

Feb. 3, 1942.

R. W. GEORGE

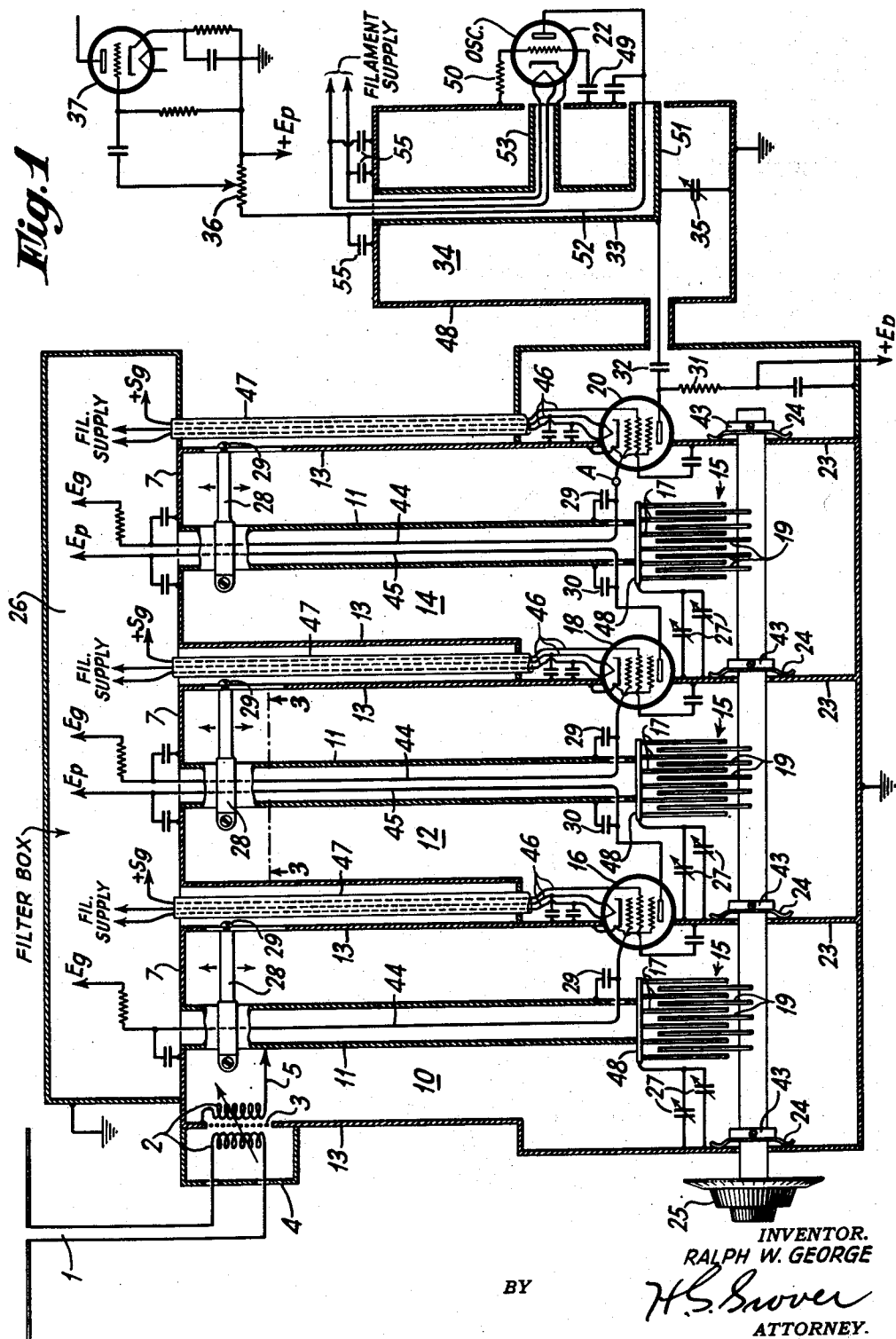
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COAXIAL LINE ULTRA HIGH FREQUENCY AMPLIFIER

