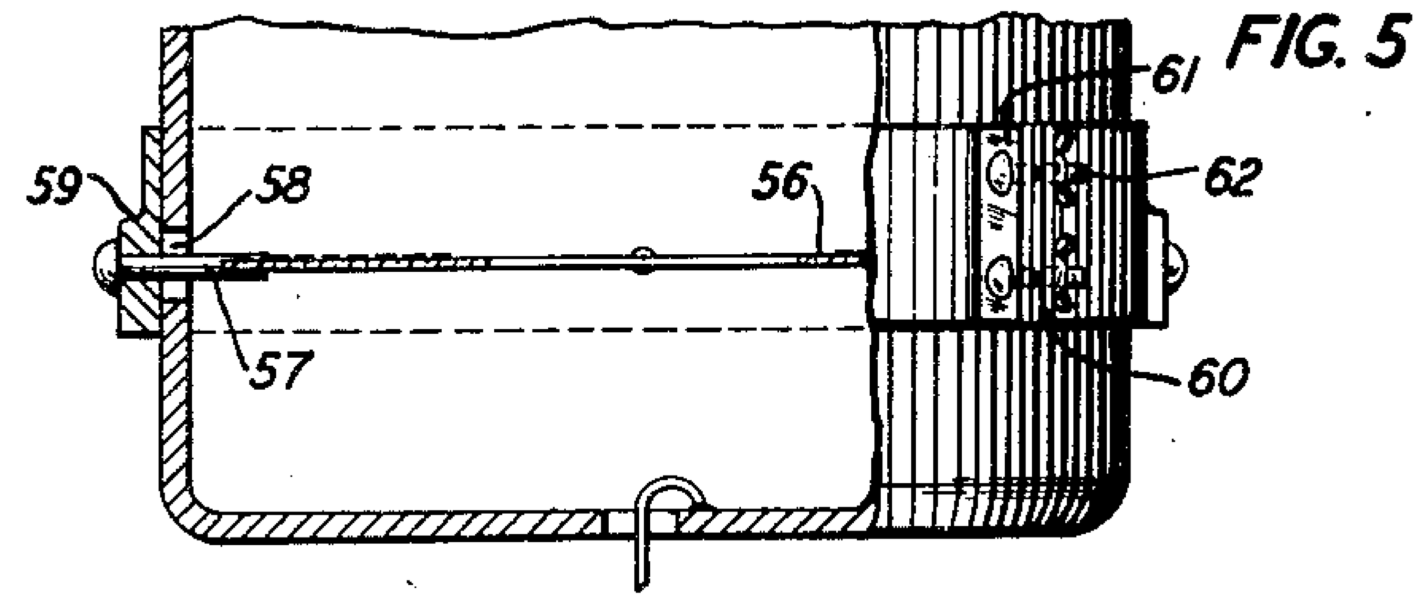

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ELECTRICAL RESONATOR AND MODE SUPPRESSOR THEREFOR

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2 Claims. (Cl. 178—44)

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 increase the Q of a cavity resonator.

Another object of the invention is to increase the discrimination against unwanted modes of oscillation in a cavity resonator.

A still further object is to substantially dissipate the energy of one of the natural resonance modes of a cavity resonator while, at the same time, causing little or substantially no loss of the energy of another natural resonance mode of the same frequency.

In accordance with one embodiment of the invention a tunable cavity resonator may comprise a cylindrical chamber having its interior surface coated with highly electrically conductive material and with a tuning piston having its interior surface similarly coated at one end. Input and output energy transfer devices may be provided at the opposite end of the resonator. The resonator may be designed to operate in TE_{01n} mode with nodal planes at equally spaced positions between the ends and parallel to them. A thin vane or plate of dielectric material may be mounted within the chamber adjacent each of one or more nodal planes and each dielectric plate may bear a coating of energy dissipating material such as "aquadag" which may be nicely located at substantially a nodal plane for the desired TE_{01n} mode oscillations. Where the range of tuning and the piston displacement are small so that each nodal plane remains within a relatively limited region the energy dissipation device may have a fixed support but where a considerable range of tuning is desired the energy dissipating device may be mounted on supports which are capable of positional adjustment in the direction parallel to the motion of the piston. In a modification of the energy dissipator, which is particularly effective for suppression of oscillations of TM_{01} mode which involve an electrical vector parallel to the longitudinal axis of the cylinder, that is, to the direction of motion of the piston, dissipation may be effected by narrow slots or apertures which extend through the cylindrical wall in a circumferential direction but the contiguous slots of which are separated at their ends by integral unslotted portions of the wall which maintain a fixed physical connection between the portion of the resonator cylinder above the slots and the portion below them.

