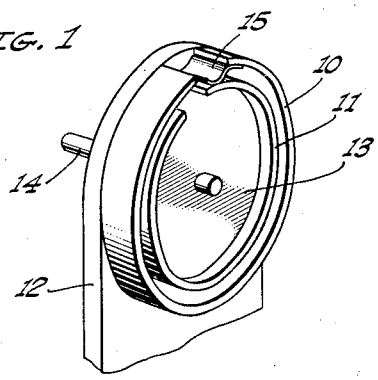
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ULTRA HIGH FREQUENCY TUNER

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FIG. 1



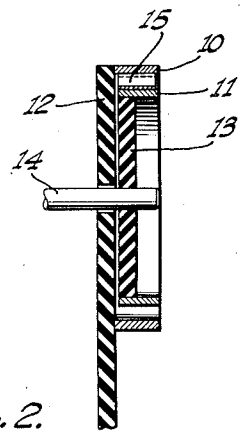


FIG. 2.

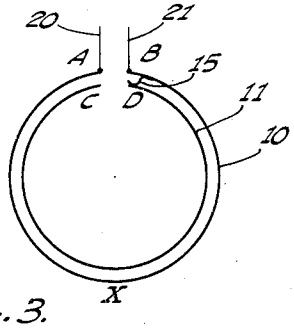


FIG. 3.

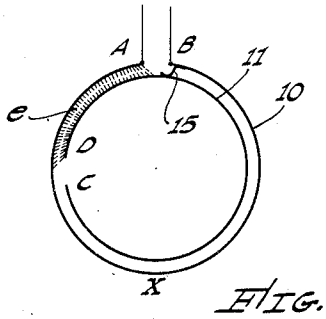


FIG. 4.

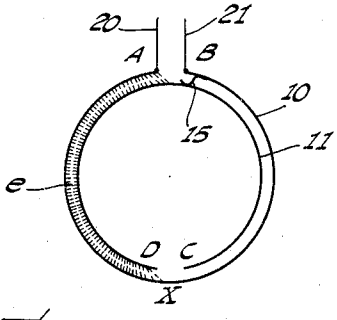


FIG. 5.

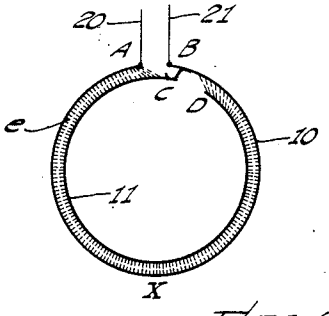


FIG. 6.

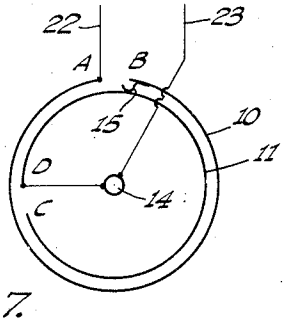


FIG. 7.

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FIG. 8.

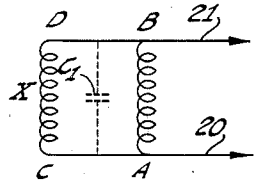


FIG. 9.

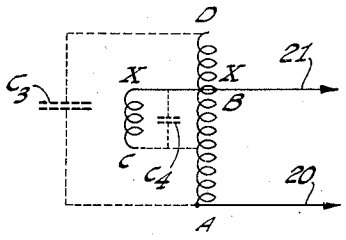


FIG. 10.

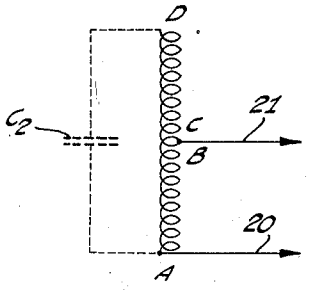
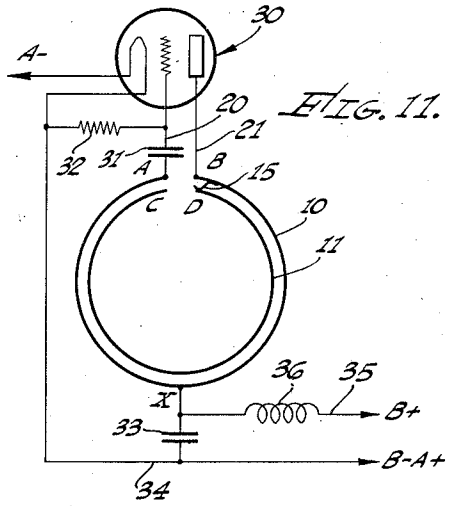


FIG. 11.



