

Aug. 4, 1942.

J. M. VAN BEUREN

2,292,254

HIGH FREQUENCY RESONANT SYSTEM AND APPARATUS

Filed June 19, 1941

2 Sheets-Sheet 1

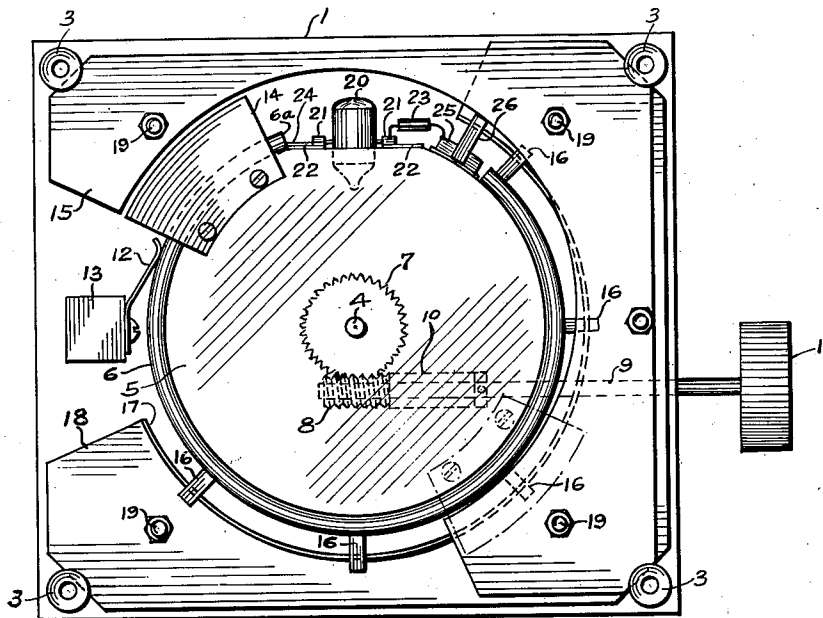


Fig. 1.

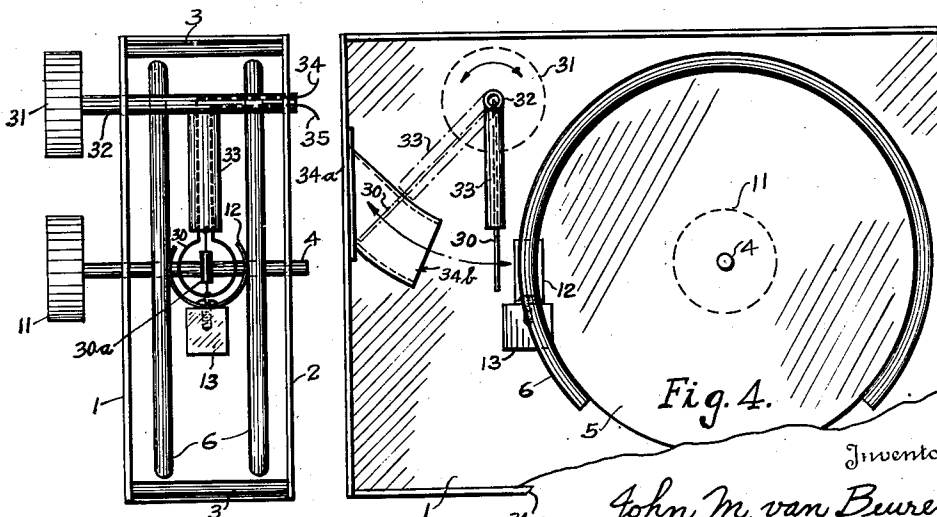


Fig. 3.

Fig. 4.

Inventor

John M. van Beuren

Thomas Appleby

Attorney

Aug. 4, 1942.

