

[54] **HYBRID TUNABLE CAVITY
RESONATOR**

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[51] Int. Cl. **H01p 7/04**, H03h 13/00, H03j 3/20

[58] Field of Search 334/44-45, 46,
334/80; 333/82, 82 A, 82 B, 83, 73 C, 73, 73 S

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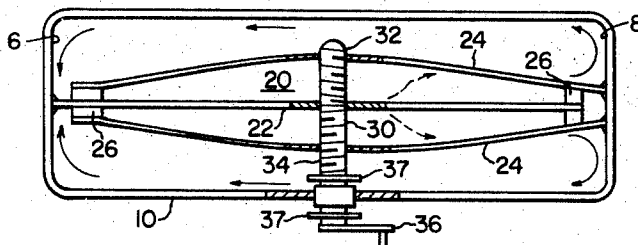
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[57]

ABSTRACT

A tunable cavity resonator of the hybrid coaxial reentrant cavity type of configuration wherein the centerline structure conductively connecting the two end walls of the cavity includes a plurality of elongated conductors each directly connected electrically at one end only to one or the other end wall within the cavity and disposed in lapped and spaced relationship to each other with means for varying the spacing between the conductors to alter the distributed capacitance therein between whereby the cavity may be tuned.

13 Claims, 8 Drawing Figures



Patented April 18, 1972

3,657,671

FIG. 1. PRIOR ART

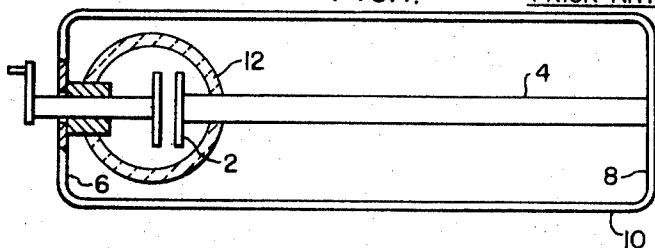


FIG. 3.

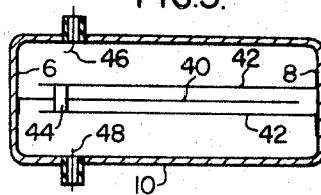


FIG. 2.

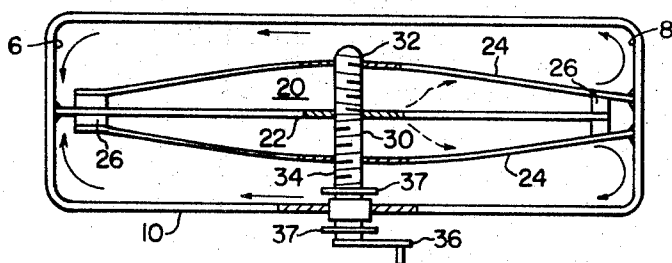


FIG. 4.

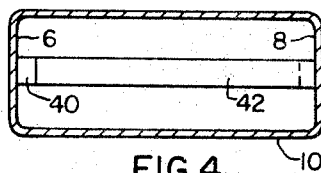


FIG. 5.

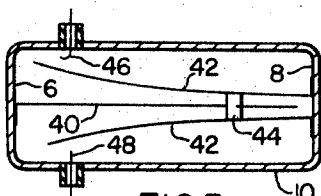


FIG. 6.

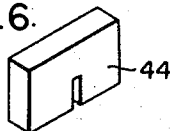


FIG. 7.

