

Feb. 25, 1947.

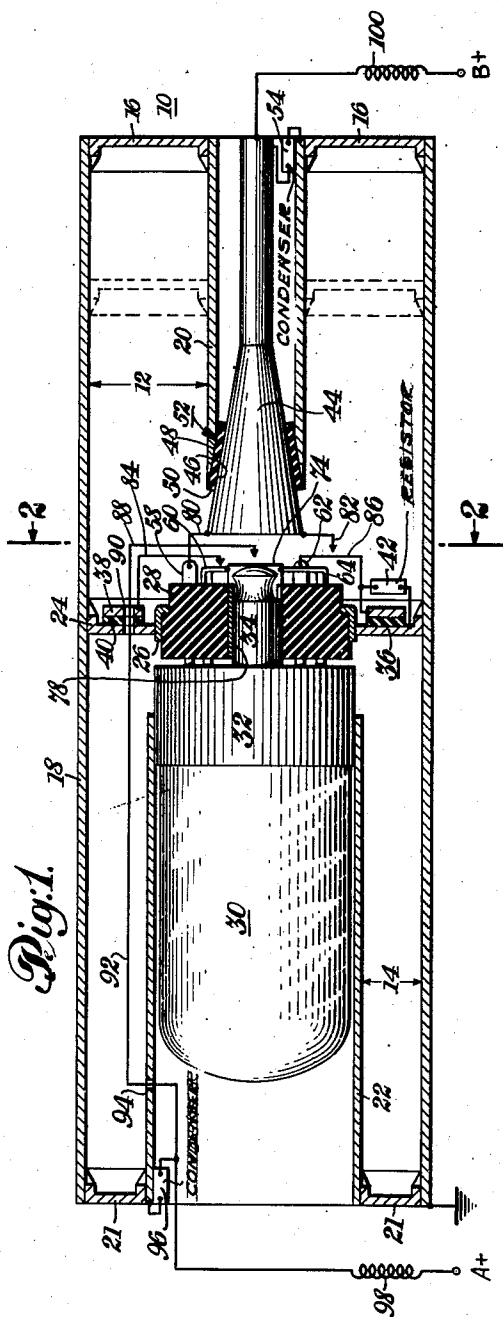
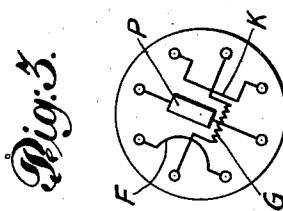
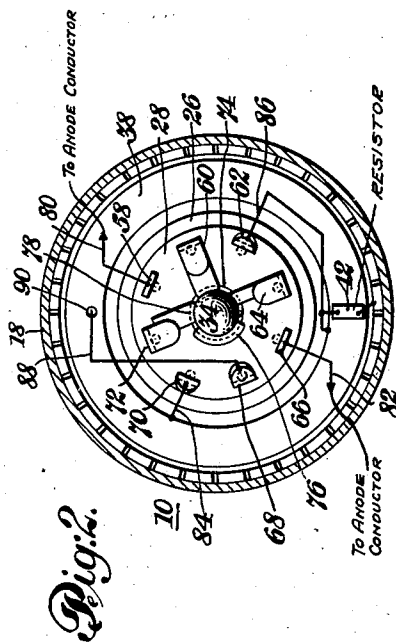
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2,416,319

HIGH FREQUENCY OSCILLATOR

Filed Oct. 8, 1942

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 4.

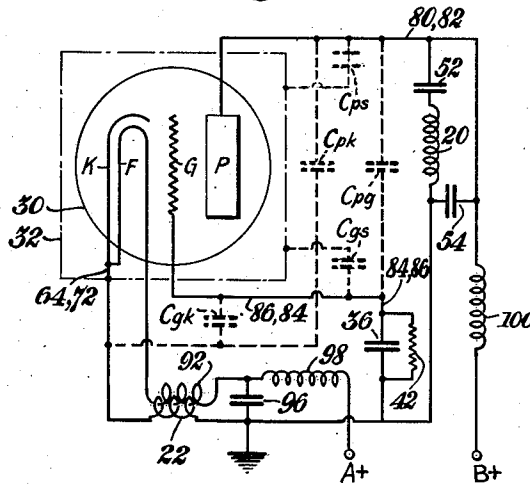


Fig. 5.

