

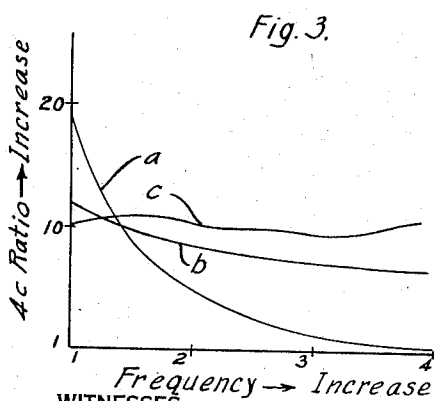
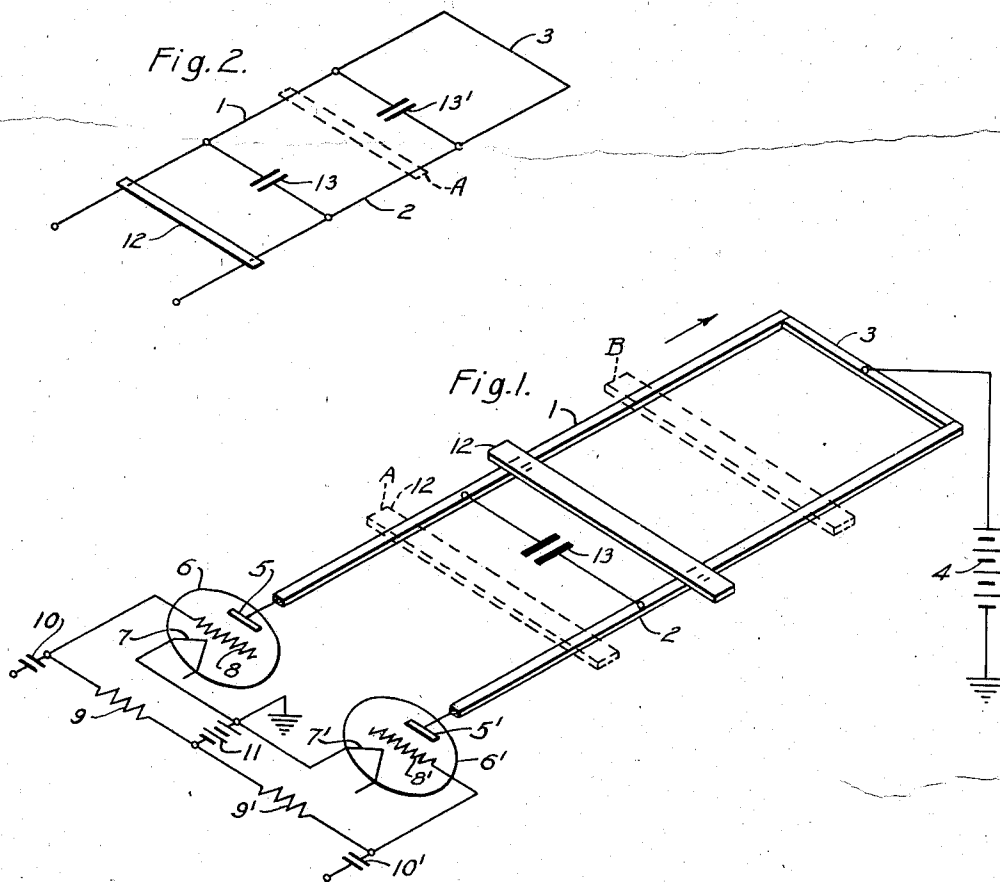
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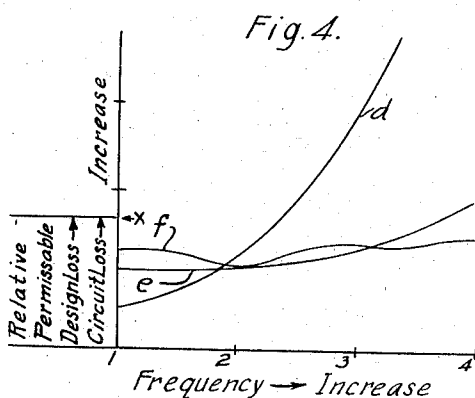
ULTRA-HIGH-FREQUENCY TANK CIRCUIT

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ULTRA-HIGH-FREQUENCY TANK CIRCUIT

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This invention relates to radio systems operating at ultra-high frequencies and, more particularly, to circuit arrangements for tuning such systems over a wide frequency range.