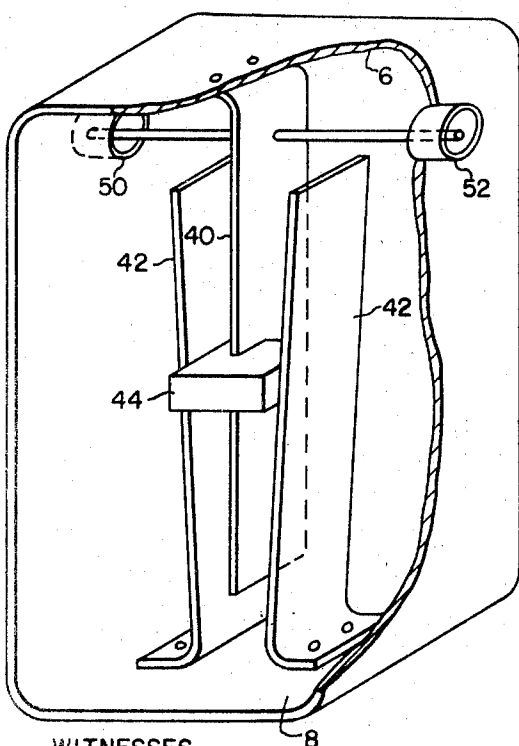
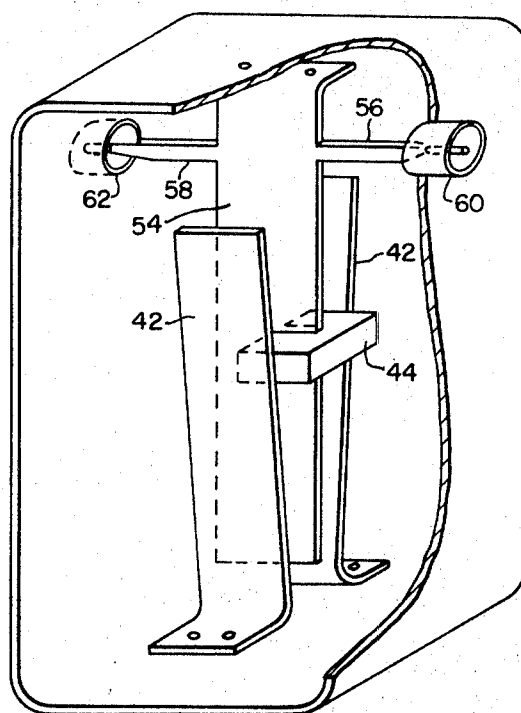


FIG. 8.



WITNESSES

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HYBRID TUNABLE CAVITY RESONATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to tunable cavity resonators and more particularly relates to a hybrid coaxial cavity of a reentrant type of construction on the centerline of a cavity for distributing the capacitance along substantially the entire length of the centerline structure with means for varying the distributed capacitance to efficiently tune the resonator.

2. Description of the Prior Art

An important consideration in the design of narrow pass-band tunable filters for medium to high power radio transmitting and/or receiving applications, such as multi-couplers, is that of energy loss or efficiency in the passband. For the low VHF range, say 30 to 76 megahertz, the filters are usually foreshortened because of space limitations by utilizing a variable capacitor connected in series with an electrically short coaxial transmission line section closed at each end by a conducting plate to form a cavity. The capacitor itself is almost invariably encased hermetically in a glass or ceramic shell to protect the precision mechanism from accumulation of dirt and to permit very close spacing of the capacitor plates without arcing. The enclosed region is either evacuated or pressurized with a corona-suppressing gas such as sulphur hexafluoride, SF₆.

It is desirable that a resonator have as high an efficiency as attainable. In a high power filter and multi-coupler application even small improvements in efficiency are important, since the power flows through a chain of resonators in succession, each taking its toll of dissipated power.

It is therefore an object of the present invention to provide a cavity resonator permitting higher overall resonator efficiency than heretofore attainable.

Another object of the present invention is to provide a cavity resonator wherein the structure of the tunable capacitor minimizes power losses in the resonator and makes optimum use of the space available.