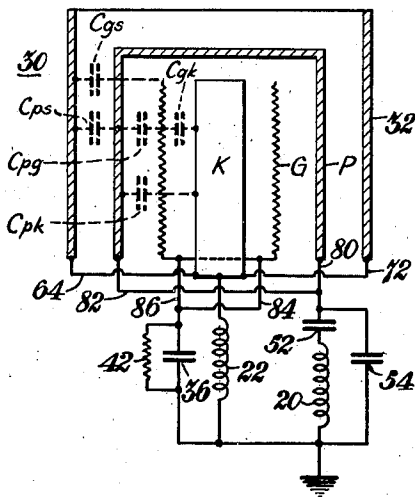
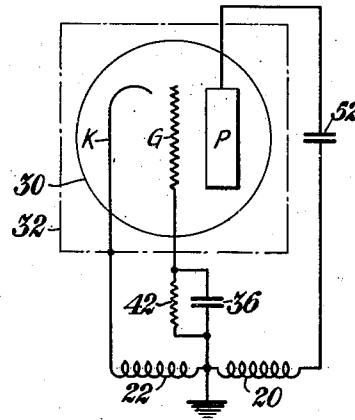


Fig. 6.



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2,416,319

HIGH-FREQUENCY OSCILLATOR

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Application October 8, 1942, Serial No. 461,305

12 Claims. (Cl. 250—36)

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This invention relates to improvements in high frequency oscillators, and more particularly to such oscillators of the type wherein a vacuum tube forms a mechanical unit with the oscillator tank circuit.

An object of this invention is to obtain higher oscillator frequencies than heretofore possible with vacuum tube oscillators using standard types of vacuum tube.

Another object of this invention is to provide a novel high frequency vacuum tube tank oscillator in which the plate-to-ground capacitance is lower than in comparable arrangements now known to the art.

Still another object of this invention is to provide a novel and improved high frequency oscillating circuit for a vacuum tube having externally shield electrodes.

Other objects and advantages of the present invention will appear from the following description of a preferred physical embodiment of the invention as well as from the described circuit connections therefor, all illustrated in the accompanying drawings, wherein:

Fig. 1 is a longitudinal cross-sectional view of an improved tank oscillator formed in accordance with the present invention, and also diagrammatically illustrates the circuit connections therefor;

Fig. 2 is a transverse cross-sectional view of the oscillator illustrated in Fig. 1, taken along the line 2—2;

Fig. 3 is a circuit diagram illustrating the relationship between the electrodes and the external leads of the vacuum tube shown in Fig. 1;

Fig. 4 is a complete circuit diagram of the tank oscillator illustrated in Fig. 1;

Fig. 5 is a diagrammatic representation of the relationship between the electrodes of the vacuum tube shown in Fig. 1, together with a circuit diagram of the external oscillating circuit connections; and

Fig. 6 is a circuit diagram illustrating the basic high frequency oscillating circuit of the oscillator illustrated in Fig. 1.

A preferred physical embodiment of my improved tank oscillator is shown in Figs. 1 and 2, and is drawn to an enlarged scale for the sake of clarity. In these figures the oscillator as a whole is designated by the reference numeral 10 and consists essentially of two coaxial lines 12 and 14 in the form of resonant cavities. The coaxial line 12 may consist of concentric metal cylinders 18 and 20 having a metal ring 16 slidable therebetween, the outer cylinder 18 being

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preferably common to both coaxial lines 12 and 14, and, as more clearly described hereinafter, the inner cylinder 20 forming a reactive anode conductor for the oscillator. The coaxial line 14