J. M. VAN BEUREN

2,292,254

HIGH FREQUENCY RESONANT SYSTEM AND APPARATUS

Filed June 19, 1941

2 Sheets-Sheet 2

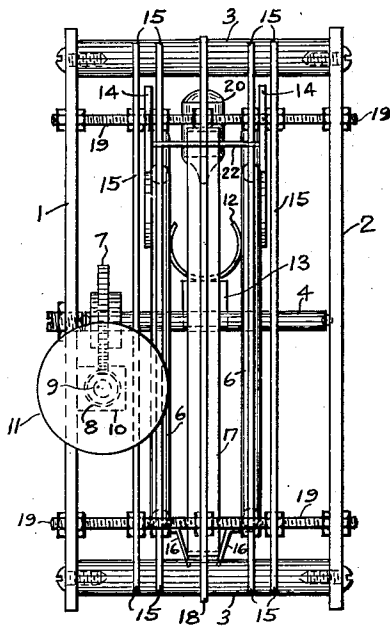


Fig. 2.

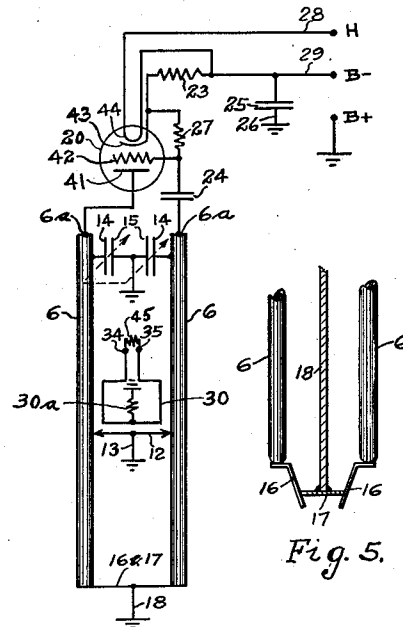


Fig. 9.

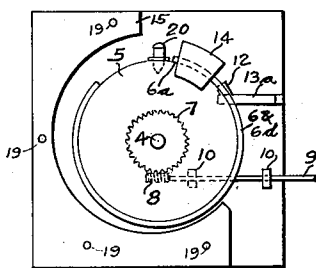


Fig. 6.

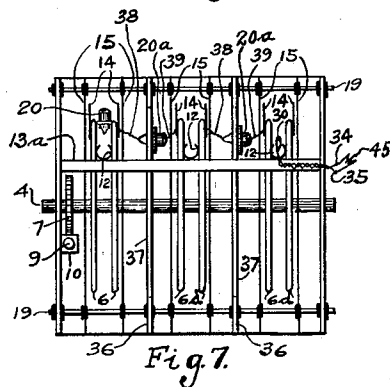


Fig. 7.

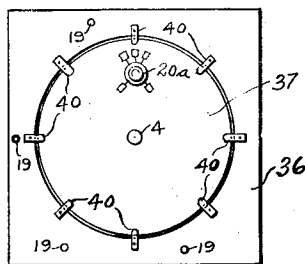


Fig. 8.

Inventor
John M. van Beuren
Thomas Appleby
Attorney

UNITED STATES PATENT OFFICE

2,292,254

HIGH FREQUENCY RESONANT SYSTEM
AND APPARATUS

John M. van Beuren, Boonton, N. J., assignor to
Measurements Corporation, Boonton, N. J., a
corporation of New Jersey

Application June 19, 1941, Serial No. 398,858

18 Claims. (Cl. 250—36)

This invention relates to ultra short wave radio resonant systems and apparatus, particularly of the resonant parallel line type.

The primary object of this invention is to provide a simple means for efficiently generating ultra high frequency currents capable of adjustment over a wide frequency range and having considerable frequency stability with a minimum of apparatus and mechanical complications.

Another object of this invention is to provide a generator of ultra high frequencies wherein the voltage of the high frequency current may remain substantially constant over a wide frequency range.

A further object of this invention is to provide an ultra high frequency generator wherein the frequency of the currents generated may be varied over a wide range with any desired frequency versus frequency-changer-motion characteristic.

A still further object of this invention is to provide an ultra high frequency coupler for multi-stage amplifiers, and further adaptable to simultaneous frequency variation, over a wide range of frequencies, of a multiple of coupler units by means of a single control member.

Other objects of this invention reside in the features of construction, combination, method and arrangement hereinafter described and claimed.

