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2,428,622

TUNING AND COUPLING MEANS FOR HIGH FREQUENCY SYSTEMS

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Fig. 1.

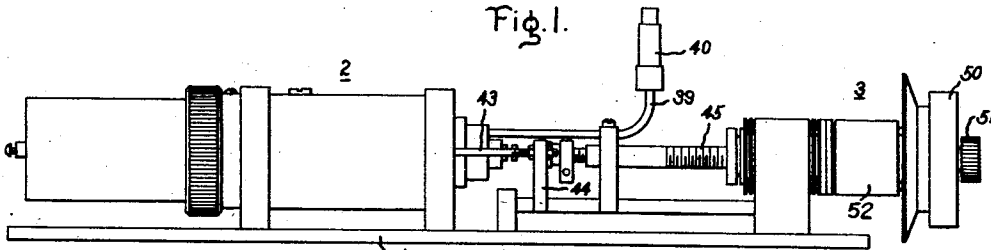


Fig. 2.

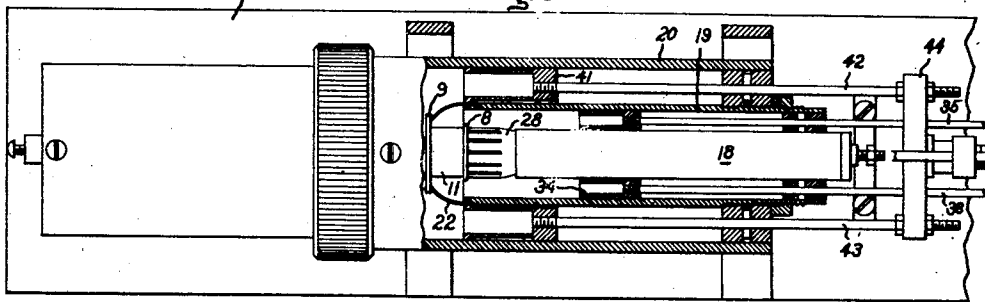


Fig. 3a.

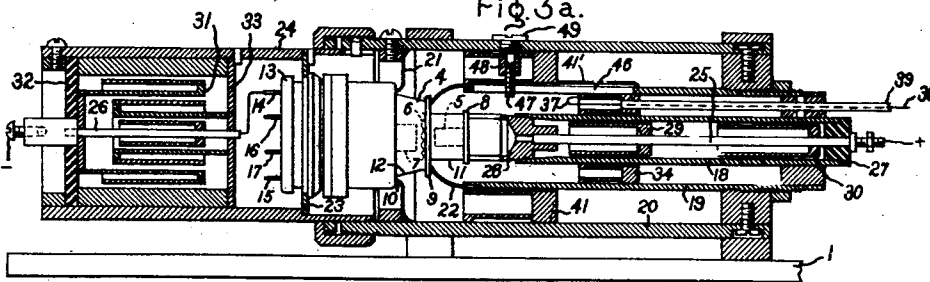


Fig. 3b.

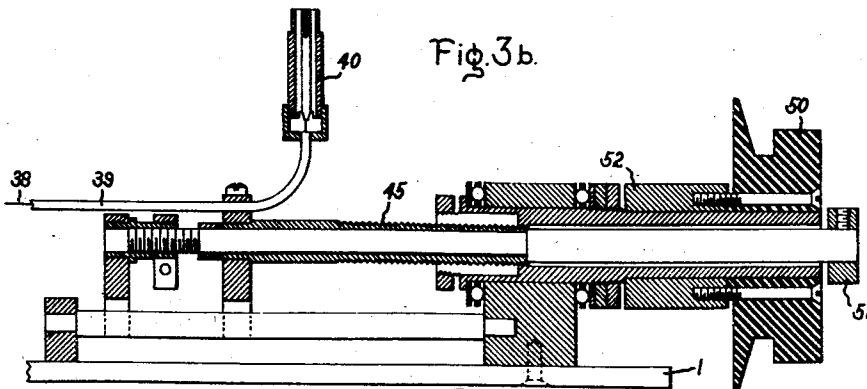
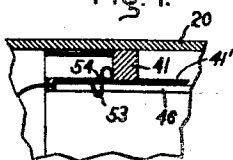


Fig. 4.



