

June 14, 1938.

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2,120,518

SHORT WAVE TUNED OSCILLATORY CIRCUIT

Original Filed Sept. 18, 1934 2 Sheets-Sheet 1

Fig. 1

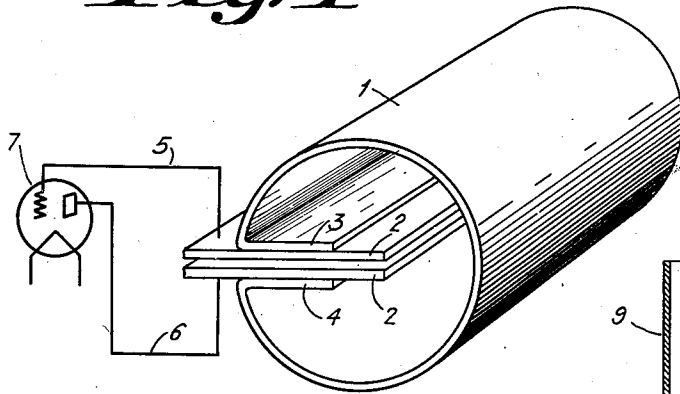


Fig. 2a

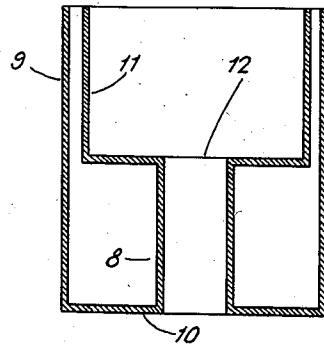


Fig. 2

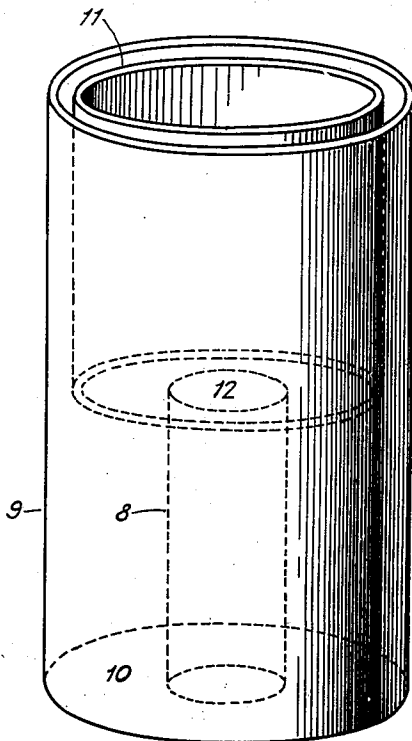
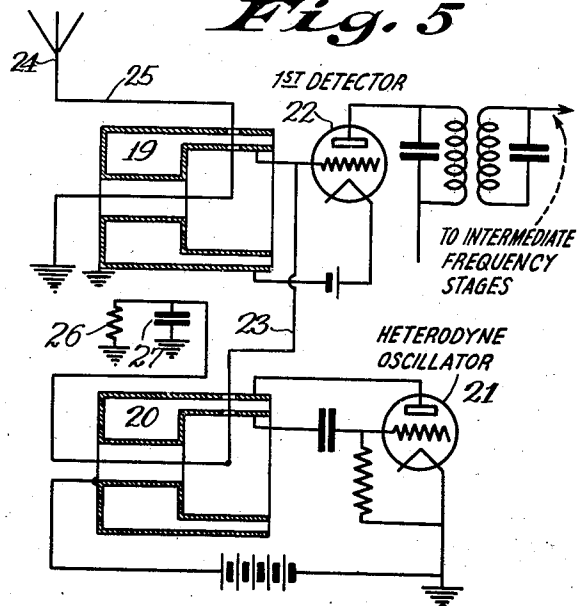


Fig. 5



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Original Filed Sept. 18, 1934 2 Sheets-Sheet 2

