April 24, 1951 N. T. LAVOO ET AL 2,550,485

ULTRA HIGH FREQUENCY ELECTRIC DISCHARGE DEVICE AND CAVITY RESONATOR APPARATUS THEREFOR

Filed June 3, 1949

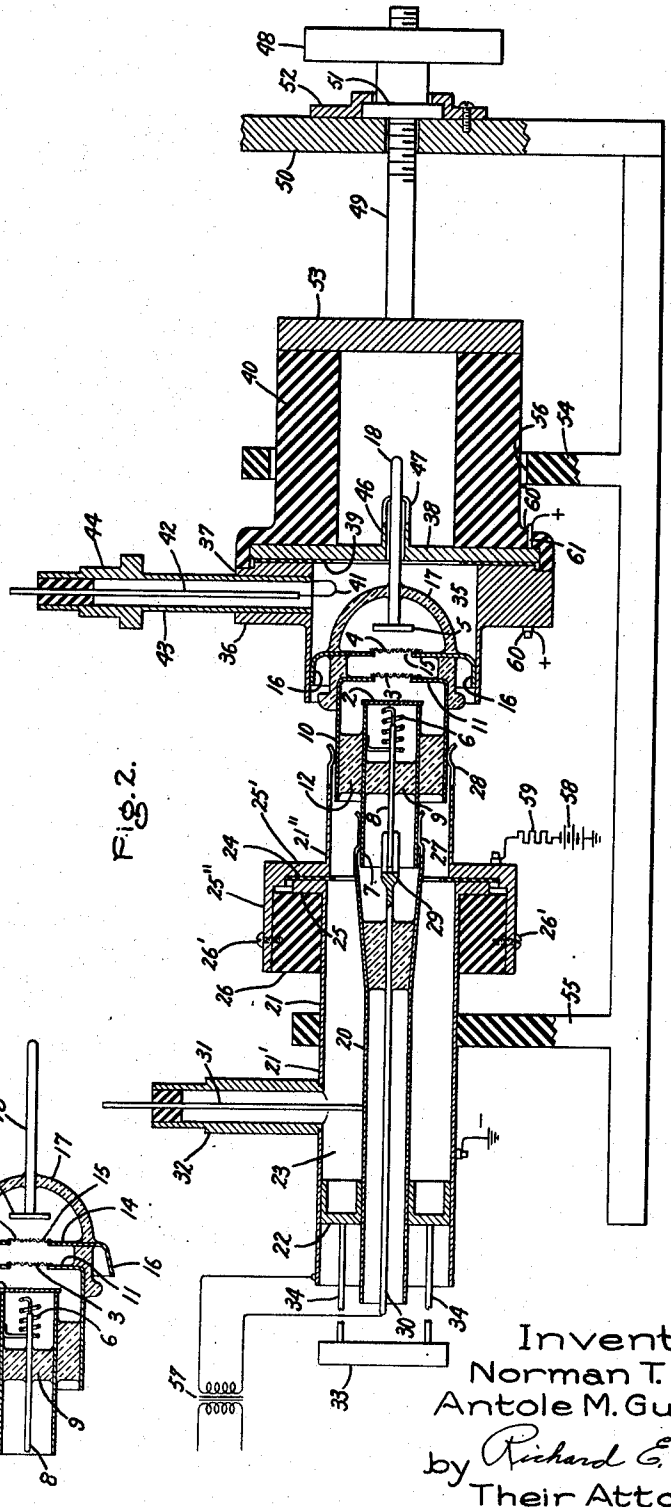


Fig. 2.

Fig. 1.

Inventors:
Norman T. Lavoo,
Antole M. Gurewitsch,
by Richard E. Horley
Their Attorney.

Patented Apr. 24, 1951

2,550,485

UNITED STATES PATENT OFFICE

2,550,485

ULTRA HIGH FREQUENCY ELECTRIC DISCHARGE DEVICE AND CAVITY RESONATOR APPARATUS THEREFOR

Norman T. Lavoo and Anatole M. Gurewitsch, Schenectady, N. Y., assignors to General Electric Company, a corporation of New York

Application June 3, 1949, Serial No. 96,994

4 Claims. (Cl. 315—6)

1

Our invention relates to space resonant systems for use at ultra high frequencies and more particularly to an ultra high frequency electric discharge device and an associated cavity resonator system adapted to be used with ultra high frequency electromagnetic waves.

