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T. McL. DAVIS ET AL

2,491,480

HIGH-FREQUENCY TUNABLE CIRCUIT

Filed May 21, 1945

2 Sheets-Sheet 1

FIG. 1

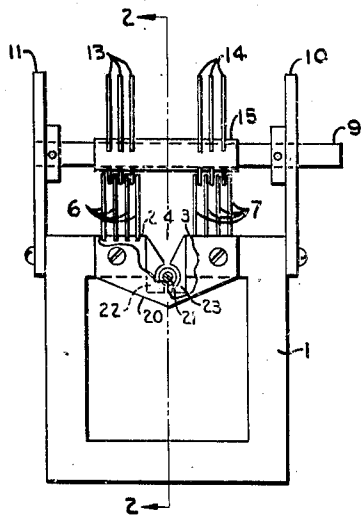


FIG. 2

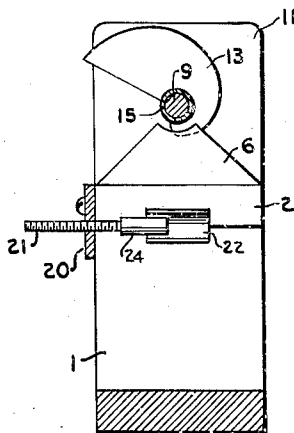


FIG. 3

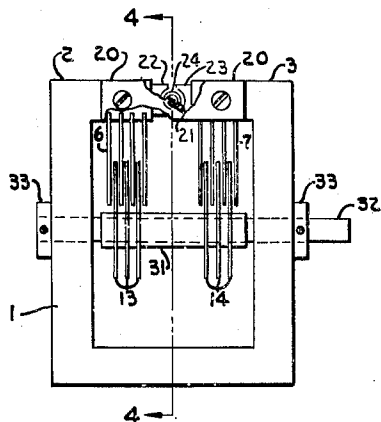
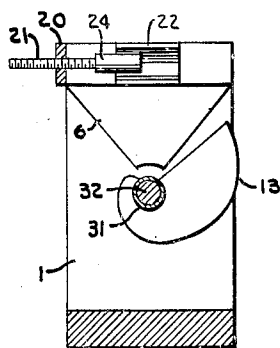


