July 18, 1944. E. D. McARTHUR 2,353,742

HIGH FREQUENCY APPARATUS

Filed Aug. 26, 1941 2 Sheets-Sheet 1

Fig. 1.

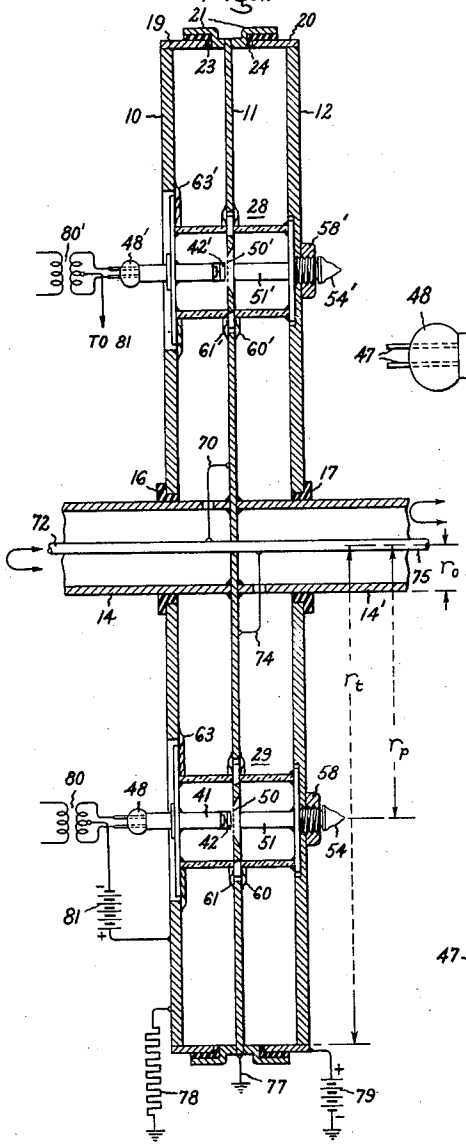


Fig. 2.

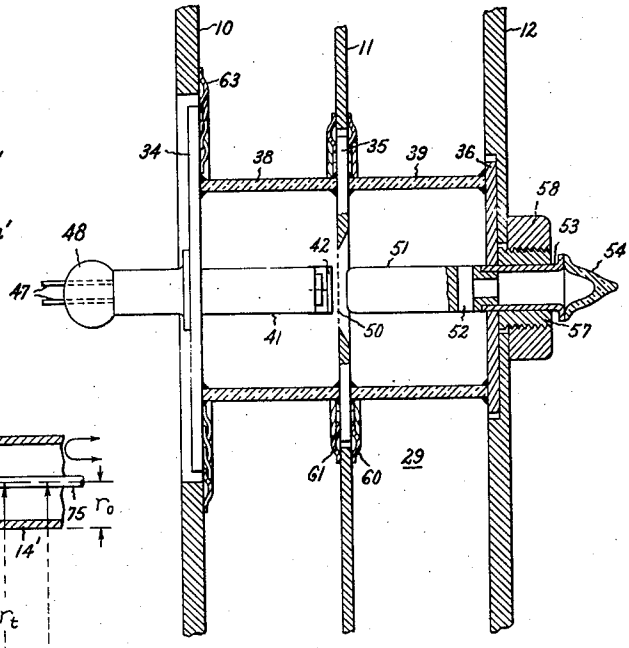
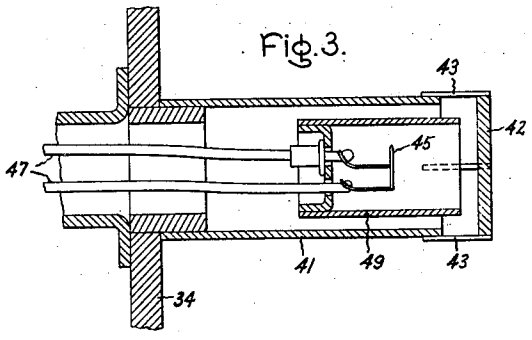


Fig. 3.



