Nov. 13, 1951 C. A. STUTT **2,575,199**

WIDE-RANGE TUNING DEVICE FOR USE AT ULTRAHIGH FREQUENCIES

Filed Nov. 18, 1947 2 SHEETS—SHEET 1

FIG. 1.

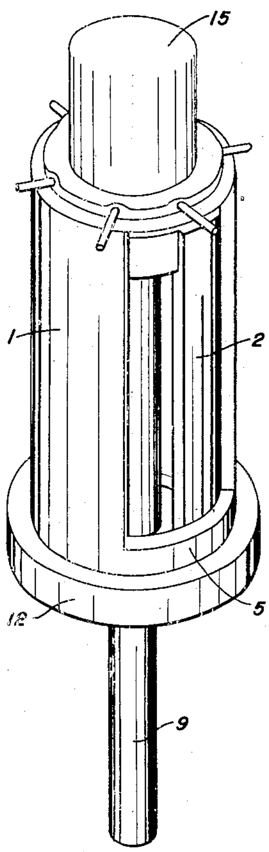


FIG. 2.

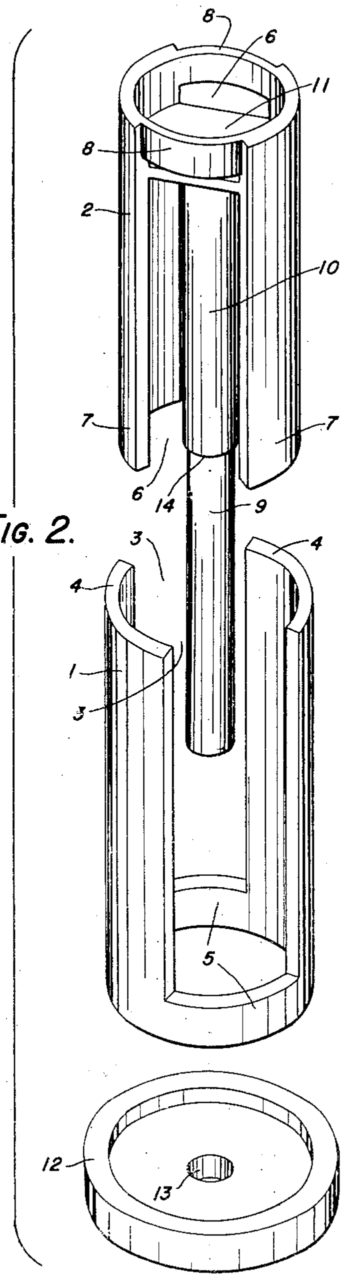
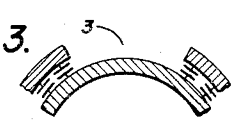


FIG. 3.



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Filed Nov. 18, 1947 2 SHEETS—SHEET 2

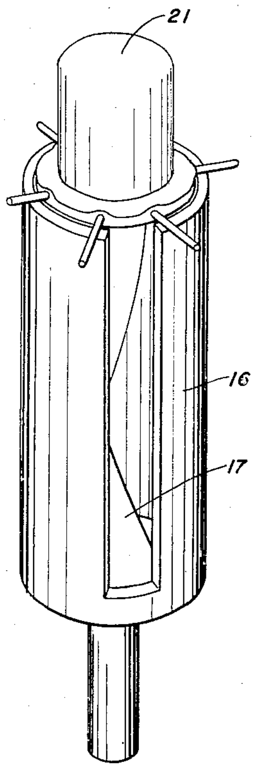

FIG. 4.

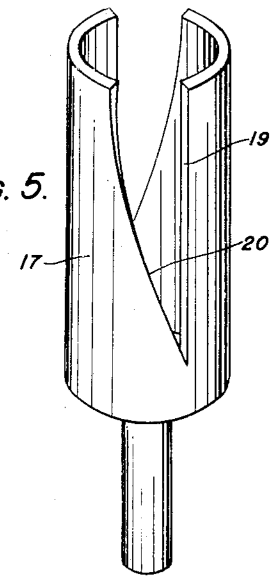

FIG. 5.

