Dec. 16, 1952 J. A. BOLTSON 2,622,238

RESONANT TANK CIRCUIT FOR DIATHERMY APPARATUS OR THE LIKE

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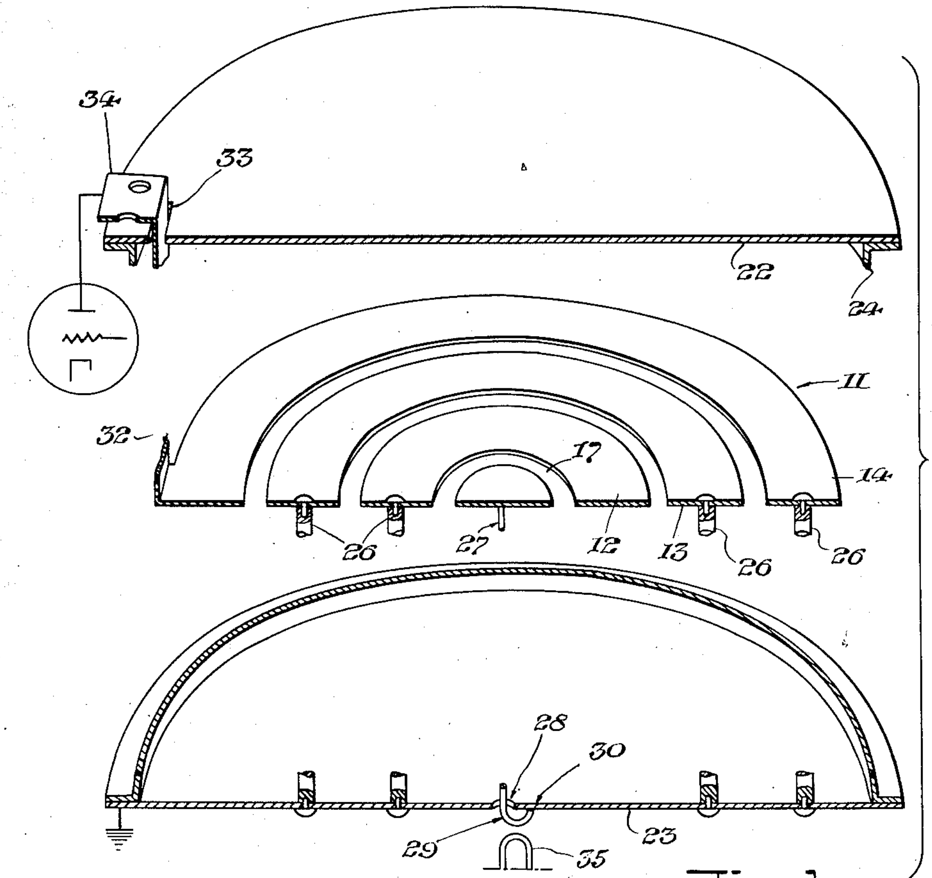

Fig. 1.

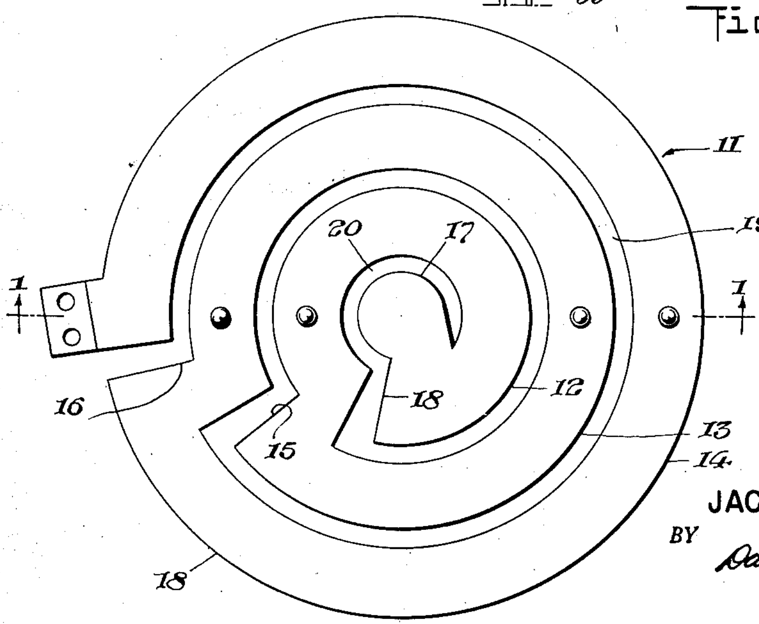

Fig. 2.