Referring to the drawing:

Fig. 1 discloses diagrammatically and in partial

section a cavity resonator having extraneous mode suppression devices positioned at two nodal planes;

Fig. 2 is a cross-section of the structure of Fig. 1 viewed in the direction of the arrows along the plane 2—2;

Fig. 3 illustrates a modification of the structure of Fig. 1 in which the energy dissipators at nodal planes take the form of electromagnetic "leaks";

Fig. 4 is a section of the structure of Fig. 3 viewed in the direction of the arrows at plane 4—4 of Fig. 3; and

Fig. 5 shows a portion of the structure of Fig. 1 modified to permit adjustment of the position of the dissipator to reduce the dissipation for desired oscillations as the nodal plane shifts in the course of tuning operations.

Referring to Figs. 1 and 2 there is illustrated in section a cavity resonator 10 in the form of a cylindrical structure having a closed lower end 11 and an upper open end provided with a cover 12.

The cylinder of the cavity resonator 10 and the cover 12 may consist of electrically conducting material such as aluminum or copper. The interior surface of the cylindrical member of the resonator 10 may be coated with any highly conductive coating such as silver or electrolytically deposited copper, as indicated at 13. Both the cylindrical member 10 and the cover 12 may be made of any suitable rigid non-conducting material if provided with the interior electrically conducting coating.

The resonator may be provided with input and output connections as, for example, coaxial end loop structures 14 and 15 each of which terminates in a soldered connection on the inside of the resonator. The loops 14 and 15 are preferably arranged to pass through circumferential slots 16 and 17 extending through the lower end 11 of the resonator and arranged diametrically opposite each other tangential to a circle in the region of a strong electric vector for oscillations of the TE_{018} mode at which the resonator is to operate.

At the opposite end of the resonator space is a tuning piston 18 supported by a plunger 19 passing through the guide 20. Connected in a slot at the upper end of the plunger 19 is a flat stiff spring 21, to the upper end of which is attached a slotted cross-head member 22 pivotally connected at 23 to the outer end of a crank arm 24, the inner end of which is fixed to a shaft 25 supported on a frame 26 mounted on the cover plate 12. Also, carried by the shaft 25 is a wormwheel

27 which cooperates with a worm 28 integral with and rotated by the knob 29 and spindle 30. Accordingly, by rotation of the knob 29 it is possible to place the piston 18 at any position within a desired range and to tune the interior space of the resonator 10 so that it may have a natural resonance frequency at a $TE_{0,1,8}$ mode at any point within a desired range of tuning.

With the piston 18 placed at some position as, for example, at the dotted line position 32, there will be a number of nodal planes as at 33, 34, 35, 36, etc., along which the electric vector for oscillations of the desired TE_0 mode is of substantially zero intensity. However, oscillations of extraneous or undesired modes may present substantial electric fields in these planes. If, therefore, a dissipating dielectric or conductive material should be placed in one of the nodal planes it will present little attenuation for the negligible electric fields of the desired mode oscillations but may substantially attenuate and effectively suppress oscillations of extraneous or unwanted modes. For this purpose supports in the form of radially inwardly extending pins 37, 38, 39 and 40 may be placed in the region of a nodal plane. These supports may have slotted inner ends which closely engage and hold in fixed position a very thin flat annulus 41 of dielectric material such as "polystyrene."

In a structure such as that illustrated in Fig. 1 in which end energy transfer connections are used the dissipator may advantageously be located at the nodal plane nearest the fixed end as, for example, dissipator 43 at plane 33 for the reason that the displacement of the nodal plane with change in tuning is least near the fixed end of the resonator. The plane 33 selected may be that at which the node occurs for oscillations of the desired mode at the mid-frequency of the band over which tuning is to occur. If additional attenuation is desirable dissipators may be placed at both the first and second nodal plane as illustrated at 41 and 43 in Fig. 1. If, however, the energy transfer connections are to be made through side openings in the wall of the resonator it may be desirable to locate the dissipators at positions more remote from the fixed end as at the second and third nodal planes. This will permit a greater latitude in placing the energy connections and it will also tend to reduce any distorting effect which might be occasioned if the energy transfer connections and the extraneous energy dissipators were located in closely adjacent positions.

Under some circumstances the attenuation effected by the thin sheet of dielectric material is adequate. However, it may be desirable in special cases to augment the attenuation and this may be done by application to the dielectric annulus of a coating of aquadag 42. The aquadag may be applied only to that portion of the dielectric annulus in which the extraneous electric field is of greatest intensity.