Fig. 3

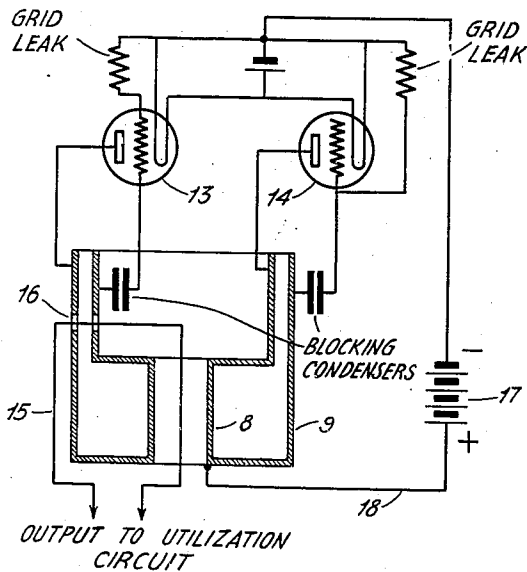


Fig. 3a

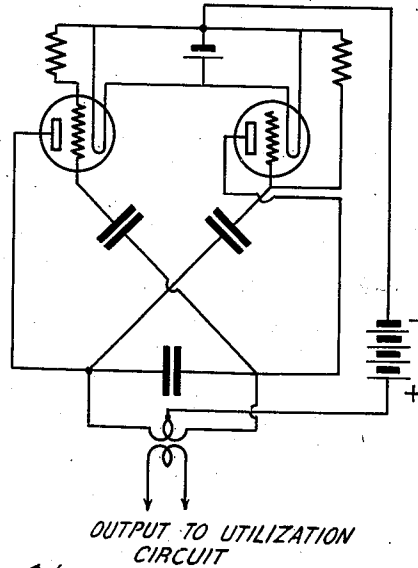


Fig. 4

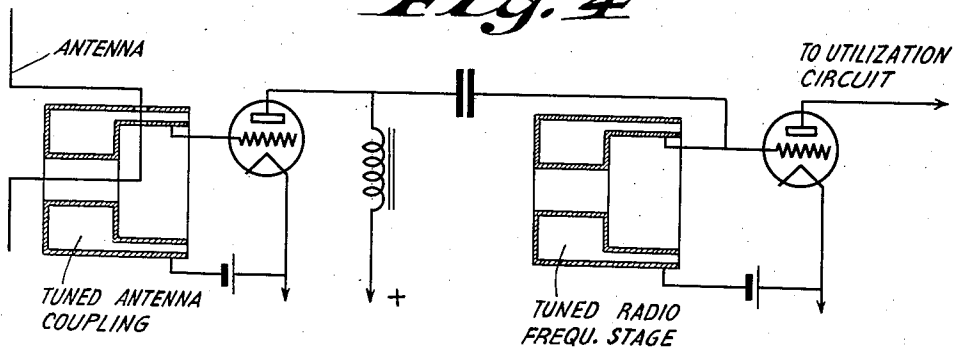
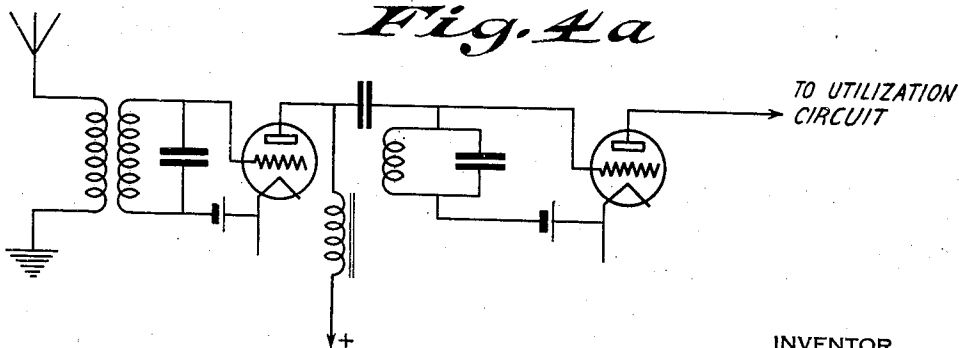