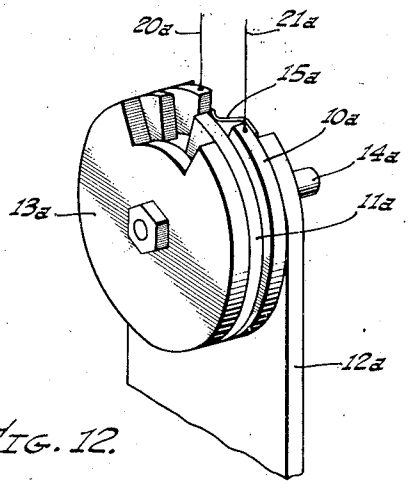


FIG. 12.

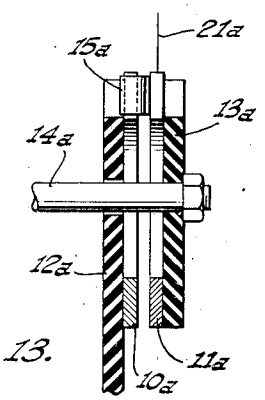


FIG. 13.

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2,482,393

ULTRA HIGH FREQUENCY TUNER

Frank Wilburn, Los Angeles, Calif.

Application March 4, 1946, Serial No. 651,908

8 Claims. (Cl. 250—40)

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This invention relates generally to ultra high-frequency tuners and oscillators.

Resonant circuits of the conventional type using coils and condensers fail to operate satisfactorily above about 100 megacycles, and efforts have been made in the past to provide tuners more suitable for the range of 100 to 1000 megacycles. The quarter-wave coaxial cable is known to constitute a satisfactory electrical solution to the problem, though it involves complications of a mechanical nature. Another class involves, speaking generally, a parallel tuned circuit wherein the inductive and capacitive features are combined in a pair of relatively movable structural elements. It is to this latter class that the present invention particularly appertains.

A general object of the invention is to provide an improved ultra high-frequency tuner of the type mentioned characterized by increased tuning range and high Q.

A further object is to provide such a tuner which is extremely simple in mechanical construction and relatively inexpensive to manufacture.

A further object is to provide an improved ultra high-frequency tuner in which a pair of relatively rotatable tuning members are capable of simultaneously increasing both the inductance and the distributed capacity of the combination.

A still further object of the invention is to provide an ultra high-frequency tuner wherein the voltage is at substantially its maximum value in the high-frequency position.

Another object is to provide a tuner which approaches a substantially uniform output throughout a wide tuning range.

The invention in its preferred form provides a pair of relatively rotatable inductor elements of one turn each, which may, in effect, be progressively converted from parallel to series connection to increase their inductance, while at the same time the distributed capacity between them is increased through a substantial range. A great tuning range is thereby achieved, while at the same time the device is highly efficient and characterized by an unusually high Q.

The invention will be most readily understood by referring now to the following detailed description of certain present preferred forms thereof, reference being had to the accompanying drawings in which:

Figure 1 is a diagrammatic perspective view of one simple embodiment of the invention;

Figure 2 is a vertical medial section through the device shown in Fig. 1;

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Figures 3 through 6, inclusive, are diagrammatic views illustrative of certain operative positions of the device;

Figure 7 is a view similar to Fig. 4 but showing a modified method of making electrical connection to the device;

Figures 8, 9 and 10, inclusive, are electrical diagrams showing substantially the electrical equivalents of the device in several different operating positions;

Figure 11 is a diagram showing the use of the device as the coil of an oscillator;

Figure 12 is a somewhat diagrammatic perspective view of a modification; and

Figure 13 is a vertical medial section through the device of Fig. 12.