5 is formed by the outer metal cylinder 18, the inner concentric metal cylinder 22 and the slidable ring 21 movable between them. Between the resonant lines 12 and 14 and intermediate the ends of the common outer cylinder 18, is positioned a metal disk 24 whose outer periphery is in electrical contact with the inner surface of the cylinder. The disk 24 is open at its center and rigidly supports the outer metallic ring 26 of a vacuum tube socket 28 extending through the opening in the disk 24 and supported coaxially relatively to the cylinder 18. The socket 28 is adapted to receive a vacuum tube 30 of a type well known in the art. This tube is provided with a metallic strengthening shield 32 surrounding the electrode elements therein, the glass bulb serving merely for sealing and gripping purposes, and with a metal plug 34 which is locked in the socket 28 and which is electrically connected with the shield 32. The tube which has been illustrated, by way of example, may be of the type known as the "Sylvania 1201" tube, although it is to be distinctly understood that the invention is not to be limited to use in connection with this or any other specific vacuum tube.

The disk 24, in addition to supporting the vacuum tube socket 28, also preferably supports and forms part of a condenser 36 which consists of a thin metal sheet 38 separated from the disk 24 by a thin sheet of insulating material 40. It will be clear to those skilled in this art that the plates of the condenser 36 are, in this case, formed by the metal sheet 38, on the one hand, and the disk itself on the other hand. A resistor 42 is preferably connected across the condenser 36.

Mounted within the reactive anode conductor 20 of the coaxial line 12 is an anode supply lead in the form of a rod 44, one end of which is provided with an enlarged head having a conical surface 46 spaced from a corresponding inner conical surface 48 formed on the inner end of the reactive anode conductor 20. A thin sheet of insulation 50 is interposed between the adjacent conical surfaces, whereby these conical surfaces form a condenser 52 in series with the reactive anode conductor. The outer end of the rod 44 will be supported in any suitable manner (not shown) and, for the purpose of preventing the flow of high frequency current to the plate

supply, I prefer to connect another condenser 54 between the outer end of the rod 46 and the outer end of the reactive anode conductor 20. This condenser may be mounted in the space between the rod 44 and the reactive anode conductor 20.

The inner cylinder 22 of the coaxial line 14 will engage the metal shield 32 of the inserted vacuum tube 30, and forms a reactive cathode conductor, as will be explained in more detail hereinafter.

The manner in which the electrodes of the vacuum tubes are interconnected with the afore-described constructional elements of the oscillator will now be described, and in this connection reference is made to Fig. 2 as well as to Fig. 1. The socket 28 mounted within the disk 24 is of the usual type being provided with spaced electrode connectors 58, 60, 62, 64, 66, 68, 70 and 72. Although the type of vacuum tube contemplated is provided with only three electrodes and a heater, each electrode has two terminals, some of which are diametrically opposite, as indicated, for example, in Fig. 3. Thus, when the tube 30 is mounted in the socket 28 the socket connectors will be connected to the electrodes in such a manner that, for example, connectors 58 and 66 will lead to the anode P, the connectors 60 and 64 to the cathode K, the connectors 62 and 70 to the grid G and the connectors 68 and 72 to the heater F. This arrangement of diametrically opposed anode and grid connectors is particularly adaptable for the type of oscillator contemplated since it permits the use of extremely short leads, important in ultrahigh frequency circuits. The type of socket 28 commonly used in the art is also provided with spaced spring contacts 74, 76, and 78 which are adapted to engage and hold the metal plug 34 which, as previously described, is also electrically connected to the external shield 32 surrounding the vacuum tube electrodes. Applicant also takes advantage of this constructional arrangement to provide short leads for the high frequency oscillator circuit.

