

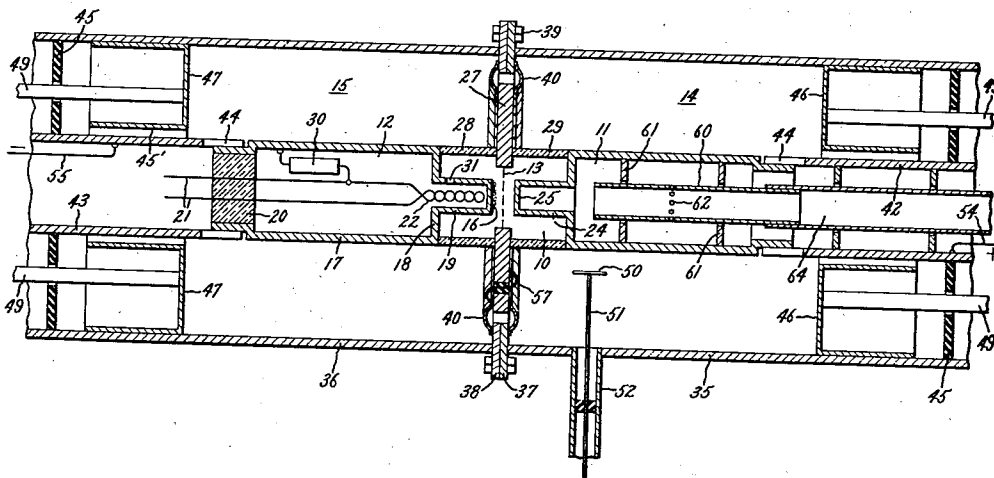
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ELECTRIC DISCHARGE DEVICE AND COAXIAL LINE CAVITY RESONATOR THEREFOR

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ELECTRIC DISCHARGE DEVICE AND CO-AXIAL LINE CAVITY RESONATOR THEREFOR

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My invention relates to high frequency electric discharge devices and, more particularly, to space-resonant systems of the ultra high frequency type.

It is an object of my invention to provide a new and improved high frequency electric discharge device.

It is another object of my invention to provide a new and improved form of ultra high frequency electric discharge device suitable for use in connection with space-resonant cavities.

It is a further object of my invention to provide a new and improved ultra high frequency electric discharge device of the space-resonant type in which electrodes of the device also function as inner conductors of a coaxial cavity.

It is still another object of my invention to provide a new and improved ultra high frequency device in which electrodes thereof extending in opposite directions function as inner conductors of aligned coaxial cavities.

One of the features of my invention is the provision of a new and improved ultra high frequency electric discharge device of the space-resonant type comprising a plurality of enclosed electrodes formed in part by a pair of oppositely extending cylindrical metallic members which provide, respectively, externally accessible high frequency terminals and also function as inner conductors of at least a part of a space-resonant coaxial cavity, the cavities being aligned and longitudinally spaced. A transverse metallic member, supporting a control grid between the adjacent ends of the electrodes, functions to separate the aligned cavities and to provide a smooth transit from the cavity to the elements of the discharge device. The cavities may be formed by a detachable continuous metallic cylinder conductively connected to the transverse member and include means external of the electric discharge device for controlling or adjusting the frequency of the energy within the cavities and supplied to utilization circuits connected therewith.

For a better understanding of my invention, reference may be had to the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims. In the drawing, the single figure diagrammatically illustrates an embodiment of my invention applied to a space-resonant system and wherein a central control device used as an electric discharge device is of the construction which may be easily inserted into a concentric transmission line.

In the single figure, my invention is illustrated

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as including an electric discharge device 10 comprising an elongated cylindrical anode member 11, an elongated cylindrical cathode member 12, and a grid or control electrode 13 maintained in spaced relation with respect to each other by a structure to be described presently. The cylindrical anode 11 and the cylindrical cathode 12 extend externally of the sealed region of the discharge device in opposite directions and function as at least part of space-resonant cavities 14, 15 of the coaxial line type.

