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TUNED CIRCUIT

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Fig. 3

Fig. 2a

Fig. 2

Fig. 1a

Fig. 1

INVENTOR
BERTRAM TREVOR

BY

H. S. Grover

ATTORNEY

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TUNED CIRCUIT

Bertram Trevor, Riverhead, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

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This invention relates to tuned circuits, and particularly to such of these which are known as resonant lines.

As is now known, a resonant line is a tuned circuit comprising a pair of parallel conductors having substantially uniformly distributed inductance and capacitance. The line may consist of inner and outer concentric conductors or a pair of straight linear rods coupled together at one or more points in their lengths. Such resonant lines may be used as the frequency controlling element in an electron discharge device oscillator, or as an input or output circuit of an amplifier, or as a filter. Examples of concentric lines and the forms they may take are described in the article by Clarence W. Hansell entitled "Resonant lines for frequency control," published August, 1935, in "Electrical Engineering," pages 852 to 857, to which reference is made for a more detailed description.

For tuning or changing the resonant frequency of the resonant line, it is known, among other things, to change the physical length of the line, as is described, for example, in the Hansell article, supra. The present invention simplifies the tuning procedure, and provides a novel and simple means for quickly and efficiently changing the tuning of the resonant line.

In brief, the invention provides a tuning arrangement which simultaneously changes both the capacity and inductance of the concentric resonant line, thus enabling a quick change in the tuning of the line with the smallest possible movement of the tuning element. For achieving this result, there is preferably provided a rotatable metal vane located between the conductors for changing the inductance of the line, the free end of this vane cooperating with a metallic plate on the inner conductor of the line for simultaneously changing the capacity of the line. This vane may be a solid piece of metal or a short circuited turn. Rotation of the vane causes a change in the number of magnetic lines and also a change in capacitance between the conductors of the resonator.

A more detailed description of the invention follows, accompanied by drawing, wherein:

Figs. 1 and 2 show views of a concentric line resonator equipped with the improved tuning arrangement of the present invention, this improvement being shown in two different positions in both figures;

Figs. 1*a* and 2*a* are views in cross-section of the resonators of Figs. 1 and 2 along the lines 1*a*—1*a* and 2*a*—2*a*, respectively; and

Fig. 3 shows the improved resonant line of the present invention in association with an automatic frequency control circuit for automatically controlling the tuning of the resonant line to maintain constant the frequency of a local oscillator.

Referring to Figs. 1, 1*a*, 2 and 2*a* in more detail, the concentric resonant line of the present invention comprises an outer conductor 1 and an inner conductor 2 conductively coupled together at one of their adjacent ends by means of an end plate 3. The other end of the inner conductor 2 may, if desired, be equipped with a capacity plate 4 for providing a capacitance between the inner conductor and the adjacent end plate 5 of the outer conductor. The resonant frequency of the line is determined by such factors as the length of the inner conductor 2 of the line, the ratio of the diameters of the inner and outer conductors, and the capacity between the plate 4 of the inner conductor and the adjacent end 5 of the outer conductor. For effecting a change in the resonant frequency of the concentric line, there is provided, in accordance with the present invention, a metallic vane 6 of low resistance material, such as copper, placed as shown between the conductors 1 and 2 and in the magnetic field of the line. Vane 6 is provided at one end with a flat plate 7 which cooperates with the spaced though adjacent metallic plate 8 on the inner conductor 2 for providing an additional capacity effect between the conductors of the resonant line. Vane 6 is rotatable in position by means of a shaft 9 which is located externally of the line and connected to the vane by a friction clutch or suitable bearing 10. It is preferred that this vane be located at a point of appreciable current flow in the resonant line. If desired, of course, the vane which comprises a solid piece of metal may have a central portion cut away to simulate a single short circuited turn.

In the position shown in Figs. 1 and 1*a*, which are right angle views of each other, the vane 6 will cut or interrupt a minimum number of magnetic lines (flux) produced by the current in the two conductors 1, 2 and thus enable the line to function with its maximum inductance; simultaneously, of course, the plate 7 on the vane 6 and the plate 8 on the inner conductor 2 will be adjacent to each other for a maximum portion of their areas, thus producing a maximum capacitance effect between the two plates. At this position of the vane shown in Figs. 1 and 1*a*, the operating frequency of the resonant line will be a minimum. In Figs. 2 and 2*a* which show the

same resonant line with the vane 6 rotated 90° with respect to the position shown in Figs. 1 and 1a, the vane 6 will interrupt or cut a maximum number of magnetic lines (flux) produced by the current in the two conductors 1 and 2 and simultaneously provide a minimum capacitance between the plates 7 and 8, thus enabling the resonant line to function at its maximum or nearly normal resonant frequency. Intermediate frequencies are obtainable from the resonant line depending upon the intermediate angles the vane 6 makes with respect to the conductors of the line compared to the positions shown in Figs. 1 and 2.

