April 28, 1942. H. O. PETERSON 2,281,247

ULTRA SHORT WAVE RESONANT CIRCUIT

Filed Feb. 29, 1940

Fig. 1

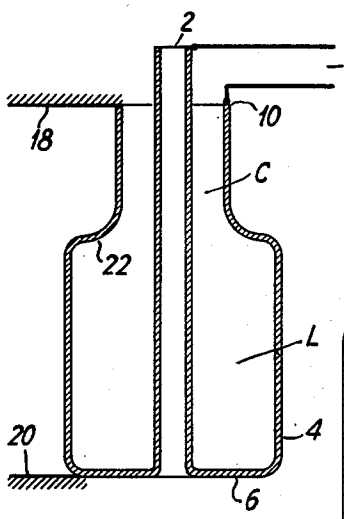


Fig. 3.

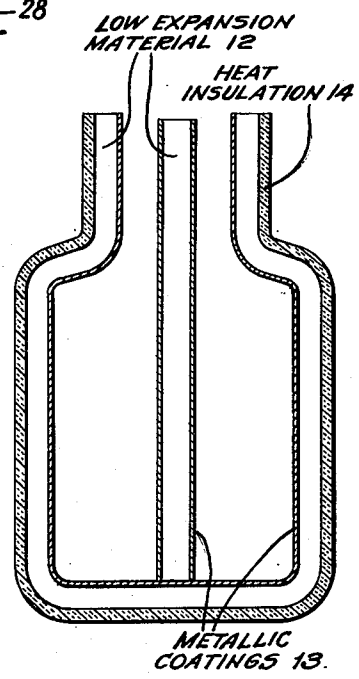
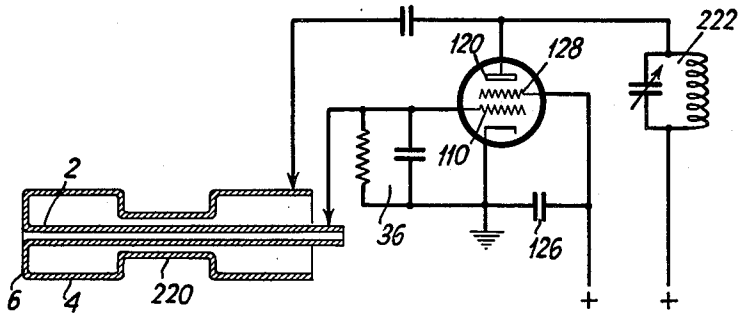


Fig. 2



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ULTRA SHORT WAVE RESONANT CIRCUIT

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13 Claims. (Cl. 178—44)

My present invention relates to ultra short wave electrical apparatus and has for one of its objects the provision of tuned circuits which at high frequencies have extremely low power factors and which occupy relatively small spaces. This application is a continuation-in-part of my application Serial No. 718,738, filed April 2, 1934, now United States Patent No. 2,201,199, granted May 21, 1940.

If the sources of loss in the conventional tuned circuit consisting of an inductance coil and a lumped capacitor are examined, it will be found that it is possible to reduce the loss in the capacitor by constructing it so as to utilize a low loss dielectric such as air or fused quartz while at the same time using a mechanical arrangement which will insure uniform distribution of current with a minimum of eddy current losses. The production of a very low loss inductance is more difficult. Thus, in the ordinary coil shaped inductor or inductance coil, it is practically impossible to obtain a uniform current distribution over the surfaces of the conductor at very high frequencies. And, even though a conductor having large circumference is provided, it will be found that most of the current crowds towards one side of this conductor when it is bent into a helical shape. Furthermore, eddy currents are set up in the surface of the conductor which may become serious when the size thereof is made large. To overcome the foregoing difficulties is one of the objects of my present invention, and I do so by providing an inductance system made of two hollow concentric metallic conductors or cylinders. By making the conductors coaxial and cylindrical, the current travels uniformly distributed over and down on the outside surface of the inner conductor and returns uniformly distributed over the inside surface of the outer conductor. Since the lines of magnetic flux are almost completely contained within the space between the outer conductor and the outside of the inner conductor, the possibilities of eddy current losses are minimized for the reason that the space through which the magnetic lines of force constituting the flux pass is nothing but air. Further, according to my present invention, I combine a low loss capacitance with a concentric tube inductance to produce a tuned circuit having an extremely low power factor.