The cathode 12 is arranged to have an emissive part in the form of a flat disk surface 16 coated with a suitable electron emitting material, such as barium and strontium carbonates. The disk 16 is of a smaller diameter than the main portion 17 of the cathode structure 12 and is connected thereto by means of a transverse flange or shoulder 18 and a neck portion 19. The left-hand end of the main portion 17 is of slightly reduced diameter and is sealed by means of a disk 20 of insulating material, such as glass. A pair of leads 21, sealed within the disk 20, extend within the hollow cathode 12 to provide connection with a heating element or filament 22 located within the neck portion 19. The metallic portions of the cathode member 12, preferably, are constructed of a rigid conductor, such as copper-plated iron and the glass disk 20, sealed across the end of the cathode structure, is of the type having a coefficient of expansion substantially equal to that of the cathode material.

The anode member 11 similarly is provided at its end adjacent the cathode structure with a portion 24 of reduced diameter sealed at its extreme end in a flat plate or disk 25. Preferably, for reasons which will become more apparent later, the outer diameters of the main portions of cathode 12 and anode 11 are made substantially equal. Like the cathode structure, the anode 11 preferably is formed of a good electrical conducting material, such as copper-plated iron. The grid 13 is supported from a transverse metallic plate 27 and a pair of insulating cylinders 28, 29, constituted by a suitable material such as glass, are hermetically sealed, respectively, between plate 27 and the transverse portion 18 of the cathode structure and between plate 27 and the transverse portion of the anode structure. In this way, the plate 27 serves also as an externally accessible high frequency terminal for grid 13. The glass cylinders 28, 29 constituted of a material having a temperature coefficient of expansion substantially equal to that of the anode, cathode, and the plate 27, serve to maintain the electrodes

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of the discharge device in spaced relation and to define a closed region about these electrodes. This region may be evacuated to a desired degree, a getter 30 enclosed within the hollow cathode 12 and connected between one of the conductors 21 5 and the outer portion 17 serving as means to produce a desired low gas pressure within the evacuated region. An aperture 31 in the neck portion 19 of the cathode provides communication between the previously mentioned sealed region and 10 the interior of the cathode.

An important aspect of the embodiment of my invention illustrated comprises the substantially coaxially aligned anode-cathode construction extending in opposite directions from the transverse member 27 which defines a boundary between the cylindrical electrodes. By virtue of this construction, the discharge device is one which may be detachably incorporated in the plurality of space-resonant cavities 14 and 15 of the coaxial line type, the cylindrical anode and cathode serving as inner conductors of these coaxial cavities. Since these inner conductors have equal diameters the adjacent sections of coaxial transmission lines formed thereby have equal impedance characteristics. To define the outer walls or concentric conductors of the cavities, I provide a pair of tubular metallic members 35, 36 concentrically surrounding the anode 11 and the cathode 12, respectively, and conductively connected at their adjacent ends to the transverse metal plate 27, the latter serving to define one end wall of the cavities 14, 15. The adjacent ends of metallic conductors 35, 36 are provided with transverse ring members 37, 38 attached to their ends, as by welding, the rings or flanges 37, 38 being secured together by means of bolts 39. The rings 37, 38, at their inner edges, are provided with a plurality of spring-like fingers 40 which engage the outer surface of the transverse metal plate member 27.

The space-resonant system shown comprises two tuned resonant cavities or regions, one of which is the anode-grid cavity 14 and is defined by the anode 11, the transverse member 27, and the outer cylinder 35 and the other of which is the grid-cathode cavity and is defined by the cylindrical cathode 12, the transverse member 27, and the outer cylinder 36. A pair of cylindrical inner conductors 42, 43, having at their ends a plurality of spring-like fingers 44, slide over the outer ends, respectively, of the anode 11 and the cathode 12 to serve as supports for maintaining the discharge device concentrically aligned and as extensions of the inner conductors of which these electrodes form a part. The inner conductors 42, 43 may be maintained in concentric position within the outer conductors 35, 36 by means of any required number of insulators 45.

