Oct. 7, 1952 H. E. S. STOCKMAN 2,613,269

WIDE RANGE ULTRAHIGH FREQUENCY TUNING CAVITY

Filed June 23, 1950 2 SHEETS—SHEET 1

FIG. 1.

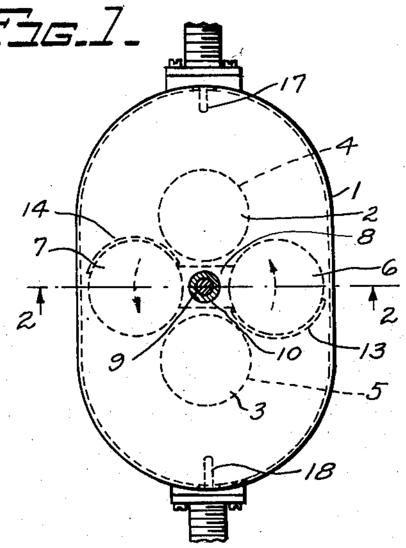


FIG. 2.

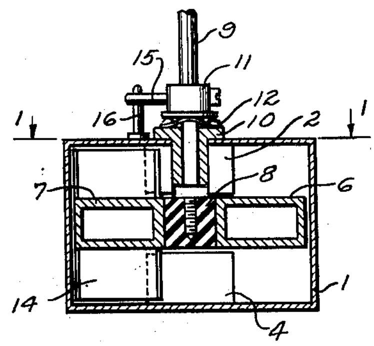


FIG. 4.

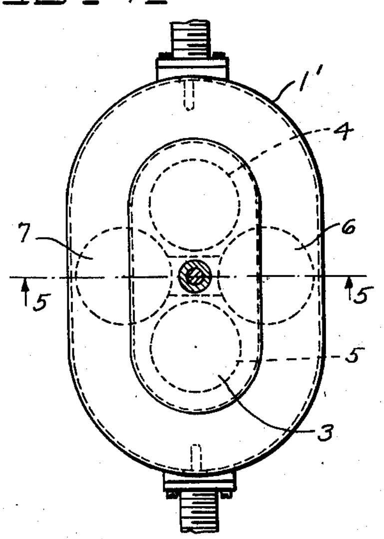
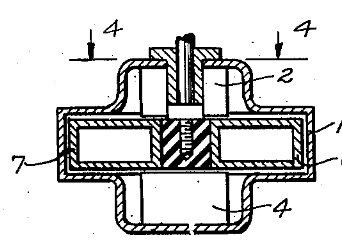


FIG. 5.



INVENTOR.
HARRY E. S. STOCKMAN
BY Wade Koontz
ATTORNEY AND
James S. Shannon
AGENT

WIDE RANGE ULTRAHIGH FREQUENCY TUNING CAVITY

Filed June 23, 1950 2 SHEETS--SHEET 2

FIG. 6.

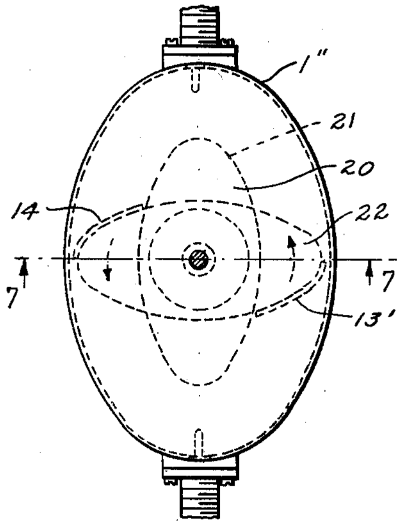


FIG. 7.

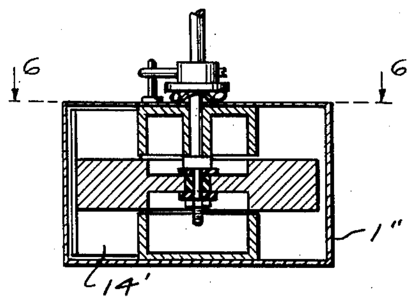
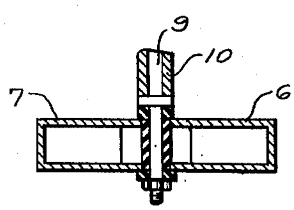


FIG. 3.



INVENTOR.
HARRY E. S. STOCKMAN
BY Wade Koontz
ATTORNEY
James S. Shannon
AGENT

Patented Oct. 7, 1952 2,613,269

UNITED STATES PATENT OFFICE

2,613,269

WIDE RANGE ULTRAHIGH FREQUENCY TUNING CAVITY

Harry E. S. Stockman, Waltham, Mass.