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TUNING AND COUPLING MEANS FOR HIGH-FREQUENCY SYSTEMS

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11 Claims. (Cl. 315—39)

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

It is important in ultra high frequency systems of the space-resonant type to provide means of simple construction which permit ready adjustment or control of the operating frequency thereof, and which obtain such control without effecting a loss of power output. In accordance with the teachings of my invention described hereinafter, I provide a new and improved tuneable ultra high frequency space-resonant system which obviates many of the disadvantages of the prior art arrangements.

It is an object of my invention to provide a new and improved ultra high frequency space-resonant system.

It is a further object of my invention to provide a method of operating a space-resonant system.

It is a further object of my invention to provide a new and improved ultra high frequency system of the space-resonant type the operating frequency of which is readily adjustable or controllable, and in which coupling means between various associated space-resonant cavities, or regions, is automatically and simultaneously controlled by the frequency controlling means.

It is a still further object of my invention to provide a new and improved ultra high frequency space-resonant system which employs an electric discharge device as a central or control element and in which the coupling means between the anode-grid and grid-cathode cavities, or regions, is mechanically connected to the frequency controlling means which establishes the natural frequency of one of the regions.

Briefly stated, in the illustrated embodiment of my invention I provide an ultra high frequency space-resonant system which, for the purposes of illustration, is presented as comprising an ultra high frequency oscillator comprising a pair of space resonant cavities and also comprising, as an element thereof, an electric discharge device including an anode, a cathode and a grid. A plurality of metallic or conductive cylinders are connected to the electrodes of the discharge device and means are provided for simultaneously controlling not only the natural frequency of at least one of the cavities but also for controlling the position of the coupling means so that the coupling means automatically assumes the optimum position for each operating frequency.

For a better understanding of my invention,

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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. Fig. 1 diagrammatically illustrates an overall side view of an ultra high frequency oscillator of the space-resonant type embodying my invention. Fig. 2 is a partial cross-sectional plan view of the oscillator, and Figs. 3a and 3b, considered jointly, are a cross-sectional side view of the high frequency space-resonant oscillator showing the adjustable tuning and coupling means. Fig. 4 represents an alternative arrangement for the coupling means which may be employed in carrying out my invention.

Referring now to Fig. 1 of the accompanying drawing, I have there illustrated my invention as applied to an ultra high frequency space-resonant system, such as an ultra high frequency oscillator, which may be arranged in a compact and readily adaptable form mounted upon a base plate 1 which supports the space-resonant cavities generally identified at 2. As a means for tuning or controlling the operating frequency of the oscillator, I may employ any suitable adjusting means as for example a vernier adjustment means 3.

A better appreciation of the system may be had by referring to Figs. 2 and 3a jointly. As a central control element of the system, I may employ an electric discharge device 4 which may take the form of that ultra high frequency discharge device disclosed and claimed in the copending patent application Serial No. 436,633 of James E. Beggs, filed March 28, 1942, and which is assigned to the assignee of the present application. This discharge device is peculiarly adapted for the utilization of ultra high frequency energy and comprises an anode 5, a grid 6 and a thermionic cathode 7 having its emissive surface in proximity to the grid 6. Connections to the anode 5, grid 6 and cathode 7 are provided for use as high frequency terminals and which may comprise discs 8, 9 and 10 having a stepwise configuration, as illustrated, to facilitate connection of high frequency means thereto and which will be described presently. Of course, it is to be appreciated that the electrodes of the discharge device 4 are enclosed or sealed hermetically, the discs 8, 9 and 10 being maintained in spaced relation by means of vitreous or glass cylinders 11 and 12 which are sealed to these discs. The discharge device 4 may also be provided with a socket 13 having contact pins 14-17, inclusive. Contact pins 14 and 15 may be employed as means for impressing a unidirectional potential on cathode

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7, and contact pins 16 and 17 may be employed as terminals for supplying unidirectional current to the heating element (not shown) for the cathode 7.

As a means for defining space-resonant regions or cavities associated with the anode-grid and the grid-cathode circuits of the discharge device 4, I employ a plurality of conductive members which may take the form of three concentric or coaxial metallic or conductive cylinders 18, 19 and 20. Cylinders 18 and 19 define the anode-grid cavity or region, and cylinders 19 and 20 define the grid-cathode cavity or region. Cathode 7 and more particularly its terminal comprising disc 10 is connected to cylinder 20 by means of a plurality of resilient contact fingers 21, and in like manner grid 6 or its associated disc terminal 9 is connected to the cylinder 19 by means of a plurality of resilient fingers 22. In addition to affording electrical connection between the respective elements of the system, fingers 21 and 22 also serve to position firmly the electric discharge device 4 within the assembly. In order to form a further axial support for the discharge device 4, I employ an annular metallic ring 23 which is supported by a shoulder of a cylinder 24 and which also engages socket 13 for the discharge device 4.