FIG. 4



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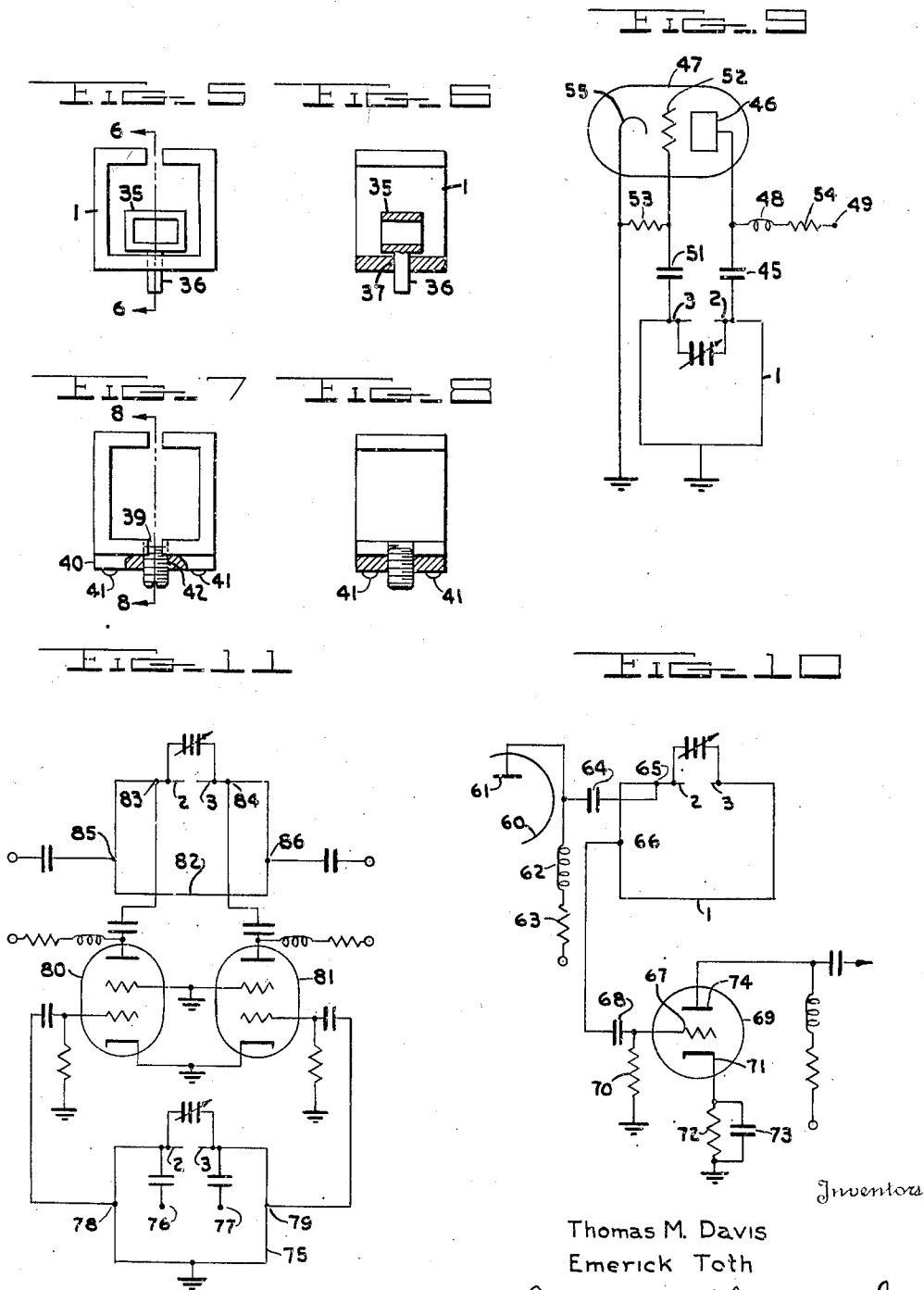
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HIGH-FREQUENCY TUNABLE CIRCUIT

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6 Claims. (Cl. 250—40)

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amended April 30, 1928; 370 O. G. 757)

1

This invention relates to tuned circuits and is particularly directed to tunable high stability very high and ultra-high frequency circuits.

It is accordingly the object of the invention to provide an adjustably tunable circuit of high stability and efficiency for use in high frequency radio apparatus.

The invention will be further described with reference to the exemplary embodiments shown in the drawings in which:

Figure 1 shows an elevational view of one embodiment of the invention,

Figure 2 shows a sectional view along the line 2—2 of Figure 1,

Figure 3 shows a second embodiment of the invention,

Figure 4 shows a sectional view taken on the line 4—4 of Figure 3,

Figure 5 shows diagrammatically a trimmer for the tuned circuit,

Figure 6 shows a sectional view on the line 6—6 of Figure 5,

Figure 7 shows another trimmer for the tuned circuit,

Figure 8 shows a sectional view on the line 8—8 of Figure 7,

Figure 9 shows an exemplary oscillator circuit employing the invention,

Figure 10 shows an exemplary amplifier circuit employing the invention, and

Figure 11 shows another exemplary amplifier circuit employing the invention.