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Fig. 4.

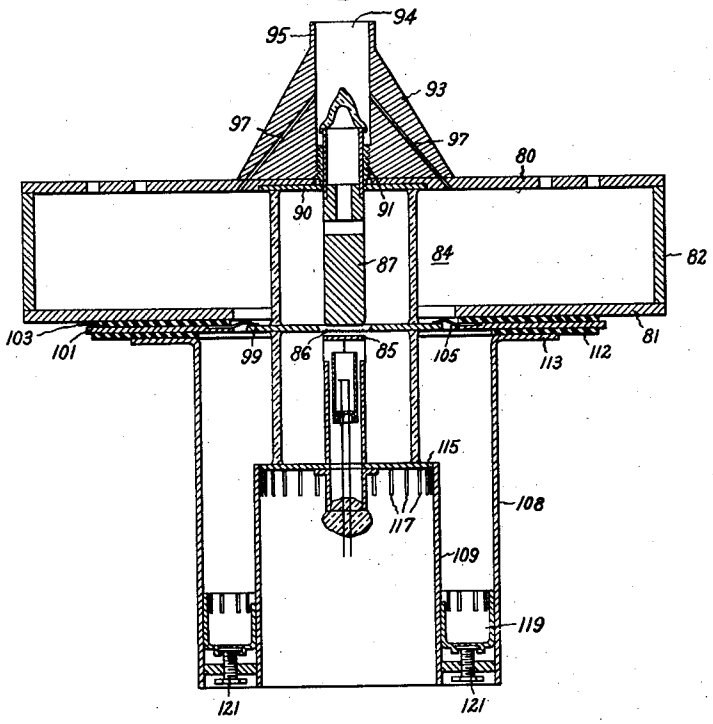
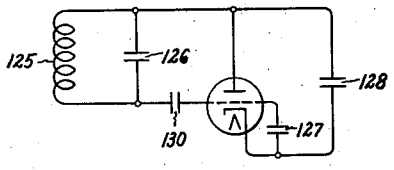


Fig. 5.



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UNITED STATES PATENT OFFICE

2,353,742

HIGH-FREQUENCY APPARATUS

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Application August 26, 1941, Serial No. 408,363

9 Claims. (Cl. 315—6)

This is a continuation-in-part of my prior application Serial No. 353,132, filed August 17, 1940, for High frequency apparatus, and which matured on May 26, 1942, into U. S. Letters Patent 2,284,405.

In the aforesaid prior application there is described and claimed an improved form of resonant structure useful at high frequencies as a tank circuit or energy-converting means. This comprises a pair of disk-like members arranged in face-to-face relation and adapted to support standing waves propagated radially between the members. In the preferred case it includes a central hub which is coaxial with the members and which provides a conductive bridge between them as far as high frequency currents are concerned. A resonant system of this kind is especially adapted for use in the ultra-high frequency range and makes available several novel and desirable ways of operating a number of high frequency vacuum tubes in parallel to assure their effective cooperation.

The present invention is primarily concerned with means for combining a resonant structure of the general type referred to above with an electronic discharge device adapted to coact with the structure. In this connection an arrangement is provided in which an appropriate type of discharge device is interposed directly between the planar members defining the resonant structure (i. e. in the space resonant cavity bounded by the members) and is connected to the members by electrode terminal elements which are themselves of planar character and which are so disposed as to constitute electrically continuous extensions of the members. In a particular embodiment this is accomplished by making the terminal elements of disk-like form and of such size as to interfit with correspondingly dimensioned openings provided for that purpose in the wall surfaces of the cavity-forming members.

The advantages of this arrangement include, among others, the fact that the lead inductance of the various electrodes is incorporated directly and usefully into the resonant system and that the interelectrode capacitance is, for the most part, similarly absorbed. In addition, as will be explained more fully hereinafter, the resultant structural arrangement facilitates cooling of the anode and grid electrodes in a manner which does not in any way interfere with the operation of the high frequency system as a whole.