Fig. 4a



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SHORT WAVE TUNED OSCILLATORY
CIRCUITJohn F. Dreyer, Jr., Brooklyn, N. Y., assignor to
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of DelawareApplication September 18, 1934, Serial No. 744,497
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17 Claims. (Cl. 250—36)

This invention relates to ultra-high frequency oscillatory circuits, and has for its primary object to provide a tuned oscillatory circuit which is characterized by low loss. A further object is to provide an oscillatory circuit for ultra-high frequency currents which is both highly efficient and substantially radiationless.

In the conventional tuned oscillatory circuit which includes an inductance coil and a lumped capacitor, a difficulty hitherto experienced has been due to the concentration of the flow of currents at certain parts of the circuit, a trouble which manifests itself in energy losses. When these conventional circuits are employed in connection with electron discharge devices, a further source of loss is believed to exist in the leads extending from the tuned oscillatory circuit to the electron discharge device and in the inter-electrode capacitances of the device, all of which possess appreciable series impedances, as compared to the resistance of the tuning conductors.

It is proposed to overcome the foregoing difficulties in accordance with the invention by using an oscillatory circuit comprised of an inductance in the form of a conductor of extremely low resistance and low inductance, and a relatively large tuning capacity, said conductor being, in its preferred form, a surface of revolution. Such an oscillatory circuit, it has been found, provides a uniform flow of current throughout the circuit without any concentration of currents such as is occasioned when conventional coils and lumped condensers are employed.

An oscillatory circuit in accordance with one embodiment of the invention comprises a circularly arranged wide metallic conductor in the form of a copper strip and a relatively large tuning capacity. This strip provides a relatively long flux path and hence low inductance plus low resistance. When an electron discharge device is connected to said oscillatory circuit, the capacitance of the tuning capacity will be larger than the inter-electrode capacitance of the electron discharge device.

Another and a preferred embodiment is an arrangement composed of two concentric co-axial conductors of cylindrical form having cylindrical capacity extension plates connected to the inner conductor. By making the conductors co-axial and cylindrical, the current travels uniformly down on the inner surface of the outer conductor and returns uniformly distributed over the outer surface of the inner conductor. Since the lines of magnetic flux are almost completely contained within the space between the inside

of the outer conductor and the outside of the inner conductor, the possibilities of any eddy current losses are minimized because the space through which the magnetic lines of force, constituting the flux, pass is only air.

An advantage of the present invention is that the improved oscillatory circuit is, for the most part, substantially radiationless.

The improved oscillatory circuit of the present invention, it is to be distinctly understood, may be utilized both in transmitters and receivers wherever there is need for a tuned circuit. For example, the improved oscillatory circuit may be employed in a transmitter as the frequency determining element in a master oscillator, or as a tank circuit, and in a receiver as an interstage coupling unit, or as an oscillator circuit in a superheterodyne receiver.

A better understanding of the invention may be had by the following description which is accompanied by drawings.

Figs. 1 and 2 illustrate in perspective, and by way of example only, two embodiments of oscillatory circuits in accordance with the teachings of the invention;

Fig. 2a shows a cross sectional view of Fig. 2;

Fig. 3 illustrates schematically a push-pull circuit employing the improved tuned oscillatory circuit;

Fig. 3a shows, in conventional form, the equivalent circuit for the system of Fig. 3;

Fig. 4 illustrates a receiving system employing the improved oscillatory circuit, both as an antenna coupling device and as an interstage tuning circuit;

Fig. 4a is its equivalent circuit, in conventional form;

Fig. 5 illustrates the improved oscillatory circuit in the super-heterodyne receiver both as an antenna coupling device and as the frequency determining element of the heterodyne oscillator.