As will be seen from a study of Figs. 1 and 2 the anode connectors 58 and 66 will be attached by short leads 80 and 82 respectively to the rod 44 leading, on the one hand, to the reactive anode conductor 20 through the condenser 52 and, on the other hand, to a suitable high potential source B+. The grid connectors 62 and 70 will be attached to the metal sheet 38 forming one plate of the condenser 36 by the short leads 84 and 86. The cathode connections 60 and 64 may be directly attached, as by soldering to the spring member 74 so that, in this case, the cathode is effectively directly connected to the shield 32. One of the heater connectors 72 is likewise directly soldered to a spring member 78 which, as previously described, is also electrically interconnected with the shield 32. The other heater connector 68 is attached through a lead 88 to a low potential source A+. In order to bring the lead 88 out of the oscillator for connection to the low potential source A+, I preferably provide a small opening 90 through one portion of the condenser 36 and extend the lead 88 through this opening in the form of a line 92 running parallel to the cathode line 22 of the coaxial line 14. The line 92 will then pass through another opening 94 in the cylinder 22 and then outwardly through the open end of the oscillator. A condenser 96 may be connected at any suitable point between the line 92 and the cylinder 22 and this, in connection with a high frequency

choke 98, will prevent the flow of high frequency currents to the direct current circuit. Similarly, in the connection to the high potential source B+, a suitable high frequency choke 100 may be inserted.

Keeping in mind that at the frequencies contemplated, the internal capacities of the tube and the capacities between the various electrodes and the surrounding metallic shield 32 actually form part of the oscillator circuit, reference is next made to Fig. 4 which illustrates the complete circuit diagram of the oscillator whose constructional features have just been described. In Fig. 4 the metallic shield 32 has been indicated as a box about the electrodes of the tube 30. Considering, first of all, the inter-electrode capacities, it will be clear that there exists a capacitance C_{pk} between the anode P and the grid G, a capacitance C_{pg} between the grid G and the cathode K. The capacitance between the anode and the shield 32 is indicated as C_{ps} while the capacitance between the grid G and the shield 32 is represented by C_{gs} . As the cathode is directly connected to the shield 32 in the manner described above, there will be no capacitance between these parts.

A study of the circuit shown in Fig. 4 will reveal the novel feature of the present invention whereby the grid is grounded for high frequency currents and the shield 32 is connected to the cathode K which, in this case, is a swinging electrode, being isolated from ground at the frequencies contemplated by the cathode conductor 22. The grid G is connected to the outer cylindrical member 18 of the oscillator through condenser 36 and shunt resistor 42 and, as shown in Fig. 1, the outer cylinder 18 is grounded. The anode P, on the other hand, is connected to ground only through condenser 52 and reactive anode conductor 20 and the cathode with the shield 32 are only connected to ground through the reactive cathode conductor 22.

The advantages of this circuit which permit the operation of the oscillator at extremely high frequencies may appear more clearly by reference to Fig. 5. In this figure the arrangement of the electrodes relatively to one another and to the surrounding shield 32 is portrayed, but no attempt has been made to show the relationship between parts in scale. With an arrangement such as shown in Fig. 5 and which represents the actual conditions within the tube 30, it will be noted that internal capacitances indicated will, of course, exist between and among the various electrodes and between each electrode and the surrounding shield. In the case of ultra-high frequency oscillators the controlling capacitance which limits the value of the oscillation frequency is the capacitance existing between the anode and ground. If, for example, the shield 32 were connected to ground the resultant anode-ground capacitance would, in the ordinary case, consist not only of the anode-cathode capacitance C_{pk} but also of the anode-grid C_{pg} plus grid-cathode C_{gk} capacitance and the anode-shield capacitance C_{ps} . If the shield 32 were floating instead of grounded no great reduction in anode-ground capacitance would result, since there would still exist capacitance between the shield and ground which would result in additional anode-shield and shield-ground capacitance. If, on the other hand, the grid is grounded for high frequency currents, as has been done in the present case, and the shield is connected to the cathode, the only anode-ground capacitance existing is the anode-grid capacitance C_{pg} . Such an arrange-

ment does increase the resultant anode-cathode C_{pk} capacitance but this increase is more than compensated for by the reduction in anode-ground capacitance. The actual tests upon the type of oscillator which have been described and illustrated have shown that whereas the highest frequency obtainable with the cathode grounded and the shield, either grounded or floating, is in the neighborhood of 500 megacycles; by changing the connections and using the arrangement of the present invention frequencies above 700 megacycles can be obtained. The actual resultant effective high frequency circuit which the present oscillator provides and, omitting the inter-electrode and electrode-shield capacitances, is illustrated in a simplified circuit diagram for the sake of clarity in Fig. 6, in which all parts have the same reference numerals previously used. In this connection, it is to be noted that while the cathode conductor 22 has been illustrated as an inductive reactance, it has been found that under certain resonant conditions this may act as a capacitive reactance, effectively isolating the cathode from ground at high frequencies.