A suitable operating voltage, such as a unidirectional voltage, may be impressed across anode 5 and cathode 7 by circuit connections which may assume the form of an anode connecting rod 25 and a cathode connecting rod 26 which is connected to either contact pin 14 or 15. Anode rod 25 may be centrally positioned within cylinder 18 by means of an end insulator 27 and may be connected to anode 5 by a metallic adaptor 28, the latter being tapered to firmly engage the inner surface at one end of cylinder 18.

Due to the tendency to produce coupling between cylinder 18 and anode rod 25, I employ suitable filters 29 and 30 which may take the form of hollow metallic sleeves having a wave length, such as a quarter wave length of the operating frequency of the device, or in the vicinity thereof, to prohibit or restrict the transmission of high frequency energy within the region defined by the surface of anode rod 25 and the inner surface of cylinder 18.

In like manner, in order to prevent the dissipation of electromagnetic energy from the enclosure for the system as a whole and particularly through the cylinder 24, I may employ a folded filter or choke 31, such as that disclosed and claimed in my copending patent application Serial No. 452,946, filed July 30, 1942, and which is assigned to the assignee of the present application. The filter 31 may be supported by a spacing insulator 32 and a transverse metallic wall 33.

I provide means for tuning or controlling the natural frequency of the space resonant regions or cavities. These tuning means may take the form of axially adjustable end walls or plungers associated with the respective cavities. For example, the anode-grid cavity may be provided with an adjustable plunger 34 which engages the outer surface of cylinder 18 and the inner surface of cylinder 19 and which may be positioned or adjusted by any suitable mechanical expedient such as connecting rods 35 and 36. Plunger 34, of course, is slidable along these latter mentioned surfaces and the position of the plunger determines the natural frequency of the anode-grid space-resonant cavity or region, 75

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Energy may be extracted from the space-resonant regions, as for example from the anode-grid cavity, by electrode means which may assume the form of a loop 37 which constitutes an extension of an inner conductor 38 of the concentric transmission line comprising the inner conductor 38 and outer conductor 39 which may be terminated in a socket 40, shown in Figs. 1 and 4, to facilitate connection to an external utilization circuit.

In like manner, I provide a plunger 41 for controlling the axial dimension of the grid-cathode space resonant region and this plunger may also be controlled by any suitable mechanical expedient such as a pair of actuating rods 42 and 43 which with rods 35 and 36 are connected to a transversing stud 44 which rides upon a threaded rod 45 connected to the vernier adjustment 3.

I provide means for simultaneously adjusting the natural frequency of one of the space-resonant regions and for controlling the position of coupling means which controls the interchange of energy between the anode-grid and the grid-cathode space resonant regions. More particularly, I provide means for mechanically connecting the coupling means to the frequency controlling means. For example, cylinder 19 is provided with an axial opening or slot 46 through which an electrode coupling means, such as a probe 47, extends thereby providing coupling between the anode-grid and the grid-cathode cavities. The probe 47 may be mechanically supported by and positionable with plunger 41 and may be transversely adjustable, being provided with a screw-thread which engages threads of a protuberance 48 formed within the hollow annular portion of plunger 41. In this manner, the distance which the probe 47 extends into the anode-grid cavity may be readily controlled or adjusted. As a means to facilitate external adjustment of the position of probe 47, I provide a threaded cap 49 which screws into an aperture of outer cylinder 20.

In order to prevent the establishment of an undesired region of a confined electromagnetic wave and to prevent the undesired extraction of energy from the anode-grid cavity through slot 46, plunger 41 may be provided with a follower part 41' which serves as a cover for slot 46 and is slidable along the outer surface of cylinder 19. The part 41', of course, is conductive, preferably formed integral with the plunger 41 and adapted to follow it.

In like manner, the plunger 34 may also be provided with a follower (not shown) adjacent the slot 46 to prevent the transfer of electromagnetic energy from the grid-cathode cavity to the region between cylinders 18 and 19 beyond the plunger 34.