Heretofore, in the construction of high frequency generating systems employing vacuum tubes, when a continuous unbroken range of frequencies, or a continuous band of frequencies, was desired the frequency determining elements usually consisted of a fixed inductance coil shunted with a variable condenser. Such an arrangement, due to residual inductance and capacity, usually limited the practical frequency range from the lowest frequency obtainable with the values of inductance and capacity used, to a maximum frequency about three times greater. When greater variations of frequency, or greater frequency band width, were desired inductance coils of different inductive values were switched into circuit or substituted. It will be readily seen that the switching into circuit of various inductance coils resulted in broken steps of frequency variation requiring some form of compensation or multiple scale arrangement on the frequency indicator, and when different coils were substituted the potential values in the circuit were materially altered.

The present invention serves to materially increase the width or range of the frequency band to any desirable amount, and ranges as high as 55

twenty-five to one have been obtained while still keeping the dimensions of the apparatus within practical limits for portable instruments.

For an understanding of this invention reference is made to the accompanying drawings in which:

Fig. 1 is a front elevational view with one end plate and the containing casing removed.

Fig. 2 shows an end elevation of Fig. 1.

Fig. 3 is a modified partial end elevation showing the pick-up loop and coupling actuating mechanism.

Fig. 4 is a partial projected front elevation of Fig. 3.

Fig. 5 is a partial elevation of Fig. 2, showing the short-circuiting bar and support in section and contacting the inductance short-circuiting and grounding clips.

Fig. 6 is a partial end elevation, with one end plate removed, of a modification adapted for multiple resonant units.

Fig. 7 is a projected side elevation of Fig. 6.

Fig. 8 is an elevational view of one of the shields of Fig. 7.

Fig. 9 is a schematic diagram of the resonant circuit, and associated apparatus of Figures 1, 2, 3 and 4.

In Figures 1, 2, 3 and 4, metallic end plates 1 and 2, secured in spaced relationship by means of metal spacers 3, provide bearings for rotatable metal shaft 4. Secured to shaft 4 in desired spaced relationship are two rotatable insulating discs 5 of any suitable material such as, for example, polystyrene. Around about three-quarters of the periphery of each disc 5 is secured a rod or tube 6 of copper, or other suitable conductor, preferably silver-plated to increase surface conductivity. This pair of parallel rods or tubes rolled into approximately three-quarters of a circle forms a fundamental resonant circuit of a parallel rod type resonant transmission line of considerable electrical stability and simplicity, as will be hereinafter described in greater detail.

Suitable motion is imparted to the parallel conductors 5 by means of gear 7 secured to shaft 4 and coacting with worm drive 8 which is secured to a drive shaft 9 journaled in bearing 10 and actuated by means of thumb knob 11. In place of the thumb knob 11 a small electric motor may be utilized to drive shaft 9.

Stationary short-circuiting spring 12, better shown in Fig. 3, is mounted on a metal conducting support 13 electrically grounded to the casing and arranged to simultaneously contact both of the conductors 6 and thus alter their electrical

length and vary the frequency as they are rotated to include more or less of their physical length between the operating ends and short-circuiting spring 12.

In order to obtain a wider band of frequencies than would prevail due to the inductance and inherent capacity of the active portions of conductors 6, there is provided a condenser plate 14 secured to and in electrical contact with each of the conductors 6. As these condenser plates rotate with conductors 6 they intermesh with stationary grounded plates 15 (Figures 1, 2, 6, 7 and 9). Stationary plates 15 are provided with excentric shaped portions with respect to the arc formed by rotatable plates 14, so that when a minimum portion of conductors 6 is included between their high potential ends 6a (Figures 1, 6 and 9) and short-circuiting contact spring 12 the rotatable condenser plates 14 and stationary plates 15 will not yet be in mesh and will therefore add practically no additional capacity, other than their inherent capacity, to the circuit of conductors 6 at which position the LC value of the circuit in which they are located will be at a minimum and the highest frequencies will prevail. But as conductors 6, and their respective condenser plates 14, are rotated the moving plates 14 will gradually intermesh with stationary plates 15 until the maximum active portion of conductors 6 are included between their ends 6a and short-circuiting spring 12 at which position the moving condenser plates will be intermeshed with the stationary plates to their maximum amount and the highest LC value of the circuit will prevail with a corresponding low frequency.