A further object is to provide a simplified form of coaxial line resonator wherein a portion of the outer conductor is of reduced cross-section to form a capacitance with the inner conductor. By making the resonator in the form of a bottle as I propose, it can be very cheaply manufactured by automatic machines.

The following is a more detailed description of the invention accompanied by a drawing wherein Fig. 1 shows a preferred form of my concentric line resonator, Fig. 2 shows another form of my improved resonator together with a suitable vacuum tube utilization circuit, and Fig. 3 shows another form of concentric line resonator similar to that of Fig. 1.

Fig. 1 shows a concentric inductance consisting of two coaxial hollow metallic cylinders 2, 4 connected together at their bottom ends by means of a low direct current resistance connection here in the form of a metallic disc 6. In connection with the arrangement shown in Fig. 1 (and this is true also of Fig. 2), conductors having cross sections other than that of a circle may be used, but it is preferable to use circular cross sections inasmuch as this will result in most uniform current distribution at the tube surfaces. Also, it is to be borne in mind in connection with Figs. 1 and 2 that the two conductors should preferably be coaxial since a departure from the condition of coaxiality will result in a tendency towards unequal current distribution at the tube surfaces. Such an undesirable result follows because of the fact that current will flow over paths of less impedance. The tubes 2, 4 of Fig. 1 are of such a length that their inherent inductance, together with the capacitance existing between them, will be resonant to a desired frequency of operation. This will be found to be, because of the capacity between the tubes, equal to a physical length somewhat less than a quarter wavelength at the desired operating frequency.

In Fig. 1 the concentric inductance 2, 4, 6 is formed so that the outer tube 4 is bottle shaped or has a reduced necked portion at the open end 10. Because of the reduction in diameter of the outer tube 4, the reduced diameter portion, together with the adjacent portion of the inner conductor, forms effectively a lumped capacitor.

With the arrangement shown in Fig. 1, the effect of temperature change may be avoided by supporting the outside conductor 4 between non-expanding supports 18, 20 whereby the spacing between the inside corner 22 of the neck and the bottom end cannot vary.

In Fig. 1 connection is made to the elements of the tuned circuits by means of conductors 28 when it is desired to obtain parallel resonance effects. Also, the tubes may be filled with a low

loss dielectric, if desired, such as pure sulphur or certain gases, or facing surfaces of the tubes may be covered with mica. Also, to enhance frequency stability the tuned circuit of Fig. 1 and also that of Fig. 2 are preferably rigidly mounted, and may be, if desired, placed within an hermetically sealed container and temperature controlled. As an added precaution, the circuits may be placed within an evacuated container before being placed within a temperature control box so as to prevent moisture from condensing upon the surfaces thereof, although this undesirable effect may be avoided by simply maintaining the elements above room temperature. It will, of course, be appreciated that the inner concentric conductor may, if desired, be a solid rod instead of a tube.

The resonator of Fig. 1 is in the form of a bottle consisting of Pyrex or other very low expansion coefficient glasses which might be coated with metal to form resonant lines, and may be manufactured by molding. Because of the simplicity of design of the resonant line of the invention, the design is suitable for mass production of accurate frequency control devices. In this way molded forms of Pyrex glass, fused quartz or other low expansion coefficient material could be provided in large numbers at very reasonable cost. Of course, metallic coatings, such as copper, silver or gold, would be applied to the glass to provide electrical conductivity and the addition or subtraction of metal at proper places may be used at the time of manufacture, or afterward, to adjust the exact resonant frequency of each circuit to the desired value.

If desired, the glass base resonant circuits can be so designed that the metallic coatings are exposed only to vacuum and so are not subject to deterioration with age. The vacuum chamber has the further advantage of reducing the possibility of arcing and it facilitates adjustment to exact frequencies by applications of heat to move the metal coatings from one place to another by simple evaporation and condensation, sometimes called sputtering. These metal coated glass forms would, of course, be mounted in suitable protective mountings to protect them from mechanical injury and from too rapid temperature changes which would tend to distort their shape. For resonant devices used only for frequency checking purposes where the energy dissipation in them may be very small, it is preferred that very good heat insulation be applied to make all temperature changes very slow. The heat insulation may readily be provided by means of a vacuum chamber on the principle of the DeWar flask or Thermos bottle.

As an alternative to metal coated low expansion coefficient glass forms for resonant circuits, I propose using forgings or castings of metal alloys having low expansion coefficient, such as nickel-iron alloys similar to Invar, Elinvar etc., coated with low electrical resistance material such as copper, silver or gold. Obviously, if desired, the resonators may be totally constructed from copper or other highly electrically conductive material.