Fig. 3b indicates somewhat in detail the vernier adjustment which may be employed to adjust the positions of plungers 34 and 41, and may comprise a rough adjusting knurled thumb member 50 and a finer adjusting member 51 which are connected, respectively, to an outer or large diameter adjusting cylinder 52 and an inner connecting rod which is connected to the threaded rod 45.

In operation, upon the impression of a unidirectional voltage across anode 5 and cathode 7, the space-resonant system will oscillate at a frequency determined by the natural resonance frequency of the cavities or regions and the discharge device 4. The operating frequency is determined, of course, by the position of plungers 34 and 41. Energy may be extracted from the

system, particularly the anode-grid region, by means of loop 37 and supplied to an external or utilization circuit which is connected to the socket 40.

The feed-back of energy from the anode-grid cavity to the grid-cathode cavity is obtained principally by means of the probe 47 which constitutes a coupling means to supply to the latter region a voltage of proper magnitude and phase to maintain the system, as a whole, in oscillation. I have found that in systems of this nature where it is desired to provide a substantial range of operating frequencies, it is also important to position the coupling means, such as the probe 47, for each operating frequency in order that the optimum coupling effect be obtained and so that power output is not sacrificed in obtaining the frequency control. Consequently, by mechanically connecting one of the frequency controlling means, such as plunger 41, to probe 47 upon adjustment of the operating frequency the coupling means automatically assumes that position which produces the optimum feed-back or coupling between the anode-grid and the grid-cathode cavities or regions.

It will be noted that plungers 34 and 41 are both connected to the transversing stud 44 through connecting rods 35, 36 and 42, 43. Consequently, upon actuation of the vernier adjustment both of these plungers will be actuated, thereby concurrently and simultaneously controlling the dimensions of the anode-grid and the grid-cathode cavities and simultaneously controlling the natural frequencies thereof.

While in the embodiment of my invention illustrated in Fig. 3a I have shown the coupling means as comprising a probe 47, it will be appreciated by those skilled in the art that the coupling means may assume a variety of configurations and that my invention is not limited to the particular coupling means illustrated. For example, in Fig. 4 I have shown an alternative form of the coupling means which may comprise a loop 53 which extends through opening 46 in cylinder 19, and which is conductively connected to the inner surface of plunger 41 within the grid-cathode cavity and connected to the outer surface of plunger 41 facing the anode-grid cavity, the loop 53 extending through an opening 54 in the plunger 41.

While I have shown and described my invention as applied to a particular system and as embodying various devices diagrammatically shown, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention, and I, therefore, aim in the appended claims to cover all such changes and 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 system comprising an electric discharge device including a plurality of enclosed electrodes including an anode, a cathode and a grid, a pair of space resonators one of which is connected to the anode-grid circuit of said discharge device and the other of which is connected to the grid-cathode circuit of said device, coupling means between said resonators, and positionable means in operative relation to one of said resonators for tuning said one of said resonators said coupling means being mounted on said tuning means, whereby the position of said coupling means is controlled as said resonator is tuned.

2. A high frequency space resonant system

comprising an electric discharge device including a plurality of enclosed electrodes including an anode, a cathode and a grid and being provided with externally accessible high frequency terminals, a plurality of conductive members connected to the electrodes of said discharge device defining anode-grid and grid-cathode space resonators, coupling means for effecting the transfer of electromagnetic energy between said resonators, and positionable means in operative relation to one of said resonators for tuning said one of said resonators, said coupling means being mounted on said tuning means, whereby the position of said coupling means is controlled as said resonator is tuned.

3. A high frequency space resonant system comprising an electric discharge device including a plurality of enclosed electrodes including an anode, a cathode and a grid, a plurality of substantially coaxial conductive cylinders connected respectively to said electrodes defining anode-grid and grid-cathode resonators, and a conductive plunger interposed between two of said cylinders for tuning the resonator defined therebetween and supporting an adjustable coupling means.

4. A high frequency space resonant system comprising an electric discharge device including an anode, a cathode and a grid having externally accessible high frequency terminals, a pair of coaxial conductive cylinders connected to said anode and said cathode and an intermediate conductive cylinder connected to said grid thereby defining anode-grid and grid-cathode resonators, said intermediate cylinder being provided with an opening extending axially, means for tuning one of said resonators comprising a conductive plunger adjustable axially of said system and supporting a coupling means which extends through said opening.

