Dec. 17, 1946. J. R. FORD 2,412,805

ULTRA HIGH FREQUENCY OSCILLATION GENERATOR

Filed Feb. 5, 1944 2 Sheets-Sheet 1

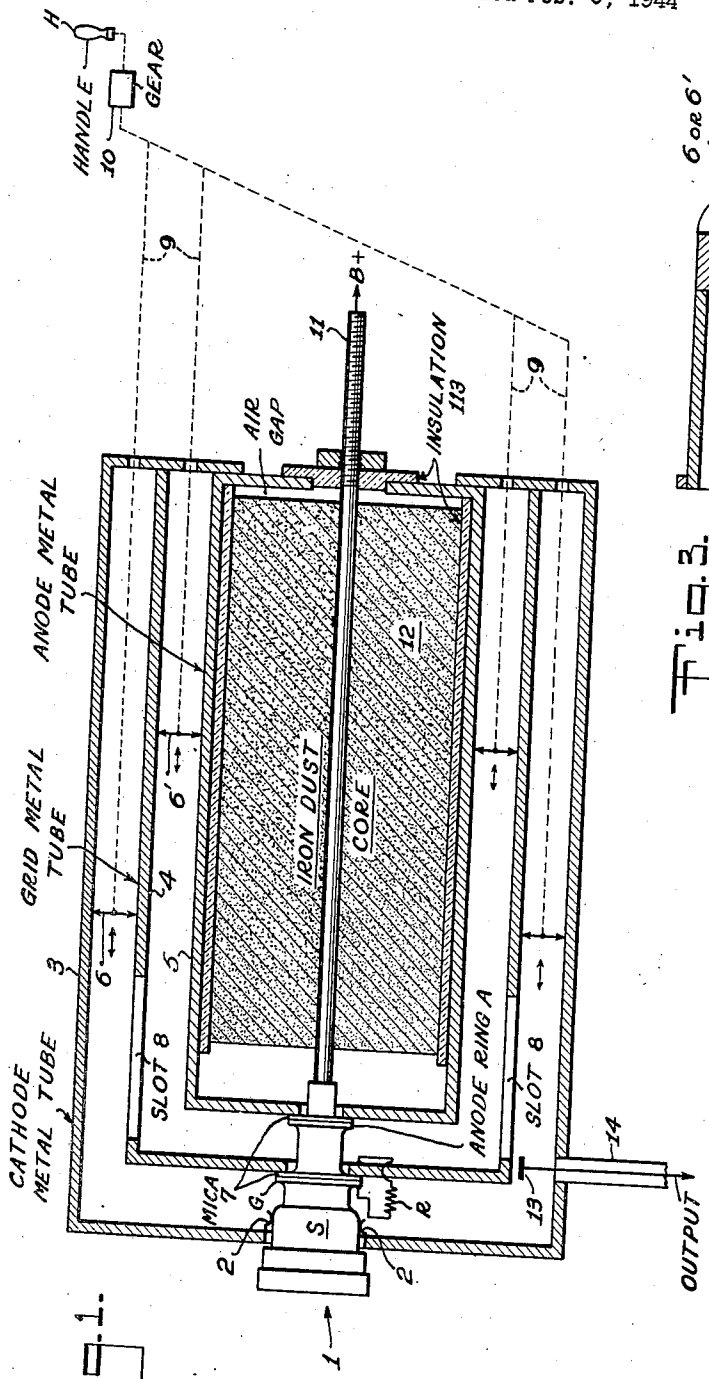


Fig. 1.

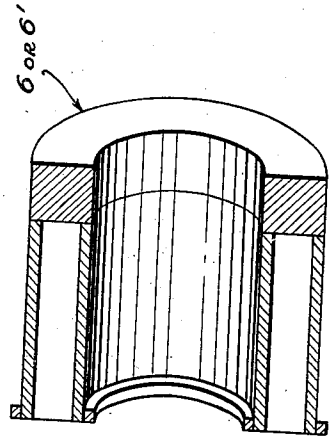


Fig. 3.