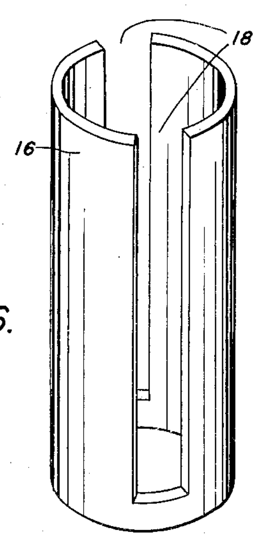

FIG. 6.

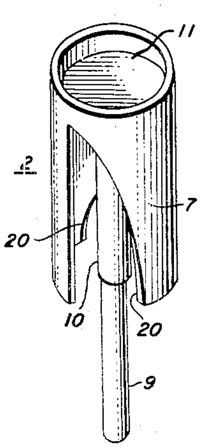

FIG. 7.

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Patented Nov. 13, 1951

2,575,199

UNITED STATES PATENT OFFICE

2,575,199

WIDE-RANGE TUNING DEVICE FOR USE AT ULTRAHIGH FREQUENCIES

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Application November 18, 1947, Serial No. 786,726

4 Claims. (Cl. 178—44)

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This invention relates to tuning devices and more particularly to relatively wide-range tuning devices for use at ultra-high frequencies.

Conventional capacitance-inductance tuner circuits are satisfactory up to frequencies of the order of 100 to 200 megacycles. At still higher frequencies it is difficult to make conventional circuits function properly and there is an upper frequency limit beyond which satisfactory operation is unobtainable. Electron discharge devices available for use in ultra-high frequency circuits, by which is meant the region extending from about 250 to about 3000 megacycles, are such that the design of tuning circuits involve not only electrical but also mechanical considerations because electrical and mechanical problems are intimately related in such designs. The structure of such electron discharge devices often varies greatly from more conventional shapes and arrangements in order, for example, to reduce inter-electrode capacitance, lead inductance, and transit time whereby the resulting structures sometimes present difficult design problems for tunable circuits associated therewith.

It is an object of my invention to provide a new and improved tuning device for use in ultra-high frequency systems.

Other objects of my invention are to provide a new and improved tuning device of the type referred to which is simple, compact, employs no sliding contacts, is mechanically sound with respect to bearing thrust effects, is positive of adjustment, and embodies improved adaptability to and better utilization of the high frequency capabilities of available tubes such as the "acorn" type, for example.

In carrying out the objects of the present invention, there is provided a tuning device which, generally, comprises a pair of cylinders each of which has diametrically opposed slots extending from one end of the cylinder to the vicinity of the opposite end of the cylinder, the cylinders being arranged one within the other, and one being provided with means for causing rotation thereof with respect to the other. In one embodiment of my invention, the open end of one slotted cylinder is adjacent the closed end of the other slotted cylinder, thereby providing a tuning device in which both capacitance and inductance are varied. In a second embodiment of my invention, the open ends of both cylinders are placed adjacent each other so that there is provided a tuning device in which only the inductance is varied, and the leading side or edge of each slot in the rotor is curved, whereas the

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other or trailing edge of each rotor slot is substantially parallel to the axis of rotation.

Further objects and advantages of my invention will become apparent as the following description proceeds, and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of my invention, reference may be had to the accompanying drawings in which:

Fig. 1 illustrates one embodiment of my invention;

Fig. 2 is an exploded view of the device shown in Fig. 1;

Fig. 3 is a graphical representation of a modification of Figs. 1 and 2 and is helpful in understanding the principles of my invention;

Fig. 4 is a second embodiment of my invention;

Fig. 5 shows a rotor suitable for use in the device of Fig. 4;

Fig. 6 depicts a satisfactory stator member for use in the assembly shown in Fig. 4.

Fig. 7 illustrates a modification of the rotor cylinder or member shown in Figs. 1 to 3, inclusive, incorporating the inclined or curved edge of the embodiment shown in Figs. 4 and 5.

Refering to the first embodiment of my invention illustrated in Figs. 1 and 2, there is disclosed a wide-range tuning device whose tuning is achieved through simultaneous variations of capacitance and inductance. The tuning device comprises two slotted concentric cylinders of suitable material, the outer cylinder 1 being fixed in position and the inner cylinder 2 being rotatably mounted, in any suitable manner, (not shown). The diameters of the cylinders are proportioned to avoid physical contact. The stator member is provided with a pair of diametrically opposed slots 3 extending axially from one end of the stator toward the vicinity of the other end of the cylinder 1, thereby providing a substantially U-shaped member having segments or arms 4 and connecting portions 5. The rotor member is similarly provided with diametrically opposed slots 6, the slots also extending axially from one end of the rotor cylinder or member 2 toward the other end of the cylinder 2. Again, this construction results in a substantially U-shaped member having segments or arms 7 and connecting portions 8.