An alternative structure involves use of supporting pins having dielectric tips and replacement of the dielectric annulus by a very thin metal plate. It has been found that this structure may very effectively suppress oscillations of unwanted modes if first it be coated with a dielectric material such as collodion and then with a coating of aquadag or other energy dissipating substance which is insulated from the metal plate by the dielectric coating. In this instance the design should be such as to place the energy dissipating coating as nearly as possible at the nodal plane for oscillations of the desired mode. With these expedients the attenuation for undesired oscillations of all types having an electric vector in either of these nodal planes may be made relatively high without, however, producing excessive attenuation of the oscillations of the desired mode since for the desired mode the electric field at these nodal or energy dissipating planes may be of very small or negligible intensity.

It transpires that reduction of unwanted or extraneous modes not only enables the selective resonator to exhibit a greater discrimination in favor of the desired mode but it actually increases or enhances the intensity of the desired field or viewed from another standpoint enhances the Q of the resonator. This is particularly true with respect to the reduction of TM_{11n} mode oscillations of the same frequency as the desired TE_{01n} mode, the TM_{11n} oscillations when present as a strong field acting in parasitic fashion to cause increased energy loss for the desired TE_{01n} mode.

Figs. 3 and 4 disclose an alternative form of nodal plane attenuator in which the attenuation is brought about by permitting leak of electromagnetic energy of unwanted modes. This is produced by cutting through the wall of the resonator 46 a series of slots 47, 48, 49, 50 extending in a circumferential direction about the cylindrical wall of the resonator at the region which includes a nodal plane for the desired oscillations. The circumferential slots are of such length as to leave between their contiguous uncut portions or webs 51, 52, 53, 54 of the cylinder wall which physically connect upper and lower portions of the resonator and maintain the structural integrity of the cylinder. Modes of oscillation which inhibit electric vectors in the direction of the longitudinal axis of the resonator 46 as, for example, $TE_{0,1,8}$ mode, tend to set up a strong difference of potential between the opposite margin of the slots thus giving rise to an escaping field through the slot which dissipates that particular mode of oscillation. Since, however, oscillations of the desired mode have a nodal plane in the region of the slots and no electric vector in the direction of the longitudinal axis of the resonator there is little or negligible attenuation for these desired mode oscillations. It is to be understood that this expedient may be utilized at more than nodal planes in exactly the same manner as is the dissipating expedient of the structure of Fig. 1. In other respects the structure of Figs. 3 and 4 is to be understood as identical with that of Figs. 1 and 2.

Fig. 5 discloses a modification of the structure of Fig. 1 in which annular dielectric plates 56, coated with energy dissipating material, are mounted at one or more of the nodal planes for oscillations of the desired mode. The structure differs from that of Fig. 1 in that in lieu of the fixed pin supports there are provided pins 57 which similarly support the dielectric discs but are movable in a direction parallel to the longitudinal axis of the resonator. This is accomplished by passing the pins 57 through narrow vertical slots 58 in the wall of the resonator and through holes in which the pins closely fit in an external clamping ring 59. The clamping ring fits tightly over the slots 58 and effectively shields them against transfer of energy either into or out from the resonator. The ring 59 terminates in flanges 60 and 61 which may be drawn together with bolt and wing nuts 62 thus fixing the position of the clamping ring. In order to adjust the position of the energy dissipator 56 it is merely necessary to loosen the wing nuts and slide the structure up or down to the position at which the energy dissipating coating is in the nodal plane. It is to be understood that in all other respects the structure of Fig. 5 is identical with that of Figs. 1 and 2.

What is claimed is:

1. A hollow cavity resonator of high Q having a movable end wall for tuning over a frequency range, means for exciting a desired TE_{01n} electromagnetic mode of oscillation therein, and a thin plate of lossy material located in a nodal plane for the desired TE_{01n} mode oscillations of the mid-frequency of the tuning band, said plate extending into a region of high field intensity of extraneous modes, and being located remote from said end wall, and a movable support for said plate mounted on a side wall to adjust the longitudinal position of said plate in parallelism to said end wall and to maintain it in the nodal plane as the tuning of the resonator is varied.

2. A cylindrical hollow cavity resonator of high Q having a fixed end plate, means for exciting a desired TE_{01n} electromagnetic mode of oscillation within the cavity resonator, and thin circular discs of lossy material located in parallel nodal planes for the TE_{01n} mode and extending into a region of high field intensity of extraneous modes, said discs being equispaced, and mounted on the side walls of said resonator.

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