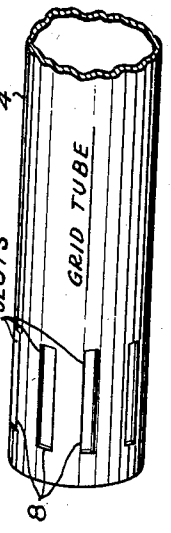


Fig. 2.

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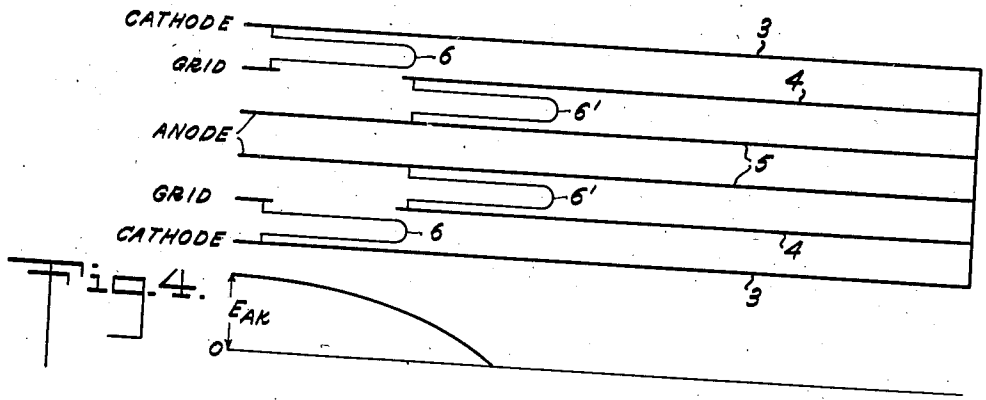


Fig. 4.

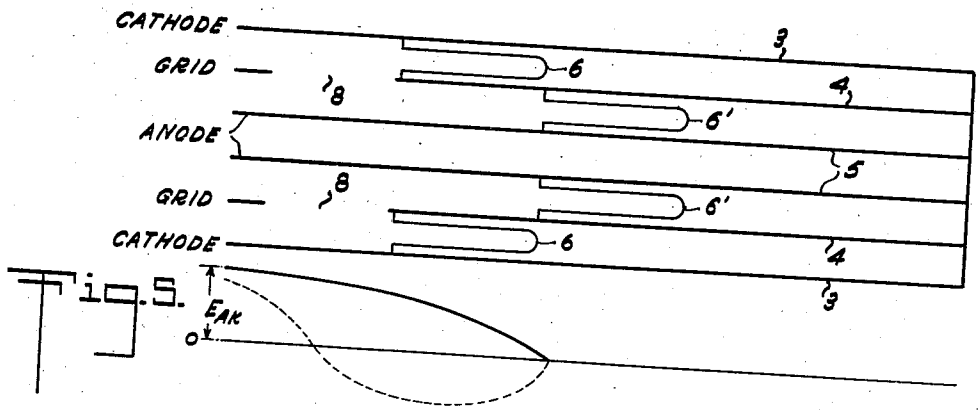


Fig. 5.