In ultra high frequency electronic applications, cavity resonator systems are commonly employed in conjunction with a properly constructed electric discharge device in order to overcome circuit losses due to the distributed capacity and inductance of connecting leads and circuit components. The general size and shape of such electric discharge devices and cavity resonators are dictated to a great extent by the wave length of the electromagnetic waves at the frequency to be employed and the particular mode at which the cavity resonators are to be operated. Where the wave length of the electromagnetic wave to be employed is, for example, in the vicinity of 10 centimeters, the size of these components must be very small, and difficulties are encountered in arranging them in a proper cooperating relation without sacrificing efficiency or introducing higher order waves.

As is well known in the art, the greatest efficiency of such space resonant systems as well as their broadest frequency response pattern is accomplished when the cavity resonators are operated as quarter wave length resonant circuits. Because of the diminutive size of cavity resonators operating as quarter wave resonant circuits for centimeter waves, the problems of construction and component arrangement are aggravated. Furthermore, since a minute change in the size of such cavity resonators causes a large change in the natural resonant frequency thereof, it becomes exceedingly difficult to construct an efficient quarter wave space resonant system which is easily tunable at these ultra high frequencies.

It is a principal object of our invention, therefore, to provide an improved ultra high frequency space resonant system.

Another object of our invention is to provide an improved electric discharge device suitable for use in conjunction with cavity resonators constructed to resonate at ultra high frequencies.

A further object of our invention is to provide an electric discharge device suitable for use in conjunction with cavity resonators operating as quarter wave length resonant circuits for electromagnetic waves having a wave length in the order of 10 centimeters.

An additional object of our invention is to provide an improved ultra high frequency space resonant system adapted to be used as an amplifier for ultra high frequency electromagnetic waves.

2

A further specific object of our invention is to provide an ultra high frequency cavity resonator system which may be easily tuned over a fairly wide band of frequencies without a substantial loss of efficiency or an introduction of higher order waves.

One of the principal features of our invention is the provision of an electric discharge device having a small tapered dome of suitable insulating material supporting an anode whose external portion spires axially through the top of the dome. A conductive member which extends out of the base of the dome both supports and enables an external connection to a grid of the discharge device. This arrangement of electrodes permits a cylindrical cavity resonator functioning, for example, as a conventional grid-anode output resonating circuit, to be telescoped over this domed end portion of the discharge device. In order to obtain this telescoped arrangement, an end wall of the resonator has a centrally positioned sleeve accommodating and making slidable contact with the externally extending portion of the anode, while the inner peripheral surface of the cylindrical wall of the resonator is constructed to fit with close engagement around the conductive member at the base of the dome. The natural resonant frequency of this cavity resonator is controlled by changing the axial position of the entire resonator with relation to the domed end portion of the electric discharge device.

The novel features which we believe to be characteristic of our invention are set forth with particularity in the appended claims. The invention itself, however, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 is a sectional view of an electric discharge device embodying the invention and Fig. 2 is a sectional view of a space resonant system which may be employed in conjunction with the electric discharge device of Fig. 1.

Referring to Fig. 1, we have shown an electric discharge device 1 embodying our invention having a cathode 2, a first control grid 3, a second screening grid 4, and an anode 5 consecutively spaced along the axis of the device 1. The adjacent end surfaces of the cathode 2 and the anode 5 are in opposed alignment to form elec-

tron emitting and electron receiving surfaces. The cathode 2 is heated by a filament 6 within a metallic cylinder 7 which is in conductive relation with the cathode 4 and extends outside the enclosed region of the discharge device 1. One end of the filament 6 is connected to the cathode cylinder 7 while the other end of the filament 6 is connected to a rod 8 which extends axially through the center of cylinder 7 and is supported by a glass sealing disk 9.

Concentrically surrounding the internal portion of cathode cylinder 7 is another conductive cylinder 10 having an inwardly turned shoulder 11 which functions both to support and make conductive connection to grid 3. The grid cylinder 10 is maintained in a proper spaced apart relation to the cathode cylinder 7 by an annular collar 12 of insulating material such as glass which also functions to seal the cylinders 7 and 10 hermetically.

Another annular insulating collar 13 is hermetically sealed at one end to the grid supporting shoulder 11 of cylinder 10 and is sealed at the other end to a conductive member or disk 14 which supports grid 4 across a centrally located aperture 15 formed in the disk 14. Extending annularly from the circumference of disk 14 are a plurality of resilient contact fingers 16. These contact fingers are preferably shaped to overlay insulating collar 13 and to taper outward slightly as illustrated. Although the disk 14 is preferably terminated in the contact fingers 16 as illustrated, it will be appreciated that the disk may alternatively be terminated in a solid annular member and that slidable contact to an associated cavity resonator may be accomplished by virtue of contact fingers formed on the resonator.