Referring to Fig. 1 in more detail, there is shown an improved oscillatory circuit comprising an inductance in the form of a wide cylindrically shaped metallic inductor strip 1, and a comparatively large tuning capacitor consisting of two metal plates 2, 2, which are connected to the ends of inductor strip 1. Inductance 1 is preferably made of copper and of circular form, having ends which fold inwardly at 3 and 4 to provide supports for the metallic plates 2 of the tuning capacity. It will be apparent, of course, that, if desired, the ends 3 and 4 of strip 1 may be turned outwardly and still function satisfactorily. Conductors 5 and 6 merely indicate how

the oscillatory circuit can be connected to high frequency apparatus, such as an electron discharge device 7. Tuning may be obtained by varying the separation between the plates 2, 2.

5 With the arrangement shown in this figure, two meter oscillations were obtained with a two volt tube (330 type) having 90 volts on the plate and approximately 120 micro-microfarads of capacity between the plates 2, 2.

10 The capacity between plates 2, 2 and the inductance of strip 1 can be calculated from the following formulae:

$$15 \quad C = \frac{\epsilon S}{1} L = \frac{.0008a^2N^2}{6a+9b+10c}$$

where ϵ is the specific inductive capacity of the dielectric having unit dimensions, S is the cross sectional area of the dielectric of the condenser, 1 is the distance through the dielectric, a is the radius of the coil, N is the number of turns of the coil, b is the axial length of the coil, and c is the radial depth of the coil. In the present instance c is negligible and can be taken as zero, since with the high frequency current involved, the current flows only on the surface of the conductor, which surface, by way of example, may be of the order of .003 of an inch. Such a depth obviously is negligible as compared to a and b .

Fig. 2 illustrates a preferred embodiment of the present invention comprising two cylindrical coaxial conductors 8 and 9, both of which are directly connected together by a circular plate 10 at the bottom. Conductor 8 in the preferred arrangement is hollow. To provide the tuning capacitance, there is an upper portion 11 in the form of a concentric tube placed within the outer tube 9 and positioned adjacent thereto, the lower portion of tube 11 being directly connected to the upper end 12 of inner conductor 8 in any suitable manner. The arrangement is more clearly indicated in Fig. 2a, which is a cross section of Fig. 2.

Although the arrangement of Fig. 2 is shown as being that of a circle, it will be understood that conductors of cross sections other than that of a circle may be employed, although it is preferred to use the circular cross section, inasmuch as it will result in most uniform current distribution on the tube surfaces. It is also important that the two conductors be coaxial, inasmuch as a departure from this construction will result in a tendency to unequal current distribution on the tube surfaces, an undesirable result which will follow if the current is made to flow over paths of different impedances. Tubes 8 and 9 are of such length that their inherent inductances, together with the capacitance existing between them, will form an oscillatory circuit which will be resonant to a desired frequency of operation.

60 The foregoing formulae for C and L for determining the capacitance and inductance of the cylindrical oscillatory circuit are also applicable to this structure.

Fig. 3 shows the improved oscillatory circuit of Fig. 2 in circuit with a pair of push-pull electron discharge devices 13 and 14. The output of the circuit is shown electromagnetically coupled to the oscillatory circuit by means of a loop of wire 15. This wire passes from the outer surface of the cylinder 9 through an aperture indicated at 16 and through the hollow of conductor 8, as shown in the drawings. A battery 17 applies positive potential to the anodes of the tubes through a connection 18 which is joined to the cylinder 9 at the plane-cylinder intersection di-

agonally opposite the point where the capacitance is placed. Fig. 3a shows the equivalent circuit. Since the circuit arrangement is conventional and forms no part of the present invention per se, it is not believed necessary to further describe the arrangement.