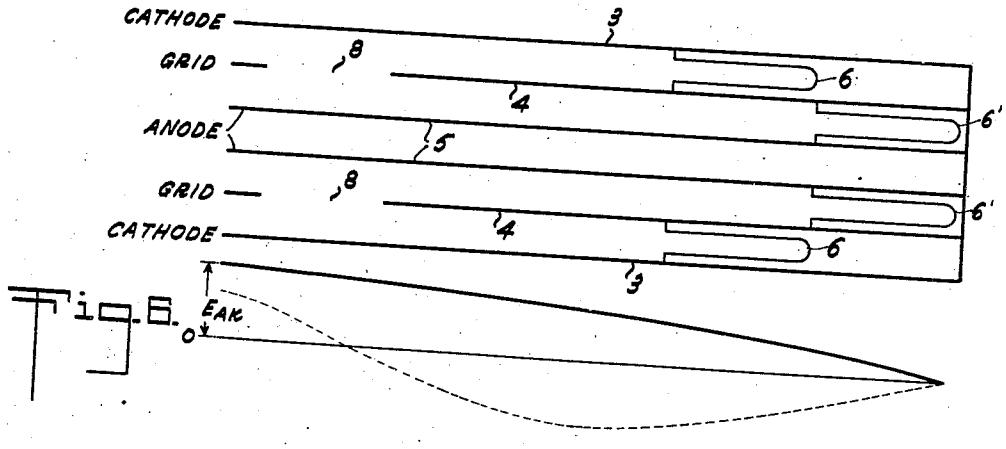


Fig. 6.

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UNITED STATES PATENT OFFICE

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ULTRA HIGH FREQUENCY OSCILLATION GENERATOR

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Application February 5, 1944, Serial No. 521,179

11 Claims. (Cl. 250—36)

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This invention relates to an ultra high frequency oscillator system, and particularly to such a system employing concentric line tuned circuits.

An object of the present invention is to provide a wide frequency range ultra high frequency oscillator employing feed back and producing a reasonably constant output level over its entire range, in which both feed back and frequency of operation are adjusted simultaneously by a single control.

Another object is to provide an ultra high frequency oscillator capable of operating in the range of about 300 to 1500 megacycles and having a frequency range of three or four to one.

A further object is to provide an ultra high frequency oscillator employing a "lighthouse tube" with individual grid-cathode and anode-grid tuned lines arranged concentrically and coupled to each other through a plurality of slots of adjustable effectiveness in one of the lines.

In general, the oscillator of the invention employs a vacuum tube whose grid and cathode electrodes are connected to one concentric line resonator, and whose grid and anode electrodes are connected to another concentric line resonator. The two resonators are concentrically arranged in such manner that the hollow inner conductor of the outer resonator forms the outer conductor of the inner resonator. This same common conductor is provided with a plurality of slots to enable capacitive feed back coupling between the two resonators externally of the vacuum tube. Each resonator is equipped with a circular tuning slider which contacts the two conductors of the resonator, and the slider of one resonator is staggered with respect to the slider of the other resonator. The slider of outer resonator has such length that in one position it substantially covers the slots and prevents feed back coupling through the slots. The slotes are preferably located at or near a voltage maximum point for a desired mode of oscillation, and this location is so chosen as to be a point of minimum or low voltage for an undesired mode of oscillation. In this way, the invention tends to suppress oscillations in the three-quarter and higher modes of oscillation. The sliders of the two resonators are unicontrolled to enable simultaneous adjustment of both the feed back and frequency.

A more complete description of the invention follows in conjunction with drawings, wherein:

Fig. 1 is a view, partly in cross-section, of an ultra high frequency oscillator system embodying the principles of the invention;

Fig. 2 is a perspective view of that portion of

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the grid tubular conductor forming the common wall of the two concentric resonators and which is provided with a plurality of slots for coupling the two resonators together externally of the vacuum tube;

Fig. 3 is a cross-section of the slider arrangement used in both resonators; and

Figs. 4, 5 and 6 show, diagrammatically only, the conductors of the two concentric line resonators with the sliders in different positions along the lengths of the conductors. The average potential across the slots between cathode and anode conductors is graphically illustrated for the different slider positions.