5. A high frequency space resonant system comprising an electric discharge device including a plurality of enclosed electrodes including an anode, a cathode and a grid having externally accessible high frequency terminals, three concentric conductive cylinders connected respectively to said anode, said grid and said cathode thereby defining anode-grid and grid-cathode resonators, the intermediate cylinder connected to said grid being provided with a longitudinal slot, coupling means extending through said slot thereby providing a path for the transfer of electromagnetic energy between said resonators, and means for tuning one of said resonators comprising an adjustable plunger mechanically connected to said coupling means.

6. A high frequency space resonant system comprising an electric discharge device including a plurality of enclosed electrodes including an anode, a cathode and a grid having externally accessible high frequency terminals, three coaxial conductive cylinders connected respectively to said anode, said grid and said cathode thereby defining anode-grid and grid-cathode resonators, the intermediate cylinder connected to said grid being provided with an axial opening, and means for simultaneously controlling the natural frequency of one of said resonators and for establishing the optimum coupling between the resonators comprising an axially adjustable conductive plunger interposed between two of said cylinders and supporting a coupling means which extends through said opening.

7. A high frequency oscillator of the space-resonant type comprising an electric discharge

device including a plurality of enclosed electrodes including an anode, a cathode and a grid provided with externally accessible high frequency figuration, 3 coaxial conductive cylinders connected respectively to said anode, said grid and said cathode thereby defining anode-grid and grid-cathode resonators, the intermediate cylinder being provided with an axial slot, and means for simultaneously controlling the natural frequency of one of said resonators and for controlling the coupling between the anode-grid and the grid-cathode resonators comprising an axially adjustable conductive plunger provided with a coupling means which extends through said opening.

8. A high frequency system comprising an electric discharge device including a plurality of enclosed electrodes including an anode, a cathode and a grid, a pair of resonators one of which is connected to the anode-grid circuit of said discharge device and the other of which is connected to the grid-cathode circuit of said device, coupling means between said resonators, and positionable means in operative relation to said resonators for tuning both of said resonators, said coupling means being mounted on said tuning means whereby the position of said coupling means is controlled as said resonators are tuned.

9. A high frequency space resonant system comprising an electric discharge device including an anode, a cathode and a grid having externally accessible high frequency terminals, a pair of coaxial conductive cylinders connected to said anode and said cathode and an intermediate conductive cylinder connected to said grid thereby defining anode-grid and grid-cathode resonators, said intermediate cylinder being provided with an opening extending axially, and means for tuning the grid-cathode resonator comprising a conductive plunger adjustable axially the dimension of said system and supporting a coupling means which extends through said opening, said plunger being provided with a conductive follower which partially covers said opening.

10. A high frequency system comprising an

electric discharge device including a plurality of enclosed electrodes including an anode, a cathode and a grid, a pair of cavity resonators one of which is connected to the anode-grid circuit of said discharge device and the other of which is connected to the grid-cathode circuit of said device, adjustable means for adjusting the dimensions of one of said resonators to tune said one of said resonators, and a coupler coupling said resonators together and connected to said adjustable means and movable in unison therewith whereby said adjustable means and the coupling between said resonators may be adjusted simultaneously.

11. A high frequency system comprising an electric discharge device including a plurality of enclosed electrodes including an anode, a cathode and a grid, a pair of space resonators one of which is coupled with the anode-grid circuit of said device and the other of which is coupled with the grid-cathode circuit of said device, coupling means extending between said resonators for effecting the transfer of electromagnetic energy between said resonators, tuning means in operative relation to one of said resonators for adjusting the dimensions thereof for tuning said resonator to a desired frequency, said coupling means being connected to said tuning means and movable in unison therewith whereby said tuning means and said coupling means may be adjusted simultaneously.

ANATOLE M. GUREWITSCH.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,280,824	Hansen et al.	Apr. 28, 1942
2,311,520	Clifford	Feb. 16, 1943
2,283,895	Mouromtseff et al. ...	May 19, 1942
2,226,653	Allerding et al.	Dec. 31, 1940
2,169,396	Samuel	Aug. 15, 1939
2,278,210	Morton	Mar. 31, 1943

Certificate of Correction

Patent No. 2,428,622.

October 7, 1947.

ANATOLE M. GUREWITSCH

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Column 7, line 3, claim 7, after "frequency" insert *terminals of disc form having a stepwise con-*; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 6th day of January, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.