A tapered insulating member such as the dome-shaped member 17, which may also be constructed of glass, extends from the conductive disk 14 at the base of the dome up to a conductive rod 18 which spires axially through the center of the dome. Rod 18 is secured within discharge device 1 to an anode 5 and forms an externally extending portion thereof. The dome-shaped member 17 functions both to support the anode 5 in a proper spaced relation to grid 4 and to complete the hermetic enclosure of the electrodes of the discharge device 1.

The over-all size of the device 1 is, of course, determined by the wave length of the electromagnetic wave with which it is to be employed. Due to the consecutive spacing of the electrodes 2 to 5, it will be appreciated that a discharge device such as described above may easily be constructed to have very small dimensions without the danger of internal shorting between the electrodes. For operation in the vicinity of 10 centimeters, we have found that an electric discharge device 7 centimeters long having a dome-shaped member 17 whose base diameter is 2 centimeters and whose height is 1.25 centimeters is quite satisfactory. In addition, the step-wise configuration caused by the location of the concentric conductive cylinders 7 and 11 permits an easy plug-in type of connection to assocated resonant cavities as will be more fully explained hereinafter.

Referring to Fig. 2, we have shown the discharge device of Fig. 1 in conjunction with a space resonant system adapted to be employed as an amplifier of ultra high frequency voltages. An inner conductive cylinder 20 and a concentrically positioned outer conductive cylinder 21 define, together with an annular plunger 22, inserted intermediate cylinders 20 and 21, three bounding surfaces of an input cavity resonator 23. The outer cylinder 21 is divided into two portions 21′ and 21″ by an insulating washer 24 placed between two annular conductive flanges 25 and 25′ extending radially from adjacent edges of the cylinder portions 21′ and 21″ respectively. The flanges 25 and 25′ together with the insulating washer 24, which is preferably composed of a suitable dielectric material such as silvered mica, comprise a small capacitor enabling different unidirectional potentials to be impressed on each portion of the outer cylinder 21 and also serving as a low impedance path for high frequency currents between these cylinder portions. A ring 26 of suitable insulating material is interfitted between a turned back portion 25″ of flange 25′ and the adjacent end of cylinder portion 21′. The entire capacitive assembly is fastened together by such means as screws 26′ which secure the ring 26 to the flange portion 25″.

The inner conductive cylinder 20 terminates in a plurality of resilient contact fingers 27 which are constructed to fit contiguously around the outer surface of the external portion of cathode cylinder 7. Similarly, the outer cylinder portion 21″ terminates in a plurality of resilient contact fingers 28 which are constructed to engage the surface of grid cylinder 10. The cathode end portion of discharge device 1 may, therefore, be plugged into the cylinders 20 and 21 thereby completing the enclosure of the input cavity resonator 23 as illustrated. Filament rod 8 thereupon fits within a socket 29 formed at the end of a conductive rod 30 which extends axially through the center of cylinder 20.

The input space resonant cavity resonator 23, commonly referred to as the grid-cathode space resonant cavity resonator, may be excited in a well-known manner by the inner conductor 31 of a transversely communicating concentric transmission line 32. The natural resonant frequency of this input cavity resonator 23 may be controlled by adjusting the longitudinal position of the annular plunger 22 with any suitable mechanical means such as a handle 33 and connecting rods 34. The plunger 22 is in close engagement with the surfaces of cylinder 20 and 21′ to prevent any discontinuity in the conductive medium which defines the cavity resonator 23.

An output cavity resonator 35 is associated with the device 1 and is defined by another cylindrical member 36 having wheel-like extending portion 37, and a circular conductive end plate 38 which fits against extending portion 37 but is separated therefrom by another insulating washer 39 similar to washer 24. The cylinder portion 37, the end plate 38 and the insulating washer 39 also function as a small capacitor to isolate unidirectional potentials applied to the anode 5 and the screening electrode 4, while permitting an easy path for ultra high frequency currents between these components. A cylindrical insulating member 40 is sealed at one end to both the plate 38 and the cylinder portion 37 and thereby serves to secure these components together.

Energy may be extracted from this output cavity resonator 35 by any suitable output electrode means such as a coupling loop 41 inserted within the volume of the resonator 35 and making connection between an inner conductor 42 and outer conductor 43 of a coaxial transmission

line 44 supported by the wheel-like extending portion 37 of cylinder 36.