Referring to Fig. 1, there is shown a vacuum tube 1 of generally known "lighthouse" type, wherein the grid and anode connections protrude through the glass envelope in the form of metallic discs or rings. The grid ring is labeled G and the anode ring is labeled A. These rings are physically parallel to each other, but insulatingly spaced from each other by the glass envelope. These metallic rings or discs G and A make contact all around their respective electrodes with the external circuit elements. In practice, the anode, cathode and grid electrodes within the evacuated glass envelope are positioned very close to each other. The anode within the tube forms one end of a metallic cylinder which is connected to the anode disc ring A and has its other end extend externally of the glass envelope along the longitudinal axis thereof. One such "lighthouse" tube mentioned here by way of example only is the General Electric type GL-446 triode. The details of this "lighthouse" tube are now well known in the art and described in "Electronic Industry," September, 1944, page 178; and in "Science News Letter," August 19, 1944, page 115. The cathode of the tube is capacitively coupled to an outer metallic shell S, from a radio frequency standpoint. Directly connected to shell S by means of spring contacts 2 is the outer cylindrical conductor 3 of a concentric line resonator whose inner cylindrical conductor 4 is capacitively coupled at one end to the grid ring G. The ring G is separated from the conductor 4 by means of a mica spacer 7 which, in effect, comprises part of a by-pass condenser for the radio frequency energy flowing between the grid G and conductor 4. The resonator formed of conductors 3, 4 is tuned by means of slider 6 which is a circular affair engaging the inner surface of 3 and the outer surface of 4. Conductor 4 is hollow and accommodates in its interior a hollow cylindrical conductor 5 which is capacitively coupled at one end

to the anode ring A. The ring A is separated from the conductor 5 by means of a mica spacer 7 which comprises part of a by-pass condenser for radio frequency energy flowing between the anode A and conductor 5. The inner surface of conductor 4 forms with conductor 5 a concentric line resonator which is tuned by means of a circular metallic slider 6' engaging both conductors 4 and 5. It should be noted that sliders 6 and 6' for the different resonators are staggered in position. The two sliders 6 and 6' are unicontrolled over links 9 and suitable gearing 10 operated by a handle H.

Conductor 4 which forms a common conductor for both resonators is provided at one end with a plurality of slots 8 for capacitively coupling both resonators together externally of the tube 1. Slider 6 is adjustable over the entire length of the slots 8, thus adjusting the effectiveness of these slots. Stated in another way, the slider 6 is adjustable from a point near the grid electrode where there would be no capacity coupling through the slots to a point well beyond the slots where the slots are completely effective.

A grid leak resistor R shunts the condenser formed by the grid ring G and the spaced tubular grid conductor 4. Anode polarizing potential is supplied from a source B+ to the anode via a rod 11. High energy loss material, such as iron dust core 12, surrounds the rod 11 and is insulated from the tubular anode conductor 5 by means of an insulation tube 113 which may be paper. This iron dust core prevents the radio frequency energy from flowing along rod 11. If desired, the iron dust core can be replaced by conducting rubber. The means for keeping the vacuum tube 1 in position has not been shown for the sake of simplifying the drawing, although it will be understood that such means may include suitable springs for exerting pressure on the socket of the vacuum tube in the direction of the line resonators.

The construction of the slots in the grid line conductor 4 is illustrated in more detail in Fig. 2. The construction of the sliders 6 and 6' is illustrated in Fig. 3 which shows a cross-section of one of these sliders. The effective length of the slider 6 is such that it can substantially completely cover the slots 8 in the grid line 4 when positioned at the extreme left of Fig. 1.

In the operation of the oscillator shown in Fig. 1, there is always some capacity feed back between the two resonators 3, 4 and 4, 5 through the interelectrode capacities of the tube 1. The slots 8 in tubular conductor 4 augment this interelectrode capacity coupling to a desired degree. The slots serve to boost the feed back at the lower frequencies of operation and also decreases the tendency for the oscillator to produce oscillations at higher modes of oscillation. This is shown more clearly by reference to Figs. 4, 5 and 6 which show the sliders 6 and 6' in three different positions along the lengths of the resonators, and also show the average potential E_{a-k} across the slots between anode and cathode conductors 5 and 3, respectively.