Fig. 4 shows the improved oscillatory circuit used first as a tuned antenna coupling device and as a tuned radio frequency circuit. The mode of operation of the system shown herein is deemed obvious from a mere inspection of the equivalent circuit of 4a and from what has been stated above.

Fig. 5 illustrates how the oscillatory circuit may be used as a tuned antenna coupling 19 for a superheterodyne receiving circuit and as the frequency determining element 20 of a heterodyne oscillator 21, both of which are shown connected to the first detector 22 of a superheterodyne circuit. In this figure, the grid of the first detector is inductively coupled to the frequency determining oscillatory circuit 20 of the heterodyne oscillator 21 by means of connection 23 in circuit with a high resistance 26 and a small capacity 27. Similarly, the antenna 24 of the receiving circuit is inductively coupled to oscillatory circuit 19 through connection 25.

It will be understood from what has gone before that the invention is not limited to the precise arrangements of parts shown, since they may be modified to meet different conditions encountered in their use without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A tuned high frequency circuit comprising a pair of hollow coaxial metallic conductors, both of said conductors being entirely open electrically at one of their adjacent ends, the inner conductor being of larger diameter at said one end than at its other end to increase the effective capacitance between the conductors, and a direct connection in the form of a plate at the other end connecting inner and outer conductors together.

2. A tuned high frequency circuit comprising a pair of inner and outer hollow concentric metallic conductors, one end of said outer conductor being entirely open, the inner conductor being of larger diameter at its end adjacent said open end of said outer conductor to increase the effective capacitance between the conductors, and an electrical connection between the other end of said outer conductor and the adjacent end of said inner conductor.

3. A high frequency circuit comprising a pair of inner and outer hollow coaxial metallic conductors, one end of said outer conductor being entirely open, the inner conductor having a concentric hollow portion of larger diameter at its end adjacent the open end of said outer conductor to increase the effective capacitance existing between said conductors, and an electrical connection between the other end of said outer conductor and the adjacent end of said inner conductor.

4. In combination, an oscillatory circuit comprising a pair of inner and outer coaxial conductors coupled together more closely at one portion in their lengths than at another portion, a pair of electron discharge devices each having anode, cathode and control electrodes, the anode of one device being directly connected to the outer conductor, and the anode of the other device being directly connected to the inner conductor, the control electrode of said one device

being capacitively coupled to said inner conductor and the corresponding electrode of said other device being capacitively coupled to said outer conductor, said cathodes being connected together, a source of energy for supplying positive potential to said conductors, and an output circuit including a loop of wire coupled to said conductors.

5. An oscillatory circuit comprising a pair of hollow inner and outer coaxial conductors, said conductors being directly connected together at only one of their adjacent ends, the other end of said outer conductor being entirely open, said outer conductor having a length appreciably greater than said inner conductor, and a third hollow coaxial conductor also within said outer conductor, said third conductor having a diameter greater than said inner conductor and being directly connected thereto, said third conductor having a length extending at least from the open end of said inner conductor substantially to the open end of said outer conductor, whereby the capacitance between said outer conductor and said third conductor due to their spacing together with the inductance of said inner conductor comprises a resonant circuit.

6. The combination with a high frequency circuit comprising inner and outer hollow coaxial metallic conductors, the inner conductor having a portion of larger diameter at one end to increase the effective capacitance existing between said conductors, the other end of said inner conductor being electrically coupled to said outer conductor, of an electron discharge device having an anode, cathode and control electrode, said control electrode being coupled to said inner conductor, said cathode being coupled to said outer conductor, and said anode being coupled to an output circuit.

7. The combination with a high frequency circuit comprising inner and outer hollow coaxial metallic conductors, the inner conductor having a portion of larger diameter at one end to increase the effective capacitance existing between said conductors, the other end of said inner conductor being electrically coupled to said outer conductor, of an electron discharge device having an anode, cathode and control electrode, said control electrode being coupled to said inner conductor, said cathode being coupled to said outer conductor, said anode being coupled to an output circuit, and an input circuit including a loop of wire coupled to said coaxial conductors, said wire extending externally over a portion of the length of said outer coaxial conductor and internally through the hollow of said inner coaxial conductor.

