July 31, 1951 R. L. MEISENHEIMER 2,562,239

MEANS FOR REDUCING OR ELIMINATING UNDESIRED RESONANCE EFFECTS IN ULTRA HIGH FREQUENCY APPARATUS

Filed July 23, 1946

Fig. 1

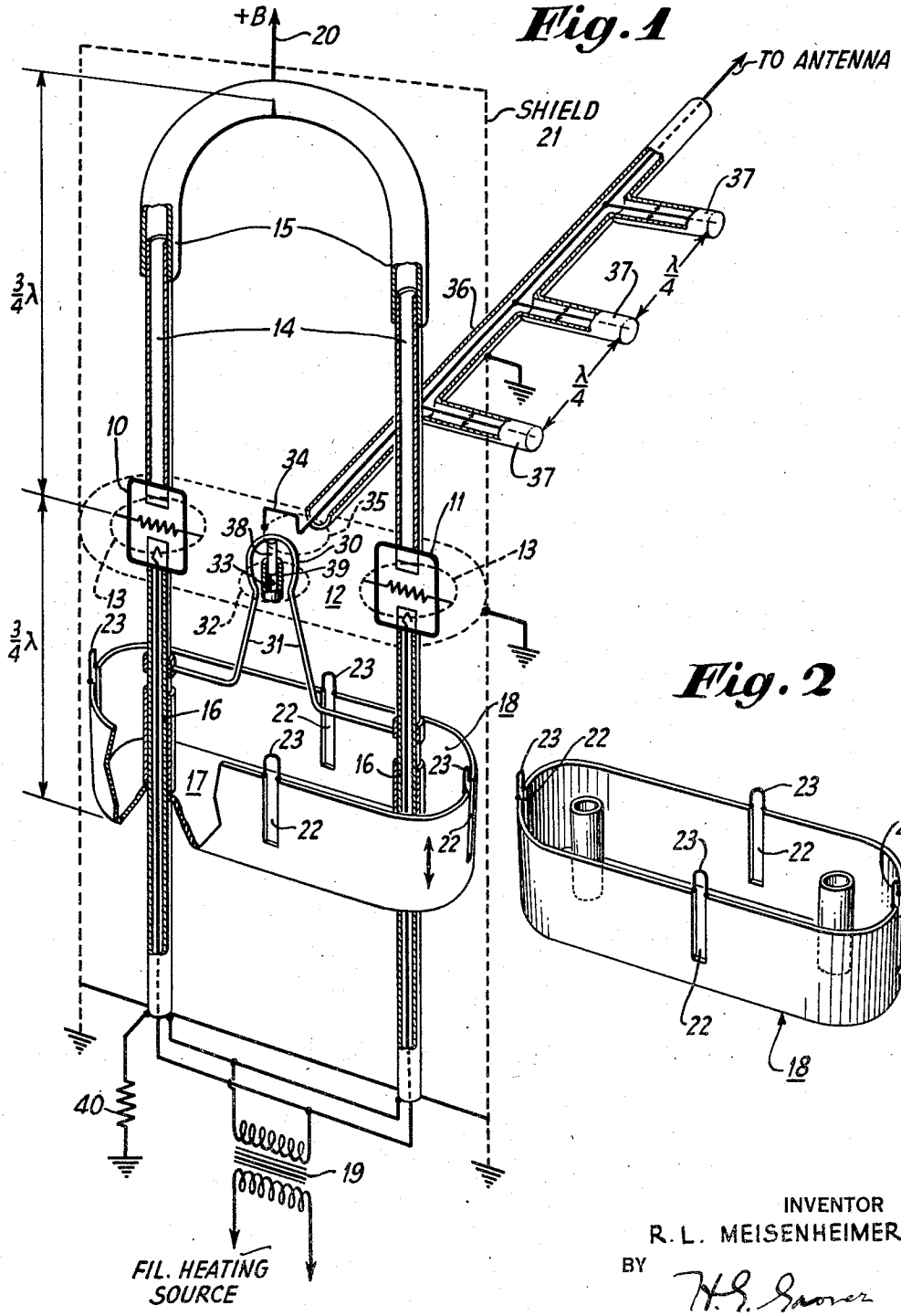


Fig. 2

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Patented July 31, 1951 2,562,239

UNITED STATES PATENT OFFICE

2,562,239

MEANS FOR REDUCING OR ELIMINATING UNDESIRED RESONANCE EFFECTS IN ULTRA HIGH FREQUENCY APPARATUS

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Application July 23, 1946, Serial No. 685,580

11 Claims. (Cl. 250—36)

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This invention relates to apparatus for use at ultra high frequencies, and has for its principal object to eliminate or reduce undesired resonance effects in elements having appreciable surface area in an oscillation generator system.