It will be readily understood that by properly proportioning and shaping stationary plates 15 and movable plates 14 any desired frequency versus rotation characteristic may be obtained, and thus any desired type of scale utilized to determine the electrical frequency constants of the resonant system. This feature of proportioning and shaping the condenser plates may also be utilized where a multiple of resonant systems are to be used, as shown in Fig. 7, with unitary frequency control member to permit the various stages to properly "track," or maintain substantially similar frequency values.

Inasmuch as long unused portions of conductors 6 may set up, at ultra high frequencies, undesired and spurious resonances and cause "suck-outs," grounding springs 16 have been provided mechanically and electrically secured at short intervals of length to conductors 6 (Figures 1, 2 and 5) and arranged to rotate with conductors 6 and contact concentric grounding strip 17 which is electrically secured to and supported by plate 18 in contact with the frame and case.

Threaded spacing screws 19 (Figures 1, 2, 6, 7 and 8) together with their cooperating nuts serve the double purpose of securing in proper spaced relationship the end plates 1 and 2, stationary plates 15, and grounding plate 18, and electrically connecting or grounding these members to the frame and casing comprising members 1, 2 and 34a.

In ultra high frequency circuits the length of leads connecting the various apparatus is of great concern and must be kept at a minimum, the apparatus and circuits in which the useful high frequency oscillations occur has therefore been mounted on, and rotates with, the conductor support 5 adjacent the high potential ends 6a of conductors 6. Some of the associated parts rotating with the conductors 6 are shown in Fig-

ure 1 where a vacuum tube 20 is suitably mounted in spring clips 21 supported by plate 22 which is secured to both of the discs 5, resistor 23 (Figures 1 and 9), condenser 24, condenser 25, and grounding springs or terminal 26. The grid-leak resistor 27 is not shown in Figure 1 but is shown in Figure 9.

In the system indicated it will be readily understood that only two flexible leads 28 and 29 (Fig. 9) are required to complete the circuit to the source of current for the heater and the B minus current. These leads are not a part of the high frequency system, they merely convey the necessary actuating currents to the vacuum tube from which are generated high frequency oscillations, and therefore their length, location and arrangement are immaterial with respect to the frequency constants of the system and they may be partially wound around the shaft 4 and brought out near the center of the rotating members to their respective terminals.

In order to convey high frequency currents from the conductors 6 at a suitable point of transformation and without altering the coupling value as the conductors 6 are rotated, there is provided a movable secondary pick-up loop 30 (Figures 3, 4 and 9), coaxing with short-circuiting spring 12 and thus forming the primary and secondary of a variable oscillation transformer, whose coupling is varied by means of rotatable knob 31 secured to hollow shaft 32 journaled in end plates 1 and 2 and supporting tube 33 in which loop 30 is supported for arcuate rotation relation with respect to primary 12. The terminals 34 and 35 of pick-up loop 30 are led through the tube 33 and hollow shaft 32, which act as shields, to any suitable terminals or transmission line. Secured to the casing 34a is a shielding tube 34b, partially slotted, which loop 30 enters as it is moved away from primary 12. As indicated in Figure 4, secondary 30 is so arranged that it may be rotated toward a position of normal zero coupling which would occur should it assume a position at right angles to primary 12. In order to save space and at the same time protect coil 30 against the influence of stray fields upon assuming a position of decreased coupling with respect to coil 12, the shield 34b has been provided. This shield reduces the coupling between these coils substantially to zero value prior, and without resort, to the complete positioning of these coils at right angles to each other. Thus the mutual inductance of primary 12 and secondary 30 will be altered to a greater extent than would prevail without the proximity of this shield and use of this feature is made to reduce the transfer of energy between these coils to a greater extent than would otherwise prevail particularly at the point of minimum coupling position.