8. An oscillation generator comprising a high frequency circuit comprising inner and outer hollow coaxial metallic conductors, the inner conductor having a portion of larger diameter at one end to increase the effective capacitance existing between said conductors, the other end of said inner conductor being electrically coupled to said outer conductor, an electron discharge device having anode, cathode and control electrodes, said anode being directly connected to said outer coaxial conductor, said control electrode being coupled through a blocking condenser to said inner coaxial conductor, and means in circuit with said cathode for applying a suitable potential to said outer coaxial conductor for energizing said anode.

9. A tuned high frequency circuit comprising inner and outer hollow metal cylinders consid-

erably different in diameter joined together at one of their adjacent ends and capacitively connected together at their other adjacent ends through a third cylinder which is connected to said inner conductor and only slightly smaller in diameter than the outer of the first two cylinders, said outer metal cylinder having its other end entirely open.

10. A resonant high frequency circuit comprising a pair of hollow inner and outer conductors, a low resistance direct current connection connecting together one of the adjacent ends of said conductors, the cross-sectional area of said conductors being arranged and shaped so that there is more capacity between certain portions of the inner and outer conductors relative to that existing between other portions of said conductors, the other ends of said inner and outer conductors being entirely open from an electrical standpoint.

11. A tuned high frequency circuit comprising a pair of coaxial cylindrical conductors, one of the adjacent ends of said cylindrical conductors being connected together by a low resistance connection, the other ends of said conductors being electrically entirely open and capacitively coupled together by virtue of the space between their side walls.

12. In combination, a tuned high frequency circuit comprising a hollow inner conductor and a hollow coaxial outer conductor, said inner conductor being electrically coupled to said outer conductor more closely at one of its ends than at the other, a connection extending within the interior of said inner conductor for a substantial portion of the length thereof, and a translating circuit coupled to both terminals of said connection.

13. In combination, a high frequency tuned circuit having hollow inner and outer conductors electrically coupled together more closely at one of their adjacent ends than at the other end, a multi-electrode electron discharge device, and means for influencing the action of said device at the frequency of said tuned circuit comprising a connection between a pair of electrodes of said device, said connection extending within the interior of said inner conductor for a substantial portion of the length of said inner conductor.

14. In combination, a high frequency tuned circuit having hollow inner and outer conductors electrically coupled together more closely at one of their adjacent ends than at the other end, a multi-electrode electron discharge device detector, and means for impressing oscillations of the frequency of said tuned circuit upon said detector comprising a connection between a pair of electrodes of said detector, said connection extending within the interior of said inner conductor for the entire length thereof.

15. In combination, a tuned high frequency circuit comprising a hollow inner conductor and a hollow coaxial outer conductor, said inner conductor being electrically coupled to said outer conductor more closely at one of its ends than at the other, a connection extending within the interior of said inner conductor for a substantial portion of the length thereof, and an antenna located externally of said outer conductor coupled to said connection.

16. In combination, a high frequency tuned circuit having hollow inner and outer conductors electrically coupled together more closely at one of their adjacent ends than at the other end, a multi-electrode electron discharge device including a control electrode, and means for influencing

the action of said device at the frequency of said tuned circuit comprising a connection between said control electrode and another electrode of said device, said connection extending within the interior of said inner conductor for a substantial portion of the length of said inner conductor.

17. In combination, a tuned high frequency circuit comprising a hollow inner and a hollow

coaxial outer conductor, both coupled together to form a resonant circuit, a connection extending within the interior of said inner conductor for a substantial portion of the length of said inner conductor, and a translating circuit coupled to both terminals of said connection.

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