In testing ultra high frequency pulsed power oscillators wherein the surface dimensions of a hollow shell-like tuning element become comparable with or an appreciable fraction of the operating wavelength in free space, I have found that undesired circulating currents flow around the tuning element in a circumferential direction and cause resonance effects responsible for deleterious operation.

According to the invention, these deleterious effects are overcome by providing in the tuning element in which the undesired circulating currents flow, a plurality of slots which extend transversely to the flow of the current, and bridging the slots with inductive loops to prevent the building up of excessive radio frequency voltages across the slots.

A more detailed description of the invention follows in conjunction with a drawing showing its application to an ultra high frequency oscillator, wherein:

Fig. 1 shows the application of the invention to an ultra high frequency oscillator; and

Fig. 2 is a perspective view of the sliding element showing in greater detail the transverse slots and the inductive loops across the slots.

Fig. 1 shows an ultra high frequency generator comprising a pair of vacuum tubes 10 and 11 mounted in and supported by a metallic plate 12. This metallic plate is provided with a pair of apertures 13, 13 for accommodating the envelopes of the vacuum tubes. The grids of the tubes 10 and 11 are directly connected to the metallic plate 12, which in turn is grounded. It will thus be seen that the grid of each tube and associated mounting electrostatically shield the anode and cathode and their associated circuits from each other. A tunable parallel conductor circuit composed of hollow conductors 14 connect the anodes of the two tubes together in push-pull relation. The ends of conductors 14 at 15 are in telescopic relation to the other portions of the conductors in order to provide adjustment of the lengths of these conductors for tuning purposes. Putting it in other words, we have essentially a collapsible end 15 for tuning the anode circuit.

Another pair of hollow conductors 16 forms a tunable circuit between the cathodes of the tubes. The conductors 16 are directly connected together by means of a short-circuiting disc 17 forming the bottom part of an open metallic shell or can-like element 18. The filaments of the two tubes 10 and 11 are supplied with heating currents through wires extending within the interiors of the hollow conductors 16 and connected to the secondary winding of a suitable filament supply transformer 19 whose primary winding is connected to a low frequency alternating current filament heating source.

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The anodes of the two tubes 10 and 11 are supplied with a suitable positive polarizing potential from a source + B through conductor 20 which is connected to the center of tubular conductor 15 and to the upper adjacent ends of the conductors 14 of the anode tuned circuit. The cathode tuning circuit is tunable by moving the hollow shell-like element 18 up or down along the lengths of the conductors 16 by means of a suitable rod connected to plate 17. The anode and cathode tuned circuits 14 and 16, respectively, are separately shielded by metallic sheets shaped to form an oval shield represented diagrammatically by means of the dash lines 21. It will thus be seen that the anode and cathode tuned circuits are shielded from each other externally of the vacuum tubes 10 and 11 by shield 21 and also shielded from each other electrostatically by means of the grounded grids which are directly connected to the metallic disc-like plate 12. The shell 18, it should be noted, is open at the end nearest the cathodes. Shell 18 is separated by an air gap from the shield 21 and is capacitively coupled to the shield, thus isolating the shell from ground for D. C. and low frequencies, while at the same time providing a low impedance to ground for the high radio frequencies.

In order to provide feedback between the anode and cathode circuits, there is provided a self-balancing feedback circuit in the form of a loop 30 whose center or midpoint is coupled to the metallic ground plate 12 by means of a capacitor connection 38, 39. It will be seen that loop 30 extends above the metallic plate 12 through an aperture 32 while its legs 31 are below the metallic plate 12. The legs 31 of loop 30 are tapped or tied to the cathode line 16, as shown. The legs of the loop 30 can, if desired, be telescoped to enable adjustment of their lengths, though this is not necessary if the feedback system is designed for a particular oscillator. The center-point ground connection 38, 39 comprises two lengths of conductors which are capacitively coupled to each other through mica insulation 33, thus grounding the midpoint of the loop over a path having slight reactance at the operating frequency. The mica 33, in effect, provides a series condenser in the connection between the center point of the loop and ground. Obviously any other arrangement of a series condenser will also function satisfactorily. The primary purpose of this condenser is to isolate the cathode circuit

from ground so that a bias voltage may be applied between the grids and cathodes of the tubes. Because of this slight reactance in the center point ground connection, the system permits substantially perfect balance to be obtained in the currents through the two vacuum tubes despite slight differences in tube characteristics. The voltage nodal point on the loop 30 can shift slightly to either side of the actual center point and thus permits self-balancing of the push-pull circuit. The center tap prevents flash-over at the operating power levels by holding the midpoint of the loop near ground potential and thus increasing the threshold value of flash-over.