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RESONANT TANK CIRCUIT FOR DIATHERMY APPARATUS OR THE LIKE

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8 Claims. (Cl. 323—76)

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The present invention is related to the art concerning resonant tank circuits, and particularly those adapted for use in short-wave diathermy apparatus requiring high stability of output frequency.

At the present state of the art, it is well known to use high frequency short-wave oscillations for physiotherapy purposes, to produce internal and/or surface heating of the body or members thereof for therapeutic benefit. Diathermy apparatus for these purposes essentially comprises a short-wave oscillation generator in combination with means for usefully applying the generated short wave power to the subject to be treated. During normal use of such apparatus extremely wide variations in the conditions of electrical loading are encountered. This produces great difficulty in maintaining substantially constant frequency within the requirements imposed by the Federal Communications Commission. Further difficulty has been encountered in minimizing spurious frequencies, such as harmonics, from the generated output.

According to the present invention these difficulties have been substantially minimized and almost entirely overcome by the use of a novel form of resonant tank circuit which provides a large degree of stability despite the wide variation in loading of the oscillator and which is inherently self-shielding to minimize production and radiation of spurious frequencies.

In its preferred form, the tank circuit of the present invention comprises a flat conductor arranged generally in the form of a spiral and completely enclosed in a metallic enclosure which provides a capacitive effect combining with the inductance of the conductor to form the resonant circuit.

The present invention thereby provides an extremely simple and highly useful, self-shielded, resonant circuit element, especially adapted for use in the frequency range between 5 and 100 megacycles per second. In this frequency range, conventional coil and conductor elements for producing resonance present difficulties because of the factors of stray and distributed capacitance which become troublesome as the wave length becomes commensurate with the physical dimensions of the circuit elements. On the other hand, sections of conventional transmission lines cannot be utilized because, at the frequencies involved, their physical length becomes excessive; for example, at 30 megacycles a quarter-wave line section becomes 2½ meters long, which is too large for practical use.

By the present invention, a compact, useful

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tank circuit is provided of convenient size and with good efficiency which overcomes these disadvantages and usefully employs the natural capacitance of the device.

The present invention provides a completely enclosed condenser formed of a conductive plate suspended within and spaced closely to a conductive housing, the plate and housing forming the two condenser elements. To provide resonance, the path of the current flow in the device is lengthened to form the necessary inductive effect. This is done preferably by making the internal condenser element or plate in the form of a flat spiral, as by cutting a generally spiral slot therein to create a coil providing sufficient inductance, the inductance being a direct function of the length of conductive path over which the current is forced to flow.

Other objects and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the appended drawing in which:

Figure 1 shows an exploded perspective cross-sectional view of a preferred form of tank circuit according to the invention, and

Figure 2 is a plan view of coil 11 of the tank circuit of Figure 1, the section of Figure 1 being taken along line 1—1 of Figure 2.

Referring to the drawing, the present tank circuit comprises a flat generally spiral conductive coil 11. For convenience of fabrication, this spiral coil 11 may be formed of concentric circular arcuate portions 12, 13, 14, each formed as a nearly complete circle. Consecutive ones of these arcuate portions are joined by radially extending connecting portions 15, 16. Thus, at the center the coil 11 has a substantially circular disc portion 17 joined to the innermost arcuate portion 12 by the radial converting portion 18. Arcuate portion 12 is connected to the succeeding arcuate portion 13 by the radial connecting portion 15. Similarly, arcuate portion 13 is connected to next outermost arcuate portion 14 by the radially extending connecting portion 16. The coil 11 is preferably formed of relatively wide strips of conductive material arranged in the same plane and only slightly spaced from one another. In one example which has been constructed, the width of each of the arcuate portions 12, 13, 14 was one inch, while the gap 19 spacing the consecutive arcuate portions was ¼ inch. Gap 20 between center disc 17 and the innermost arcuate portion 12 may have the same width as the remainder of the gap 19, or may be substantially larger, such as of the order of ¾ of an inch in the example given.

Coil 11 is mounted symmetrically between two parallel circular plates 22 and 23 which are relatively closely spaced to coil 11 (in the embodiment indicated above this spacing was $\frac{5}{16}$ inch). Connecting the two plates 22, 23 is a cylindrical element 24 which is joined at either end to plates 22 and 23 to form a completely enclosed housing of pillbox configuration containing and surrounding the coil 11. It will thus be seen that coil 11 presents a larger area in close juxtaposition to each of these plates 22 and 23 and therefore has a larger inherent capacitance. It is this capacitance in combination with the inherent inductance of the coil which provides the resonance of the tank circuit. Coil 11 is supported within the enclosure 22, 23, 24 by a plurality of insulating studs 26.