In effect, it can be stated that the vane 6 in one position (Figs. 2 and 2a) carries a maximum of eddy currents and provides a minimum of capacity across the conductors 1 and 2 of the tuned circuit, causing a maximum operating frequency; while in the other position (Figs. 1 and 1a) the vane 6 carries a minimum of eddy currents and provides a maximum capacity across the conductors 1, 2 of the tuned circuit, thus providing a minimum frequency of operation for the tuned circuit. Thus, there is a simultaneous change in capacity and inductance of the resonant line with rotation of the vane 6, and a consequent quick and efficient change in the tuning of the line with the smallest possible movement of the tuning element 6.

The vane 6 may be insulated from the outer conductor at the bearing or friction clutch 10, at such locations where the support for the vane 6 is at a different potential from the two conductors 1, 2 of the resonant line. Although the vane is illustrated as being located at a point of large current flow, this vane with its plate 7 can take other positions along the length of the line; in which case, of course, the plate 8 on the inner conductor will assume a corresponding position.

Fig. 3 shows the resonant line 1, 2 connected by way of example, as the frequency control element in the input circuit of an electron discharge device oscillator 11 whose output may be utilized to provide a beat frequency for a superheterodyne receiving circuit, the intermediate frequency of which may be connected to a shielded cable 12 impressing the intermediate frequency upon the control grid of an amplifier 13. In the output of the amplifier 13 there is provided a suitable discriminator circuit and automatic frequency control unit for controlling the frequency of the oscillator 11 whenever the mid frequency or carrier frequency in the band departs from its assigned value. In the circuit of Fig. 3, an eight megacycle band of frequencies comprising an intermediate frequency of an ultra short wave receiver, is impressed upon the intermediate frequency amplifier 13 in order to drive a pair of diode structures 14. The output of the amplifier 13 comprises a parallel tuned circuit 15 which is tuned to the desired intermediate frequency, this circuit being coupled through a condenser 16 to the mid point of another tuned circuit 17, also tuned to the desired intermediate frequency of the band. The inductance coils of circuits 15 and 17 are shown inductively coupled together in order to provide voltages in 17 which are phase displaced with respect to the voltages impressed on the tuned circuit 17 through the condenser 16. Such an arrangement is known in the art as a discriminator circuit and is employed to interpret changes in frequency in the output of the amplifier 13 into corresponding changes in direct current voltage in the output of the rectifier structure 14. The characteristic of the whole discriminator circuit, including the diode structures 14, is such that when the intermediate frequency is at mid band, balanced and opposite direct current voltages appear across terminals D_1 and D_2. A departure from mid band frequency will unbalance the direct current voltages on terminals D_1 and D_2 and, depending on whether the frequency is high or low, the terminals D_1 and D_2 will become more or less positive with respect to each other.

Connected to the terminals D_1 and D_2 is an automatic frequency control circuit (labeled AFC and shown within the boundaries of the box formed by the dash line). This AFC circuit includes a pair of direct current amplifier tubes 18, 18 in whose outputs are a double-diode rectifier structure 19 and a pair of relays 20, 21. These relays serve to energize a telechron motor 24, whose shaft is linked by 25 (as shown) to the vane 6 in order to control the frequency of the oscillator 11. The two tubes 18, 18 in the AFC circuit act as a balanced direct current amplifier and are affected by any unbalance in the voltages appearing on D_1, D_2 to produce a concomitant unbalance in their anode load resistors R, R. The diode structure 19 interprets the direct current unbalance in the outputs of the tubes 18, 18 so as to close one relay 20 or the other 21, to energize the motor 24 in the proper direction to turn the metal vane 6 until the high frequency oscillator 11 returns to a frequency such that the intermediate frequency signal impressed on shielded cable 12 is again at mid band.

An important advantage of the present invention lies in the fact that the improved tuning arrangement gives a faster frequency change and a greater tuning range than known systems employing other types of tuning control elements.

It should be understood that the present invention is not limited to the precise arrangements shown in the drawing, since various modifications may be made without departing from the spirit and scope of the appended claims.

What is claimed is:

1. A resonant circuit comprising a pair of spaced conductors forming a tuned circuit, means for tuning said resonant circuit comprising an electrically closed path of low resistance placed in the magnetic field of said circuit, a metallic element mounted on one conductor of said pair and located in the space between said conductors at an angle to the lengths of said conductors and cooperating with said electrically closed path to provide an auxiliary capacitance between said spaced conductors, said closed path having a surface adjacent said metalilc element of substantially the same contour to provide maximum coupling thereto when said surface and metallic element are parallel to each other, said auxiliary capacitance being substantially a maximum when the number of magnetic lines interrupted by said path is a minimum, and vice versa.

