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ULTRA HIGH FREQUENCY RESONANT CIRCUIT

Filed June 28, 1946

Fig. 1.

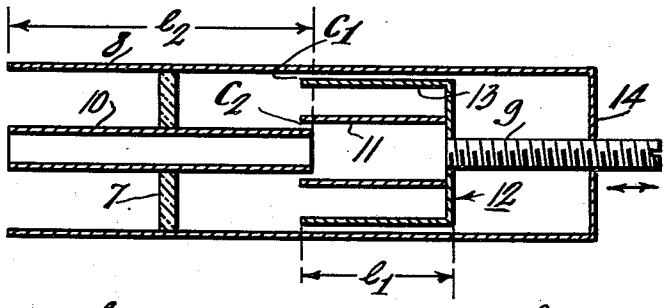


Fig. 2a.

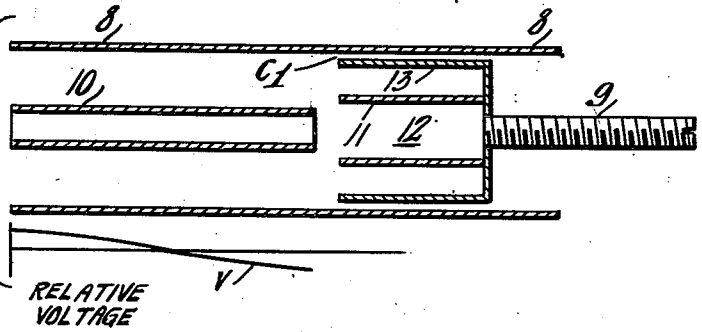


Fig. 2b.

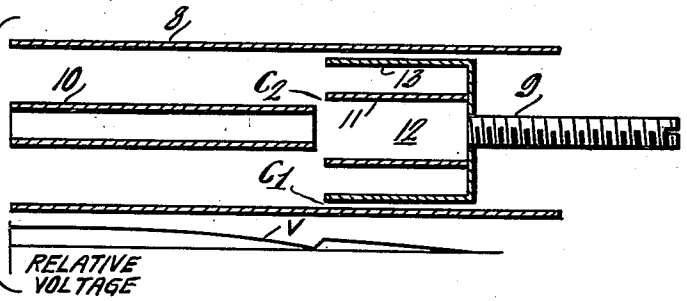
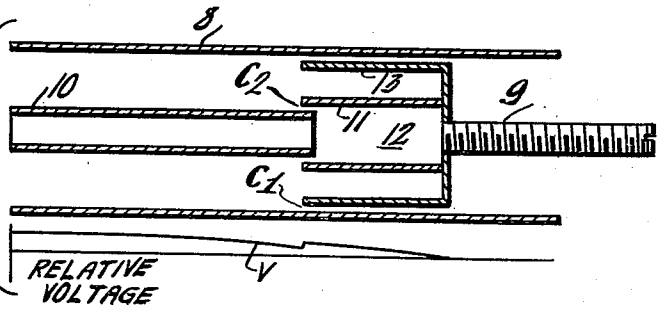


Fig. 2c.



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ULTRA HIGH FREQUENCY RESONANT CIRCUIT

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4 Claims. (Cl. 178—44)

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This invention relates to resonant circuits, and particularly to a resonant circuit of the concentric line type.

Among other objects of the invention are:

To provide a resonant circuit for use above 300 megacycles which has a frequency tuning range greater than two and somewhat less than 3;

To provide a concentric line resonator which eliminates the need for sliding contacts to engage the inner and outer conductors and which has a wider tuning frequency range than known concentric line resonant circuits which do not have sliding contacts.

To provide a concentric line type of resonator which is more compact than a cavity resonator for the same frequency of operation and which requires a relatively smaller mechanical motion to cover the entire tuning range than known types of concentric line resonators.

A more detailed description of the invention follows in conjunction with a drawing wherein:

Fig. 1 illustrates a tunable resonator circuit in accordance with one embodiment of the invention, and

Figs. 2*a*, 2*b* and 2*c* illustrate the resonant circuit of Fig. 1 for three different conditions of tuning.