The features which I desire to protect herein are pointed out with particularity in the appended claims. The invention itself, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the drawings in which Fig. 1 is a sectional view of a complete high frequency apparatus suitably embodying the invention; Fig. 2 is an enlarged detail view of one of the electronic discharge devices employed in the construction of Fig. 1; Fig. 3 is a still further enlarged representation illustrating the cathode structure of the device of Fig. 2; Fig. 4 is a sectional view of an alternative embodiment of certain features of the invention; and Fig. 5 is a diagrammatic circuit representation useful in explaining the apparatus of Fig. 4.

Referring particularly to Fig. 1, there is shown a resonant structure which includes a series of three generally planar conductive members 10, 11, and 12 arranged in face-to-face relation to define a pair of space resonant cavities between them. These members are of circular (disk-like) configuration and are coaxially arranged so that they have a common line of centers. The members may suitably be constituted of copper, brass or other highly conductive metal.

At their central portion the disk-like members 10, 11, and 12 are associated with a conductive hub having separate parts 14 and 14' which are joined to the member 11 and which respectively extend through the members 10 and 12. The hub parts 14 and 14' are insulated from the members 10 and 12 by means of insulating bushings 16 and 17, but, because of capacitance effects, may be assumed to provide an electrical circuit between the various members as far as high frequency currents are concerned.

In order to obtain resonant operation of the character desired in the present connection, it is important that the hub parts 14 and 14' be sufficiently short so that their lumped inductive effect is negligible in comparison with the lumped capacitive effect of the members 10, 11, and 12 at the resonant frequency of the system. This may be assumed to be the case as long as the conductive hub reactance is on the order of or less than 10% of the lumped capacitive reactance of the members.

Further means are provided for the purpose of peripherally short-circuiting the members 10, 11, and 12 with respect to high frequency currents without establishing a path for direct currents between them. This is accomplished by providing inwardly directed flanges 19 and 20 in connection with the members 10 and 12 respectively and by attaching to the central member 11 a double flange structure 21 which overlaps the

flanges 18 and 20, being separated from them by insulating spacers 23 and 24.

It has been shown in my aforesaid U. S. Letters Patent 2,284,405 that a resonant cavity of the type under consideration may be designed to resonate at a particular frequency provided the radius of the connecting hub structure is properly correlated to the radial dimensions of the cavity-forming members. In particular, this correlation requires the fulfillment of the following relationship:

$$\frac{J_0(2\pi r_o/\lambda)}{N_0(2\pi r_o/\lambda)}=\frac{J_0(2\pi r_t/\lambda)}{N_0(2\pi r_t/\lambda)}$$

where J_0 and N_0 respectively represent Bessel functions of the first and second kinds and zero order, r_0 represents the radius of the hub, r_t the common radius of the cavity-forming members, and λ represents a wave length corresponding to the desired operating frequency. With these conditions realized, radially propagated standing waves may be developed within the resonant cavity thus defined, such waves having nodal points at the hub and at the periphery of the cavity and an antinodal point at a distance r_p from the hub determined by the following relationship:

$$\frac{J_0(2\pi r_o/\lambda)}{N_0(2\pi r_o/\lambda)}=\frac{J_1(2\pi r_p/\lambda)}{N_1(2\pi r_p/\lambda)}$$

where J_1 represents a Bessel function of the first kind and of the first order, N_1 represents a Bessel function of the second kind and of the first order, and the other quantities correspond to the conventions adopted above.

In order to employ the properties of a resonant cavity of the type under consideration in the production of useful energy conversion effects, it is desirable to provide in connection with the cavity one or more electronic discharge devices adapted to function at the ultra-high frequencies to which such cavities are responsive. In the arrangement of Fig. 1, this is accomplished by arranging in a symmetrical grouping about the axis of the resonant structure a plurality of discharge tubes, of which only two are shown in the drawing, these being indicated at 28 and 29 respectively. In accordance with the present invention, the devices 28 and 29 extend through openings provided in the central disk-like member 11 and have their respective extremities positioned in the cavities formed between this member and the outer members 10 and 12. Their location with respect to the other elements of the structure is such that the radial displacement of their axes from the hub 14 corresponds at least approximately to the location of the antinodal point of waves propagated within the resonant cavities when the apparatus is in a condition of normal operation.

