

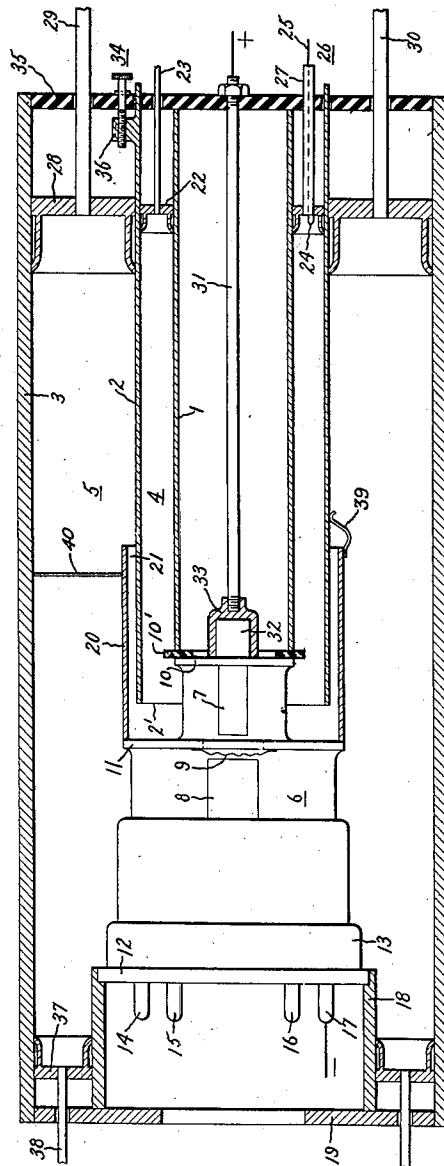
June 22, 1948.

A. M. GUREWITSCH

2,443,908

ULTRA HIGH FREQUENCY OSCILLATOR

Filed Jan. 28, 1943



Inventor:
Anatole M. Gurewitsch,
by *Harry E. Dunkham*
His Attorney.

UNITED STATES PATENT OFFICE

2,443,908

ULTRA HIGH FREQUENCY OSCILLATOR

Anatole M. Gurewitsch, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application January 28, 1943, Serial No. 473,876

13 Claims. (Cl. 315—39)

1

My invention relates to ultra high frequency systems and more particularly to ultra high frequency space resonant oscillators.

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

It is another object of my invention to provide a new and improved high frequency oscillator.

It is a further object of my invention to provide a new and improved high frequency oscillator of the space resonant type.

It is a still further object of my invention to provide a new and improved control and tuning means for an ultra high frequency oscillator of the space resonant type.

Briefly stated, in the illustrated embodiment of my invention I provide a space resonant system, which may be operated as an oscillator, for the utilization of ultra high frequency currents having a wave length of one meter or less. A high frequency electric discharge device including a plurality of electrodes is associated with three concentric and telescoped conductive cylinders to establish space resonant anode-grid and grid-cathode regions or cavities and wherein the intermediate cylinder is adjustable or controllable for the purpose of controlling the feedback between the anode-grid and the grid-cathode regions. Tuning means are provided for the respective space resonant regions for controlling the operating frequency of the system as a whole, and the adjustability of the intermediate cylinder which is coupled to the grid of the electric discharge device serves to control principally the magnitude of the feedback voltage between the respective cavities.

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. The single figure of the accompanying drawing illustrates my invention as applied to an ultra high frequency oscillator employing an electric discharge device having externally accessible high frequency terminals of step-wise configuration to facilitate coupling or connection to the various conductive members or cylinders which define the space resonant regions.

Referring now to the single figure of the drawing, my invention is there illustrated as applied to an ultra high frequency system, such as a space resonant oscillator, for the utilization or generation of ultra high frequency electromagnetic energy. I provide three telescoped con-

2

ductive members or conductors, such as metallic cylinders 1, 2 and 3, which define therebetween space resonant regions or cavities 4 and 5. As a central control element of the system, I employ an electric discharge device suitable for the utilization of ultra high frequency electric currents and, for example, I may employ an electric discharge device 6 of the general nature disclosed and claimed in copending patent application Serial No. 436,633 of James E. Beggs, filed March 28, 1942, now Patent 2,416,565, issued February 25, 1947, and which is assigned to the assignee of the present application. The electric discharge device 6 includes a plurality of enclosed electrodes including an anode 7, a cathode cylinder 8 having an emissive surface facing the anode 7 and an interspaced grid 9. The enclosing and supporting structure for the above described electrode of the discharge device 6 include externally accessible high frequency terminals which comprise metallic disks 10, 11 and 12, preferably having progressively increasing diameters in the order named, thereby affording a stepwise configuration of these elements for the purpose of facilitating connection or coupling to cylinders 1, 2 and 3. The end of cylinder 1 is spaced slightly from the terminal 10 and an insulating disk 10' may be inserted between the terminal 10 and the end of the cylinder 1 to insulate these parts as far as direct current voltages are concerned. It will be understood that the parts 1 and 10 are effectively coupled with respect to high frequency currents. Discharge device 6 includes a base part 13 which supports a plurality of terminal posts 14-17, inclusive. Within the cathode cylinder 8 there is provided a cathode heating element (not shown) which may be energized through terminal posts 15 and 16. Cathode connections to cylinders 8 are afforded through connections to either, or both, of terminal posts 14 and 17. The base of discharge device 6 is held firmly in the position illustrated by means of a cylinder or collar 18 which is supported by an apertured end plate 19.