SUMMARY OF THE INVENTION

Briefly, the present invention accomplishes the above cited and other objects and advantages by providing a tunable cavity resonator utilizing a hybrid type of construction of a coaxial reentrant cavity wherein the centerline structure forming the inner conductor of the coaxial type cavity includes a plurality of lapped electrical conductors, some electrically connected at only one end thereof directly to an end wall of the cavity and others likewise connected at only one end to the opposite end wall of the cavity with the elongated conductors spaced apart from each other but lapping substantially along their entire length whereby the capacitance to foreshorten the electrical length of the resonator is distributed over substantially the entire centerline structure. Means are provided for varying the spacing between the electrical conductors to accomplish the necessary variation in capacitance to tune the cavity resonator.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects and advantages of the present invention will be readily apparent from the following detailed description taken in conjunction with the drawing in which:

FIG. 1 is a plan view, partly in section, of a tunable cavity resonator in accordance with the prior art;

FIG. 2 is a plan view partly in section, of an illustrative embodiment of the present invention;

FIGS. 3 and 4 are plan and side views, respectively, partly in section, of an alternate embodiment of the present invention;

FIG. 5 is a plan view illustrating another operating position of the illustrative embodiment of FIGS. 3 and 4;

FIG. 6 is a perspective view of an element utilized in the illustrative embodiment of FIGS. 3 through 5; and

FIGS. 7 and 8 are perspective views of still other alternate embodiments of the present invention.

Cavity resonators for certain frequencies, such as the low VHF range, generally utilize a variable capacitor 2 connected to an electrically short coaxial transmission line section 4 thereby electrically connecting walls 6 and 8 of the cavity 10.

The capacitor 2 is usually encased hermetically in a glass or ceramic shell 12 to protect the precision mechanism from accumulation of dirt and to permit very close spacing of the capacitor plates without arcing. The separation of the plates of the capacitor 2 foreshortens the electrical length of the resonant cavity. Variation in the separation of the plates will tune the cavity to resonate at a desired frequency.

It is desirable that the cavity resonator be tuned with the highest possible efficiency. The illustrative embodiment shown in FIG. 2 provides a higher unloaded Q in the cavity 10 through a novel embodiment of the tuning capacitor which permits higher overall resonator efficiency than has been heretofore obtained using ceramic encased capacitors of conventional design.

Opposite end walls 6 and 8 connected by side walls enclose a space within the cavity 10. The walls are all conducting. A centerline structure 20 electrically connects the opposite end walls 6 and 8. The center structure 20 comprises a plurality of elongated electrical conductors, the disposition and mounting of which will be discussed in greater detail hereinafter. It is to be noted however, that the centerline structure results in the cavity being of a hybrid coaxial type. Of course, the outer walls of the cavity may be cylindrical or rectangular or of any other well known configuration. The cavity of FIG. 2 has a reentrant portion in that the outer elongated conductors can be thought of as protruding into the space within the cavity.

More specifically, an elongated, cantilever mounted electrical conductor 22 is electrically and mechanically connected directly to the end wall 6 and extends towards but short of the opposite end wall 8. A pair of cantilever mounted elongated conductors 24 are electrically and mechanically connected directly to the end wall 8 and extend almost to the opposite end wall 6.

The end of each elongated cantilever conductor 22 and 24 which is not directly connected electrically and mechanically to an end wall of the cavity 10 is captivated by dielectric supports 26 which are slidably mounted in relation to the elongated conductors so that as the outer conductors 24 are flexed the centerline structure 20 is provided with the necessary give or resiliency. A cantilever conductor is one which is fastened to one of the end walls 6 and 8, but not to the other.

The above centerline structure results in the cavity being of a hybrid coaxial type. That is, the cavity can be considered to be coaxial up to the end of electrical conductor 22 which is captivated by the dielectric support 26. To the right of the dielectric support 26, the presence of elongated conductors 24 results in a hollow cavity. As a result of the centerline structure, the electromagnetic field is distorted at the end of the resonator. The field is a combination of fields which are due to the coaxial cavity and the hollow cavity.

The improved efficiency is achieved through the use of a reentrant type of construction on the centerline of the cavity. Capacitive tuning is obtained by the quasi-parallel set of elongated conductors, which are preferably flat and disposed in a face-to-face lapping spaced relationship, the spacing of which is variable to accomplish the necessary variation in capacitance for tuning. The separation between the elongated plates is varied in FIG. 2 by a dielectric threaded screw 30 bearing left-hand threads 32 on one side of the centerline and right-hand threads 34 on the opposite side. A crank 36 rotates the screw 30 to accomplish a smooth control of separation, and hence upon the tuning. Insulation 37 electrically shields the crank 36.