Because of the ultra-high frequency range in which the apparatus under consideration is expected to operate, considerable difficulty is presented with respect to the provision of suitable means for connecting the operating elements of the various discharge devices to the parts of the resonant structure. In the present instance this difficulty is substantially overcome through the use of an improved high frequency tube construction and terminal arrangement for the tube.

Referring to Fig. 2, which represents the discharge device 29 on an enlarged scale, it will be seen that the device comprises a cylindrical structure which includes a series of three planar disk-like elements 34, 35, and 36, insulatingly separated by vitreous (glass) cylinders 38 and 39 sealed between the elements. As is shown more clearly in Fig. 3, the disk 34 is provided centrally with a protuberant cathode structure comprising a hollow metal cylinder 41 bearing at its extremity a circular plate 42. The plate 42, which may suitably consist of molybdenum, is mounted on a series of wire or ribbon supports 43 and is coated on its outer surface with an electron emissive material such as thoria (thorium oxide). In operation, the emissive part 42 is maintained at a temperature of thermal emissivity by bombardment from an auxiliary cathode 45 which is in the form of an incandescible filament supported in spaced relation with reference to the part 42. The element 45 may be maintained in heated condition by passage of current through lead-in conductors 47 which are sealed into the discharge enclosure through a glass-to-metal seal indicated at 48 (Fig. 2). The electrons projected from the filament are focused against the inner surface of the part 42 by means of a metal cylinder 49 which is directly connected to one of the filament leads. In the use of the apparatus, a unidirectional potential is impressed between the filament 45 and the part 42 so as to produce a discharge between them.

At the other end of the tube and projecting from the central area of the terminal disk 36 there is provided a substantially solid metal cylinder 51 which extends into relatively close proximity with the emitting disk 42 and which is adapted to serve as an anode element. In order to permit evacuation of the discharge enclosure, the anode 51 is provided near one end with an opening 52 communicating with an exhaust tubulation 53 which extends outwardly from the extremity of the discharge device, the end of the exhaust tubulation being closed by means of a glass seal-off tip 54.

The anode 51 and the cathode part 42 are separated by means of a grid 50, suitably of tungsten, or molybdenum, which extends across a central aperture formed in the disk 35.

The tube 28 is provided with a cathode 42', a grid 50', and an anode 51' which correspond in all particulars to the similar elements of tube 29.

The terminal disks 34, 35, and 36 of the various tubes are so related that their spacing corresponds to the spacing of the resonator parts 10, 11, and 12, and in the construction illustrated the disks are co-planar with these parts so as to form substantially continuous extensions of them. In order to make this arrangement possible, the disks interfit with corresponding openings provided in the various cavity-forming members, and are peripherally electrically connected to the surrounding metallic structure of the members.

In order to permit assembly of the devices 28 and 29 in the resonator system, the disks 34, 35, and 36 and the resonator openings with which they are associated are of graduated sizes, the smallest disk comprising the anode terminal and the largest disk being that connected with the cathode structure. The anode disk 36 is provided on its outer surface with a screw threaded stud 57 which cooperates with a correspondingly threaded nut 58. In initially positioning the discharge tube in the resonator system, the anode end of the tube is passed through the openings provided in the cavity-forming members 10 and 11 and is brought into such position as to permit the application of the nut 58. The dimensions of the parts are such that when the nut 58 is tightened, the outer edge of the disk 35 simul-

taneously engages a resilient dentate annulus 60 which is secured to one surface of the member 11. The disk 35 is itself provided with a circular spring annulus 61 which is rigidly secured thereto and which engages a face of the resonator member 11 when the parts are in the assembly shown in Fig. 2. Finally, the disk 34 engages a resilient annulus 63 which is secured to the resonator part 10.