In the high frequency field in which the primary utility of the present invention lies, frequency stability and simplicity of the tuning circuit is required. Due to the small absolute values of the inductances and capacitance present in tuned circuits at high frequency, such apparatus is difficult to construct with a minimum of undesired inductance and capacitance, and also without moving contacts in the tuning capacitor which may produce electrical noise. The present invention provides mechanical sturdiness, very low values of stray or unwanted inductance and capacity, freedom from friction contacts to the variable capacity rotor and a wide angular rotation of the variable capacity, with linearity of the frequency-rotation characteristic. At the same time, the stator and rotor plates are so disposed as to be essentially parallel to the lines of magnetic flux linking the inductance element of the structure. Under these conditions, adjustments of the condenser plates, such as those normally necessary in ganged circuits in production

2

radio equipment, do not appreciably affect circuit inductance.

As shown in Figure 1, the invention comprises inductive and capacitive elements. The inductive element comprises a single turn which is formed of a rigid conducting member 1. The upper section of the inductive element provides two aligned sections 2 and 3, interrupted medially at 4. Sections 2 and 3, which are stably positioned relative to one another by the rigid inductor, carry elements forming parts of a variable capacity across the inductance.

In the embodiment of Figure 1, these comprise a pair of sets of stationary conducting plates 6 and 7, carried by sections 2 and 3 respectively. These conductor plates extend laterally away from the inductor sections 2 and 3, and in this embodiment are fixed and electrically bonded in slots machined in the upper surfaces of the opposed sections. Conducting plates 6 and 7, which form the stationary elements of an adjustable capacitor, extend outwardly from the inductor rectangle. The cooperating movable condenser plates are carried by shaft 9, which is rotatably mounted adjacent stationary plates 6 and 7. Shaft 9 is journaled at either end in members 10 and 11 which are attached to, and extend upwardly from, the vertical sides of the rectangular inductor. The movable condenser members are provided by two sets of spaced elements 13 and 14 positioned on shaft 9 for adjustable nesting relationship with stationary plates 6 and 7 respectively. Movable plates 13 and 14 are electrically connected and may be constructed as shown in Figure 1 integrally with a conducting tube 15 surrounding shaft 9.

The adjustable condenser element provides variable capacitive coupling between plates 6 and 7. For this purpose, the movable condenser assembly is insulated from the inductor frame 1. In the embodiment shown, members 10 and 11 are constructed of insulating material. Consequently, shaft 9 may also be either of conducting or insulating material.

An adjustable trimming capacity may be additionally provided across the inductor sections 2 and 3, as shown in Figures 1 and 2. This comprises a conducting member 21 mounted in threaded engagement in insulating plate 20 which in turn is carried by the inductor sections 2 and 3. Conductor 21 may carry an insulating sleeve 24 of high dielectric constant. The trimmer assembly is interposed between conductive extensions 22 and 23 depending from the inductor elements 2 and 3 respectively, and furnishes a variable capacitive coupling across the inductor.

3

The construction of Figure 1 is further shown in the sectional view of Figure 2, and particularly discloses a useful condenser plate section which may be used in carrying out the invention. With the rotor section shown, the area of engagement of the stator and rotor plates, over most of the tuning range, is substantially symmetrically distributed with regard to the center plane of the inductor as shown in Figure 2. Consequently the current density in the upper inductor sections 2 and 3 is equalized and unbalance is eliminated.

In one physical embodiment of the construction of Figure 1, the circuit was tunable from 225 to 430 megacycles per second, complete with capacity and inductance trimmers and a shunt padding fixed capacitor, and provided high frequency stability.

The tuned circuit shown in Figure 3 differs from that of Figure 1 in that the variable capacitor elements are positioned internally in the inductor. This construction is particularly useful due to its space economy. As in Figure 1, stationary plates 6 and 7 may be fixed in slots machined in the inner surface of sections 2 and 3. The movable elements 13 and 14 may be carried by a conducting tube 31. In order to insulate the movable condenser assembly from the inductor, shaft 32 is provided of insulating material and is axially positioned in the inductor frame by collars 33.

A trimmer assembly comprising a conductive element 21 carrying a high dielectric constant sleeve 24 is interposed between sections 2 and 3. The design and operation of the trimmer assembly is further disclosed in the sectional view of Figure 3, where the relationships of the trimmer assembly and the movable condenser component with the inductor are shown.