Referring to Fig. 1, there is shown a concentric line type of resonant circuit in accordance with the invention, having an outer conductor 8 and a concentric inner conductor composed of a member 10 terminating without conductors, as shown, and a cup-shaped member 12. The cup-shaped member 12 comprises a hollow inner conductor 11 which is slightly larger than the diameter of the member 10, and a surrounding outer hollow conductor 13 which is slightly smaller in diameter than the hollow conductor 8. If conductor 8 and conductor 10 are circular in cross-section then it is preferred that conductors 11 and 13 of cup 12 also be circular in cross section. If, on the other hand, conductors 8 and 10 are rectangular in cross-section, it is preferred that conductors 11 and 13 also be rectangular in cross-section.

Rod 10 is supported at its center and maintained in spaced relation with respect to the outer conductor 8 by means of an insulating ring or spider 7 fixedly positioned between the conductors 8 and 10. The conductor 11 is sufficiently large to permit movement of this conductor over the right-hand end of conductor 10 without making contact with this rod. The capacity between the conductor 10 and the conductor 11 is designated by C2. The hollow conductor 13 of the cup 12 is similarly spaced from the surrounding outer conductor 8 and forms therewith a capacity C1. The cup 12 is movable along the axis of the resonant circuit in the direction of the arrows by means of an insulating rod 9 which is secured to the cup and which is slidable within an end plate 14 attached to the surrounding outer conductor 8. It should be noted that as the conductor 12 is moved toward or away from the right-hand end of the conductor 10, the capacity C2 will vary from a very low value to a relatively high value.

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In practice, the length of the cup 12 which is designated L1 is approximately one-half the length of the rod 10 which is designated L2. The length L2 of the rod 10 is one-half wave length at the highest frequency of operation, while the length L1 of cup 12 is less than one-fourth of a wave length at the highest frequency of operation.

An inspection of Fig. 1 will show that when the cup 12 is arranged in the position shown, the inductance of conductor 10 will be in series with the capacitor C2, in series with the inductances of hollow conductors 11 and 12, and in series with the capacitor C1. Capacitor C1 is a relatively large capacity and has a value appreciably larger than capacitor C2.

Fig. 2*a* illustrates the voltage distribution curve of the resonant circuit when the cup 12 is pulled away from the right-hand end of rod 10 so as to have no effect on the resonant circuit. In this condition, the voltage curve of the resonant circuit is indicated by V which represents the distribution of the voltage along the rod 10. In this position, the frequency of the resonant circuit is the highest. Capacitors C1 and C2 do not enter into consideration in the particular position of Fig. 2*a* because of the large spacing between conductor 10 and cup 12.

Fig. 2*b* illustrates the condition where the cup 12 is sufficiently close to rod 10 so that the capacity between the rod 10 and cup 12 tunes out the inductance of the conductors of cup 12. In this

condition, the system is so tuned that the frequency of operation corresponds to rod 10 being one-fourth of a wave length. This frequency is an intermediate frequency for the tuning range of the resonant circuit.

Fig. 2c shows the condition of tuning which is opposite to that of Fig. 2a; namely, where the tuned circuit is resonant to the lowest frequency of operation in the tuning range. An inspection of the voltage curve distribution V of Fig. 2c will show that the entire length of L1 plus L2 corresponds to one-fourth of a wave length at the operating frequency.

As an illustration only, assuming that the resonant circuit of the invention is designed to operate over a frequency range of 300 megacycles to 850 megacycles, L2 will be slightly larger than one-sixth of a meter long, while L1 will be slightly less than one-twelfth of a meter, both L1 and L2 together having a total length of one-fourth of a meter. It will thus be seen that L2 is approximately twice as long as L1.

In practice, it is necessary to move the cup 12 only a very short distance in order to overlap the right-hand end of rod 10 for obtaining the lowest frequency of operation in the tuning range. This is shown in Fig. 2c. Any further increase in capacity of C2 caused by further movement of the cup 12 over the rod 10 will cause further shortening of the effective length of the resonant circuit and hence, increase in frequency. In using the resonator, of the invention, it is preferred that the point of minimum frequency not be passed by moving cup 12 too far to the left over the adjacent end of rod 10. The preferred modus operandi is to have the tuning range extend from the condition shown in Fig. 2a where L2 equals one-half wave length at the highest frequency to the condition shown in Fig. 2c where L1 plus L2 equals one-fourth of a wave length at the lowest frequency. In the variation between the highest frequency to the lowest frequency in the tuning range, the operation is smooth and continuous.