With the arrangement described above, it will be seen that the only lead-in connections to the various ends of each tube are the disks 34, 35, and 36 which constitute, in effect, integral parts of the various cavity-forming members. As a result, all lead inductance to the grid 58 is absorbed as a useful and necessary part of the resonant system itself, and all inductance in the cathode and anode circuits is similarly absorbed except that due to the cathode cylinder 41 and to the axially extending portion of the anode 51. Moreover, all the interelectrode capacitance is incorporated into the oscillating circuit except the relatively insignificant capacitance existing between the extremity of the cathode cylinder and the grid and between the grid and the end of the anode. The anode and grid electrodes are effectively cooled by heat conduction through the disks 35 and 36 to the resonator plates, these in turn being well adapted for forced air cooling. Consequently, the energy-handling capacity of the system is considerably increased over that realizable by the use of conventional tubes.

In order to make possible a tube construction such as that illustrated in Fig. 2, it is necessary to select for the material of the terminal disks a metal which is capable of being sealed directly to glass. In this connection, one may use, for example, an alloy of nickel, iron and cobalt which contains approximately 54 per cent of iron, 28 per cent nickel, and 18 per cent cobalt, this alloy being suitable for sealing to the glass which is known as Corning 705AO or 705BA glass. Alternatively, the disks may be constituted of iron, and may be sealed to one of the glasses described in Hull and Navias U. S. Letters Patent 2,272,747, granted February 10, 1942, and assigned to the same assignee as the present application. Each of the metals referred to is of relatively low electrical conductivity and high permeability and is therefore not inherently well adapted for use in a high frequency system. In order to overcome this difficulty, it is found advantageous in some cases to provide the active surfaces of the terminal disks with a plating of a high conductive material, for example, copper. For instance, in connection with terminal disks consisting of nickel-cobalt-iron alloy, the disks may be plated with copper to a thickness on the order of from 1 to 4 mils and thereafter sealed to the glass parts of the discharge enclosure. It is found that the addition of a plating of copper of the thinness specified does not modify to any significant degree the expansion characteristics of the treated parts. It does, however, make it desirable to interpose a thin layer of a fluxing glass between the copper covered surface and the 705AO glass in order to assure satisfactory adherence. In the case of iron disks, this intermediate glass may be omitted since certain glasses which adequately match the expansion of iron are also capable of adhering to copper.

In spite of the extreme thinness of the copper layer thus provided, it is found that the conductivity of the terminal disks with respect to high frequency currents is much increased by its use. This is attributable to the fact that such currents tend to flow mainly in regions very near the surface of the conductive parts by which they are carried, this being the well known "skin effect."

In the use of the apparatus of Fig. 1 as an amplifier, the resonant cavity formed between the members 10 and 11 may be excited by coupling into the cavity, as by an inductive loop 70, signal energy supplied through a concentric conductor transmission line having as an outer conductor the hub part 14 and as an inner conductor a wire 72. The wave disturbance thus produced within the cavity excites the cathode-grid circuits of the tubes 28 and 29 and thus produces a reaction in the grid-to-plate circuits of these tubes. This latter reaction in turn produces radially propagated waves of magnified intensity within the cavity between the members 11 and 12. The amplified wave energy thus realized may be employed to excite an appropriate utilization device by means of an inductive loop 74 coupled into the second resonant space and connected with a conductor 75 which is arranged as the inner member of a concentric conductor transmission line having the hub part 14' as its outer component.

Suitable direct current connections for such a system are illustrated at the lower part of Fig. 1 and include a grounding connection 77 for the grid-bearing member 11, a grid leak resistor 78 connected between the various cathode-supporting disk 10 and ground, and a source of plate potential 79 connected between the various grids and the plates. A transformer 80 is used to supply heating current to the cathode filaments, and a unidirectional potential source 81 of the polarity indicated is employed to produce a discharge between the heated filaments and the emitting surfaces of the cathode structures.

In Fig. 4 there is shown an oscillator construction which utilizes in a somewhat different fashion the principal features of the present invention. In this case, the grid-anode tank circuit comprises a parallel disk resonator analogous to, although not identical with, that previously described herein, and the cathode grid circuit is provided by a concentric conductor transmission line. The disk resonator comprises in this instance a pair of disk-like members 80 and 81 which are peripherally joined by a conductive ring 82 and which are bridged at their central region by a high frequency tube 84 including a cathode 85, a grid 86, and an anode 87.