The output circuit includes a metallic loop 34 which is arranged above the plate 12 for coupling to the anode tuned circuit. One end of the output loop 34 is connected directly to the plate 12 while the other end extends down through an aperture 35 for connection to the inner conductor of a concentric transmission line 36. Concentric transmission line 36, which connects the output loop 34 to a suitable utilization circuit such as an antenna, is shown provided with three impedance matching stubs 37 spaced one-quarter of a wavelength apart at the mid operating frequency. A cathode bias resistor 40 is connected between ground and that end of the cathode conductor 16 farthest removed from the vacuum tubes. The metallic shell 18 which tunes the cathode tuned circuit serves as one terminal of a condenser whose other terminal comprises the grounded metallic shield 21.

The lengths of the anode and cathode tuned circuits, which are here shown to be electrically (although not necessarily mechanically) three-quarters of a wavelength long, enable the attendant to tune the circuits at the extremely high frequencies at which the oscillator is capable of functioning.

The oscillator of Fig. 1 is operable anywhere in the range from 350 to 1400 megacycles with anode voltages of positive polarity supplied to lead 20 anywhere in the range from 300 volts to 15,000 volts. Obviously, if the circuit of the invention is to be operated continuously, the anode voltages would be somewhere near the 300 volt value, whereas, if the oscillation generator is to be used for pulse operation, for extremely short intervals of the order of a microsecond or so, the anode voltage may be in the upper regions near 15,000 volts. When using pulsing methods it is possible to obtain an output of at least 350 kilowatts employing an anode voltage of around 15,000 volts. Such pulse operation is obtainable by interrupting the anode voltage supply at the rate at which it is desired to produce pulses of high frequency energy.

By way of example only, the reactance of the condenser provided by the mica insulation 33 (separating the short conductors 38, 39) of the center point ground connection may be about 5 ohms at an operating frequency of 600 megacycles. The impedance of this center point ground connection 38, 39, 33 may be of the order of 20 to 100 ohms at operating frequencies in the range from 485 to 715 megacycles. The value of the impedance of this center ground connection is not critical in this range.

The oscillator, so far described, forms no part of the invention per se and is described in detail in copending application, Serial No. 608,576, filed August 2, 1945, by L. S. Nergaard, now U. S. Patent 2,471,535, May 31, 1949, to which reference is herein made.

The gist of the present invention comprises the feature of slotting the tuning shell 18 at several places by means of slots 22 which extend vertically as shown, but transversely to the flow of currents in a circumferential direction around the tuning element 18, and bridging each slot 22 at the free end of the shell 18, nearest the vacuum tubes, by an inductive loop 23. It should be noted that there are four slots located symmetrically around the oval shaped tuning element 18 and that these slots are parallel to each other and extend for about three-quarters of the vertical height of the shell 18. Obviously the invention is not limited to any particular number of slots nor to a vertical arrangement of the shell 18.

I have found that in operating the oscillator of Fig. 1 without slots 22, with the dimensions of the shell 18 comparable with the wavelength at the operating frequency there developed resonance effects due to currents flowing around the perimeter of the shell with the following deleterious effects in circuit operation: (1) Flash-over between shell 18 and grounded shield 21; (2) Erratic tuning with dead spots in the frequency range of the equipment; and (3) Unbalanced circuit operation.

The slots 22 eliminated these undesired resonance effects. The inductive loops 23 were added to prevent the existence of excessive RF voltage across the slots at the edges nearest the vacuum tubes. At the particular location of these inductive loops 23, the magnitude of the undesired circulating currents in the shell 18 is the greatest, therefore tending to produce arcing across the slots.

As an example only, with the oscillator operating in the range of 550 to 660 megacycles corresponding to a wavelength range of 54.5 to 45.5 centimeters, the shell 18 was of oval configuration with a major axis dimension of about 8 inches and a minor axis dimension of about 4⅜ inches and a vertical height or depth of about 5 inches. This five-inch vertical height was approximately one-quarter wavelength at the operating frequency. The slots 22 were each about ⅛ or $\frac{3}{32}$ inch wide while the loops 23 each were about $\frac{5}{16}$ inch long.

Fig. 2 illustrates, in perspective, the general appearance of the shell 18 of the invention when removed from the oscillator of Fig. 1.

If desired, the inner sleeves which are designed to contact the cathode lines, may be provided with spring-like (resilient) contact fingers, not shown.

What is claimed is:

1. In a high frequency system, a shell having a metallic surface on which undesired circulating currents appear, said surface having such dimensions as to produce resonate effects for said undesired currents, said surface having a slot extending from one end of said shell transversely to the flow of said undesired currents on said surface, and an inductive loop across the edges of said slot.

2. In a high frequency system, a hollow metallic shell open at one end whose dimensions are comparable with the operating wavelength in free space, said shell having a plurality of spaced slots extending from one end of said shell transversely to the flow of undesired circumferential currents on the surface of said shell, for a length measured from said one end which is appreciable compared to the height of said shell, and individual inductive loops across the edges of said slots.