The arrangement thus far described may be used as a signal generator for the generation of ultra high frequency oscillations for measurement and other purposes.

In Figures 6, 7 and 8 there is shown a modification of the device in which the generated oscillations may be amplified, or by means of which ultra high frequency oscillations from any source may be amplified. In these figures the same general arrangement as previously described is shown for the generation of oscillations, but it is understood that by omitting the generating stage and applying ultra high frequency currents to the first amplifier tube 20a the device indicated in

Figures 6, 7 and 8 may be used as a resonant ultra high frequency two stage amplifier.

As shown in Figures 6 and 7, two additional pairs of resonant conductors 6d are secured to additional rotatable discs 5 of insulating material and these additional discs are secured to and actuated by shaft 4. These resonant conductors are each provided with movable condenser plates 14 coating in similar manner with their respective associated stationary plates 15, as previously described.

Between each pair of resonant conductors 6 and 6d there is placed a metallic shield made in two parts, a stationary portion 36 grounded to the frame members and provided with a circular opening (Fig. 8), and a rotatable portion 37, of slightly smaller diameter than the opening in 36, secured to shaft 4 and aligned to rotate within the opening of stationary shield 36. Vacuum tube amplifier 20a is mounted on and extends partially through rotatable shield disc 37 to enable the interstage high frequency leads 38 and 39, and other circuit connecting leads, to be kept as short as possible and rotate with their associated equipment to avoid the necessity of otherwise providing sliding contacts. In order to thoroughly ground the rotatable shield 37 at short intervals of length around its periphery there are provided a multiple of grounding spring contacts 40 secured to and in electrical contact with the stationary shield 36 and in slidable electrical contact with the rotating shield 37.

A pick-up loop 30 (Fig. 7) with terminals 34 and 35, and associated actuating members as previously described and shown in Figures 3 and 4, is also provided in this case to convey the amplified currents to an external circuit. A short-circuiting spring 12 mounted on grounding support 13a is provided for each pair of resonant conductors 6 and 6d. While an interstage connection may be made directly between the resonant conductors 6 and the vacuum tube amplifiers 20a as shown in Fig. 7, it is also desirable to utilize a plurality of pickup-loops 30 with their associated actuating equipment to convey the high frequency currents from the oscillation generating system to the amplifier and from one amplification stage to another in order that any desired value of coupling between the various stages may be utilized.

Figure 9 shows a schematic wiring diagram, suitable for use with the high frequency generating portion of the system, in which a vacuum tube 20 has its plate member 41 directly connected to one end of one of the resonant conductors 6 and its grid member 42 connected through a blocking condenser 24 to the corresponding end of the other resonant conductor 6 and also connected, through grid-leak resistor 27, to the cathode 43 and through resistor 23 to the B minus terminal. Cathode heater 44 is connected at one end to heater current terminal H by means of conductor 28 and to the opposite side of the heater current circuit marked B minus by means of conductor 29. One side of a by-pass condenser 25 is connected to lead 29 and the other side grounded to the frame through lead 26. The B plus or plate current is supplied by connecting a source to terminal marked B minus and to grounded terminal marked B plus. It will be understood that the grounded connections indicated in Fig. 9, refer to the frame of the apparatus. In this manner it will be seen that high tension current is supplied to the plate member 41 of the vacuum tube 20 through the

frame and frame grounds of the apparatus while the return circuit for the B current is provided through cathode 43 resistor 23 and lead 29 to the B minus terminal. The cathode heater current is supplied to the heater element 44 by connecting a source of supply to terminals marked H and B minus, respectively. Variable condensers comprising plates 14 and 15 refer to the movable and stationary plates respectively, previously described, and simultaneously operated by means of a single actuating member. An output circuit is provided consisting of variable oscillation transformer secondary 30 with terminals 34 and 35, and primary 12 as previously described.