It is found that a space-resonant cavity of this type may be caused to sustain standing waves propagated radially between the cavity-forming members, provided the radial dimensions of the members are properly correlated to the desired operating wave length of the system. In this connection the resonant structure of Fig. 4 may be regarded as a special case of that of Fig. 1 in which the hub radius has become zero and in which all the discharge tubes have been moved to the axis of the resonator. When appropriately adjusted, this modification may be caused to operate with a voltage anti-node at its central axis (that is to say, at the gap between the grid 86 and the anode 87) and with a voltage node at the periphery of the cavity.

The terminal connections for the anode 87 (Fig. 4) are in many respects similar to those provided in connection with the tube 29 illustrated in Fig. 2. They include a copper plated metal disk 90 forming the extremity of the tube and seated in a conforming depression formed centrally in the resonator member 80. A screw

threaded stud 91 projecting externally from the end of the tube provides a means of attachment to a correspondingly threaded attachment block 93 applied to the outer surface of the member 80. This block is of conically tapered form and relatively large mass and is provided with an axially extending passage 94 which terminates in a tubular extension 95 adapted for connection to a source of a suitable coolant such as air. Radial orifices 97 provided in the body of the attachment block 93 permit air which is introduced through the passage 94 to be blown through the block and into the interior of the cavity resonator in such fashion as to insure adequate cooling for both the anode and grid structures. The inblown air may escape through small holes drilled in the plates of the cavity. Since the heat-dissipating block 93 is wholly external to the active compartment of the high frequency system, its presence has no significant effect on the high frequency operation of the apparatus as a whole (i. e., other than to increase the permissible power rating of the apparatus).

The grid 86 is also provided with a disk-like terminal 99 which extends from the lateral wall surface of the discharge enclosure. In this case, the grid terminal 99 is not connected directly to the resonator member 81 but is capacitively coupled to it by being connected to an annular plate 101 which is slightly spaced from the member 81 by the interposition of an insulating part 103 consisting, for example, of polystyrene. Connection between the part 101 and the grid terminal 99 is provided by means of an annular spring member 105 which is fixedly secured to the part 101 and which bears at its inner edge against the grid terminal. By virtue of the insulation of the part 101 from the structure of the resonant cavity, it is possible to apply a unidirectional potential between the grid 86 and the anode 87 while, at the same time, in so far as high frequency potentials are concerned, the grid may be considered as being directly connected to (in fact, substantially electrically continuous with) the cavity wall 81.

The cathode grid circuit includes an outer conductive cylinder 108 and an inner conductive cylinder 109, the two cylinders providing in combination a second type of space-resonant cavity in the form of a concentric conductor transmission line which is open circuited at one end by virtue of the gap existing between the cathode 85 and theg rid 86. The outer cylinder 108 is directly capacitively connected to the grid bearing member member 101 in so far as high frequency currents are concerned, although insulated from it for direct currents by means of an insulating washer 112 interposed between the part 101 and an outwardly directed flange 113 provided on the extremity of the cylinder. The inner cylinder 109 is directly connected to the cathode structure at its extremity by means of a cathode terminal disk 115 which is fitted into the end of the cylinder. In order that this latter connection may be of demountable character, the extremity of the cylinder 109 is provided with a large number of slots 117 by means of which it is given a resilient quality.

At a point relatively remote from the cathode terminal the cylinders 108 and 109 are effectively short circuited by the use of a conductive ring 119 interposed between them. This ring, which is of generally U-shaped cross section, is also made of a slotted construction in order to give it some degree of flexibility. The axial position of the ring with reference to the cylinders 108 and 109 may be adjusted by screws 121 or by any other appropriate positioning means.