The rotor member 2 is properly oriented inside the stator member 1 when its closed end is located adjacent the open or high potential end of the stator member 1 as best seen in Fig. 2.

The rotor is tunable as by means of a suitable shaft 9 having an enlarged portion 10 suitably connected at its upper end, as viewed in Fig. 2, to a suitable base portion 11 arranged or disposed adjacent the closed end of the rotor 2. The bottom end of the stator member is, as viewed in Fig. 2, closed by a suitable base 12 composed of any suitable material such as a low-loss dielectric or a conducting material such as brass or aluminum, for example. Shaft 9 extends through a suitable opening 13 in the member 12, the shoulder portion 14 of the enlarged portion 10 of the tuning shaft engaging the bottom surface of the member 12 around the opening 13. The parts may be maintained in asembled relationship in any suitable manner.

The tank capacitance of the circuit disclosed in Figs. 1 and 2 is that which appears across the open end of the stator segments 4 and the capacitance introduced by the rotor and the fixed capacitance of any electron discharge device or other accessories placed across the open end of the stator as represented by the numeral 15. The tank inductance is that of the loop formed by the slotting operation on the stator. Conditions for minimum frequency (maximum inductance and capacitance) are those in which the rotor segments are opposite the stator segments, in which position the rotor causes maximum capacitance across the open end of the stator. The stator inductance is also a maximum because the slots are unobstructed. Conditions for maximum frequency (minimum inductance and capacitance) are those in which the rotor has been turned so that its segments are opposite the stator slots, in which position the rotor adds a minimum capacitance across the stator and by obstructing the stator slots the inductance is reduced to a minimum. With the arrangement shown in Figs. 1 and 2 in which the width of the slots is substantially the same as the width of the segment tips a ninety degree rotation is required to tune from one frequency extreme to the other. The leading edges of the rotor segments may be spiralled or curved or otherwise formed in order to obtain a predetermined rate of change of a predetermined electrical characteristic such as a desired frequency distribution.

While the arrangement shown in Figs. 1 and 2 is one in which the stator and slot widths are substantially the same, greater tuning range can be achieved by making the segments of the rotor wider than the slots of the stator, or vice versa. With such an arrangement, when the rotor is turned to the high frequency position there is an overlap as indicated in Fig. 3 Under this condition, the capacitance across the slot due to the overlap is of such magnitude that it tends to by-pass part of the stator inductance and thereby lowers the effective inductance. It should be noted that this lowering of effective inductance is in addition to the inductance reduction caused by the obstruction of the slot. At first thought it might seem that wider segments should also lower the minimum frequency since the enlarged segments give greater capacitance at the low frequency position, but it has been found that as soon as the segment width is increased at the expense of slot width, the stator inductance has been reduced by the modification so that the net result is little change, if any, in minimum frequency.

Actual data may be of interest in connection with a full understanding of the principles of the device shown in Figs. 1 and 2. Thus two

tuners have been adapted to type 6F4 acorn tubes. Each has a stator diameter of one inch, a rotor diameter of .735 inch, stator-rotor spacing of 0.0075 inch, and a slot length of 1.75 inches. One tuner is provided with 90° segments and slots, i. e., slot width is substantially the same as segment width, and the resulting tuning range is 273 to 700 megacycles. The other embodies rotor segments which are 120° wide and slots 60° wide, the resulting tuning range being 285 to 810 megacycles. The rotor slots may be provided with inclined or curved edges 20 as shown in Fig. 7.

Referring to Figs. 4, 5, and 6 there is illustrated a different embodiment of a wide-range tuner which is arranged to vary only the inductance of the tunable circuit. There is provided a stator member 16 and a rotor member 17 concentrically arranged one within the other in a similar manner to that described in connection with Figs. 1 and 2. For convenience the mounting means is omitted, but any suitable arrangement may be employed. The stator is provided with diametrically opposed slots 18, the segments of the rotor being wider than the slots so that when the members are assembled in their proper positions the over-lapping portions add capacitance across the stator slots as indicated in Fig. 3. As was the case in the first described embodiment, there is no physical contact between the rotor segments and the stator. The rotor slots are formed so that the trailing edge is substantially parallel to the axis of the rotor as indicated by the numeral 19 and the leading edge is slantwise with respect to edge 19 or spiralled or curved as indicated by the numeral 20 to provide a predetermined rate of change of a predetermined electrical characteristic as explained below.