The elongated conductor 22 and elongated pair of conductors 24 serve as the inner conductor of the resonator along which the capacitance is now distributed, instead of being lumped. Since the capacitance is distributed over a much larger structure, the same degree of protection from voltage breakdown and deterioration from dirt accumulation can be obtained with the open type geometry of the present invention.

as compared with the hermetically sealed type of the prior art. Spacings between the elongated conductors which serve as the plates of the distributed capacitor, may be much wider than the hermetically sealed type and the edges of the conductors at which corona might develop are well rounded to minimize the voltage gradient.

Current flowing onto the conductor 22 at the end wall 6 gradually bleeds off as indicated by the dotted arrows to the elongated conductors 24 and exits the centerline structure at the end wall 8 to return to the end wall 6 via the side walls of the cavity 10. The solid arrows indicate current flow along the conductors as well as the conducting walls of the cavity 10. Of course, the action is oscillatory reversing itself periodically at the resonant frequency of the system. By varying the separation between the elongated conductors, the distributed capacitance can be altered to tune the cavity to resonance. It is to be noted that the length of the current path on the first elongated conductor 22 is virtually the same as the length of the conductor itself.

An alternate embodiment of a simpler structure yet is illustrated in FIGS. 3 through 6. An inner cantilever conductor 40 extends within the space of the cavity. A pair of elongated flat cantilever conductors 42 protrude into the cavity space and can be considered a reentrant portion of the walls of the cavity 10. The pair 42 are sprung so that they tend to close. It is to be noted that the opposite ends of each of the elongated conductors is uncaptivated. A spacer 44 straddles the inner conductor 40 and is slid back and forth within the cavity to vary the separation of the conductors and hence the distributed capacitance. FIG. 5 illustrates how the position of the insulator block 44 can be altered to vary the plate separation shown in FIG. 3. A coupling loop 46 is used to energize the resonator. A probe 48 is used to detect the resonant frequency. The loop and probe enable the unloaded Q (Q_u) to be measured because they are made negligibly small in order to avoid loading the resonator.

Even without any special attempt to optimize the design of the embodiment illustrated in FIGS. 3 through 6, a higher Q was obtained than that previously available from prior art capacitors utilized in such cavity resonators.

FIGS. 7 and 8 show other illustrative embodiments with identical character references assigned to similar parts for purposes of clarity. In both Figs. the cover of the cavity has been removed.

In FIG. 7 coax connectors 50 and 52 enable the resonator to be connected in a circuit so that it may be loaded. Additional cavities may be connected together such as might be used in a multi-coupler for radio transmitting and receiving applications. Such a multi-coupler is utilized to control energy flow to and from an antenna to a transmitter or receiver. An antenna coupler is generally operated by means of a controller which tunes each of the cavities within the multi-coupler.

An alternate configuration for loading connections is shown in FIG. 8. A inner conductor 54 is formed by punching out a plate with projecting portions 56 and 58 to form center conductors for coax connectors 60 and 62.

Hence, it should be apparent that a tunable capacitor has been provided for such an application which by its distributed nature constitutes substantially the entire inner conductor of a hybrid coaxial type reentrant cavity resonator. The tunable capacitor has quasi-parallel surfaces which are capable of continuous variation in spacing or overlap to achieve a variation in capacitance. The tunable capacitor minimizes power losses in the resonator by making optimum use of the space available in the region of the centerline structure. The capacitor in accordance with the present invention permits the ready adaptation of a resonator to the higher order complexity of a tunable filter for high power radio frequency signals.

While the present invention has been described with a degree of particularity for the purposes of illustration, it is to be understood that all modifications, alterations, and substitutions within the spirit and scope of the present invention are herein meant to be included.