While not in any manner limiting this application thereto, an apparatus of the type herein described has been constructed by bending about 18 inches of $\frac{1}{4}$ inch diameter copper tubing into a three-quarter circle of 8 inches diameter to form the rotor or resonant conductors, and proportioning the movable condenser plates and the stationary plates so that when intermeshed with all of the resonant conductors in the circuit the maximum capacity across the ends of the resonant line was from 50 to 75 micro-microfarads a frequency of 50 megacycles per second was obtained, and when rotated to minimum capacity and inductance position a frequency of 400 megacycles was obtained in one unbroken range. By increasing the diameter and length of the rotor (resonant conductors) a still greater band of frequencies may be obtained. At the high frequency end of rotation there is effectively no added capacity in the circuit as the condenser plates do not start to engage until the rotor has traveled some distance. This maintains a high "Q" at the high frequency end. After the plates start to engage or intermesh, control of the frequency versus rotation characteristic may be obtained by the manner in which they are shaped.

A non-loaded resonant transmission line may respond to certain undesired harmonics of the fundamental frequency, the addition of capacity by means of plates 14 and 15 serves to maintain an L/C ratio in the transmission line formed by conductors 6 favorable to the suppression of undesired harmonics of the fundamental frequency. The capacity loading of the transmission line 6 by means of condenser plates 14 and 15 therefore serves the double purpose of maintaining a suitable L/C ratio and extending the frequency coverage of the line as previously described.

It has been found that if the center of pick-up loop 30 (Figures 4 and 9) is ungrounded or improperly terminated, the balanced shielded conductors 34 and 35 forming its line may act together as the central conductor of a coaxial line, and not being properly terminated at the loop end, may resonate at a frequency within the range of the apparatus with which it is associated. It has been found that this effect can be avoided by connecting a resistor 30a, equal approximately to the surge impedance of such a coaxial line, from a point substantially at the center of the loop to the shield 33 as shown in Figures 3 and 9. It will be understood that the opposite end of the balanced line formed by the loop leads 34 and 35, Figures 7 and 9 may also be terminated by a resistor 45 of the same substantial value as the characteristic or surge impedance of the line.

A suitable scale indicating frequency, wavelength, or other desirable functions of the resonant circuit, may be attached to main shaft 4

or auxiliary shaft 9 (Figures 1, 2, 3, 4, 6 and 7), or located in proximity to either of these shafts and an indicator attached to the shaft. In the event the indicating device is operated by auxiliary shaft 9 a suitable spiral scale may be employed to produce a more uniform spread of the indicated values.

What I claim is:

1. The method of obtaining a wide range of ultra high frequency oscillations in a vacuum tube oscillation generating system comprising simultaneously moving the frequency determining elements and the oscillation generating system.

2. The method of maintaining a substantially stable wide range of ultra high frequency oscillations in a vacuum tube system comprising simultaneously moving the frequency determining elements and the oscillation system.

3. The method of controlling amplification over a wide range of ultra high frequency oscillations in a vacuum tube amplifying system comprising simultaneously imparting frequency determining motion to the frequency maintaining elements and the oscillation amplifying system.

4. The method of controlling amplification over a wide range of ultra high frequency oscillations in a vacuum tube amplifier comprising simultaneously imparting frequency determining motion to a multiple of frequency maintaining elements and oscillation amplifying systems.

5. In an ultra high frequency system a parallel transmission line in arcuate shape and arranged for diametrical rotation, means for rotating said transmission line, stationary means for altering the electrical length of said transmission line as it rotates, and means rotating with said transmission line for increasing its normal electrical length.

6. In an ultra high frequency system a parallel transmission line in arcuate shape and arranged for diametrical rotation, means for rotating said transmission line, stationary means for altering the electrical length of said transmission line as it rotates and comprising one portion of an oscillation transformer coupler, and an external circuit containing a loop cooperating with and forming the other portion of said oscillation transformer coupler.

7. In an ultra high frequency system a parallel transmission line in arcuate shape and arranged for diametrical rotation, means for rotating said transmission line, stationary means for altering the electrical length of said transmission line as it rotates and comprising one portion of an oscillation transformer coupler, and an external circuit containing a movable loop cooperating with and forming the other portion of said oscillation transformer coupler whereby the transfer of electrical energy between said transmission line and said external circuit may be varied.