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Fig. 1



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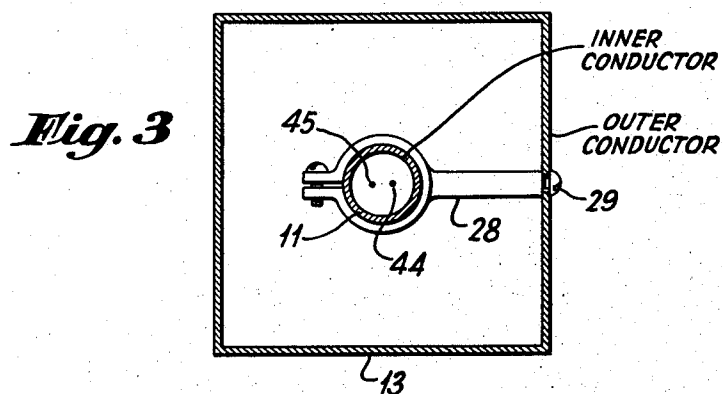
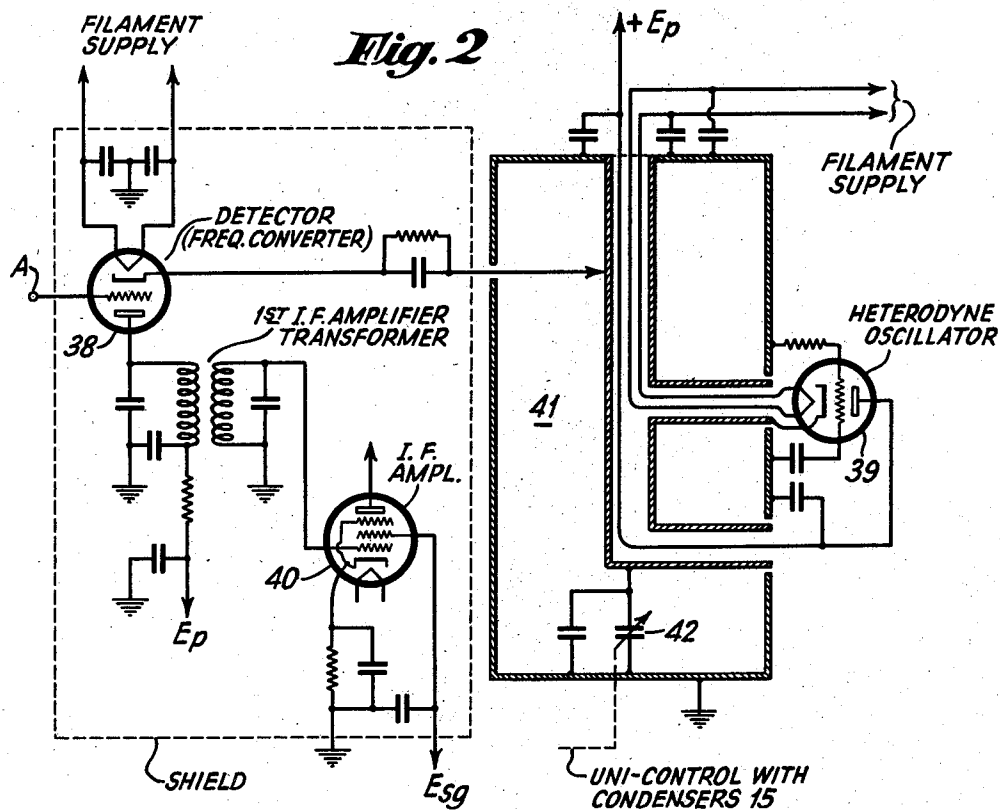
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UNITED STATES PATENT OFFICE

2,272,062

COAXIAL LINE ULTRA HIGH FREQUENCY
AMPLIFIER

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17 Claims. (Cl. 179—171)

This invention relates to ultra high radio frequency circuits, and particularly to a multi-stage ultra high frequency amplifier employing tuned coaxial lines as interstage coupling impedances.