With reference first to the embodiment of the invention shown in Figs. 1 through 8, the tuner comprises a stator 10 and a rotor 11, each comprising a one-turn inductor loop, and being in this instance in the form of coaxial and concentric split or slotted cylinders, annularly or circumferentially spaced from one another a short distance as indicated. The split in each cylinder forms a one-turn loop with spaced end portions forming a gap. These members 10 and 11 may be referred to generally as coaxial ring sectors, and as will later become evident, they are sufficiently close spaced as to have substantial inductive and capacitive effects on one another throughout the frequency band of interest. In general, the spacing between the ring sectors will not be in excess of twenty percent of the inside diameter of the outer cylinder. The cylinders may be of various lengths, or, to achieve particular capacitive characteristics, of varying widths circumferentially, though they are here shown in a simple form having comparatively short length and uniform width. In general, the effect of increasing width is to increase the capacitance and thereby reduce the lowest frequency of operation, without, however, appreciably affecting the highest frequency of operation. As diagrammatically indicated in Fig. 2, stator 10 may be secured at one circumferential edge, as by cementing, to an insulation mounting plate 12, and rotor 11 is tightly mounted on an insulation disk 13 fixed on coaxial operation shaft 14. In the specific embodiment of Figs. 1 through 7, one end of stator 10 carries a spring contact or brush 15 bearing on the periphery of rotor ring 11. This device constitutes a resonator, the dimensions being usually such as to afford a natural period of resonance above 30 megacycles.

In Figs. 3 through 6, which are diagrams in-

dicating several relative positions of the stator and rotor, the two ends of the one-turn stator inductor 10 are identified by letters A and B and the two corresponding ends of the one-turn rotor inductor 11 are designated by letters C and D, the midpoint of the stator 10 being designated by letter X. Assuming use of the tuner as an absorption wave meter, external terminal connections for a suitable indicating instrument may be made to the stator 10 at points A and B, as has been indicated by the short leads 20 and 21. As will become evident as the description proceeds, the tuner presents a high parallel resonant impedance across points A and B, and while alternative modes of making connection to the device are feasible, that indicated has certain advantages as will appear.

The extreme high frequency position of the device is shown in Fig. 3, and the extreme low frequency position thereof appears in Fig. 6, with intermediate positions shown in Figs. 4 and 5. In the position of Fig. 3, the slots or air gaps in the stator and rotor are directly alined, i. e., opposite one another, and it will be evident that all corresponding points around the circumference of the two one-turn inductor loops are equipotential. The sliding contact or brush 15 might therefore theoretically be one of a multiplicity of such contacts placed at all positions around the inductor loops without affecting the electrical characteristics of the device, no current flow occurring between stator and rotor by way of such brush or brushes. In this position of the tuner as a whole, it comprises a coil of one turn, with minimum capacitance. Corresponding points of the stator and rotor being equipotential about the circumference, there is no electric field between them in a radial direction. The tuner is not, of course, entirely without capacitance in this position, since circumferentially spaced points around the stator and rotor will be at different potentials, and particularly between their end portions there is some electric field. Such field is relatively weak, however, and the capacitance is in any event at a minimum in the position of Fig. 3.

Fig. 4 shows the inner inductor loop or rotor rotated 90° counterclockwise from the position of Fig. 3. The two ends of the circuit are now at points A and D, and the circuit is traced counterclockwise from A to B, then through the brush 15, and finally to D, it being seen that the inductance has been increased by adding one quarter of a turn to the original one-turn coil. At the same time, capacitance has been added to the circuit, as represented by the overlapped areas of the inductor loops between A and D, where an electric field is now established, as indicated by the dotted lines *e*. The remaining space between the stator and rotor is in the original condition, that is, equipotential for all points opposite one another, and has therefore no tuning effect upon the circuit.