It will be clear to those skilled in this art that while the oscillator in accordance with the present invention has been described in some detail, it is contemplated that changes may be made which, as far as the principles of the invention are concerned, will not alter the basic operation of the system. For example, the characteristics of the coaxial lines 12 and 14 may be varied by the shifting of the connectors 16 and 21, as indicated in dotted lines in Fig. 1. The manner in which these members may be moved is unimportant and within the skill of those working in this art. As previously pointed out, while the construction has been described in connection with a specific type of vacuum tube, the invention is applicable to other types of tubes suitable for high frequency work, in which the electrodes are surrounded by an external shield. A tube which provides double leads from each electrode is extremely advantageous for use at ultra-high frequencies in order that the leads may be kept as short as possible, but this is a refinement which is not necessary for the operation of my improved oscillator. Moreover, while it has been found advantageous to form the condenser between the grid and ground by using a part of the socket-supporting disk, as far as the principle of connecting the shield to a swinging cathode for the purpose of reducing the anode-ground capacitance is concerned, this is of no importance. It will thus be seen that I have provided a novel oscillator construction as well as a novel circuit for such oscillator, but that I do not intend to limit the invention to the particular embodiment shown, except as may be required by the claims which follow.

What I claim is:

1. In a high frequency electron discharge tube oscillator of the type in which the tube includes a cathode, a grid, an anode, and a generally hollow tubular shield surrounding these electrodes, and wherein the inter-electrode and electrode-shield capacitances are of appreciable value at the frequencies to be generated, the combination of means for connecting said cathode directly to said shield, a reactive cathode conductor connecting said shield and cathode to ground, a first condenser, a resistor, means for connecting said condenser and resistor in parallel between said grid and ground, a second condenser, a reactive anode conductor, and means for serially connect-

ing said second condenser and reactive anode conductor between said anode and ground.

2. In a high frequency electron discharge tube oscillator of the type in which the tube includes a cathode, a grid, an anode, and a shield surrounding these electrodes, and wherein the inter-electrode and electrode-shield capacitances are of appreciable value at the frequencies to be generated, the combination of a first hollow resonator in the form of a coaxial line having a grounded outer conductor, means for connecting said cathode directly to said shield, means for connecting said shield to the inner conductor of said line, a second hollow resonator in the form of a coaxial line whose outer conductor is electrically interconnected with the outer conductor of said first coaxial line, a first condenser, a resistor, means for connecting said condenser and resistor in parallel between said grid and the grounded common outer conductor, a second condenser, and means for serially interconnecting said second condenser between said anode and the inner conductor of said second coaxial line.

3. In an electron discharge tube circuit, a hollow metal cylinder, a metal disk mounted in and electrically coupled to said metal cylinder intermediate the ends thereof, an electron discharge device having a cathode, a grid, an anode and an external cylindrical metal shield about these electrodes, insulating means for supporting said tube on said disk so that said shield is concentric with said metal cylinder, a second hollow metal cylinder mounted concentrically within the first metal cylinder on one side of said disk, one end of said second cylinder surrounding and electrically coupled to said metal shield, a third metal cylinder supported at one of its ends at the other end of the first metal cylinder and extending concentrically inwardly toward the other side of said disk, and means for electrically connecting the ends of the first cylinder with the corresponding adjacent ends of the second and third cylinders, whereby said first and second cylinders form one hollow resonant cavity in the form of a coaxial line and said first and third cylinders form a second hollow resonant cavity in the form of a coaxial line, means for connecting the cathode to said shield and second cylinder, means for connecting the grid to the first, outer cylinder, and means for connecting the anode to the third cylinder.