One of the objects of the present invention is to provide a practical mechanical construction for such a multistage amplifier, wherein the elements lend themselves readily to quick and simple assembly.

Another object is to provide an improved uni-control arrangement for tuning a plurality of coaxial resonant lines. A specific object is to provide coaxial resonant line circuits employing variable capacitors as tuning elements with uni-control means for simultaneously varying all of said capacitors. It is also an object to provide a rotary tuning condenser for each of said coaxial resonant lines and to control all of said condensers from a single driving element mechanically coupled thereto.

A feature of the invention resides in the use of coaxial resonant lines whose outer conductors have flat faces or sides extending parallel to the longitudinal dimension of the line. These outer conductors may take the form of square or rectangular metallic tubes or pipes.

Another feature of the invention lies in the use of a multi-stage ultra high frequency receiver employing tuned coaxial lines as interstage coupling elements, wherein a balanced signal input circuit is coupled to the coaxial resonant line of the first stage.

Other objects, features and their advantages will appear from a reading of the following description which is accompanied by drawings, wherein:

Fig. 1 illustrates an ultra high frequency receiving system embodying the principles of the invention;

Fig. 2 illustrates a frequency changer circuit which can be used with the major portion of the circuit of Fig. 1 for providing an intermediate frequency output; and

Fig. 3 illustrates a cross-section of one of the coaxial resonant lines of Fig. 1 along the line 3—3, showing the adjustable short-circuiting bar by which the inductance of the line can be changed.

Referring to Fig. 1, there is shown an ultra high frequency receiving system comprising three radio frequency stages composed of vacuum tubes 16, 18 and 20 and an autodyne oscillator-detector 22 coupled to the last stage 20. Coupled to the input circuits of vacuum tubes 16, 18 and 20 are, respectively, tuned coaxial lines 10, 12 and 14, 55

each of the latter comprising an inner, hollow, circular conductor 11 and a hollow outer conductor of square cross-section. The signal input circuit comprises a balanced antenna and transmission line 1 coupled via coils 2 to the first tuned coaxial circuit 10 of the first radio frequency amplifier vacuum tube 16. The output or load circuit of the entire receiving system is in the form of audio frequency energy derived from the oscillator-detector circuit and utilized in an audio frequency amplifier 37.

Coaxial resonant lines 10, 12 and 14 are so mounted that their longitudinal dimensions are parallel to each other with a small space between adjacent lines for enabling the leads from certain electrodes of the vacuum tubes to be taken out through shielded conduits located between coaxial lines, said leads extending to suitable filter and energy supply means. If desired, the coaxial lines may be placed side by side with their flat outer surfaces integrally arranged to conserve space, in which case the foregoing leads (heater and screen in particular) may be taken out through suitably placed shielded conduits. For instance, these conduits can be placed inside one corner of the square pipes, or they could run just outside the square pipes—not necessarily between adjacent coaxial resonant lines. The coaxial lines are electrically shielded from each other by means of metallic partitions 23 in which are mounted the vacuum tubes 16, 18 and 20. These partitions which, if desired, may form an extension of the outer conductors of the coaxial lines, serve to shield or isolate the input circuit of a vacuum tube from its own output circuit. The inner conductor 11 of each coaxial line is directly connected at one end to its outer conductor 13 by means of a metallic end plate 7 and capacitively coupled at its other end to the outer conductor by means of a rotary air condenser 15 having stator condenser plates 17 and rotor condenser plates 19, the latter being mechanically linked to a uni-control shaft 21 and vernier tuning dial 25. Stator plates 17 of each rotary condenser are connected to a metallic plate 48 forming part of the high voltage end of the inner conductor 11 of the coaxial line. This metallic plate 48 forms a terminal of extremely low inductance for the stator plates 17, thus avoiding the use of leads or connecting wires from the condenser to the coaxial line. These rotary condensers 15 which tune the coaxial lines to resonance, are connected to the high voltage ends of the inner conductor 11, 11. The outer conductors 13, 13 of the coaxial lines are grounded to the framework and to the