The operation of an oscillator such as that shown in Fig. 4 is analogous to that of the well-known Colpitts circuit which is illustrated diagrammatically in Fig. 5 (direct current connections being omitted). In this circuit the resonant tank represented by the parallel combination of inductance 125 and capacitance 126 corresponds to the resonant cavity provided in Fig. 4 between the members 80 and 81. The condensers 127 and 128 are provided in part by interelectrode capacitance and, as to the capacitance 127, in part by the effect of the concentric conductor transmission line represented by the cylindrical members 108 and 109. The condenser 130 corresponds to the blocking condenser provided in Fig. 4 by the interposition of the insulating disk 103 between the parts 101 and 81. It is known that the proper operation of a system of the type under consideration depends upon proper proportioning of the interelectrode capacitances, and this feature may be controlled in connection with the structure of Fig. 4 by proper positioning of the short circuiting ring 119. The preferred adjustment appears to be that in which the equivalent electrical length of the transmission line is slightly in excess of that of a quarter wave line (at the desired frequency) so that the line together with the interelectrode capacity of the tube represents a high impedance having a slight excess of capacity. With this condition realized, the operating frequency of the system is controlled substantially entirely by the frequency of resonance of the cavity provided between the members 80 and 81. On the other hand, the ability of the apparatus to oscillate is critically responsive to the adjustment of the member 119 and can be brought to the point of optimum operation only by careful adjustment of this element.

While the invention has been described by reference to particular embodiments, it will be understood that numerous modifications may be made by those skilled in the art without actually departing from the invention. I therefore aim to cover in the appended claims all such equivalent variations as come within the true spirit and scope of the foregoing disclosure.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. High frequency apparatus including three coaxial disk-like members mounted in mutually spaced relation and forming the boundaries of a pair of cavity resonators, an electronic discharge device having a cathode, a grid and an anode mounted in end-to-end relation in the order named, the said device extending through the central one of said members and having its extremities respectively located within the said cavity resonators, means providing high frequency connections between the said cathode and anode and the outer ones of said members, and further means providing a high frequency connection between the grid and the central one of the members, said connecting means including a pair of planar conductive bodies respectively defining the end walls of the said discharge device and constituting terminals for the said cathode and anode, and a third planar conductive body extending peripherally from the lateral wall surface of the device and providing a terminal for the said grid, the said conductive bodies being approximately coplanar with said mem-

bers to which they are respectively connected, whereby the bodies form electrically continuous extensions of the members.

2. High frequency apparatus comprising a pair of adjacent cavity resonators separated by a common metal wall forming part of the bounding surfaces of both of said resonators, a detachable electronic tube including an anode, a cathode and a grid sealed within an enclosing envelope, said envelope having its respective extremities disposed within said cavity resonators, metallic parts providing end walls for said envelope and constituting terminals for said anode and cathode respectively, said metallic parts forming electrically continuous elements of the bounding surfaces of said cavity resonators, and a further metallic part extending from the intermediate portion of said envelope and providing a high frequency connection between said grid and said common metal wall.

3. High frequency apparatus comprising a pair of rotationally symmetrical and coaxial cavity resonators separated by a common metal wall forming part of the bounding surfaces of both of said resonators, a generally cylindrical electronic tube including an anode, a grid and a cathode enclosed within a common envelope, said envelope having its respective extremities disposed within said cavity resonators, metallic parts forming the end walls of said envelope and providing high frequency terminals for said anode and cathode respectively, said parts respectively having high frequency connections to the wall structure of said cavity resonators at points displaced from and on opposite sides of said common wall, and means providing a high frequency connection between said grid and said common wall.

4. A high frequency oscillator comprising a space-resonant structure bounded by a conductive wall, an electronic tube disposed within said space resonant structure, said tube including an anode, a cathode, and a grid enclosed within a common envelope, metallic parts providing separate sections of the wall of said envelope and constituting high frequency terminals for said anode and cathode respectively, said metallic parts forming electrically continuous elements of the conductive boundary of said space resonant structure and means connecting said grid to a portion of said structure between said elements thereby to facilitate feed-back operation of said oscillator.