With an oscillator of the type shown in Fig. 1 operating over a frequency range from 400 megacycles to 1500 megacycles, the illustration of Fig. 4 shows the arrangement of the sliders 6 at a point near the grid electrode where the slots 8 are ineffective to provide capacity coupling therethrough. The slider 6, it will be seen, covers the slots and shields the resonators from each other. The only feed back which exists in this case is

now through the vacuum tube 11. In the arrangement shown in Fig. 4, the oscillator produced oscillations at 1500 megacycles. The voltage curve between anode and cathode for the desired mode of oscillation is shown in the solid line immediately below the circuit arrangement. The arrangement of Fig. 5 shows the slots 8 completely uncovered by the slider 6 which is now in a position intermediate the ends of the cathode-grid line resonator. In the arrangement of Fig. 5, the oscillator operated at about 900 megacycles, and the average potential across the slots is shown by the solid curve which slopes more gradually. The dotted line curve shows the voltage that would exist between anode and cathode for the three-quarter mode of oscillation. The slots are positioned at a null for this last voltage. The arrangement of Fig. 6 shows the sliders in the extreme right position, in which location the oscillator operated at about 400 megacycles. It should be noted (Fig. 6) that the average potential across the slots between anode and cathode conductors is close to the maximum possible, while the slots are positioned near a null for the voltage that would exist between anode and cathode for the three-quarter mode of oscillation. In Figs. 5 and 6, the three-quarter mode voltage curves are shown dotted, while the desirable one-quarter voltages are shown in solid lines. It will be noted that the oscillator produced its highest frequency at the one-quarter mode when the cathode-grid line resonator is shortest, and this is the case with the slots covered over by the slider 6. Due to the loading on the resonators by the vacuum tube, the maximum voltage (E_{AK}) across the slots in the case of Figs. 5 and 6 is a greater fraction of the voltage which would be present with no loading by the vacuum tube than that obtainable in the case of Fig. 4.

In the practice of the invention, the slots are so dimensioned and positioned that feed back at the desired frequency of oscillations is considerably greater than that for higher frequencies corresponding to higher modes of oscillation. Because of the greater feed back at the desired frequencies, the oscillator is constrained to generate oscillations at only the desired frequency. The slots are preferably located near or at a voltage (anode-cathode) maximum point for the desired mode of oscillation, which point is also a voltage minimum for the undesired mode, thus providing a considerable difference in feed back for the two modes. To obtain the greatest benefits of the invention, this difference in feed back between the cases of the desired mode and the undesired mode should be the greatest possible, although the benefits of the invention can be achieved so long as there is any appreciably greater feed back at the desired mode than at the undesired mode. The slots should be located near the grid electrode, as shown, in order to obtain a wide range of frequencies by adjusting the position of the sliders. However, if it is desired to obtain only a single frequency corresponding to, let us say, the third harmonic of the lowest frequency, then the slots should be positioned near the end of the grid line farthest removed from the vacuum tube, and in this position the greatest feed back will be at the higher mode (third harmonic) of oscillation, and oscillation will take place only at the higher mode. The exact position of the slots and their exact dimensions are best determined by experiment

in order to obtain the maximum effect at these higher frequencies.

Output from the oscillator may be taken from probe 13 connected to the inner conductor of a coaxial line 14.

In one embodiment successfully tried out in practice, the tuned grid-anode line resonator had a surge impedance of forty ohms, while the tuned grid-cathode resonator had a twenty ohm surge impedance. These lines were about seven inches long. The anode was by-passed to the radio frequency anode conductor 5 by a 150 $\mu\mu$f. concentric capacitor. The grid was connected by means of an annular spring to the tubular grid conductor through an annular three plate capacitor, the annular spring forming the central plate of the capacitor. Two .003" annular mica discs served as the dielectric. One disc was painted a thin line of aquadag to make a 5000 ohm grid leak. the grid conductor 4 had six slots 3/8" wide starting at the grid condenser and running 1" away from the vacuum tube. The B+ supply was 250 volts positive impressed on conductor 11 through a 5600 ohm resistor. The osccillator system had a frequency range from 400 mc. to 1200 mc.