The inner disc portion 17 is conductively connected to the lower plate 23 by a preferably rigid conductor 27 which passes through an aperture 28 at the center of plate 23, and is then curved back to form a loop 29 conductively connected to plate 23 as to 30. This conductor 27, therefore, acts both as a further support for the coil 11, and as output connection. The outermost arcuate portion or turn 14 of coil 11 is provided with an upward extension 32 which passes through a suitable aperture 33 in upper plate 22 to form a terminal 34.

In customary use the terminal 34 serves as the high potential terminal of the tank circuit, and the housing 22, 23, 24 serves as the low potential or ground terminal. Output is derived from the tank circuit by inductive coupling, by means of coupling loop 35 inductively coupled to the loop 29. It will be appreciated that this coupling is extremely low, since the coupling occurs adjacent the low potential point 30 of the tank circuit. Especially when used in diathermy equipment, this loose coupling permits the attaining of proper frequency stability since the reaction of the highly variable load upon the frequency of oscillation is thereby minimized.

The use of the extremely large capacitative effect between the coil 11 and the top and bottom plates 22, 23 is highly important in the present invention, since this capacitance forms a very low impedance for harmonics or higher spurious frequency, whereby such harmonics or spurious frequencies are greatly minimized. In addition, the self-enclosing and self-shielding nature of the device and the low potential output coupling greatly minimize any radiation of such harmonics or spurious frequencies. Also, the design of the device is such as to produce extremely low thermal drift, because of the large heat-radiating area made available. An embodiment of this tank circuit provided a drift in frequency of only 12 kilocycles at an operating frequency of 27.12 megacycles, after one hour of operation under the worst conditions. This tank circuit therefore combines the desirable features of non-radiation of harmonics and high stability which are especially important in short-wave diathermy apparatus.

While the coil 11 has been illustrated as formed of circular arcs and having circular arcuate gaps, it will be understood that this form need not be strictly adhered to, but is preferred solely for ease of fabrication when the coil 11 is machined from a single sheet of conductive material. However, coil 11 need not be restricted in its manufacture of this method of fabrication. Where other methods of fabrications are used, the gap 19 may be made as a spiral gap and the conductive portion of the coil 11 may similarly be of spiral configuration without departing from the essential spirit of the invention.

In designing the coil 11, it is found that in general the dimensions of the coil (that is, its diameter, number of turns, width of turns, and spacing of turns) may be empirically determined to provide a close approximation to the desired resonant frequency; thereafter, a fine adjustment to attain exactly the desired frequency of resonance is provided by loop 29. It will be appreciated that the inductance of loop 29 is added to that of coil 11, and is thereby reflected into and affects the resonance frequency of the tank circuit. By making loop 29 larger, for example, its inductance is increased and correspondingly increases the inductance of the tank circuit, reducing its resonant frequency. Conversely a decrease in the area of loop 29 serves to increase the resonant frequency of the tank circuit. In this way a minor adjustment can be made of the resonant frequency of the tank circuit after fabrication of the coil 11.

In the form of the invention described above, the dielectric material between the coil 11 and the housing 22, 23, 24 is air. Where desired, other forms of dielectric may be used. Thus, where voltage arc-over may be an important factor, the housing may be evacuated by using insulating vacuum seals at the aperture 33, 28. Where increased capacitance may be desired, mica or other high dielectric constant material may be placed between coil 11 and plate 22 and/or plate 23, or else the entire housing may be filled with a desirable dielectric material.

While the tank circuit described above is particularly suitable and adapted for use with short wave diathermy apparatus, especially in the 27.12 megacycle frequency range, it will be apparent that its utility is not restricted merely to such apparatus, but it is useful wherever such tank circuits are desired. Its relatively massive construction, containing as it does a large area and amount of conductive material, renders it especially adaptable for uses in the high frequency inductive heating field, where relatively large amounts of power are handled.

In addition to serving as a tank circuit, it is also highly useful as a radio frequency choke coil of the resonant type. When so used, lead 29 would not be connected to plate 23 by loop 29 as shown, but would be connected directly to any desired circuit as a second terminal.

The present apparatus is also useful as a direct-current shorting and high frequency isolating element. For this purpose, for example, terminal 34 may be connected to upper plate 22 and the input terminal then provided by lead 27 (loop 29 being, of course omitted). Alternatively, terminal 34 may be the input terminal, and lead 27 may be directly connected to plate 23, without loop 29 being formed therein. Thus either terminal 34 or 27 may be connected to the housing 22, 23, 24, or either or both may be isolated from the housing and connected to external circuit elements.