In connection with the space-resonant system, means are provided for tuning or controlling the natural resonant frequency of the cavities 14, 15. This means may take the form of the annular plungers 46, 47 positionable within the cylinders 35, 36. The plungers 46, 47 have a longitudinal length equal to a quarter wave length of the oscillations within cavities 14, 15 and are in spaced relation with the inner surfaces of cylinders 35, 36 and the outer surfaces of the anode 11 and cathode 12 and the hollow conductors 42, 43 connected therewith to provide a required capacitive coupling for the ultra high frequency currents of the space resonant system, these plungers being insulated from the respective electrodes and associated conductors for unidirectional currents by

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means of this spacing. The positions of plungers 46, 47 may be adjusted by any suitable mechanical expedient, such as the rods 49, and energy may be extracted from the space-resonant region by any suitable output electrode means, one form of which may be the capacitive probe or plate 50 extending into the cavity 14 in spaced relation with the anode 11 and connected to a conductor 51 to form a part of a coaxial transmission line having an outer conductor 52 conductively connected to the outer cylinder 35. A similar energy extracting or energy coupling means may be employed with the cathode-grid cavity, if desired.

Upon impressing a suitable unidirectional voltage across the anode 11 by means of conductor 54 and across cathode 12 by means of conductor 55, high frequency electromagnetic energy may be derived from the space-resonant system through the transmission line comprising conductors 51, 52. From the standpoint of elementary analysis of the operation of the system as a whole, it may be considered that the coupling between the anode-grid and grid-cathode regions is obtained by virtue of the mutual capacitance between the opposing surfaces of anode 11 and cathode 12 so that energy may be fed back from the anode-grid cavity to the grid-cathode cavity maintaining the system in a state of oscillation.

The occurrence of such oscillation depends, of course, upon the assumption that proper resonance conditions are provided by the tuning of the transmission line sections by means of the plungers 46 and 47 and that ample feed back exists between the anode and grid circuits. Under some conditions, the internal plate-to-cathode capacitance of the tube described above is sufficient to maintain such oscillations. In most cases, however, it is desirable that this coupling be augmented in some way and, to this end, there is provided in the present instance a coupling element 57 which extends between the anode-grid and grid cathode cavities. Since the two cavities are engaged end-on, that is, are adjacent and coaxially aligned, it is possible to obtain a smooth transit from the main part of the coaxial cavities defined by the outer conductors 35, 36, the plungers 46, 47, the inner conductors 42, 43, and the enlarged sections of the anode and cathode to the active portions of the tube elements. All the corners or other changes of direction of the electromagnetic waves within the cavities are thus made very small. The spring fingers 40 engage the transverse plate 27 which defines the adjacent ends of the cavities and provide a smooth path for current flow on both sides of the common wall 27 of the cavities. In this manner, the necessity of employing re-entrant sections between the active elements of the discharge device and the space-resonant cavities connected therewith is avoided. The particular electric discharge device shown is of a structure which may be easily inserted between adjacent sections of a concentric transmission line to function as a smooth continuation of these sections, the grid of the device being conductively connected to the outer conductor of the transmission line and the anode and cathode forming extensions of the inner conductors of the line. The construction of the system is such that the tuning plungers 46, 47 may be pressed inwardly from either end until they actually overlap the glass cylinders 28, 29 and reach disk 27. In other words, the structure of the electric discharge device is such that there is no interference with the sliding of the plungers 46, 47 over the glass cylinders to define a very

small volume enclosed, for example, within the elements 18, 19, 27, and the inner surface 45' of plunger 45. Such a structure is particularly useful at extremely high frequencies.

The anode 11 may be a solid anode if desired or, where operating conditions require, may be hollow and cooled by any cooling medium, such as air. A construction suitable for this purpose is shown in the drawing in which a hollow tube 60 is supported within the hollow anode 11 by means of metallic supports 61 and is provided with a plurality of holes 62, by means of which the air may be directed against the walls of the anode in addition to the stream of air directed against the active surface 25 from the open left-hand end of the tube 60. The tube 60, at its right-hand end, may engage, through a slip connection, a similar hollow tube 64 supported within inner conductor 42.

Although in the above described embodiment of my invention I have chosen to represent certain of the structural features as applied to a space-resonant system used as an oscillator, it is readily apparent that the improved structure and system which I provide may be applied with equal facility to space-resonant systems used for other purposes, such as amplifiers, converters, and the like. Furthermore, while I have shown the employment of a pair of outer cylindrical conductors 35, 36, a single metal cylinder may be used instead, this cylinder being conductively connected to the plate 27 defining a wall between adjacent cavities within the cylinder.