Trimming means functioning in cooperation with the inductor is shown in Figure 6, wherein the inductor section 1 is diagrammatically indicated. The trimming means comprises a rotatable closed loop 35, which in the embodiment of Figure 5 is shown of rectangular section. Loop 35 is carried by shaft member 36, and is journaled in the base of the inductor 1 at 37. By adjusting the orientation of closed loop 35 with respect to the inductor, the coupling therebetween may be adjusted to effect the desired variation in its inductance.

The construction shown in Figure 7 effects variations of the inductance in the tuned circuits by variation in the current density at a point in the main inductor. For this purpose, the base of the inductor is centrally interrupted at 39. The two inductor halves are mounted on a non-conducting supporting member 40 by screws 41, thus affording a rigid inductor construction. Member 40 is centrally apertured at 42, and the aperture is continued through the base of the inductor halves, providing a bore extending through the base of the inductor assembly. This bore is internally threaded, and a conducting screw member 42 is threaded therein. Adjustment of screw 42 affords the desired variation in the conducting path between the two inductor sections and permits variation in the total inductance for trimming purposes.

An exemplary circuit embodying the invention is shown in Figure 9. This circuit constitutes a tunable oscillator of high frequency stability. Inductor section 2 is coupled through condenser 45 to the anode 46 of triode 47. The anode is returned through a radio frequency choke 48 and

4

resistor 54 to a source of positive potential 49. Section 3 is coupled through condenser 51 to grid 52 of triode 47. Grid 52 is returned to ground through resistor 53. Cathode 55 of tube 47 is grounded directly, as is also the center of the inductor element 1.

The operation of the circuit in Figure 9 as an oscillator will be well understood. In this circuit, the tuning component provided by the present invention furnishes a tuned circuit which is balanced to ground.

In Figure 10 the tuned circuit of the present invention is shown as a coupling device between two stages of a high frequency amplifier. The input stage comprises a tube 60 provided with anode 61 returned to a positive source of potential through choke 62 and resistor 63. The anode is coupled through condenser 64 to the point indicated at 65 on upper inductor section 2. It will be therefore seen that the impedance of the input stage is matched at a comparatively low value.

The output from the coupling section is taken at point 66 centrally of the vertical inductor leg supporting section 2. This output is coupled to control grid 67 of the output stage through coupling condenser 68. The grid 67 of the output tube 69 is returned to ground through resistor 70, and bias is obtained through the return of cathode 71 to ground through resistor 72 shunted with condenser 73. The output of anode 74 of tube 69 may be obtained similarly to that of tube 60 in the input stage.

The operation of the tuned circuit of the present invention as a coupling device affords high efficiency and wide tuning range in a circuit such as shown in Figure 10. The same advantages may be obtained in balanced push-pull operation. An exemplary embodiment of such a circuit is shown in Figure 11 of the drawing. For this purpose an input coupler 75 is shown. A driving voltage may be applied to a point of desired impedance on section 2 or 3. In Figure 11, it is assumed that balanced driving voltages are available, and both sections 2 and 3 are driven from input terminals 76 and 77 respectively. The high voltage output of the input coupling device is taken from the high impedance points 78 and 79 for application to the control grids of the amplifier tubes 80 and 81. The anodes of the amplifier tube are coupled to output coupler 82 at points 83 and 84 on sections 2 and 3 respectively. The operation of the circuit is similar to that of Figure 10, the output voltages being obtained at points 85 and 86 to supply a load (not shown) having an intermediate impedance value.

The embodiments of the present invention described and shown above have been selected for the purpose of example only, and the scope of the invention will be determined with reference to the appended claims.