At frequencies lying between 60 to 200 megacycles and higher, generally referred to as ultra-high frequencies, the physical size of the reactive components is extremely critical and difficulty is experienced in the design and practical application of the circuits. In oscillator or amplifier tank circuits requiring adjustment over a certain range of frequencies, the conventional coil and condenser combination of parallel tuned circuits cannot be used. It is customary to employ transmission lines for the tank circuits either in the form of a concentric conductor or in the form of parallel conductors known in the art as Lecher wires. These arrangements, however, have certain physical limitations and when tuned either by a small size variable condenser or by a short circuiting slider, particularly applicable to the parallel conductor arrangement, the tuning range which can be efficiently covered is comparatively narrow.

When it is necessary to cover an extended tuning range, for example, between 60 to 200 megacycles, practical investigation has shown that in either of the circuits above referred to, to cover a tuning range of $3\frac{1}{2}$ to 1, the value of the tuning capacity is so large that the ratio of inductive over capacitive reactance becomes prohibitively low. When only the inductance is varied, to accomplish the desired tuning, as in the parallel line circuit, the length of the conductors would have to be too great considering a practical arrangement.

For example, in the parallel line circuit, with only the anode to cathode and stray capacities shunting the line, the length of the conductors would be too great at the lower frequency portion to be practical. It is customary engineering practice to connect a capacitor between anode and cathode to reduce this length to a usable value. This capacitor may be a fixed one, the length of the line being varied, or it may be variable to give frequency coverage by capacitor change. Both may be arranged to be simultaneously variable. However, when covering wide frequency ranges, such as 60 to 200 megacycles, the value of the capacity which must be added to reduce the line length to a practical value at 60 megacycles, is far too large for efficient operation at 200 megacycles.

The primary feature of this invention is the extension of the tuning range of ultra-high fre-

quency tank circuits while maintaining high efficiency of energy transfer throughout the tuning range.

An additional feature of this invention is the construction of a tuning arrangement in which over the entire range of operation a substantially uniform ratio of inductive over capacitive reactance is maintained.

A distinct advantage of the tuning system in accordance with this invention is the relatively small physical dimensions necessary for constructing a tank circuit whereby it can be arranged in a small space, yet being tunable over an extended range of frequencies.

The invention contemplates the use of the parallel conductor type of tuning by means of a variable short circuit which can be progressively applied to the conductors and the placement of a condenser at one or more strategic points between the two conductors whereby the inductive reactance alone is varied over a certain portion of the tuning range and beyond said portion a change of the capacitive reactance is effected by the presence of the condenser as the inductive reactance is caused to vary further in the other portion of the range.

Other features and advantages will be apparent from the following description of the invention, pointed out in particularity by the appended claims and taken in connection with the accompanying drawing, in which:

Figure 1 is a schematic diagram, drawn in perspective, of a tank circuit connected to a pair of vacuum tubes arranged in push-pull operation;

Fig. 2 is a diagram of a modified form of the tank circuit;

Fig. 3 illustrates, by means of curves, the operation of the circuit of Fig. 1 or 2, with respect to variation of the ratio of inductive over capacitive reactance with the increase of frequency; and

Fig. 4 illustrates the circuit losses with respect to frequency increase.