3. In a high frequency system, a hollow metal-

lic shell whose dimensions are comparable with the operating wavelength in free space, said shell having a plurality of spaced slots extending from one end of said shell transversely to the flow of undesired circumferential currents on the surface of said shell for a length measured from said one end which is appreciable compared to the height of said shell, said slots being symmetrically arranged around said shell, and individual inductive loops across the edges of said slots at locations where the magnitude of said undesired currents is greatest.

4. In a high frequency system, an electron discharge device having an electrode and a lead to said electrode, a hollow electrically conducting tuning element over which currents flow in a circumferential direction, said element being coupled to said electrode by electrical contact with said lead, said hollow element having a plurality of spaced slots extending from the same end of said hollow element transversely to the flow of undesired circumferential currents on the surface of said element for a length which is at least half of the height or depth of said element, and individual inductive loops across the edges of said slots.

5. In a high frequency system, an electron discharge device having an electrode and a lead to said electrode, a hollow electrically conducting tuning element over which currents flow in a circumferential direction, said element being coupled to said electrode by electrical contact with said lead, a shield maintained at zero radio frequency potential spaced from and capacitively coupled to said tuning element, said element and shield functioning as a path of low impedance to energy of the operating frequency, said hollow element having a plurality of spaced slots extending from an end of said hollow element transversely to the flow of undesired circumferential currents on the surface of said element for a length which is at least half of the height or depth of said element, and individual inductive loops across the edges of said slots.

6. An ultra high frequency oscillator operating in the range of 300 megacycles and higher, comprising a pair of vacuum tubes each having anode, cathode and grid electrodes, a direct connection from said grid electrodes to ground, a tuned circuit coupled to said anodes, and a tuned circuit connected to said cathodes, one of said tuned circuits including a pair of conductors each connected to a corresponding electrode of one of said vacuum tubes and a hollow metallic shell element having a bottom electrically contacting said conductors and having dimensions comparable with the operating wavelength, said hollow shell element having a plurality of spaced slots extending from an end of said hollow element transversely to the flow of undesired circumferential currents on the side surface of said element for a length which is at least half of the length or depth of said element, and individual inductive loops across the edges of said slots.

7. An ultra high frequency oscillator operating in the range of 300 megacycles and higher, comprising a pair of vacuum tubes each having anode, cathode and grid electrodes, a direct connection from said grid electrodes to ground, a tuned circuit coupled to said anodes, and a tuned circuit connected to said cathodes, one of said tuned circuits including a pair of conductors and a hollow metallic shell element having a bottom portion electrically contacting said conductors and having dimensions comparable with the operating

wavelength, a shell maintained at ground potential spaced from and capacitively coupled to said metallic shell element, said shell element and shield functioning as a path of low impedance to energy of the operating frequency, said hollow shell element having a plurality of spaced slots extending from an end of said shell element transversely to the flow of undesired circumferential currents on the surface of said element for a length which is at least half of the length or depth of said element, and individual inductive loops across the edges of said slots.

8. An ultra high frequency oscillator comprising a pair of vacuum tubes each having an anode, a cathode and a grid, a parallel conductor tuned circuit of substantially uniformly distributed constants connecting said anodes together, a parallel conductor tuned circuit of substantially uniformly distributed constants connecting said cathodes together, a connection from ground to each of said grids to electrostatically shield the anode and cathode of each tube from each other means external of said tubes for shielding said tuned circuits from each other, and a feedback circuit coupling said two tuned circuits, a hollow metallic shell capacitively coupled to said shielding means and having a bottom portion an integral part of said cathode tuned circuit, said shell having a plurality of physically parallel slots symmetrically arranged around said shell and extending from an end of said shell transversely to the flow of undesired circumferential currents on the surface of said shell, and individual inductive loops across said slots.

9. In a high frequency system, a hollow metallic shell whose dimensions are comparable with the operating wavelength in free space and having a side portion and an open end, said shell having a slot in the side thereof parallel to the axis of said shell and which extends from the open end of said shell, said slot having a length appreciable compared to the height of said shell, and an inductive loop across the edges of said slot.

10. In a high frequency system, a hollow metallic shell whose dimensions are comparable with the operating wavelength in free space and having a side portion, an open end and a closed bottom portion, said shell having a slot in the side portion thereof parallel to the axis of said shell and extending from the open end, said slot having a length appreciable compared to the height of said shell, and an inductive loop across slot at the open end of said shell.

11. In a high frequency system, a hollow metallic shell, said shell having a plurality of spaced slots each extending from an end of said shell transversely to the flow of undesired circumferential currents on the surface of said shell for a length measured from said one end which is appreciable compared to the height of said shell, and individual inductive loops across the edges of said slots at locations where the magnitude of said undesired currents is greatest.

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