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

What is claimed is:

1. A tuned circuit comprising a conductor formed in the shape of a loop, the ends of the loop being bent inwardly toward each other to form two rigidly positioned opposed sections, a set of condenser stator plates carried by each of said opposed sections extending laterally therefrom parallel to the axis of the loop, a rotatable shaft mounted in cooperative relation to said condenser

5

stator plates rotatable about an axis perpendicular to the axis of the loop, and a respective set of condenser rotor plates for each of said sets of stator plates carried by said shaft in adjustable capacitative relationship to their corresponding stator plates, said rotor plates being electrically integral and insulated from said conductor, whereby the effective capacity between the opposed sections of said conductor may be varied by shaft rotation.

2. A tuned circuit comprising a rigid conductor formed in the shape of a loop, the ends of the loop being bent inwardly toward each other to form two opposed sections, trimming means capacitatively coupling said opposed sections, a set of condenser stator plates carried by each of said opposed sections extending laterally therefrom parallel to the axis of the loop, a rotatable shaft mounted in cooperative relation to said condenser stator plates rotatable about an axis perpendicular to the axis of the loop, and a respective set of condenser rotor plates for each of said sets of stator plates carried by said shaft in adjustable capacitative relationship to their corresponding stator plates, said rotor plates being electrically integral and insulated from said conductor, whereby the effective capacity between the opposed sections of said conductor may be varied by shaft rotation.

3. A tuned circuit comprising a conductor formed in the shape of a rectangular loop interrupted intermediately on one side to form two sections of said side, a separate set of condenser stator plates carried by each of said two sections extending laterally therefrom parallel to the axis of the loop, a rotatable shaft supported by said rectangular loop in cooperative relation with said stator plates rotatable about an axis perpendicular to the axis of the loop, a respective set of condenser rotor plates for each of said stator plates carried by said shaft in adjustable capacitative relationship to their corresponding stator plates, said rotor plates being electrically integral and insulated from said rectangular loop whereby the effective capacity between said two sections may be varied by shaft rotation.

4. A tuned circuit comprising a conductor formed in the shape of a rectangular loop interrupted intermediately on one side to form two sections of said side, a separate set of condenser stator plates carried by each of said two sections extending laterally therefrom parallel to the axis of the loop, externally of said conductor, a rotatable shaft supported by said rectangular loop in cooperative relation with said stator plates rotatable about an axis perpendicular to the axis of the loop, a respective set of condenser rotor plates for each of said stator plates carried by said shaft in adjustable capacitative relationship to their corresponding stator plates, said rotor plates being electrically integral and insulated from said rectangular loop whereby the effective capacity

6

between said two sections may be varied by shaft rotation.

5. A tuned circuit comprising a conductor formed in the shape of a rectangular loop interrupted intermediately on one side to form two sections of said side, a separate set of condenser stator plates carried by each of said two sections extending laterally therefrom parallel to the axis of the loop internally of said conductor, a rotatable shaft supported by said rectangular loop in cooperative relation with said stator plates rotatable about an axis perpendicular to the axis of the loop, a respective set of condenser rotor plates for each of said stator plates carried by said shaft in adjustable capacitative relationship to their corresponding stator plates, said rotor plates being electrically integral and insulated from said rectangular loop whereby the effective capacity between said two sections may be varied by shaft rotation.

6. A tuned circuit comprising a conductor formed in the shape of a rectangular loop interrupted intermediately on one side to form two opposed sections of said side, a dielectric member adjustably positioned between the opposed sections of said conductor loop to thereby adjust the fixed capacity therebetween, a separate set of condenser stator plates carried by each of said two sections extending laterally therefrom parallel to the axis of the loop, a rotatable shaft supported by said rectangular loop in cooperative relation with said stator plates rotatable about an axis perpendicular to the axis of the loop, a respective set of condenser rotor plates for each of said stator plates carried by said shaft in adjustable capacitative relationship to their corresponding stator plates, said rotor plates being electrically integral and insulated from said rectangular loop whereby the effective capacity between said two sections may be varied by shaft rotation.

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