The resonant circuit of the present invention eliminates the need for sliding mechanical contacts between inner and outer conductors and requires only a small mechanical motion to cover the entire tuning range of frequencies. By way of illustration, the motion of cup 12 need be only one-half inch to cover a range from 300 megacycles to 850 megacycles with suitable dimensions of the conductors and suitable spacing of these conductors to provide condensers C2 and C1, whereas the conventional type of resonant circuit may need a movement of five inches or more to cover a considerably narrower band of frequencies. It has further been found that the system of the invention is much more compact than a cavity resonator designed to operate at an equivalent frequency of operation.

A feature of the present invention lies in the fact that the resonant circuit decreases in frequency with decreasing overall effective length which is a condition opposite to concentric line tuned circuits wherein a decrease in frequency requires an increase in effective length of the tuned circuit.

The resonant circuit of the invention is not limited to any particular range of frequencies and may be designed to operate anywhere in the range up to 10,000 megacycles. The tuning range of the resonant circuit of the invention is about 2.8 to 1 which provides a frequency coverage considerably greater than known types of concentric lines resonators which do not use sliding contacts. Thus a resonator in accordance with the invention can be constructed over a range of 300 megacycles to 850 megacycles or a range of 1,000 megacycles to 2,800 megacycles.

The load may be coupled to the resonator of the invention by connecting the grid and anode of a vacuum tube to the left-hand end of the outer conductor 8 and the rod 10 where the resonant impedance is large, or by inserting a loop between the outer conductor 8 and the rod 10 at an intermediate position where the current at resonance is relatively large.

What is claimed is:

1. A tunable resonant circuit comprising a coaxial line having an outer conductor and an inner conductor terminated therewithin, and a tuning structure axially movable with respect to said line and comprising a tubular outer conductor spaced from and capacitively coupled to said first outer conductor and a coextensive tubular inner conductor within said outer conductors, a direct connection between said tubular conductors at one end, said tubular inner conductor having a hollow end portion at the end opposite said direct connection and facing the termination of said first inner conductor, the cross-section of said tubular inner conductor being sufficiently different from said first inner conductor to permit overlapping without contact therebetween with a consequent capacitive coupling therebetween.

2. A tunable resonant circuit comprising a coaxial line having an outer conductor and an inner conductor terminated therewithin, and a tuning structure axially movable with respect to said line and comprising a tubular outer conductor insulatingly spaced from and within said first outer conductor and capacitively coupled thereto and a substantially coextensive tubular inner conductor within said first outer conductor and having a physical length approximately one-half that of said first inner conductor, said tuning structure having a member short-circuiting said tubular conductors at one end, said tubular inner conductor having a hollow end portion facing the termination of and of a different cross-section than said first inner conductor to capacitively couple said inner conductors by virtue of the spacing therebetween, the capacity between said outer conductors being greater than the capacity between said inner conductors over the entire tuning range.

3. The tunable resonant circuit claimed in claim 2, said hollow end portion having an inner diameter greater than the outer diameter of said first inner conductor and said movable tuning structure being axially movable to bring said hollow portion around the terminating portion of said first inner conductor and spaced therefrom.

4. A tunable resonant circuit comprising a coaxial line having an outer conductor and an inner conductor terminated therewithin, said line having an electrical length substantially equal to a half wave length at the highest operating frequency, and a tuning structure axially movable within said outer conductor and comprising a conductive end plate, a tubular outer conductor physically spaced from and adjacent to said first outer conductor to be capacitively coupled thereto and conductively connected to and extending from said end plate and a tubular inner conductor within said tubular outer conductor and conductively connected to and extending from said end plate, one of said inner conductors having a hollow terminating portion within which

the terminating portion of the other said inner conductor may be received and in which when so received the one end portion is closely spaced from the other end portion received by it to capacitively couple together said inner conductors, said tubular inner conductor having a length slightly less than a quarter wavelength at the highest operating frequency, both inner conductors together having a total length of one-quarter wavelength at the lowest operating frequency, the capacity between said outer conductors being greater than the capacity between said inner conductors over the entire tuning range.

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