As illustrated in Fig. 2, end plate 38 is provided with a centrally located axially extending sleeve 46 which is constructed to accommodate the external portion 18 of anode 5. The sleeve 46 terminates in contact fingers 47 which press firmly against the surface of the anode portion 18. Similarly, the contact fingers 16 of the grid supporting disk 14 press firmly against the inner peripheral surface of cylindrical conductor 36. Due to the slidable contact made by these fingers 16 and 47, the enclosing portion of the output resonator 35 may be telescoped axially over the domed end portion of the discharge device 1. As previously suggested, it is obvious that slidable contact between cylindrical conductor 36 and the external position of grid supporting disk may alternatively be accomplished by terminating the cylindrical conductor 36 in a plurality of contact fingers instead of the disk 14 as illustrated.

It is evident that this relative longitudinal movement between the output resonator 35 and the discharge device 1 alters the axial dimension of the output resonator 35 and thereby functions to control its natural resonant frequency. Because of the extremely small length of the electromagnetic waves to be propagated within this resonator, a minute change in its dimensions causes a relatively large change in its resonant frequency. We, therefore, preferably provide a rotary mechanical driving device whereby the enclosing portion of the resonator 35 may be moved longitudinally in small determinable increments. A tuning knob 48 is threaded on a shaft 49 which is inserted as a free fit through a rigid supporting member 50. The base of the tuning knob 48 has an annular shoulder 51 which is journalled within a collar 52 which, in turn, is secured to the supporting member 50. As the knob 48 is turned, a longitudinal motion is thereby imparted to the shaft 49. This shaft 49 is secured to a transverse plate 53 which is sealed to the end of cylindrical insulating member 40. It will be appreciated that insulating member 40 must be long enough to provide considerable spacing between the end of anode portion 18 and the transverse plate 53 to prevent the arcing of a high voltage which may be applied to the anode 5.

A pair of upright mechanically strong insulating members 54 and 55 support the entire space resonant assembly. The insulating member 55 is securely fastened to the outer surface of cylinder portion 21' while the insulating member 54 has an aperture 56 of slightly larger diameter than the insulating cylinder 40 which it encircles, thereby to enable the longitudinal motion of shaft 49 to impart a longitudinal movement to the output cavity resonator 35 with respect to the securely positioned discharge device 1.

The above-described embodiment of the invention permits proper operating voltages to be easily applied to the various electrodes of the discharge device 1. Heating current for the filament 6 may be provided by means of a transformer 57 having one of the terminals of its secondary winding connected to the outer cylinder portion 21' and the other terminal connected to rod 30. When used as a voltage amplifier, the cathode 2 may be maintained at ground potential by connecting the cylinder portion 21' to ground as indicated in Fig. 2 since the cylinder portion 21' is in electrically conductive relation with the cathode through the plunger 22 and the inner cylinder 20. The proper control grid 3 biasing voltage may be provided by such means as a battery 58 having its positive terminal connected to ground and its negative terminal connected through a grid return resistance 59 to the cylinder portion 21''. A positive voltage may be applied to the screening electrode 4 by a connection 60 to cylindrical conductor 36 of the output resonator 35, and a proper positive anode voltage may be applied by a connection 60' through a small hole 61 in the insulating cylinder 40 to the end plate 38 which is in conductive relation with the anode end portion 18.

From the foregoing description, it will be appreciated that the output cavity resonator 35 may be tuned to resonate at extremely high frequencies with the electrical characteristics of a quarter-wave transmission line short circuited at one end and having a capacitive load across its other end. The upper limit of frequency to which the resonator may be tuned is, of course, determined by the position at which the end plate 38 hits against the top of dome-shaped member 17, while the lower limit of tunable frequency is determined by the point at which the discharge device 1 no longer makes contact with the walls of resonator 35.

Although we have shown the anode rod portion 18 as having a small diameter relative to the diameter of the outer cylinder 36 in order to provide a resonator which will have a broad band frequency response, it is to be understood that rod 18 as well as anode 5 may have various diameters and cross-sectional configurations in order to provide a resonator having other desired electrical characteristics. It is also to be understood that while we have preferably shown our invention in conjunction with a discharge device having both a screen grid and a control grid, it is equally applicable to a discharge device having only one grid or, on the other hand, having more than two grids. It is necessary only that at least one of the grids employed be provided with an externally extending conductive supporting disk such as disk 14 in order to enable the slidable telescoping of a cavity resonator over the output end portion of the discharge device.