8. In an ultra high frequency system a plurality of pairs of parallel transmission lines in arcuate shape and arranged for diametrical rotation, means for simultaneously rotating said transmission lines, stationary means for altering the electrical length of said transmission lines as they rotate, and means rotating with said transmission lines for increasing their normal electrical length.

9. In an ultra high frequency system a paral-

lel transmission line in arcuate shape and arranged for diametrical rotation, means for rotating said transmission line, stationary means for altering the electrical length of said transmission line as it rotates, means rotating with said transmission line for increasing its normal electrical length, and an oscillation circuit and apparatus connected to and rotating with said transmission line.

10. In an ultra high frequency system a plurality of parallel transmission lines in arcuate shape and arranged for diametrical rotation, means for rotating said transmission lines, means for altering the electrical length of said transmission lines as they rotate, means rotating with said transmission lines for increasing their normal electrical length, an oscillation circuit and apparatus connected to and rotating with said transmission lines, and a shield rotating with and shielding said transmission lines.

11. In an ultra high frequency system a plurality of parallel transmission lines in arcuate shape and arranged for diametrical rotation, means for rotating said transmission lines, stationary means for altering the electrical length of said transmission lines as they rotate, means rotating with said transmission lines for increasing their normal electrical length, and an oscillation circuit and apparatus connected to and rotating with said transmission lines.

12. Ultra high frequency apparatus comprising a rotatable shaft, means for rotating said shaft, a plurality of supports mounted on and rotating with said shaft, a transmission line carried by and rotating with said supports, a condenser plate mounted on and rotating with said supports for increasing the electrical length of said transmission line, short-circuiting means for altering the active length of said transmission line as it rotates, means rotating with and grounding the inactive portion of said transmission line, and means cooperating with said short-circuiting means for conveying currents to or from said transmission line.

13. Ultra high frequency apparatus comprising a rotatable shaft, means for rotating said shaft, a plurality of supports mounted on and rotating with said shaft, a plurality of transmission lines carried by and rotating with said supports, a condenser plate mounted on and rotating with said supports for increasing the electrical length of said transmission lines, short-circuiting means for altering the active length of said transmission lines as they rotate, means rotating with and grounding the inactive portion of said transmission lines, means cooperating with said short-circuiting means for conveying currents to or from said transmission lines, and a plurality of shields mounted on and rotating with said shaft for shielding said transmission lines.

14. Ultra high frequency apparatus comprising a rotatable shaft, means for rotating said shaft, a plurality of supports mounted on and rotating with said shaft, a plurality of transmission lines carried by and rotating with said supports, condenser plates connected to and rotating with said transmission lines for increasing their electrical length, short-circuiting means for altering the active length of said transmission lines as they rotate, means rotating with and grounding the inactive portion of said transmission lines, means cooperating with said short-circuiting means for conveying currents to or from said transmission lines, a plurality of oscil-

lation circuits and apparatus rotating with said transmission line, and a plurality of shields mounted on and rotating with said shaft for shielding said transmission lines.

15. In an ultra high frequency system the combination of an oscillation transformer having a primary and a secondary coil, said secondary coil being connected to a balanced line enclosed within a shield, and a resistor connected from substantially the mid-point of said secondary coil to said shield to reduce spurious resonances in said line.

16. In an ultra high frequency system the combination of an oscillation transformer having a primary and a secondary coil, said secondary coil being connected to a balanced shielded line, and a resistor connected at one end to a point substantially at the center of said secondary coil and at its other end to ground, to reduce spurious resonances in said line.

17. In an ultra high frequency system, the combination of a balanced line within a shield, a loop at one end of said line having a resistor connected at one end to a point substantially at the center of said loop and at its other end to said shield, and a second resistor connected across the other end of said line, to reduce spurious resonances in said line.

18. An ultra high frequency system comprising a two conductor resonant transmission line grounded at one end, a vacuum tube containing cathode, plate and grid members, said plate member connected to one conductor and said grid member connected to the other conductor at the ungrounded end of said transmission line, and a source of actuating current having its negative terminal connected to said cathode member and its positive terminal grounded.