Application June 23, 1950, Serial No. 169,951

7 Claims. (Cl. 178—44)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

1

The invention described herein may be manufactured and used by or for the United States Government for governmental purposes without payment to me of any royalty thereon.

This invention relates to wide range ultra high frequency tuning devices. It is the object of the invention to provide a continuously tunable resonant device for use principally in the 300 megacycle to 3000 megacycle frequency band, but also useful at frequencies considerably below and above this band, and tunable over a frequency range of the order of 1:7. It is a further object of the invention to provide a tuner having a high and relatively constant Q, low radiation so that shielding is not required, and freedom from sliding contacts and switching devices.

In accordance with the invention the tuner comprises a resonant cavity having one or more charge storing gaps and a movable conductor which may be moved from a position inside the gap or gaps to a position totally outside the gaps. The cavity and movable conductor are also so arranged that as the conductor is moved away from its position inside the gaps it increasingly restricts the area through which the magnetic field lines pass thus reducing the inductance simultaneously with the reduction in capacitance of the gaps resulting from the effective increase in gap spacing. This simultaneous variation of inductance and capacitance makes possible a wider tuning range than can be achieved by variation of either alone.

For a more complete description of the invention reference is made to the specific embodiments thereof shown in the accompanying drawings in which,

Fig. 1 is a plan view of one form of tunable resonant cavity constructed in accordance with the invention;

Fig. 2 is a sectional view of Fig. 1 taken at the plane **2—2**;

Fig. 3 shows a modification of Figs. 1 and 2;

Fig. 4 is a plan view of another embodiment of the invention;

Fig. 5 is a sectional view of Fig. 4 taken at plane **5—5**;

Fig. 6 shows a third embodiment of a resonator in accordance with the invention; and

Fig. 7 is a sectional view of Fig. 6 taken at the plane **7—7**.

Referring to Figs. 1 and 2 the resonant cavity is bounded by an enclosure **1**. The enclosure is made of a highly conductive metal such as brass or copper and, if desired, the inner surfaces thereof may be plated with a metal of still higher

2

conductivity such, for example, as silver in order to reduce the losses at high frequencies to a minimum. Cylindrical conductors **2** and **3** extend downwardly from the upper inner surfaces of the cavity enclosure and cylindrical conductors **4** and **5**, located directly beneath conductors **2** and **3**, respectively, extend upwardly from the lower inner surface of the cavity enclosure. The lengths of these cylindrical conductors are such as to leave large air gaps between the ends of conductors **2** and **4** and between the ends of conductors **3** and **5** thus providing capacitances between the adjacent ends. Two additional cylindrical conductors **6** and **7** are provided and are joined by a bridge **8** which is attached to shaft **9**. The cylindrical conductors are made of highly conductive metal, plated if desired, as in the case of the cavity enclosure. The conductors may be made hollow if desired to save metal and lighten the structure. The bridge **8** may be made of insulating material, as in Fig. 2, or of metal continuous with conductors **6** and **7** as shown in Fig. 3.

The shaft **9** is rotatably supported on enclosure **1** by means of bushing **10**. Adjustable collar **11** and spring washer **12** serve to maintain the bridge **8** and attached conductors **6** and **7** in the proper vertical position. The conductors **6** and **7** are made slightly less in vertical length than the air gaps between the ends of conductors **2—4** and **3—5** so that when the shaft **9** is rotated 90° counterclockwise from the position shown conductors **6** and **7** occupy the greater part of the space between the ends of conductors **2—4** and **3—5**, respectively, thus reducing the effective air gaps between these conductors to a minimum.

In order to increase the maximum capacitance obtainable between conductors **2—4** and between conductors **3—5**, cylindrical shells **13** and **14** are attached to conductors **6** and **7**, respectively, and extend substantially for the full height of the cavity so that the capacitances between conductors **2—4** and shell **13** and between conductors **3—5** and shell **14** are in parallel with and add to the corresponding gap capacities. The minimum air gaps between the shells **13** and **14** and the conductors **2—4** and **3—5**, respectively, may be conveniently fixed by making the conductors **6** and **7** slightly larger in diameter than conductors **2** through **5** by the required amount.

The extreme angular position of shaft **9** in the counterclockwise direction is that in which the conductors **6** and **7** are axially aligned with conductors **2—4** and **3—5**, respectively, and the extreme position in the clockwise direction is that shown in Figs. 1 and 2. The rotation of shaft 9 is kept within these limits by means of pin 15, stop 16 and a second similar stop not shown in the drawing but located 90° counterclockwise from stop 16.

Input and output coupling to the cavity is provided by loops 17 and 18. Probes may be employed instead of loops if desired. In event the transmission means employed are wave guides, any suitable coupling device, such as an iris, may be used between the wave guide and the cavity.