filter box 26 later to be described. Shaft 21 is also grounded at each stage to the framework by means of metallic collars 43 which force metallic spring contacts 24 against the grounded partition walls 23. The two condensers 27, 27 shown in the interior of each coaxial line, constitute trimming condensers, one of which may be a padding condenser while the other use for fine control and driven from a link in the front of the panel. For varying the inductance of each coaxial line over a limited range, there is provided a metallic shorting-bar or collar 28 (shown in more detail in Fig. 3) which is slidable over and clamped to the inner conductor 11 and movable in a slot in the outer conductor 13. A screw 29 (note Fig. 3) serves to rigidly fasten the shorting bar 28 to the outer conductor. The condensers 27, 27, as well as others described later, may be readily mounted upon the flat sides of the outer conductor in suitable fashion. From what has gone before, it will be apparent that the shape of the outer conductors of the coaxial lines permits a quick and simple assemblage of all the elements of the receiver in extremely compact manner.

The balanced antenna and transmission line circuit 1 transfers the incoming signal via coils 2 and adjustable tap 5 to the inner conductor 11 of the coaxial resonant line 10 of the first amplifier stage. Electrostatic shielding between the two coupling coils 2, 2 is effected by element 3 which consists of a plane array of fine insulated parallel wires which are individually insulated from each other and ground at one end of the shield, and severally connected together at the other end to ground. The plane of the shield may be in the plane of one side of the outer square conductor. The coils 2 are variably coupled together and with adjustable tap 5 provide means for matching the impedance of the antenna and transmission line system 1 to the inner conductor of coaxial line 10. Element 4 is a shield for the primary coupling 2.

The control grids of the vacuum tubes 16, 18 and 20 are by-passed to the high voltage ends of the inner conductors of their respective coaxial lines by means of condensers 29, and the insulated leads 44 to these control grids are brought out through the interior of these inner conductors to suitable low pass filters located in metallic filter box 26, and then connected to a variable bias supply which provides a means for controlling the gain of the multi-stage amplifier. The anode or plate insulated leads 45 of the vacuum tubes 16 and 18 are by-passed to the high voltage ends of the inner conductors by means of condensers 30 and are brought out through the interior of the inner conductors to suitable low pass filter groups located in filter box 26, and thence to power supply equipment, not shown. The filament, screen grid and suppressor leads 46 of the vacuum tubes are by-passed to ground as shown, and brought through metallic conduits 47 to suitable low pass filters mounted in box 26 and then connected to suitable heating and polarizing sources of supply. The output of vacuum tube 20, which tube serves both as an amplifier and a coupling tube, is connected to an untuned impedance 31 from which the output energy passes through a small capacitance 32 to the inner conductor 33 of a coaxial resonant line 34, the latter constituting the stabilizing element of an oscillator-detector 22, the frequency of which may be controlled by condenser 35.

Because of the way in which the grid and plate

leads of the vacuum tubes are arranged to pass through the interior of the inner conductors of the coaxial lines, it will be evident that the signal energy impressed on the inner conductor of line 10 by the antenna and transmission line circuit 1 will also be impressed on the control grid of the first radio frequency amplifier tube 16, and the output energy from the plate of tube 16 will be impressed upon the control grid of the succeeding radio frequency amplifier tube 18. Similarly, the output energy from the plate of vacuum tube 18 will be impressed on the control grid of vacuum tube 20. Coaxial resonant line 12 thus acts as an interstage coupling impedance between vacuum tubes 16 and 18, while coaxial resonant line 14 acts as an interstage coupling impedance between vacuum tubes 18 and 20.

The local oscillator-detector 22 is stabilized as to frequency by a concentric line comprising an outer conductor 48 and an inner conductor 33 which are conductively coupled together at one of their adjacent ends and capacitively coupled together by capacitor 35 at their other adjacent ends. The control electrode of oscillator 22 is connected to the outer conductor 48 through the parallel combination of a condenser 49 and a resistor 50.