The tuner disclosed in Figs. 4 to 6, inclusive, may be considered to comprise a parallel-wire transmission line having associated therewith an adjustable capacitance short to vary the frequency, the cylinder segments representing the conductors of the line and the capacitance short being provided by the cylindrical slotted rotor. The curved or slantwise edge 20 results in a gradual movement of the short along the line. The capacitance must be large enough so that there is an effective short at the frequency of operation. This condition is satisfied, as explained above, by providing adequate overlap and relatively small spacing between the rotor and stator members. With this arrangement the tuner may be designed to have as much as 135° rotation, as when the stator slots are 30° each in the circumferential direction, the rotor segments being 60° at the open end, the leading edges of the rotor being spiralled.

This second embodiment has also been employed with a type 6F4 acron tube as generally indicated by the numeral 21. In two examples, the stators are 1 inch in diameter, the rotors 0.75 inch in diameter, the rotor spacing being .005 inch and the slot length 2½ inches. The two devices tune from 660 to 960 megacycles and from 560 to 1100 megacycles, respectively. With the second mentioned device, the lower frequency limit was decreased by widening the stator slots and the upper limit was increased by shortening the path length to the tube electrodes as much as possible and by effectively moving the short in closer to the tube through the use of greater rotor-stator overlap at the high frequency position.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention in its broaded aspects. For example, the stator may be located within the rotor. I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim is:

1. A wide-range tuning device for ultra-high frequencies comprising a cylindrical electrically conductive stator member having a pair of diametrically opposed slots extending from one end of the stator to the vicinity of the other end thereof, a cylindrical electrically conductive rotor member having a pair of diametrically opposed slots extending from one end of the rotor to the other end thereof, said rotor being coaxially disposed for operative movement with respect to said stator, at least a portion of one edge of each slot of one of said members being inclined in the direction of the other edge and said other edge of each slot of said one member being substantially parallel to the axis of said rotor, and means for rotating said rotor with respect to said stator.

2. A wide-range electrical circuit tuning device for ultra-high frequencies comprising a cylindrical electrically conductive open ended stator member having a pair of diametrically opposed slots extending from one end of the stator to the other end thereof, a cylindrical electrically conductive open ended rotor member having a pair of diametrically opposed slots extending from one end of the rotor to the other end thereof, said rotor being coaxially disposed for operative movement with respect to said stator, the closed end of one member being disposed adjacent the open end of the other member, at least a portion of the leading edge of the slots of one of said members being inclined with respect to the other edge to provide a predetermined rate of change of frequency, and means for rotating said rotor with respect to said stator.

3. A wide-range electrical circuit tuning device for ultra-high frequencies comprising a cylindrical electrically conductive open ended stator member having a pair of diametrically opposed slots extending from one end of the stator to the other end thereof, a cylindrical electrically conductive open ended rotor member having a pair of diametrically opposed slots extending from one end of the rotor to the other end thereof, said rotor being coaxially disposed for operative movement with respect to said stator, means for rotating said rotor with respect to said stator, the open end of one member being disposed adjacent the open end of the other member, and at least a portion of one edge of each slot of one of said members being inclined with respect to the other edge of each slot to provide a predetermined rate of change of frequency.

4. A wide-range electrical circuit tuning device for ultra-high frequencies comprising a cylindrical electrically conductive open ended stator member having a pair of diametrically opposed slots extending from one end of the stator to the other end thereof, a cylindrical electrically conductive open ended rotor member having a pair of diametrically opposed slots extending from one end of the rotor to the other end thereof, said rotor being coaxially disposed for operative movement with respect to said stator, means for rotating said rotor with respect to said stator, the open end of one member being disposed adjacent the open end of the other member, said rotor slots having the trailing edge substantially parallel to the axis of said rotor, and the leading edge curved toward the trailing edge to provide a predetermined rate of change of inductance as said rotor is moved with respect to said stator.

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