4. The combination according to claim 3, in which the means for connecting the grid to the outer cylinder includes a condenser formed by a side of said disk as one condenser plate, a thin layer of insulation applied to said disk, and a metal sheet on the other side of said insulation and forming the other condenser plate.

5. The combination according to claim 3, in which the means for connecting the anode to the third inner cylinder includes a condenser comprising a metallic member mounted at least partially within said third cylinder and having a peripheral surface spaced slightly from a portion of the third cylinder, a dielectric intermediate said surface and the adjacent portion of the third cylinder and means for connecting the anode to said metallic member.

6. The combination according to claim 3, in which the means for connecting the grid to the outer cylinder includes a condenser formed by a side of said disk as one condenser plate, a thin layer of insulation applied to said disk, and a metal sheet on the other side of said

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insulation and forming the other condenser plate, and in which means for connecting the anode to the third inner cylinder includes a condenser comprising a metallic member mounted at least partially within said third cylinder and having a peripheral surface spaced slightly from a portion of the third cylinder, a dielectric intermediate said surface and the adjacent portion of the third cylinder and means for connecting the anode to said metallic member.

7. In an electron discharge device circuit, a hollow metal cylinder, a metal disk open at its center, mounted in and electrically coupled to said metal cylinder intermediate the ends thereof, an electron discharge device socket supported in the open center of said disk mounted substantially coaxially relatively to said cylinder, an electron discharge device having a cathode, a grid, an anode and an external cylindrical metal shield about these electrodes, mounted in said socket so that the said shield is concentric with said metal cylinder, a second hollow metal cylinder mounted concentrically within first metal cylinder on one side of said disk, one end of said second cylinder fitting around and in electrical contact with said metal shield, a third metal cylinder supported at one of its ends at the other end of the first metal cylinder and extending concentrically inwardly toward the other side of said disk, means for electrically connecting the ends of the first cylinder with the corresponding adjacent ends of the second and third cylinders, whereby said first and second cylinders form one hollow resonant cavity in the form of a coaxial line, electrode connectors extending from said socket, means for connecting the cathode connectors to said shield and said second cylinder, means for connecting the grid connectors to the first, outer cylinder and means for connecting the plate connectors to the third cylinder.

8. A high frequency oscillator comprising, in combination, a hollow metal cylinder, a metal disk, open at its center, mounted in and supported by said metal cylinder intermediate the ends thereof, an electron discharge tube socket formed of insulating material, supported in the center of the disk and mounted substantially coaxially relatively to said cylinder, an electron discharge tube in said socket having a cathode, a heater, a grid, an anode, and an external cylindrical metal shield about these electrodes, a plug extending from the base of the tube and electrically connected to said shield, an electrode lead extending from the base of the tube about said plug, said tube having two leads for each electrode, the anode and grid leads being spaced diametrically opposite to one another, electrical connectors in said socket for each lead and for said plug, said socket being so positioned in said disk that the tube is on one side of said disk and said connectors on the other side, a second hollow metal cylinder whose inner diameter is substantially equal to the outer diameter of said shield, mounted concentrically within the first metal cylinder on the one side of the disk, one end of said cylinder being substantially co-planar with one end of said first cylinder and the other end of said second cylinder surrounding and gripping said metal shield, means for electrically interconnecting the adjacent ends of said first and second cylinders, whereby said first and second cylinder form a hollow resonator in the form of a coaxial line, a third hollow metal cylinder