The anode of oscillator 22, it should be noted, extends through a pipe 51 to the inside of inner conductor 33, near its free end and extends, by means of a connection 52, through the entire length of the inner conductor and then to the positive terminal of source of power supply +Ep. The cathode of the oscillator 22 connects with the inner conductor 33 at one point (if desired, near the middle), while the heater element extends through a pipe 53, also to the inside of the inner conductor 33 near this point and then to the heater or filament source of supply. The choice of this point of connection determines the degree and phase relations of feed-back which materially affect the operation of the oscillator. It should be noted that the cathode is directly connected to the stub pipe 53. The reasons for this manner of connection may perhaps be more readily explained by comparing the oscillator tube 22 and the line circuit 34 to the well known three point Hartley oscillator circuit as described in United States Patent No. 1,356,763, granted October 26, 1920. Such circuit comprises an inductance whose extreme terminals are coupled to the anode and control electrode and whose cathode is connected to a point intermediate the ends of the inductance. In the present case, the inner conductor 33 acts as the inductance of the Hartley circuit, and it is to the lower or free end of this inductance 33 that the anode of oscillator 22 extends. The control electrode of oscillator 22, it should be noted, is connected to the outer conductor which is at ground potential. Since this outer conductor 48 is conductively connected to the inner conductor, or inductance 33, at its other end, we thus have a connection from the control electrode to the upper or closed end of inductance 33 which is opposite the free end of the inner conductor connected to the anode. The cathode of oscillator 22, however, extends and is effectively joined for all purposes to the middle of the inductance 33, since it enters the inside of inductance 33 near its middle, as previously described and as shown in the drawings. In order to maintain both the cathode and the heater element of oscillator 22 at the same radio fre-

quency potential, so that they fluctuate simultaneously and in the same phase with respect to one another, thus introducing no unnecessary loading on the resonant line, the heater leads are brought to the middle of the line at substantially the same location to which the cathode element is brought, and extend through the inside of inner conductor 33 to the heater supply. Condensers 55 are radio frequency by-pass condensers which filter out the radio frequency currents from the anode and filament leads.

The audio frequency output from the oscillator-detector 22 is taken from the anode or plate lead 52 by means of the coupling impedance 36 to which is coupled the audio frequency amplifier tube 37.

One embodiment of an ultra high frequency amplifier constructed in accordance with Fig. 1 and successfully tried out in practice was designed to receive signals in the range from 70 to 150 megacycles. This range of frequencies is merely given by way of illustration only, and is not to be construed as limiting the invention.

Fig. 2 indicates how the receiving system of the invention may be used in a superheterodyne type of circuit. For this purpose, the lead A shown in Fig. 1, instead of being connected to vacuum tube 20, is connected to a frequency converter or mixer tube 38, Fig. 2, to which are connected a heterodyne oscillator 39 and an intermediate frequency amplifier 40. Heterodyne oscillator 39 is stabilized as to frequency by a coaxial resonant line 41 to which it is connected in substantially the same manner as oscillator 22 of Fig. 1 is connected to its stabilizing element 34. The inner conductor of line 41 is connected to the cathode of frequency converter tube 38 to which it supplies heterodyne voltage. The tuning condenser 42 of the resonant line 41 may, if desired, be ganged to the same shaft 21 to which the rotary condensers 15 are connected.

The intermediate frequency amplifier 40 may comprise any number of stages and be coupled, in turn, to another local oscillator and frequency converter to provide a second intermediate frequency, if desired. On the other hand, the output from the intermediate frequency amplifier 40 may be detected by means of an autodyne oscillator-detector, or by a diode or other equivalent arrangement.

It will be understood, of course, that the outer conductors of coaxial resonant lines 34 and 41 may be of circular form so as to be perfectly concentric to their respective circular inner conductors, and that if desired the outer conductors of coaxial lines 10, 12 and 14 may also be so shaped, although it is preferred in all cases that the outer conductors have flat sides for ease in the assemblage and mounting of elements. Also, if desired, the coaxial resonant lines may be mounted vertically on a metallic box with the inner conductor of each line protruding into the box in the manner generally shown in Fig. 1. In this case the metallic box would be divided up into sections by metallic partitions between the resonant lines, and the rotary condenser of each line will be mounted on the inner conductor and located within one of the sections, whereby the metallic wall of each section constitutes an effective extension of the outer conductor of the coaxial line whose rotary condenser is contained therein.