Fig. 3 shows, by way of example, a resonator whose inner and outer conductors are constructed from low temperature coefficient material 12 coated with high electrical conducting surfaces 13. If desired, suitable heat insulation material 14 may be provided.

In Fig. 2 the lumped capacitor is formed by indenting the outer conductor 4 intermediate its ends as at 220. If desired, the inner conductor 2 may be expanded at this portion so as to increase the lumped capacity at the center of my concentric tube system 2, 4, 6. Here the concentric tube system is connected for high frequency currents between the plate or anode 120 and the control grid 110 of a vacuum tube, proper grid bias being insured by the action of a grid leak and condenser arrangement 36. Interelectrode feed-back other than that to the concentric tube arrangement 2, 4, 6 is effectively prevented by the action of screen grid 128 grounded for radio frequency currents by a suitable condenser 126. While the plate tuned circuit 222 has been illustrated in the usual conventional form, it may be replaced, as explained before, by a concentric tube system described herein, or it may be replaced by a Lecher wire system of adjustable length.

What is claimed is:

1. A tuned circuit comprising a pair of concentric conductors having a connection of low impedance to energy of the operating frequency connecting said conductors together at one end, the outer conductor of said pair having a portion of reduced cross-section to increase the capacitance between said pair of conductors.

2. A tuned circuit comprising a pair of concentric conductors having a connection of low impedance to energy of the operating frequency connecting said conductors together at one end, the outer conductor of said pair having a portion of reduced cross-section at its other end to increase the capacitance between said pair of conductors.

3. A tuned circuit comprising a pair of concentric conductors having a connection of low impedance to energy of the operating frequency connecting said conductors together at one end, the outer conductor of said pair having a portion of reduced cross-section intermediate its ends to increase the capacitance between said pair of conductors.

4. A tuned circuit comprising a pair of concentric conductors having a connection of low impedance to energy of the operating frequency connecting said conductors together at one end, the outer conductor of said pair having a portion of reduced cross-section to increase the capacitance between said pair of conductors, said conductors being made of glass having a low temperature coefficient of expansion and coated with an electrical conducting material.

5. A tuned circuit comprising a pair of concentric conductors having a connection of low impedance to energy of the operating frequency connecting said conductors together at one end, the outer conductor of said pair having a portion of reduced cross-section to increase the capacitance between said pair of conductors, said conductors being made of low temperature coefficient material having a metallic coating of good electrical conductivity.

6. The process of making a tuned oscillatory circuit which includes the step of molding a material having a low temperature coefficient of expansion to the form of a hollow body having a reduced cross-section at one portion in its length, and coating the interior of said body with electrically conducting material.

7. A tuned circuit comprising a pair of coaxial conductors, the inner conductor being a straight rod, the outer conductor being shaped in the form of a bottle having a neck at one end of reduced cross-section, and an end plate connect-

ing the other end of said outer conductor to the adjacent end of said inner conductor.

8. The process of making a tuned oscillatory circuit which includes the step of molding glass having a low temperature coefficient of expansion to the form of a hollow body having a reduced cross-section at one portion in its length, and coating the interior of said body with high electrically conducting material.

9. The process of making a tuned oscillatory circuit which includes the step of molding a nickel-iron alloy material having a low temperature coefficient of expansion to the form of a hollow body having a reduced cross-section at one portion in its length, and coating the interior of said body with electrically conducting material.

10. The process of making a tuned oscillatory circuit which includes the step of molding glass having a low temperature coefficient of expansion to the form of a hollow body having a reduced cross-section at one portion in its length, coating the interior of said body with high electrically conducting material, and heat insulating said hollow body.

11. A tuned circuit comprising concentric inner and outer conductors conductively coupled together at one end and capacitively coupled together at the other end, said outer conductor having a portion of reduced cross-section at said last end.

12. The process of making a tuned oscillatory circuit which includes the step of molding a material having a low temperature coefficient of expansion to the form of a hollow body, and coating the interior of said body with electrically conducting material, whereby the resonance characteristic of said tuned circuit is dependent upon the interior dimensions of said hollow body tuned circuit.

13. A tuned oscillatory circuit comprising a hollow glass body of low temperature coefficient of expansion and having a reduced cross-section at one portion of its length, said body being coated in its interior with a metallic coating of good electrical conductivity.

HAROLD O. PETERSON.