It will also be appreciated that by telescoping the resonator 35 over the domed end of the discharge device 1, there is provided a plug-in type of tunable cavity resonator which has only two regions of slidable contact; one between contact fingers 16 and the inner surface of cylinder 36, and the other between fingers 47 and the anode portion 18. This telescoped arrangement may be contrasted with the conventional type of tunable cavity resonator such as the input resonator 23 which has four regions of slidable contact; one between fingers 28 and the grid cylinder 11, another between fingers 27 and the cathode cylinder 7, and two more regions between the slides of plunger 22 and the corresponding surfaces of resonator cylinders 20 and 21 respectively. Since the telescoped output resonator 35 has only two regions of slidable contact, the possibility of energy losses due to a discontinuity in the conductive medium defining this resonator 35 are considerably reduced.

While we have shown a particular embodiment of our invention, it is to be understood that we do not wish to be limited thereto since many modifications may be made, and we, therefore, intend by the appended claims to cover all such modifications as fall within the true spirit and scope of the invention.

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

1. In an ultra high frequency electric discharge device, a cathode, an anode, and at least one grid located intermediate said cathode and said anode and in axial alignment therewith, said anode having an axially extending portion, an electrically conductive member encircling and connected to said grid, insulating means hermetically sealed between said cathode and said conductive member to support said conductive member in spaced relation to said cathode, and a tapered insulating dome member hermetically sealed at its base to said conductive member and hermetically sealed at its apex to said axial anode portion to support said anode in spaced relation to said grid, said anode portion having an external portion extending through said apex, said conductive member terminating in a plurality of external contact fingers extending from said base of said tapered member whereby a grid-anode cavity resonator may be telescoped axially over the anode end portion of said discharge device in contact with said external anode portion and said contact fingers.

2. An ultra high frequency electric discharge device comprising a cathode, a control grid, a screen grid and an anode in consecutive spaced alignment along the axis of said device, said anode having an axially extending conductive rod, said cathode having an axially extending cylindrical portion, a conductive cylinder concentrically surrounding said cathode cylindrical portion, said conductive cylinder being connected to and supporting said control grid, a conductive disk connected to and supporting said screen grid and having a plurality of contact fingers extending from the circumference thereof, and insulating means supporting said electrodes in spaced apart alignment including a pair of annular insulating members hermetically sealed respectively between said cathode cylindrical portion and said conductive cylinder, and between said conductive cylinder and said disk, and a substantially dome-shaped insulating member hermetically sealed at its base to said disk and hermetically sealed at its apex to said rod to complete the enclosure of said electrodes, said rod having a portion extending externally through said apex of said dome, said contact fingers extending externally from said base of said dome.

3. An ultra high frequency cavity resonator system comprising an electric discharge device including a cathode, at least one grid, and an anode in consecutive spaced alignment, a tapered insulating end portion enclosing said grid and said anode, said anode having a portion axially extending externally through the apex of said conical end portion, and a conductive disk in conductive relation with said grid, said disk extending externally from the base of said tapered end portion; a substantially cylindrical conductor concentrically surrounding said tapered end portion, the inner surface of said cylindrical conductor being constructed to slidably engage against said external disk portion, a conductive end plate covering the anode opposing end of said cylindrical conductor and cooperating therewith to define a grid-anode cavity resonator, said end plate having a central sleeve encircling and making slidable contact with said external portion of said anode, and means to vary the axial position of said resonator relative to said discharge device thereby to tune said resonator.

4. An ultra high frequency space resonant system adapted to be employed with electromagnetic waves having a wave length in the order of 10 centimeters comprising an electric discharge device including a cathode, at least one grid and an anode in consecutive spaced alignment, a substantially dome-shaped insulating end portion enclosing said grid and said anode, said anode having a conductive rod portion axially extending externally through the apex of said dome, and a conductive disk encircling and connected to said grid, said disk extending externally from the base of said dome; a substantially cylindrical conductor concentrically surrounding said dome-shaped end portion, the inner surface of said cylindrical conductor being constructed to slidably engage against said external disk portion, a conductive end plate covering the anode opposing end of said cylindrical conductor, said end plate having a central sleeve encircling said anode rod portion and terminating in a plurality of resilient contact fingers constructed to press firmly against said rod, said end plate and said cylindrical conductor cooperating with said discharge device to provide a quarter wave grid-anode resonant cavity, direct current insulating means between said end plate and said cylindrical conductor, and mechanical means to vary the axial position of said end plate and said cylindrical conductor relative to said discharge device thereby to tune said resonator.

NORMAN T. LAVOO.
ANATOLE M. GUREWITSCH.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,406,827	Goodchild	Sept. 3, 1946
2,442,662	Peterson	June 1, 1948
2,492,618	Bowie	Dec. 27, 1949