We claim as our invention:

1. A cavity resonator comprising in combination; a cavity; a centerline structure conductively connecting the two end walls of said cavity; said centerline structure comprising a plurality of lapped electrical conductors, some electrically connected at only one end thereof to one end wall of said cavity and others electrically connected at only one end thereof to the other end wall of said cavity; means for spacing said conductors from each other to distribute the capacitance therein-between along substantially the entire length of said centerline structure; and tuning means for varying the spacing between all of said conductors to alter the distributed capacitance.

2. A hybrid coaxial reentrant cavity comprising in combination; an inner member conductively connected at one end of the cavity and extending towards but short of the other end of the cavity; a reentrant portion including a pair of generally parallel flexible flat conductors connected to the other end of the cavity and protruding into the space within the cavity, the separation of said pair from the inner member determining the distributed capacitance of the cavity; and means operably ganging together said pair of flexible members for altering the separation between the inner member and said pair of flexible members to vary the distributed capacitance.

3. In a hybrid coaxial reentrant cavity for a tunable cavity resonator, the combination comprising; a quasi-parallel set of elongated conductors each connected at one end only to one end of said cavity and extending into said cavity as a reentrant portion; an inner conductor connected at one end only to the opposite end of said cavity and extending generally parallel with said quasi-parallel set of conductors; and means operably ganging together said quasi-parallel set of conductors for varying the spacing between said inner conductor and said quasi-parallel set of conductors to alter the distributed capacitance thereinbetween.

4. A cavity resonator comprising in combination; a cavity; a centerline structure conductively connecting the two end walls of said cavity; said centerline structure comprising a plurality of lapped, generally flat electrical conductors disposed in a spaced stacked face-to-face relationship to each other, some electrically connected at only one end thereof to one end wall of said cavity and others electrically connected at only one end thereof to the other end wall of said cavity; and means for spacing said conductors from each other to distribute the capacitance thereinbetween along substantially the entire length of said centerline structure.

5. The combination of claim 4 wherein, said plurality of conductors includes a first elongated flat conductor cantilever mounted at one end wall of said cavity and at least one other elongated flat conductor cantilever mounted at the other end wall of said cavity.

6. The combination of claim 5 wherein, said tuning means comprises a spacing member slidably mounted on said first cantilever conductor to control the divergence of said at least one other elongated flat cantilever conductor from said first cantilever conductor.

7. The combination of claim 5 wherein, the free end of each cantilever mounted conductor is held in a substantially fixed separation from the other conductors; and the tuning means combination includes means for bowing the outer conductors to vary the separation of the conductors, whereby the distributed capacitance thereinbetween may be altered to tune said cavity.

8. The combination of claim 5 including means for captivating the end of each conductor opposite its respective cantilever mounted end to limit the diversion of those ends from said cantilever mounted ends.

9. The combination of claim 8 wherein said captivating means are dielectric supports capable of sliding along the face of the conductors as said conductors are flexed when separated.

10. The combination of claim 5 wherein two other elongated flat conductors are cantilever mounted at the opposite end wall of said cavity; said two conductors disposed on opposite sides of said first conductor in a face-to-face relationship overlapping at least a portion of said first conductor.

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11. The combination of claim 10 wherein said two elongated flat conductors overlap substantially all of the face presented by said first conductor.

12. The combination of claim 11 wherein, said tuning means for varying said spacing comprises crank means including a stem extending into said cavity; said stem having opposite orientated lever means for separating the outer conductors from the center conductor.

13. A resonant cavity comprising, in combination; a first elongated conductor end mounted to one end wall within the cavity and extending towards but short of the opposite wall of

the cavity; two flexible elongated conductors each end mounted to the other end wall and extending towards but short of said one end wall; said first elongated conductor disposed between said two flexible conductors, all of said elongated conductors being generally flat and disposed in spaced face-to-face relationship; and means for varying the separation of said two flexible conductors to alter the distributed capacitance between said first elongated conductor and said flexible conductors.

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