In place of the coupling loop 29, conductor 27 may be led straight through aperture 28, and coupled directly to an external circuit. Alternatively, two conductors may be led from coil 11 through aperture 28, one being conductor 27 (not here coupled to plate 23) and the other being a similar conductor connected to coil 11 at some point intermediate center disc 17 and outer terminal 34, according to the desired degree of coupling to the external circuit.

In some instances, it is desirable to provide two tank circuits, as in a tuned-grid oscillator, or in a system whereby two tank circuits are paralleled, only one being coupled to the load whereby the other stabilizes the frequency being generated. Such a double tank circuit is readily provided in the present invention merely by stacking two of the above described circuits one upon the other. In effect, the housing then becomes a single container divided into two parts by a septum extending thereacross, with a spiral element symmetrically arranged in each part, and the dual circuit can be easily constructed in this manner.

The present invention therefore provides a simple but efficient resonant circuit usefully employing deliberately augmented stray capacitance to resonant with an inductance element, whereby the resultant structure has convenient size in the megacycle region, accompanied by self-shielding, reduction of harmonics, and high frequency stability.

It will be understood that the details of the device described above are susceptible of variation in its specific features, and it is merely an illustrative embodiment of the invention, which is not limited thereto but is as defined in the appended claims.

I claim as my invention:

1. A resonant circuit adapted for use in diathermy apparatus or the like, comprising a generally spiral plane coil, each of whose turns has a radial width of a larger order of magnitude than the radial separation between successive turns, and means providing substantial capacitance to resonate with said coil, comprising a pair of conductive flat plate walls disposed respectively on either side of said coil in parallel adjacent relation thereto, and conductive means connecting said walls and enclosing said coil whereby said circuit is rendered non-radiating and harmonic resonances are suppressed.

2. Apparatus as in claim 1 wherein said flat plate walls are closer to said plane coil than the radial width of said coil turns.

3. Apparatus as in claim 1, wherein one of said walls is formed with an aperture adjacent to the outermost end of said coil, said coil having a terminal extension connected to said outermost end and passing insulatedly through said aperture to the exterior of said housing.

4. Apparatus as in claim 1, wherein one of said walls is formed with an aperture centrally thereof, and opposite the center of said coil, said coil having a terminal conductor connected to its center and passing insulatedly through said aperture.

5. Apparatus as in claim 4, wherein said terminal conductor is bent in the form of a magnetic loop and has its exterior end connected to said one wall to form a coupling for said circuit.

6. A resonant circuit for diathermy equipment or the like, comprising a generally spiral plane coil formed of a plurality of concentric arcuate portions, each only slightly less than a complete circle, each of said arcuate portions having a radial dimension of an order of magnitude larger than the spacing between successive arcuate portions, each arcuate portion having one end connected with one end of its immediately surrounding arcuate portion by a radial connecting portion to form a generally spiral coil having circular arcuate portions, means providing substantial capacitance for resonating with said coil, comprising a flat conductive plate parallel to said coil and spaced therefrom by a distance less than said arcuate portion radial dimension, and a pair of terminals connected respectively to the outermost end and to the innermost end of said generally spiral coil.

7. A resonant circuit comprising a generally spiral plane coil, means providing substantial capacitance for resonating with said coil comprising a pair of flat conductive plates disposed adjacent to and parallel to said coil on either side thereof and a cylindrical conductive wall joining said conductive plates and surrounding said coil, whereby said wall and plates form a conductive housing surrounding said coil, one of said plates having an aperture substantially centrally thereof and one of said plates having an aperture adjacent the outer edge thereof, and a pair of coil terminals connected respectively adjacent the inner and outer ends of said coil and extending insulatedly through respective one of said apertures for connecting said resonant circuit to other circuit elements.

8. A resonant circuit comprising a generally spiral plane coil and means providing substantial capacitance to said coil to resonate therewith, comprising a flat conductive plate disposed parallel and adjacent to said coil to form a lumped capacitance therewith, said plate having an aperture centrally thereof, and an output coupling comprising a conductor connected at one end to the inner end of said spiral coil and passing insulatedly through said central aperture.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,837,678	Ryder	Dec. 22, 1931
2,027,861	Fyler	Jan. 14, 1936
2,163,775	Conklin	June 27, 1939
2,367,576	Harvey et al.	Jan. 16, 1945
2,421,137	Wheeler	May 27, 1947

FOREIGN PATENTS

Number	Country	Date
223,706	Great Britain	Oct. 30, 1924
297,850	Germany	May 26, 1917