Figs. 5 and 6 show the rotor rotated, respectively, 180° and substantially 360° counterclockwise from the position of Fig. 3, and illustrate, in the instance of Fig. 5, an increase in the coil to one and one-half turns, with an increase in capacitance as indicated by the increased area of electric field lines *e*, and in the instance of Fig. 6, an increase in the coil to substantially two turns, with a corresponding increase in capacitance as represented. In the latter instance, all of the space between the two inductor loops provides effective tuning capacity, the inductance having been increased over that provided in the position

of Fig. 3 by increasing the effective length of the coil to substantially two complete turns, and the tuner having reached its minimum frequency position.

It will be evident that the stator 10 and rotor 11 may be regarded as one-turn inductors, with increasing portions of one of the inductors added in series with the whole of the other as the tuner is moved from the position of Fig. 3 to that of Fig. 6. At the same time, the self or distributed capacity of these inductors is increased from a minimum in the position of Fig. 3, wherein the equipotential condition of all points on the rings directly opposite one another eliminates capacitive effect, to a maximum in the position of Fig. 6. Figs. 8, 9 and 10 are diagrams representing the electrical circuit equivalents of the tuner for the positions of Figs. 3, 5 and 6, respectively. As represented in Fig. 8, the two inductors AB and CD are, in effect, parallel connected, with the external connections 20 and 21 made to points A and B, across which the high parallel resonant impedance is obtained. The small and nearly negligible distributed capacity for the position of Fig. 3 is represented in dotted lines at C_1. The inductance and capacitance both being at a minimum, the tuning frequency of the tuner is at its maximum. For the position of Figs. 6 and 10, the whole of the inductors AB and CD are series connected, and across these series connected inductors is the relatively high self or distributed capacitance represented in dotted lines at C_2. Fig. 9 is representative of intermediate positions, in particular, that of Fig. 5. In this instance, in effect, inductor AB is in series with one-half of inductor CD, i. e., with the section XD, while the remaining section XC of the inductor CD remains in parallel with inductor AB. A relatively large capacitance (half that for the position of Fig. 6) appears across the series connected inductors, as indicated at C_3. The relatively smaller distributed capacitance of the inductor section XC that remains, in effect, in parallel with the inductor AB, is indicated at C_4. Thus in rotating the tuner from the position of Fig. 3 to that of Fig. 6, the two inductors AB and CD are progressively changed from parallel to series connection with corresponding increases in inductance, while the distributed capacitance of the inductors is at the same time increased from a nearly negligible value to a maximum. The tuner is therefore characterized by a very great tuning range.

Another advantage inherent in the embodiment already described is the fact that the external connections 20 and 21 are made across the fixed points A and B of the tuner, which are the extreme ends of the resonant circuit for the position of Fig. 3, but which will be one end of the circuit and a fixed point increasingly distant from the other end of the circuit as the tuner is rotated toward the position of Fig. 6. This is of advantage, especially when the tuner is used as an oscillator, since the maximum voltage will appear across the stationary terminals for the highest frequency (Figs. 3 and 8) where the tendency to oscillate is generally least. In other words, the output from the resonant circuit tends to remain uniform over the entire frequency range, being at its maximum in the high frequency position, where maximum feed back and highest efficiency are most desired.

In Fig. 7 is shown an alternative mode of connection, wherein one external lead 22 is connected to point A, and another external lead 23 is connected to the rotor shaft 14 which is in

turn connected by lead 24 to the point D of the rotor. In this instance, therefore, the external circuit is at all times across the extreme ends of the resonant tuner circuit.

In another embodiment, the stator and rotor as well as the external connections 20 and 21 may be as in Figs. 3 to 6, but the sliding contact 15 is omitted, there being no conductive connection between stator and rotor. Since this embodiment may be understood simply by disregarding the brush between rings in the embodiment of Figs. 1–3, no separate illustration thereof is deemed necessary herein. With such an arrangement, the inductance is always of but a single turn, the only variable being the capacitance between the two rings, which reaches a maximum with 180° of rotation (Fig. 5).