2. A resonant line comprising inner and outer concentric conductors, a metallic plate connecting said conductors together at one end, an electrically closed path of low resistance located between said conductors and mounted on said outer conductor at a point intermediate its ends, a

metallic strip mounted on said inner conductor at a point adjacent said path and at right angles to the length of said inner conductor, said path in one position having an appreciable area adjacent to said strip to provide maximum capacitance between said inner and outer conductors and simultaneously therewith maximum inductance of the resonant line, and means for rotating said closed path through an arc for changing the resonant frequency of said line.

3. A tuned circuit comprising a pair of coaxially arranged outer and inner surfaces of revolution so constructed and arranged as to form an oscillatory circuit, a metallic strip mounted on said inner surface of revolution substantially at right angles to the length of said surface, and a metallic vane located between said surfaces of revolution and arranged to provide a maximum capacitive coupling to said strip and inner surface when the inductance of said tuned circuit is a maximum.

4. A tuned circuit comprising a pair of coaxially arranged outer and inner surfaces of revolution so constructed and arranged as to form an oscillatory circuit, a metallic strip mounted on said inner surface of revolution substantially at right angles to the length of said surface, and a metallic vane located between said surfaces of revolution and arranged to provide a minimum capacitive coupling to said strip and inner surface when the inductance of said tuned circuit is a minimum.

5. A tuned circuit comprising a pair of coaxially arranged inner and outer surfaces of revolution so constructed and arranged as to form an oscillatory circuit, a metallic strip mounted on one of and intermediate said surfaces and substantially at right angles to the length of said one surface, and a rotatable electrically closed path of low resistance located between said surfaces and arranged to provide a maximum capacitive coupling to said strip and said one surface when the inductance of said tuned circuit is substantially a maximum.

6. A tuned circuit comprising a pair of coaxially arranged inner and outer surfaces of revolution so constructed and arranged as to form an oscillatory circuit, a metallic strip mounted on one of and intermediate said surfaces and substantially at right angles to the length of said one surface, and a rotatable electrically closed path of low resistance located between said surfaces and mounted on said other surface, said electrically closed path being arranged to provide a maximum capacitive coupling to said strip and said one surface when the inductance of said tuned circuit is substantially a maximum.

7. A resonant circuit comprising inner and outer concentric conductors suitably coupled together near one end, a metallic strip mounted on one of said conductors and intermediate the ends thereof, said strip being located in the space between said conductors and substantially at right angles to the lengths of said conductors, a rotatable electrically closed path of low resistance located between said conductors and located in the magnetic field of said resonant circuit, said electrically closed path having a surface adjacent said strip and cooperating with said metallic strip to provide an auxiliary capacitance between said conductors which varies with rotation of said closed path.

8. A resonant circuit comprising a pair of spaced conductors forming a tuned circuit, means for tuning said resonant circuit comprising an electrically closed path of low resistance placed in the magnetic field of said circuit, a metallic strip mounted on one conductor of said pair at an angle to its length and cooperating with said electrically closed path to provide an auxiliary capacitance between said spaced conductors, said auxiliary capacitance being substantially a maximum when the number of magnetic lines interrupted by said path is substantially a minimum, and vice versa.

9. A resonant circuit comprising a pair of spaced conductors forming a tuned circuit, means for tuning said resonant circuit comprising an electrically closed path of low resistance placed in the magnetic field of said circuit, a metallic strip mounted on one conductor of said pair at an angle to its length and cooperating with said electrically closed path to provide an auxiliary capacitance between said spaced conductors, said closed path having a surface adjacent said metallic strip, and means for rotating one of the elements of said auxiliary capacitance about an axis at right angles to the lengths of said spaced conductors, whereby the value of said capacitance varies with rotation of said one element.

10. A resonant circuit comprising a pair of parallel spaced conductors forming a tuned circuit, means for tuning said resonant circuit comprising an electrically closed path of low resistance placed in the magnetic field of said circuit, a metallic strip mounted on one conductor of said pair at an angle to its length and cooperating with said electrically closed path to provide an auxiliary capacitance between said spaced conductors, said closed path having a surface adjacent said metallic strip, and means for rotating one of the elements of said auxiliary capacitance about an axis having the same angle to the lengths of said spaced conductors as has said metallic strip, whereby the value of said capacitance varies with rotation of said one element.

BERTRAM TREVOR.