What is claimed is:

1. An oscillation generator comprising a vacuum tube having grid, anode and cathode electrodes, a concentric line resonator coupled between said grid and cathode, another concentric line resonator coupled between said grid and anode, said resonators being coaxially arranged, the inner conductor of the outer resonator forming the outer conductor for the inner resonator and thus constituting a common wall for both said resonators, said common wall having a plurality of slots therethrough for providing feed back between said resonators, a tuning slider connecting together the inner and outer conductors of one of said resonators and adjustable in position over said one resonator, said slider having such axial length as to control the coupling between said resonators, said slider in one position rendering said slots completely ineffective.

2. An oscillation generator comprising a vacuum tube having grid, anode and cathode electrodes, a concentric line resonator coupled between said grid and cathode, another concentric line resonator coupled between said grid and anode, said resonators being coaxially arranged, the inner conductor of the outer resonator forming the outer conductor for the inner resonator and thus constituting a common wall for both said resonators, individual tuning sliders for said resonators, said sliders being staggered relative to each other, said common wall having a plurality of slots therethrough for providing feed back between said resonators, one of said sliders having such axial length as to control the coupling between said resonators through said slots, said slots being so positioned and dimensioned that when the tuning sliders are adjusted to produce a desired frequency of operation, the voltage across said slots is appreciably greater for the desired frequency than for any other mode of oscillation.

3. An oscillation generator comprising a vacuum tube having grid, anode and cathode electrodes, a concentric line resonator having an outer hollow conductor coupled to said cathode and an inner hollow conductor coupled to said grid, another hollow conductor coaxially arranged within said last conductor and coupled to said anode, whereby said last two conductors form another concentric line resonator having a common wall with said first resonator, said common wall having a plurality of slots therethrough around one portion thereof to enable feed back between said two resonators, a tuning slider for said first resonator adjustable in position between the hollow conductors of said first resonator and having such axial length as to control the coupling between said resonators through said slots, said slider in one position rendering said slots completely ineffective, and another tuning slider for said other resonator.

4. An oscillation generator comprising a vacuum tube having grid, anode and cathode electrodes, a concentric line resonator having an outer hollow conductor coupled to said cathode and an inner hollow conductor coupled to said grid, another hollow conductor coaxially arranged within said last conductor and coupled to said anode, whereby said last two conductors form another concentric line resonator having a common wall with said first resonator, said common wall having a plurality of slots therethrough arranged symmetrically around one portion thereof to enable feed back between said two resonators, a tuning slider for said first resonator adjustable in position over the length of said resonator for controlling the effectiveness of said slots, said slider having a length which is an appreciable fraction of the length of said slots, said slider in one position rendering said slots completely ineffective, and another tuning slider for said other resonator, and means for controlling the movement of said sliders simultaneously.

5. A wide tuning range ultra high frequency oscillation generator comprising a vacuum tube having grid, anode and cathode electrodes, a concentric line resonator having an outer hollow conductor coupled at one end of the resonator to said cathode and an inner hollow conductor coupled at the same end of the resonator to said grid, another hollow conductor coaxially arranged within said last conductor and also coupled at one end to said anode, whereby said last two conductors form a concentric line resonator having a common wall with said first resonator, said common wall having a plurality of slots therethrough near the end coupled to said grid to enable feed back between said resonators, tuning sliders in said resonators, unicontrol means for said tuning sliders, the tuning slider for said first resonator having such axial length as to control the coupling between said resonators through said slots and being adjustable in position over the entire length of said slots, the position of said slots being such that the anode-cathode voltage across the slots for any desired frequency at which the resonators are tuned to be one-quarter wavelength long electrically is greater than for any higher mode of oscillation.

