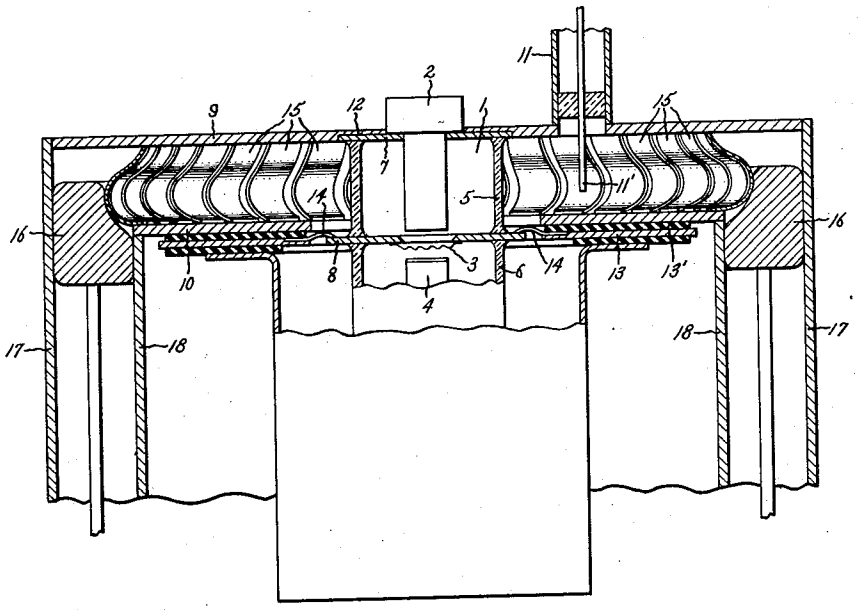
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TUNABLE CAVITY RESONATOR

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## TUNABLE CAVITY RESONATOR

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My invention relates to cavity resonators of the radial type and has for one of its objects the provision of a radial cavity resonator which is tunable over a wide band of frequencies.

Radial cavity resonators have heretofore usually been tuned by means of slugs inserted within the resonator itself so as to intercept a preponderance of either magnetic or electrical field lines depending upon whether it is desired to raise or lower the resonant frequency. These slugs, however, increase the resistive component of the impedance characteristic of the resonator, and if many slugs are used to obtain a substantial frequency adjustment, the efficiency of the resonator is thereby appreciably reduced. Furthermore, due to the consequent distortion of the radial symmetry, these slugs often introduce undesirable higher order waves within the resonator. Accordingly another object of my invention is to provide a radial cavity resonator in which the natural resonant frequency may be tuned over a fairly wide band of frequencies without the appreciable introduction of additional resistance or higher order waves.

In fullfilment of the above objects, it is a further specific object of my invention to provide a tuning arrangement for a radial cavity resonator whereby all radii of the cavity may be uniformly adjusted simultaneously.

Broadly stated, my invention comprises a radial cavity resonator wherein the conventional cylindrical wall forming the peripheral enclosure or the resonator is replaced by a plurality of circumferentially displaced resilient fingers secured to one side of the resonator and making slidable contact with the opposite side thereof. Means are provided to constrict these resilient fingers simultaneously thereby permitting a uniform adjustment of the radial dimension of the resonator.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, together with additional objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which the sole figure is a sectional view of one embodiment of my invention as employed in conjunction with a centrally positioned ultra high frequency electric discharge device 1, including an anode 2, control grid 3, and a cathode 4 maintained in consecutively spaced relation along the longitudinal axis of the device by virtue of a pair of supporting and enclosing cylinders 5 and 6 composed of suitable insulating material such as

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glass. A pair of parallel conductive rings 7 and 8 are sealed to opposite ends of insulating cylinder 5 and serve to provide suitable external terminal connections to the anode 2 and control grid 3 respectively.

A pair of conductive planar members 9 and 10, which may in one form as illustrated be a pair of disks, extend radially from the electric discharge device 1 and are aligned in parallel fashion to form opposing sides of a grid-anode cavity resonator. An output coupling connection from the resonator is provided by such means as a coaxial cable 11 fastened to planar member 9 and having a coupling probe 11' extending within the resonator. The anode connection to the upper planar number 9 is by virtue of a centrally formed depression 12 in which the anode conductive ring 7 is seated. The control grid 3 is preferably capacitively coupled to the lower planar member 10 in order to permit the application of a uni-directional potential between the anode 2 and the grid 3 and yet provide a coupling which effectively appears as a direct connection in so far as ultra high frequency potentials are concerned. A conductive annular plate 13 separated from the lower planar member 10 by an insulating washer 13' and connected to the grid conductive ring 8 by an annular spring member 14 may be employed to accomplish this capacitive coupling.