5. High frequency apparatus including three coaxial disk-like members mounted in mutually spaced relation and forming the boundaries of a pair of cavity resonators, a conductive hub extending between the members and coaxial with their line of centers, the radius of said hub being correlated to the radial dimensions of the members to compel the occurrence of radially propagated standing waves between the members when the said cavity resonators are excited at a particular frequency, and a plurality of electronic discharge devices disposed about the said hub and having their respective extremities disposed in the said cavity resonators, each of said devices including an anode, a grid, and a cathode mounted in end-to-end relation within a sealed envelope, metallic parts providing end walls for said envelope and constituting terminals for said anode and cathode respectively, said metallic parts forming electrically continuous elements of the outer ones of said disk-like members, and a further metallic part extending from the intermediate portion of said envelope and providing a high frequency connection between said grid and the central one of said disk-like members.

6. High frequency apparatus comprising a pair of generally planar conductors positioned in face-to-face relation and forming boundaries of a first cavity resonator between them, means comprising a pair of mutually telescoped conductors extending at right angles to said members and forming boundaries of a second cavity resonator contiguous with the first cavity resonator, an electronic tube comprising an envelope having an anode supported within it at one extremity, a cathode supported at its other extremity and a grid disposed between said anode and cathode, the anode-supporting extremity of the envelope extending into the first said resonator and the cathode-supporting extremity extending into the second cavity resonator, and high frequency connections between said conductors and said anode, cathode and grid, whereby said first cavity resonator provides a grid-anode circuit and said second cavity resonator provides a cathode-grid circuit for said tube.

7. A high frequency oscillator comprising a pair of disk-like conductors forming the boundaries of a first cavity resonator, a cylindrical conductor coaxial with said planar conductors and externally adjacent one of them, a second cylindrical conductor concentrically disposed within said conductor and forming with it a second cavity resonator in the nature of a transmission line section, an electronic tube having an anode disposed within said first cavity resonator, a cathode disposed within said second cavity resonator and a grid forming in electrical effect a continuous part of the boundary between the resonators, a high frequency connection between said anode and the one of said disk-like conductors which is more remote from said second cavity resonator, and a further high frequency connection between said cathode and the inner one of said cylindrical conductors, whereby said first cavity resonator provides a grid-anode circuit for said oscillator and said second cavity resonator provides a grid-cathode circuit.

8. A high frequency oscillator comprising a pair of parallel disk-like conductors forming the boundaries of a first cavity resonator, a pair of coaxial cylindrical conductors forming the boundaries of a second cavity resonator, said second cavity resonator being coaxial with and abutting the first with one of said disk-like conductors providing a boundary between the resonators, a cylindrical electronic tube extending through the said boundary and having a grid forming in electrical effect a continuous part of the said boundary, a first metallic part supporting the anode of the said tube and forming an end wall of the tube, said metallic part providing a symmetrical high frequency connection between the said anode and the one of said disk-like conductors which is more remote from said second cavity resonator, and a second metallic part supporting the cathode of the tube and forming the other end wall of the tube, said second metallic part providing a symmetrical high frequency connection between the said cathode and the inner one of said cylindrical conductors.

9. A high frequency oscillator comprising a cavity resonator including two parallel conductive surfaces and in which waves are propagated radially between said surfaces, a first cylindrical conductor perpendicular to said surfaces and externally abutting a wall of said cavity resonator,

a second cylindrical conductor extending partially within the first and defining with it a coaxial transmission line section, the inwardly extending extremity of said second conductor being spaced from the said wall of said cavity resonator, an electronic tube extending through said wall and having an anode-containing end within said cavity resonator and a cathode-containing end in proximity to the said extremity of said conductor, said tube further including a grid which forms in electrical effect a continuous part of the said cavity resonator wall, means providing a high frequency connection between the cathode of said tube and the extremity of said second conductor, further means providing a high frequency connection between the anode of the tube and the surface of said cavity resonator more remote from said wall, and adjustable means connected between said cylindrical conductors for altering the effective length of said transmission line section to adjust the resonance relationship between said section and the said cavity resonator.

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