Referring to the figures, the tank circuit of Fig. 1 comprises the two parallel conductors 1 and 2 which are short circuited at one end by the conductor 3 to which is connected the positive side of the power supply indicated by the battery 4. The free terminal of conductor 1 is connected to the anode 5 of the vacuum tube 6, whereas the free terminal of the conductor 2 is connected to the anode 5' of the tube 6'. The invention herein described centers around the output circuit of the arrangement shown in Fig. 1, consequently, the input circuit of the tubes between cathodes 1 and 1' and grids 8 and 8', re-

spectively, is only schematically indicated, containing the grid resistors 9 and 9', coupling condensers 10 and 10' and the source of bias potential battery 11. The type of input circuit may vary according to design requirements. It may comprise, instead of the shunt feed arrangement shown here, the secondary winding of a transformer or other suitable source of input voltage. The tuning of the output circuit is effected by the short circuiting sliding bar 12 which may be in the form of a simple conductor or similar mechanism which shunts both conductors 1 and 2 effecting thereby a short circuit at any desired point between the anode terminals and the other end of the line closed by the conductor 3. At a strategic point along the line formed by conductors 1 and 2, there is inserted a condenser 13 paralleling the two conductors.

The invention is illustrated and described in connection with a push-pull type circuit, mainly because in ultra-high frequency engineering practice, this type of circuit finds extensive application. It is understood, however, that no limitation is intended and that the invention may as well be used with single tube circuits.

Before describing the operation of the tank circuit, reference should be had to Fig. 2 which illustrates a modification comprising the two parallel conductors 1 and 2, the terminal conductor 3, and the sliding bar 12. Up to this point, the circuit is very much the same as the one shown in Fig. 1. The modification contemplates the insertion of more than one shunting condenser 13, such as 13', distributed at strategic points along the two conductors. This addition of a number of capacities along the line may be accomplished by any one of a number of means, including such arrangements as specially shaped capacitor plates fastened to the conductors 1 and 2 which, in effect, would provide any desired value of capacity along the line. For the sake of simplicity, the vacuum tubes, to which the tank circuit is to be connected, have been omitted. It is to be understood that the circuit can be connected to tubes in the manner shown in Fig. 1 or can be utilized in various ways wherever tuned circuits of this type function as part of a radio system.

Describing the operation of the circuit, it will be seen that the shorting bar 12, when in position A, indicated in dotted lines, tunes the circuit at the highest frequency range, let us say at 200 megacycles, and it will be noted that the capacity 13 is not effective at this frequency because the line is, in effect, terminated by the bar 12 at any position which it may occupy. Consequently, in position A from the anode terminal end up to and including the position when it will rest over the capacity 13, the inductive component of the circuit is varied and the distributed capacity, together with the anode-cathode capacity of the vacuum tube determines the capacity reactance of the circuit. When the shorting bar 12 is placed in the position B, the condenser 13 has become partially effective by being connected a short distance from the closed end of the line effected by the position B of the shorting bar 12. As the bar is moved in the direction of the arrow, and approaches the end of the line determined by the conductor 3, the condenser becomes more and more effective, since it is, in effect, progressively placed nearer and nearer the open end of the line, that is, the anode terminal end thereof. The result is a tank circuit having a practically constant L/C ratio and the circulating current in the circuit stays constant. As

stated before, at the high frequency end, the only capacity across the line is the tube capacity plus the very small distributed capacity which permits a low circulating current and high efficiency of the circuit. At the low frequency end, the condenser 13 is totally effective and produces the desired circulating current with a reasonable and usable length for the line. If a more uniform L/C ratio is desired, two or more capacities of suitable value may be connected at proper points along the line, as shown in Fig. 2.

The curves of Fig. 3 show the advantageous operation of the circuit herein described in comparison with conventional parallel wire circuits heretofore used. The variation of the L/C ratio is plotted along the ordinate, with respect to the increase of frequency plotted along the abscissa. Curve *a* shows that in circuits where there is no capacitor introduced at strategic points, the L/C ratio falls rapidly with the increase of frequency to an impractically low value. Curve *b* shows the L/C constant as substantially uniform with a slight decrease at increase of frequency and is representative of the circuit of Fig. 1, whereas curve *c* shows a more uniform maintenance of the L/C ratio and is representative of the circuit shown in Fig. 2.