What is claimed is:

1. A multistage ultra high radio frequency amplifier using tuned coaxial lines as coupling

impedances between stages, said coaxial lines being parallel to one another, a rotary condenser having stator plates mounted on the inner conductor of each coaxial line for tuning each line, the plates of each condenser being in planes which are parallel to the longitudinal axis of the line which it tunes, and a single shaft mechanically and directly connected to the rotor plates of said condensers for simultaneously varying said rotary condensers.

2. A multistage ultra high radio frequency amplifier using tuned coaxial lines as interstage coupling impedances between stages, a rotary condenser having plates mounted on the inner conductor of each of said lines between the high voltage end of said inner conductor and said outer conductor, the plates of each condenser being in planes which are parallel to the longitudinal axis of the associated coaxial line, and a shaft extending transversely of the longitudinal dimensions of said tuned coaxial lines and located at the high voltage ends of said lines for simultaneously varying the rotary condensers of said coaxial lines.

3. A multistage ultra high radio frequency amplifier using tuned coaxial lines as coupling impedances between stages, said coaxial lines being parallel to one another, a rotary condenser having stator plates mounted on the inner conductor of each coaxial line for tuning each line, the plates of said condensers being in planes which are parallel to the longitudinal axes of said lines, means for independently adjusting the effective inductance of each line, and a shaft extending through said tuned lines and linked to all of said rotary condensers for varying the electrical lengths of said coaxial lines in unison.

4. A multistage ultra high radio frequency amplifier using tuned coaxial lines as coupling impedances between stages, said coaxial lines being parallel to one another, a rotary condenser having stator plates mounted on the inner conductor of each coaxial line for tuning each line, the plates of said condensers being in planes which are parallel to the longitudinal axes of said lines, means for independently adjusting the effective inductance of each line, and a shaft extending through apertures in the outer conductors of said lines and linked to said rotary condensers for varying the electrical lengths of all of said coaxial lines in unison, said first means comprising a shorting bar movable along a portion of the length of the inner conductor of each line and making mechanical contact with both the inner and outer conductors.

5. A multistage ultra high radio frequency amplifier using tuned coaxial lines as interstage coupling impedances between stages, the outer conductors of said lines having flat sides for enabling quick and simple assemblage of the elements of said amplifier, a rotary air condenser for tuning each coaxial line, the plates of each condenser being in planes which are parallel to the longitudinal axis of the line which it tunes, a metallic partition between adjacent lines for supporting the vacuum tubes of said stages and for shielding the input of a vacuum tube from its output, the inner conductors of said lines being hollow for accommodating wire leads to the electrodes of said vacuum tubes, and means for simultaneously varying said rotary condensers in unison comprising a shaft extending through apertures in the outer conductors of said lines and linked to said condensers.

6. A multistage ultra high radio frequency

amplifier using tuned coaxial lines as coupling impedances between stages, said coaxial lines being parallel to one another, a rotary condenser having stator plates mounted on the inner conductor of each coaxial line for tuning each coaxial line, the plates of said condensers being in planes which are parallel to the longitudinal axes of said lines, means for simultaneously varying the rotary condensers of said coaxial lines, a balanced input circuit, a transformer coupling said input circuit to the inner conductor of the coaxial line in circuit with the input of the first stage of said amplifier, an electrostatic shield between the coils of said transformer, the secondary coil of said transformer having a tap movable over a portion of the length of said inner conductor, whereby the impedance of said balanced input circuit is matched to the impedance of the inner conductor of said last coaxial line.