The tuner as described has a Q of extremely high value, not exceeded, insofar as I am aware, by any previously known device of similar type save the quarter-wave concentric line. By reason of the fact that its capacitance increases over a substantial range from a low minimum to a maximum while the coil is being progressively converted from one to two turns, the tuning range is very great.

In Fig. 11, I have indicated the typical use of the tuner as a three terminal oscillator coil, such as used in the Hartley oscillator. The grid and plate of a suitable oscillator tube 30 are connected to the terminal leads 20 and 21 leading from the ends A and B of tuner status 10. The tuner in this instance is of the type shown in Figs. 1–6, having rotor 11 and brush 15. A grid condenser 31 and grid leak resistor 32 are shown in a conventional arrangement. The arbitrary mid-point X of the stator is connected through high frequency by-pass condenser 32 to cathode lead 34, and the B+ lead 35 is connected to the point X, as indicated, a radio frequency choke coil 36 being included in lead 35. The grid and plate are thus across a fixed portion (one turn) of the tuning inductance, with a center tap at the point X, giving an arrangement basically similar to the Hartley oscillator, but with a tuner suitable for the range of 100 to 1,000 megacycles.

Figs. 12 and 13 show a modification wherein the stator and rotor rings are in the physical form of radially split washers or annuli 10*a* and 11*a*, arranged coaxially in close-spaced parallel relation to one another. These members 10*a* and 11*a* may also be regarded generally as coaxial ring sectors. The annulus 10*a* is mounted on a suitable insulation support 12*a*, and the annulus 11*a* is secured to an insulation disk 13*a* tightly mounted on operating shaft 14*a*. Annulus 10*a* carries at one end a brush 15*a* which makes sliding contact with the face of annulus 11*a*. Electrical connections 20*a* and 21*a* may be made to the two ends of annulus 10*a*, as diagrammatically indicated in Fig. 12. Electrically, the embodiment of Figs. 12 and 13 is the equivalent of that shown in Figs. 1–6.

Other forms and embodiments are of course contemplated as falling within the broad scope of the invention and within the spirit and scope of the appended claims.

I claim:

1. A tuner for controlling frequencies throughout a frequency band in the megacycle range embodying a pair of coaxial ring sectors sufficiently close-spaced to one another to have substantial inductive and capacitive effects on each other throughout said frequency band, an electrical connection between said sectors comprising a brush fixed to one of the sectors and in wiping relationship to the other sector, and means mounting one of said sectors for relative rotation with respect to the other about their common axis.

2. The tuner defined by claim 1 wherein said ring sectors comprise split concentric cylinders defining a gap between them, said cylinders being of such diameters that the spacing between them is not in excess of 20% of the inside diameter of the outer cylinder.

3. The tuner defined by claim 1 in which said sectors and their associated brush constitute a resonator and are of such dimensions as to have a natural period of resonance above 30 megacycles.

4. A tuner as defined by claim 1 for controlling the frequency of a circuit, a portion of which circuit is external to the tuner and in which the said sectors and their associated brush constitute a frequency controlling unit, and means for connecting that portion of the circuit which is external to the tuner to spaced points on said unit.

5. A tuner as defined by claim 1 wherein the ring sectors comprise annuli of equal diameter disposed in close-spaced parallel planes normal to their common axis.

6. A tuner as defined by claim 1 for controlling the frequency of a circuit a portion of which circuit is external to the tuner and in which said sectors and their associated brush constitute a frequency control unit, said sectors comprising split concentric cylinders defining a gap between them of not more than 20% of the inside diameter of the outer cylinder and being of such size as to effect a natural resonance period above 30 megacycles. and means connecting said portion of said circuit to opposite faces of the split of the outer cylinder.

7. A tuner as defined in claim 1 for controlling the frequency of a circuit a portion of which is external to the tuner, including means for connecting that portion of the circuit which is external to the tuner between a point on the sector to which the brush is fixed which point is remote from the point of contact of the brush and a point on the other sector.

8. A tuner as defined by claim 1 for controlling the frequency of a circuit, a portion of which circuit is external to the tuner, including means for connecting that portion of the circuit which is external to the tuner between opposite faces of the gap in the sector to which said brush is fixed.

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