6. An oscillation generator comprising a vacuum tube having grid, anode and cathode electrodes, a concentric line resonator having an outer hollow conductor coupled to said cathode and an inner hollow conductor coupled to said grid, another hollow conductor coaxially arranged within said last conductor and coupled to said anode, whereby said last two conductors form another concentric line resonator having a common wall with said first resonator, said common wall having a plurality of slots therethrough around one portion thereof to enable feed

back between said two resonators, a tuning slider for said first resonator being adjustable in position between the hollow conductors of said first resonator and having such axial length as to control the coupling between said resonators through said slots, said slider in one position rendering said slots completely ineffective, and another tuning slider for said other resonator, a conducting rod coaxially arranged within the innermost hollow conductor of said anode-grid resonator for supplying said anode with anode polarizing potential, and high loss material surrounding said rod and insulated from said innermost hollow conductor for absorbing radio frequency energy tending to flow along said rod.

7. An ultra high frequency oscillation generator comprising a vacuum tube having grid, anode and cathode electrodes, a concentric line resonator having an outer cylindrical hollow conductor coupled at one end to said cathode and an inner cylindrical hollow conductor coupled at the same end to said grid, a conductor coaxially arranged within said last conductor and also coupled at one end to said anode, whereby said last two conductors form a concentric line resonator having a common wall with said first resonator, said common wall having a plurality of slots therethrough at one portion to enable feed back between said resonators, a metallic cylindrical tuning slider for each of said resonators, the tuning slider for one of said resonators being adjustable in position between the hollow conductors thereof and having such axial length as to control the coupling between said resonators through said slots, said sliders being in staggered relation, and unicontrol means for said sliders.

8. A generator in accordance with claim 6, characterized in this that said high loss material is an iron dust core.

9. An ultra high frequency oscillation generator comprising a vacuum tube having grid, anode and cathode electrodes, a concentric line resonator having an outer cylindrical hollow conductor coupled at one end to said cathode and an inner cylindrical hollow conductor coupled at the same end to said grid, another cylindrical hollow conductor coaxially arranged within said last conductor and also coupled at one end to said anode, whereby said last two conductors form a concentric line resonator having a common wall with said first resonator, said common wall having a plurality of slots therethrough at one portion to enable feed back between said resonators, a conductor within said innermost hollow conductor for supplying

polarizing potential to said anode, a metallic cylindrical tuning slider for each of said resonators, the tuning slider for one of said resonators being adjustable in position between the hollow conductors thereof and having such axial length as to control the coupling between said resonators through said slots, said sliders being in staggered relation, and unicontrol means for said sliders.

10. An oscillation generator comprising a vacuum tube having grid, anode and cathode electrodes, a concentric line resonator having an outer hollow conductor coupled to said cathode and an inner hollow conductor coupled to said grid, another hollow conductor coaxially arranged within said last conductor and coupled to said anode, whereby said last two conductors form another concentric line resonator having a common wall with said first resonator, said common wall having a pluraltiy of slots therethrough near one end thereof to enable feed back between said two resonators, a tuning slider for said first resonator adjustable in position over the length of said resonator for controlling the effectiveness of said slots, said slider having a length which is an appreciable fraction of the length of said slots, said slider in one position rendering said slots completely ineffective, and another tuning slider for said other resonator, and means for controlling the movement of said sliders simultaneously.

11. An oscillation generator comprising a vacuum tube having grid, anode and cathode electrodes, a concentric line resonator having an outer hollow conductor coupled at one end to said cathode and an inner hollow conductor coupled at its adjacent end to said grid, another hollow conductor coaxially arranged within said last conductor and coupled at its correspondingly located end to said anode, whereby said last two conductors form another concentric line resonator having a common wall with said first resonator, said common wall having near its end which is connected to said vacuum tube a plurality of slots therethrough to enable feed back between said two resonators, a tuning slider for said first resonator adjustable in position over the length of said resonator for controlling the effectiveness of said slots, said slider having a length which is an appreciable fraction of the length of said slots, said slider in one position rendering said slots completely ineffective, and another tuning slider for said other resonator, and means for controlling the movement of said sliders simultaneously.

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