7. A multistage ultra high radio frequency amplifier using tuned coaxial lines as interstage coupling impedances between stages, a metallic plate of low inductance mounted on the high potential end of the inner conductor of each coaxial line, and a rotary condenser having plates directly mounted on the low inductance plate of each line and located in series between the high voltage end of the inner conductor and its outer conductor, the plates of each condenser being in planes which are parallel to the longitudinal axis of the associated coaxial line, and a shaft extending through apertures in the outer conductors of said tuned lines and linked to said rotary condensers for simultaneously varying said condensers in unison, and means for electrically connecting said shaft to the outer conductors of said tuned coaxial lines near said apertures.

8. A system in accordance with claim 6, characterized in this that said electrostatic shield comprises an array of parallel conductors insulated from each other at one end and connected to each and to ground at the other end.

9. A system in accordance with claim 6, characterized in this that said electrostatic shield comprises an array of parallel conductors insulated from each other at one end and connected to each and to ground at the other end, said shield being in the plane of one side of the outer conductor of the first coaxial line of said amplifier.

10. A multistage ultra high radio frequency amplifier using tuned coaxial lines as coupling impedances between stages, said coaxial lines being parallel to one another, a rotary condenser located at one end of the inner conductor of each line, the plates of each condenser being in planes which are parallel to the longitudinal axis of the associated coaxial line, the stator plates of said rotary condenser being integral with said one end to provide a low inductance connection therebetween, and a single shaft mechanically and directly connected to the rotor plates of said condensers for simultaneously varying said rotary condensers.

11. A multistage ultra high radio frequency amplifier using tuned coaxial lines as coupling impedances between stages, a rotary condenser located at one end of the inner conductor of each coaxial line for tuning the same, the plates of each condenser being in planes which are parallel to the longitudinal axis of the line which it tunes, said one end of the inner conductor being integral with the stator plates of the rotary con-

denser associated therewith to provide a low inductance connection between the stator plates and the inner conductor, and unicontrol means for simultaneously varying the rotor plates of said condensers.

12. A multistage ultra high radio frequency amplifier using tuned coaxial lines as coupling impedances between stages, said coaxial lines being parallel to one another, a rotary condenser for tuning each coaxial line, the plates of each condenser being in planes which are parallel to the longitudinal axis of the line which it tunes, the stator plates of each rotary condenser being secured to the inner conductor of the coaxial line associated therewith through a path of low inductance, and a single shaft mechanically and directly connected to the rotor plates of said condensers for simultaneously varying said rotary condensers.

13. A tuned oscillatory circuit having a linear inductance element and a rotary tuning condenser, a metallic plate of extremely low inductance directly connecting the stator plates of said rotary condenser to one end of said element, and a rotatable shaft extending transversely of the length of said linear inductance element for moving the rotor plates of said condenser, said stator and rotor plates being in planes which are parallel to the longitudinal axis of said inductance element.

14. A tuned oscillatory circuit having a linear inductance element, a metallic shield surrounding said element, and a rotary tuning condenser coupling one end of said element to said shield, a metallic plate of low inductance mounted on said one end of said inductance element for supporting the stator plates of said rotary condenser and for electrically connecting the same directly to said element, and a rotatable shaft extending transversely of the length of said linear inductance element for moving the rotor plates of said condenser, said stator and rotor plates being in planes which are parallel to the longitudinal axis of said inductance element.

15. A resonant concentric line comprising an inner and an outer conductor, and a rotary condenser coupling one end of said inner conductor to the adjacent end of said outer conductor, said end of said inner conductor being integral with the stator plates of said rotary condenser, the plates of said condenser being in planes which are parallel to the longitudinal axis of said line.

16. A resonant concentric line comprising an inner and an outer conductor, and a rotary condenser coupling one end of said inner conductor to the adjacent end of said outer conductor, said end of said inner conductor being integral with the stator plates of said rotary condenser, the plates of said condenser being in planes which are parallel to the longitudinal axis of said line, and a shaft disposed at right angles to the length of said concentric line for moving the rotor plates of said condenser.

17. A tuned oscillatory circuit having a rod-like inductance element and a rotary tuning condenser, the stator plates of said condenser being integral with the high potential end of said inductance element, the plates of said condenser being in planes which are parallel to the longitudinal axis of said inductance element, and means for moving the rotor plates of said condenser.

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