The circuit losses with respect to frequency increase are plotted in Fig. 4. It is seen that in the conventional type of circuit represented by curve *d*, the losses rapidly increase with increase of frequency, whereas as shown by curve *e* illustrating the operation of Fig. 1, there is but a slight increase of circuit loss which is within the relative permissible design loss shown by the value X. Curve *f* representing the operation of the circuit of Fig. 2, shows the possibility of maintaining a circuit loss which is well below the permissible design loss marked X throughout the frequency range.

The tuning system herein described permits wide frequency coverage without loss of efficiency at the higher frequencies. It makes also possible the coverage of such wide range of frequencies in a restricted space. Practical applications of a tank circuit shown in Fig. 1 resulted in a substantially uniform circuit loss between frequencies of 90 and 200 megacycles with the following values being used. The length of the conductors 1 and 2 was 15 inches. The shorting bar, when placed approximately 3 inches from the anode terminal, resonated the circuit at 200 megacycles and when placed at the opposite end of the line resonated at 60 megacycles. The condenser was placed approximately 5 inches from the anode terminal and had a value of 70 micro-microfarads. The tubes employed were RCA type 832, the characteristics of which may be found in the Tube Handbook Serial HB-3 published by the RCA Manufacturing Company.

I claim as my invention:

1. In a tuning arrangement for radio systems operating at ultra-high frequencies and intended to cover a wide frequency range, means for changing the resonant frequency of the circuit, and means for maintaining the ratio of inductive reactance over capacitive reactance substantially constant over said range, comprising means for progressively varying the inductive reactance over the highest frequency portion of said range, means for automatically changing the capacitive reactance beyond said portion and means for continuing the variation of the inductive reactance in tuning toward the lower frequency end of said range.

2. In a tunable ultra-high frequency tank circuit, connected to the output electrodes of a pair of vacuum tubes operated in push-pull arrangement, a parallel conductor line forming the inductive reactance of the circuit, tuning means adapted to short circuit said line progressively at desired points along its length whereby the effective inductance of said tank circuit is varied, means for maintaining the ratio of inductive over capacitive reactance substantially constant, including a fixed capacity interconnecting said line at a point within the progressive travel of said tuning means.

3. In a tunable tank circuit for ultra-high frequency operation, a pair of parallel conductors interconnected at one end, tuning means for varying the effective length of said conductors comprising a progressively slidable contact device shunting said conductors thereby varying the effective inductance of said circuit, and a capacity inserted between said conductors in the path of movement of said device, said capacity being ineffective while said device is shunting one portion of said circuit and being effective when said device is shunting another portion.

4. In a tunable tank circuit for ultra-high frequency operation, a pair of parallel conductors interconnected at one end, tuning means for varying the effective length of said conductors comprising

a progressively slidable contact device shunting said conductors, a plurality of fixed capacities distributed at different points in parallel with said conductors and in the path of movement of said device, said capacities being ineffective while said device is shunting one portion of said circuit and being consecutively effective when said device is shunting other portions of said circuit.

5. In a tank circuit for ultra-high frequency applications, the method of tuning said circuit over a wide frequency range while maintaining substantially uniform ratio of inductive over capacitive reactance which comprises varying solely the inductive reactance at one portion of said range, effecting a change in capacitive reactance beyond said portion while varying the inductive reactance.

6. In a tank circuit for ultra-high frequency applications, the method of tuning said circuit over a wide frequency range while maintaining substantially uniform ratio of inductive over capacitive reactance which comprises varying solely the inductive reactance at the higher frequency portion of said range effecting a change in capacitive reactance beyond said portion while varying the inductive reactance at the lower frequency of said range.

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