As already stated, when the shaft 9 is in its extreme counterclockwise position the conductors 6 and 7 are located directly between and in axial alignment with conductors 2—4 and 3—5, respectively. This position provides the maximum electrical capacity or charge storing facility in the cavity. The magnitude of the capacity is proportional to the end areas of cylindrical conductors 2 through 7 and the areas of shields 13 and 14, and inversely proportional to the length of the air gaps formed between adjacent cylindrical conductors and between the cylindrical conductors and shields 13 and 14. Current paths for periodic equalization of the charge of these capacitances are provided around the boundaries of the cavity. When the conductors 6 and 7 are in the above described position giving maximum capacitance, the inductance of the cavity is also at a maximum value. This is because there is a minimum blocking of the magnetic field area by conductors 6 and 7 and shields 13 and 14 in this position. Therefore, in the extreme counterclockwise position of shaft 9 the cavity has its lowest resonant frequency.

As the shaft 9 is rotated in a clockwise direction from the above position the capacity becomes continuously less due to the movement of conductors 6 and 7 from between conductors 2—4 and 3—5, respectively, and the movement of shields 13 and 14 away from conductors 2—4 and 3—5, respectively. At the same time the inductance also becomes continuously less due to the increasing restriction of the magnetic field area by conductors 6 and 7 and shields 13 and 14. The resonant frequency of the cavity therefore increases with clockwise rotation until, after rotation through 90° to the position shown in Figs. 1 and 2, the capacity and inductance of the cavity have their minimum values and the resonant frequency of the cavity has its highest value.

The tunable cavity shown in Fig. 1 is capable of wide modification. Figs. 4 and 5 show a modification in which the cavity enclosure 1' has a rectangular channel extending around its side wall large enough to receive the conductors 6 and 7. This construction makes the shields 13 and 14 of Fig. 1 unnecessary as the conductors 6 and 7 alone are capable of a high degree of magnetic field area restriction. This modification has the advantage that the shaft 9 and conductors 6 and 7 may be rotated through 360°. The modification of Fig. 3 may be used in Figs. 4 and 5 if desired.

Figs. 6 and 7 show another tunable cavity using the principles of Fig. 1. In this modification the cavity enclosure 1'' has an elliptical shape. Also, the conductors 2 and 3 of Figs. 1 and 2 are replaced by a single elliptically shaped conductor 20, and located directly beneath conductor 20 is a similar conductor 21 which replaces conductors 4 and 5 of Figs. 1 and 2. Further, a conductor 22 of the same shape as conductors 20 and 21 is used in place of conductors 6 and 7 of Figs. 1 and 2. Conductors 20, 21 and 22 are hollowed out at the center in order to reduce the minimum capacity to a low value. As in the case of Figs. 1 and 2, shields 13' and 14' are used to raise the maximum capacity and to assist in restricting the magnetic field area. In order to provide for an air gap between shields 13' and 14' and conductors 20 and 21, conductor 22 may be made slightly larger than conductors 20 and 21.

The above are not all of the modifications of the tuner possible. Considerable variation may be had in the size, shape and number of conductors in the cavity without departing from the principles of the invention.

I claim:

1. A tuning device comprising metallic means forming an oblong resonant cavity having parallelly arranged upper and lower inner surfaces; conductive means extending from opposite positions on said upper and lower surfaces and forming oppositely disposed relatively widely spaced electrodes, each of said electrodes being centered relative to the longitudinal axis of said cavity; a conductor having a length slightly less than the transverse dimension of said cavity, a thickness slightly less than the space between said oppositely disposed electrodes and a width commensurate with the cross-sectional dimensions of said electrodes; means for supporting said conductor within said cavity and for moving said conductor to any position between and including two extreme positions, one of said extreme positions being that in which the longitudinal axis of said conductor is parallel to the longitudinal axis of said cavity and said conductor is positioned between said oppositely disposed electrodes, and the other of said extreme positions being that in which the longitudinal axis of said conductor is transverse to the longitudinal axis of said cavity; and means for coupling input and output circuits to said cavity.

2. A tuning device comprising conductive means enclosing an oblong cavity having parallel planar upper and lower inner surfaces, a pair of condensers having relatively wide air gaps, each of said condensers being composed of a pair of conductors extending toward each other from opposite points on said upper and lower surfaces, said condensers being positioned along the longitudinal axis of said cavity within a distance substantially equal to the width of said cavity, an oblong conductor having a thickness slightly less than the width of said air gaps and a length slightly less than the width of said cavity, means vertically positioning and pivoting said oblong conductor at its center at a point midway between said condensers and midway of the width of the said cavity so that when the longitudinal axis of said oblong conductor is in the direction of the longitudinal axis of said cavity said oblong conductor substantially fills said air gaps and when in a direction transverse to the longitudinal axis of said cavity said oblong conductor blocks a large portion of the transverse cross-sectional area of said cavity, means for rotating said oblong conductor between its transverse and longitudinal positions to vary the resonant frequency of said tuning device, and means for coupling input and output circuits to said cavity.