Also, while in certain of the above descriptive matter and in the accompanying claims the term "connection" or "connected" has been used relative to certain of the members defining the ultra high frequency regions, it will be appreciated that this term has been used in the sense of permitting the transfer of energy at ultra high frequencies and is not to be construed as being limited to a conductive connection, inasmuch as it will be apparent to those skilled in the art that, in some instances, it may be desirable to connect certain of the parts through an inter-spaced insulating means, in which instances the high frequency energy is, of course, transmitted by virtue of the electrostatic coupling between the parts or elements.

While I have shown a particular embodiment of my invention, it will of course be understood that I do not wish to be limited thereto since various modifications may be made, and I contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

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

1. A high frequency cavity resonator apparatus comprising an electric discharge device including cylindrical anode and cathode members of substantially equal diameter positioned in coaxial longitudinal alignment and having juxtaposed closed ends provided with axially extending mutually spaced portions of reduced diameter constituting an electron receiving surface and an electron emitting surface respectively, a transverse conductive member supporting a grid between said anode and cathode members in spaced relation to said portions, insulating means positioning said anode and cathode members and said conductive member in mutually spaced relation and forming a sealed region about said ends and said portions, said anode member and said cathode member constituting at least a portion of a

continuous inner conductor of a concentric line interrupted only by said sealed region, and a cylindrical conductive member concentrically surrounding said device and constituting an outer conductor for said concentric line, said transverse conductive member being conductively attached to said cylindrical conductive member, said cylindrical conductive member forming with said anode and cathode members at least portions of a pair of cavity resonators one on each side of said grid.

2. Apparatus as in claim 1 including adjustable plunger means between said cylindrical conductive member and said anode and cathode members for tuning said cavity resonators.

3. A high frequency cavity resonator apparatus comprising an electric discharge device including cylindrical anode and cathode members of equal diameter positioned in coaxial longitudinal alignment and having juxtaposed closed ends provided with an electron receiving surface and an electron emitting surface respectively, a transverse conductive member supporting a grid between said anode and cathode members in spaced relation to said ends, insulating means positioning said anode and cathode members and said conductive member in mutually spaced relation and forming a sealed region about said ends, said anode member and said cathode member constituting at least a portion of a continuous inner conductor of a concentric line interrupted only by said sealed region, and a cylindrical conductive member concentrically surrounding said device and constituting an outer conductor for said concentric line, said transverse conductive member being conductively attached to said cylindrical conductive member, said cylindrical conductive member forming with said anode and cathode members at least portions of a pair of cavity resonators one on each side of said grid.

4. A high frequency cavity resonator apparatus comprising an electric discharge device including cylindrical anode and cathode members of equal diameter positioned in coaxial longitudinal alignment and having juxtaposed closed ends provided with an electron receiving surface and an electron emitting surface respectively, a transverse conductive member supporting a grid between said anode and cathode members in spaced relation to said ends, insulating cylinders of diameter equal to that of said anode and cathode members coaxially aligned therewith and positioning said anode and cathode members and said conductive member in mutually spaced relation and forming a sealed region about said ends, said anode member and said cathode member constituting at least a portion of a continuous inner conductor of a concentric line interrupted only by said sealed region, and a cylindrical conductive member concentrically surrounding said device and constituting an outer conductor for said concentric line, said transverse conductive member being conductively attached to said cylindrical conductive member, said cylindrical conductive member forming with said anode and cathode members at least portions of a pair of cavity resonators one on each side of said grid.

5. A high frequency cavity resonator apparatus comprising an electric discharge device including cylindrical anode and cathode members positioned in co-axial longitudinal alignment and having juxtaposed closed ends provided with an electron receiving surface and an electron emitting surface respectively, a transverse conductive member supporting a grid between said anode and

cathode members in spaced relation to said ends, insulating means positioning said anode and said cathode members and said conductive member in mutually spaced relation and forming a sealed region about said ends, said anode member constituting at least a portion of an inner conductor of a concentric line on one side of said grid, said cathode member constituting at least a portion of an inner conductor of a concentric line on the other side of said grid, a cylindrical conductive member concentrically surrounding said anode member and constituting an outer conductor for said first mentioned concentric line, and a cylindrical conductive member concentrically surrounding said cathode member and constituting an outer conductor for said second mentioned concentric line, said transverse conductive member being conductively attached to said cylindrical conductive members, said cylindrical conductive members forming with said anode and cathode members at least portions of a pair of cavity resonators one on each side of said grid.