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mounted concentrically within the first cylinder on the other side of said disk, with one end substantially co-planar with the other end of the first cylinder and its other end spaced from said socket, means for electrically interconnecting the adjacent ends of the first and third cylinder, whereby said first and third cylinders form another hollow resonator in the form of a coaxial line, a rod concentrically positioned inside of said third cylinder, said rod having an enlarged head at one end gradually tapering from a diameter substantially equal to that of the third cylinder down to a small diameter, a solid dielectric intermediate the enlarged end of said rod and the inner end of said third cylinder, whereby the enlarged end of said rod and the inner end of said third cylinder form a condenser, a sheet of insulating material attached to the said other side of said disk outside of the socket, a metal sheet applied to said insulating sheet, whereby said metal sheet and disk form a second condenser, means for connecting both of the cathode connectors and one of the heater connectors to said metal plug and thence to said shield and second cylinder, means for connecting both grid connectors to said metal sheet and thence through said second condenser to the first cylinder, a resistor in shunt to said second condenser, means for connecting both anode connectors to the enlarged head of said rod and thence through the first condenser to said third cylinder, and a lead passing outwardly in said first resonator, connected to the other heater.

9. A high frequency oscillator comprising, in combination, a hollow metal cylinder, a metal disk, open at its center, mounted in and supported by said metal cylinder intermediate the ends thereof, an electron discharge tube socket formed of insulating material, supported in the center of the disk and mounted substantially coaxially relatively to said cylinder, an electron discharge tube in said socket having a cathode, a heater, a grid, an anode and an external cylindrical metal shield about these electrodes, a plug extending from the base of the tube and electrically connected to said shield, and electrode leads extending from the base of the tube about said plug, said tube having two leads for each electrode, the anode and grid leads being spaced diametrically opposite to one another, electrical connectors in said socket for each lead and for said plug, said socket being so positioned in said disk that the tube is on one side of said disk and said connections on the other side, a second hollow metal cylinder whose inner diameter is substantially equal to the outer diameter of said shield, mounted concentrically within the first metal cylinder on one side of the disk, one end of said second cylinder being substantially co-planar with one end of said first cylinder and the other end of said second cylinder surrounding and gripping said metallic shield, a ring-shaped metal slidable contactor engageably mounted between the first and second cylinders, whereby said first and second cylinders form an adjustable hollow resonator in the form of an adjustable coaxial line, a third hollow metal cylinder mounted concentrically within the first cylinder on the other side of said disk, with one end substantially co-planar with the other end of the first cylinder and its other end spaced from said socket, a second ring-shaped slidable metal contactor engageably mounted between the first and third cylinders, whereby said first and third cylinders form another adjustable hollow

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resonator in the form of an adjustable coaxial line, a rod concentrically positioned inside of said third cylinder, said rod having an enlarged head at one end gradually tapering from a diameter substantially equal to that of a third cylinder down to a smaller diameter, a solid dielectric intermediate the enlarged end of said rod and the inner end of said third cylinder, whereby the enlarged end of said rod and the inner end of said third cylinder form a condenser, a sheet of insulating material attached to the other side of said disk outside of said socket, a metal sheet applied to said insulating sheet whereby said metal sheet and said disk form a second condenser, means for connecting both the cathode connectors and one of the heater connectors to said metal plug, and thence to said shield and second cylinder, means for connecting both grid connectors to said metal sheet and thence through said second condenser to said first cylinder, a resistor in shunt to said second condenser, means for connecting both anode connectors to the enlarged end of said rod, and thence through the first capacitor to said third cylinder, and a lead passing outwardly of said first resonator, connected to the other heater connector.

10. A combination according to claim 9 in which said second condenser and said cylinder are provided with small openings therethrough, and said lead passes through said openings and substantially parallel to said second cylinder.

11. A combination according to claim 9 in which said second condenser and said cylinder are provided with small openings therethrough,

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and said lead passes through said openings and substantially parallel to said second cylinder in combination with a third condenser connected between said lead and said second cylinder, and a fourth condenser connected between the outer ends of said rod and said third cylinder.

12. A combination according to claim 9 in which said second condenser and said cylinder are provided with small openings therethrough, and said lead passes through said openings and substantially parallel to said second cylinder in combination with a third condenser connected between said lead and said second cylinder, and second condenser connected between the outer ends of said rod and said third cylinder, and a ground connected to said outer cylinder, a high potential source connected to the anode through said rod, and a low potential source connected to said heater lead.

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