The peripheral enclosure of the resonator is formed by a plurality of embowed resilient conductive fingers 15 rigidly secured to circumferentially displaced points on one of the planar members such as lower planar member 10 and pressing tightly against the inside conductive surface of the opposing planar member, which in the instant embodiment is designated as member 9. The embowed configuration and resilient composition of the fingers 15 create a tension therein which exerts a strong pressure against the opposing planar member 9 in order to make good contact and provide a low loss ultra high frequency connection therewith. This tension within the fingers also causes them to tend to move centrifugally.

In order to restrain this centrifugal motion and coincidently to provide one convenient means of adjusting their radial position, I preferably employ an annular shoe or plunger 16 encircling the resonator and having an annular concave depression fitting contiguously against the convex outer surface of the embowed resilient fingers 15. This annular shoe 16 is slidably inserted within a pair of telescoped guiding cylinders 17 and 18 and is adjusted to press against the resilient fingers 15

by any suitable mechanical means (not shown). A movement of annular shoe 16 toward planar member 9 constricts these resilient fingers 15 and forces their free ends to slide uniformly toward the center along the surface of planar member 9 thereby decreasing the radial dimensions of the resonator. A movement of the annular shoe 16 in the opposite direction permits the centrifugal expansion of these fingers thereby increasing the radial dimensions of the resonator again.

When a cavity resonator of the type herein described is excited at its natural resonant frequency by a proper ultra high frequency electric discharge through device 1, a standing wave is produced therein having a changing magnetic field forming closed loops normal to the axis of the discharge device 1 and a changing electrical field which is normal to the magnetic field and whose lines extend between the conductive planar member 9 and 10. This mode of propagation, commonly called a transverse magnetic mode of the first order, ($TM_{01}$) results in a voltage anti-node at the central axis and a voltage-node at the periphery of the resonator.

The natural resonate frequency of a cylindrical cavity resonator utilizing a $TM_{01}$ mode of propagation is given by the formula

$$f_n=\frac{c}{2.61a}$$

where $c$ is the velocity of light and $a$ is the radius of the cavity. As is indicated by the formula, the resonant frequency in this mode is a function of only one dimension, i. e., the radius. The other dimensions are not required to fit any particular number or half or whole periods of variations and hence do not directly affect the resonant frequency.

The cavity resonator herein described is substantially equivalent to a cylindrical cavity resonator, and the above formula may be employed to calculate the approximate resonant frequency thereof. Since the natural resonant frequency of the resonator is dependent upon the radius and since the average radius of the resonator is directly varied by the movement of fingers 15, its natural resonant frequency is thereby also varied proportionally.

It will be appreciated that since my invention employs only one set of sliding contacts instead of the two sets of sliding contacts employed in conventional piston tuned resonators, the contact losses are thereby appreciably reduced. Furthermore, since the irregularity of the periphery of the resonator caused by the embowed configuration of the resonant fingers 15 affects only a relatively small part of the total surface and is completely symmetrical, the efficiency of the resonator is not substantially affected, and the possibility of the introduction of higher order waves is minimized.

It will be appreciated that although I have shown a cavity resonator employed in conjunction with a conventional centrally positioned electric discharge device, neither the particular discharge device employed nor the means by which the cavity resonator is excited form part of my present invention. My invention is concerned with the cavity resonator itself, and it is obvious that a radial cavity resonator 9 as herein described may be employed for various purposes in radio systems with many different means of excitation. For example, a resonator such as described above may be employed in a conventional Klystron oscillator and excited by the energy transferred to the resonator from a velocity modulated electron stream.



It is also to be understood that while I have shown one particular embodiment of my invention, many modifications may be made, and I, therefore, contemplate by the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A radial cavity resonator comprising a pair of parallel electrically conductive planar members aligned to form opposing sides of said resonator, a plurality of circumferentially spaced outwardly embowed resilient electrically conductive fingers forming a convex periphery of said resonator, each finger being secured to the same one of said members and making firm slidable contact with the opposing planar surface of the other of said members under a centrifugal tensional force provided by its outwardly embowed configuration, and means encircling said fingers to constrict said fingers radially and uniformly to move the points of contact of said fingers on said opposing surface against the centrifugal tensional force of said fingers to adjust the natural resonant frequency of said resonator.

2. In combination, a radial cavity resonator comprising a pair of parallel electrically conductive planar members aligned to form opposing sides thereof, and a plurality of outwardly embowed resilient electrically conductive fingers forming a convex periphery of said resonator, said fingers being secured at one end to circumferentially spaced points on one of said members and making firm slidable contact at the other end with the opposing surface of the other of said members under a centrifugal tensional force provided by their outwardly embowed configuration, an annular shoe encircling said fingers and having a concave internal surface fitting contiguously against the embowed outer surfaces of said fingers, and means to vary the position of said annular shoe relative to said fingers in a direction parallel to the axis of said radial resonator to adjust the radial points of contact of said fingers on said other planar member, by constricting said fingers radially and uniformally against the tensional force thereof, thereby to tune said resonator.

ELMER D. McARTHUR.

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