6. A high frequency cavity resonator apparatus comprising an electric discharge device including cylindrical anode and cathode members positioned in co-axial longitudinal alignment and having juxtaposed closed ends provided with an electron receiving surface and an electron emitting surface respectively, a transverse conductive member supporting a grid between said anode and cathode members in spaced relation to said ends, insulating cylinders of diameter equal to that of said anode and cathode members coaxially aligned therewith and positioning said anode and said cathode members and said conductive member in mutually spaced relation and forming a sealed region about said ends, said anode member constituting at least a portion of an inner conductor of a concentric line on one side of said grid, said cathode member constituting at least a portion of an inner conductor of a concentric line on the other side of said grid, a cylindrical conductive member concentrically surrounding said anode member and constituting an outer conductor for said first mentioned concentric line, and a cylindrical conductive member concentrically surrounding said cathode member and constituting an outer conductor for said second mentioned concentric line, said transverse conductive member being conductively attached to said cylindrical conductive members, said cylindrical conductive members forming with said anode and cathode members at least portions of a pair of cavity resonators one on each side of said grid.

7. A high frequency apparatus comprising a pair of cylindrical cavity resonators each including concentric inner and outer conductors, said inner conductors being positioned in coaxial longitudinal alignment with each other and said outer conductors being positioned in coaxial longitudinal alignment with each other, an electron discharge device including a cylindrical anode member and a cylindrical cathode member having juxtaposed closed ends provided with an electron receiving surface and an electron emitting surface respectively and positioned in coaxial longitudinal alignment, a transverse conductive member supporting a grid between said anode and said cathode members in spaced relation to said ends, insulating means positioning said anode and cathode members and said transverse member in mutually spaced relation and forming a sealed region about said ends, said anode member having a diameter equal to that of one of said

inner conductors and constituting a detachable extension thereof, said cathode member having a diameter equal to that of said other inner conductor and constituting a detachable extension thereof, said outer conductors comprising a cylindrical conductive member conductively connected to said transverse member, concentrically surrounding said discharge device and constituting with the said anode and cathode members at least a portion of said cavity resonators.

8. A high frequency apparatus comprising a pair of cylindrical cavity resonators each including concentric inner and outer conductors, said inner conductors being positioned in coaxial longitudinal alignment with each other and said outer conductors being positioned in coaxial longitudinal alignment with each other, an electron discharge device including a cylindrical anode member and a cylindrical cathode member having juxtaposed closed ends provided with an electron receiving surface and an electron emitting surface respectively and positioned in coaxial longitudinal alignment, a transverse conductive member supporting a grid between said anode and said cathode members in spaced relation to said ends, insulating cylinders of diameter equal to that of said anode and cathode members coaxially aligned therewith and positioning said anode and cathode members and said transverse member in mutually spaced relation and forming a sealed region about said ends, said anode member having a diameter equal to that of one of said inner conductors and constituting a detachable extension thereof, said cathode member having a diameter equal to that of said other inner conductor and constituting a detachable extension thereof, said outer conductors comprising a cylindrical conductive member conductively connected to said transverse member, concentrically surrounding said discharge device and constituting with the said anode and cathode members at least a portion of said cavity resonators.

9. A high frequency apparatus comprising a pair of cylindrical cavity resonators each including concentric inner and outer conductors, said inner conductors being positioned in coaxial longitudinal alignment with each other and said outer conductors being positioned in coaxial longitudinal alignment with each other, an electron discharge device including a cylindrical anode member, and a cylindrical cathode member having juxtaposed closed ends provided with an electron receiving surface and an electron emitting surface respectively and positioned in coaxial longitudinal alignment, a transverse conductive member supporting a grid between said anode and said cathode members in spaced relation to said ends, insulating means positioning said anode and cathode members and said transverse member in mutually spaced relation and forming a sealed region about said ends, said anode member having a diameter equal to that of one of said inner conductors and constituting a detachable extension thereof, said cathode member having a diameter equal to that of said other inner conductor and constituting a detachable extension thereof, said outer conductors comprising cylindrical conductive members having abutting ends conductively connected to said transverse member, concentrically surrounding said discharge device and constituting with the said anode and cathode members at least a portion of said cavity resonators.

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