3. Apparatus as claimed in claim 2 in which shields having heights slightly less than the distance between said upper and lower surfaces of said cavity are attached to the ends of said oblong conductor to provide more complete blocking of the transverse cross-sectional area of said cavity in the transverse position of said oblong conductor and to increase the capacity of said

condensers in the longitudinal position of said oblong conductor.

4. A tuning device comprising conductive means enclosing an oblong cavity having parallel planar upper and lower inner surfaces and a wall at right angles to said surfaces, a pair of condensers having relatively wide air gaps, each of said condensers being composed of a pair of conductors extending toward each other from opposite points on said upper and lower surfaces, said condensers being positioned along the longitudinal axis of said cavity and having a maximum separation greater than the transverse distance between the walls of said cavity, an oblong conductor having a thickness slightly less than the width of said air gaps and a length substantially equal to said maximum separation of said condensers, means vertically positioning and pivoting said oblong conductor at its center at a point midway between said condensers on said longitudinal axis so that when the longitudinal axis of said oblong conductor is in the direction of the longitudinal axis of said cavity said oblong conductor substantially fills said air gaps, a channel extending completely around the wall of said cavity of substantially the same width as said air gaps and of sufficient depth to permit rotation of said oblong conductor to a transverse position, means for rotating said oblong conductor between its transverse and longitudinal positions for adjusting the resonant frequency of said tuning device, and means for coupling input and output circuits to said cavity.

5. A tuning device comprising conductive means enclosing a cavity having parallel planar upper and lower inner surfaces and a wall having a channel extending completely thereabound, a pair of condensers having air gaps equal to the width of said channel, each of said condensers being composed of a pair of conductors extending toward each other from opposite points on said upper and lower surfaces, said condensers being positioned along the longitudinal axis of said cavity, an oblong conductor having a thickness slightly less than the width of said channel and said air gaps and a length substantially equal to the maximum spacing of said condensers along said longitudinal axis, means pivoting said oblong conductor at its center at a point midway between said condensers on said longitudinal axis so that when the longitudinal axis of said oblong conductor is in the direction of the longitudinal axis of said cavity said oblong conductor substantially fills said air gaps, said channel being only deep enough to permit rotation of said oblong conductor to a position transverse to the longitudinal axis of said cavity, means for rotating said oblong conductor between its transverse and longitudinal positions to vary the tuning of

said device, and means for coupling input and output circuits to said cavity.

6. A tuning device comprising conductive means enclosing a cavity bounded by parallel planar upper and lower surfaces and a wall perpendicular to said surfaces, a condenser of relatively wide air gap composed of two stationary conductors of oblong cross-section extending toward each other from said upper and lower surfaces, said oblong conductors being positioned with their longitudinal axes in alignment with the longitudinal axis of said cavity, a movable oblong conductor of length slightly less than the width of said cavity and having a thickness slightly less than said air gap, means positioning said movable conductor between said stationary conductors and pivoting said movable conductor at its center about an axis through the center of said stationary conductors whereby said movable conductor may be rotated from a position in which its longitudinal axis is in alignment with the longitudinal axis of said cavity to a position in which its longitudinal axis is transverse to the longitudinal axis of said cavity, said movable conductor serving to increase the capacity of said condenser to its maximum value in its longitudinal position and to restrict the area for magnetic field lines to a minimum in its transverse position, means for rotatably moving said movable conductor between its transverse and longitudinal positions for adjusting the resonant frequency of said tuning device, and means for coupling input and output circuits to said cavity.

7. Apparatus as claimed in claim 6 in which the oppositely disposed surfaces of said movable conductor and said stationary conductors are hollowed out about their centers to reduce the capacity of said condenser to a low value when said movable conductor is in its transverse position, and in which shields having heights slightly less than the distance between said upper and lower surfaces are attached to the end portions of said movable conductor to further restrict the area for magnetic field lines in the transverse position of said movable conductor and to increase the maximum capacity of said condenser in the longitudinal position of said movable conductor.

HARRY E. S. STOCKMAN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,227,372	Webster et al.	Dec. 31, 1940
2,367,681	Karplus et al.	Jan. 23, 1945
2,471,705	Schmitt	May 31, 1949