As a means for controlling the coupling between the space resonant region 4, which is associated with the anode-grid circuit of the discharge device 6, and the space resonant region 5, which is associated with the grid-cathode circuit of the discharge device, I provide a conductive or metallic grid cylinder 20 which is conductively connected to disk 11 and which extends an appreciable distance along the principal axis or longitudinal dimension of the space resonant system and surrounds, at least in part, the intermediate cylinder 2, providing therebetween an annular

3

path 21 through which the principal feedback coupling between the various space resonant regions takes place.

In order to control the operating frequency of the space resonant system and for controlling the frequency of the electrical oscillations produced when the system is operating as an oscillator, I provide tuning means associated with the space resonant regions 4 and 5. For example, the tuning means for the anode-grid space resonant region 4 may comprise an annular plunger 22 which closely engages the outer surface of cylinder 1 and the inner surface of cylinder 2 and is in slidable engagement therewith. Plunger 22 may be actuated by any suitable mechanical expedient, such as a rod 23.

Ultra high frequency energy may be derived from the system by suitable coupling or output electrode means which may take the form of a loop 24 extending into the anode-grid region 4 and which constitutes an extension of an inner conductor 25 of a concentric transmission line 26 comprising conductor 25 and an outer tubular conductor 27.

The grid-cathode space resonant region 5 may also be tuned or controlled by means of a longitudinally adjustable or positionable plunger 28 which closely engages the outer surface of cylinder 2 and the inner surface of cylinder 3 and is, of course, in slidable engagement with the surfaces being actuated by rods 29 and 30.

Unidirectional potential may be impressed across the anode and the cathode of the discharge device 6 from an external source and the connection to the anode 7 may be provided by means of an anode connecting rod 31 which is joined to an anode extension 32 by means of an adaptor 33.

As a means for controlling the coupling between the anode-grid cavity 4 and the grid-cathode cavity 5, I provide means for adjusting the position of the intermediate cylinder 2 and particularly the end 2' thereof with respect to the disk 11, in this manner providing means for controlling the magnitude of the voltage derived from the anode-grid cavity and which is fed back to the grid-cathode cavity for the purpose of maintaining oscillation of the system. The longitudinal position of cylinder 2 may be controlled by any suitable manual or automatic means, and for the purpose of illustration I have chosen to represent such means as comprising a thumb-screw arrangement 34 which is supported by an apertured end wall 35 and which engages an abutment 36 on the exterior surface of cylinder 2. The end wall 35 may to advantage be formed of insulating material to facilitate the maintenance of suitable direct current voltages on the various electrodes of the device 6.

As a further means for controlling the nature, and particularly the phase of the grid-cathode voltage, I may employ an additional axially positionable tuning member, such as a plunger 37, which is associated with cavity 5 and which is placed at a position beyond the cathode 8 to control the reflections of the electromagnetic waves within this cavity and thereby to control the phase of the resultant voltage appearing across grid 9 and cathode 8. Plunger 37 may be actuated by rods 38.

Between the intermediate cylinder 2 and the grid cylinder 20, I provide a single metallic finger 39, or a plurality of annularly arranged fingers, which may be supported by grid cylinder 20 and in slidable engagement with the intermediate

4

cylinder 2 and which serves to impress a grid biasing potential on cylinder 20. Inasmuch as cylinder 2 is of the same potential as that of cylinder 3, the grid 9 of the electric discharge device 6 will be biased to the potential of these elements. Of course, the grid 9 may be biased to any predetermined potential by means of an externally accessible and insulated conductor connected to cylinder 20 and which is supported by and extends through cylinder 3.

In addition to impressing a biasing potential on grid cylinder 20, finger 39 is arranged to form a loop thereby serving to link the channel or path 21 electromagnetically with the space resonant region 5.

An additional metallic conductor 40 may be connected radially between the cylinder 3 and cylinder 20 to control the impedance encountered by the electromagnetic waves in emanating from passage 21. That is, the electromagnetic waves emanating from this channel encounter what might be considered as two impedances in series, the first of which is the impedance between the open end of cylinder 20 and plunger 28, and the other is the impedance between plungers 28 and 37. The presence of a metallic conductor 40 optimally placed with respect to the standing electromagnetic wave between plungers 28 and 37 is an effective means for controlling the impedance encountered by these waves. In addition, the conductor 40 may be employed for impressing a unidirectional biasing potential on grid cylinder 20 through an externally accessible terminal (not shown).

Upon the application of a suitable unidirectional voltage across the anode 7 and cathode 8 of the discharge device and upon the proper positioning of the tuning and coupling means, the system as a whole operates to generate ultra high frequency energy. Generally speaking, it may be said that plungers 22 and 28 are, respectively, adjusted so that the space resonant regions or cavities 4 and 5 have substantially equal electrical lengths and consequently have substantially equal natural frequencies. Of course, it is to be understood that operation of the system as a whole may be obtained by positioning the respective plungers so that operation is possible even though the electrical lengths are not geometrically equal but have properly correlated harmonic frequencies. For example, one of the plungers 22 or 28 may be adjusted so that its associated cavity has an electrical length of one-quarter wave length, and the other plunger may be adjusted to be an odd multiple of that quarter wave length.

The magnitude of the feedback voltage transmitted from the anode-grid cavity 4 to the grid-cathode cavity 5 is determined principally by the position of the end 2' of intermediate cylinder 2 with respect to disk 11. As the end 2' approaches the disk 11, it will be appreciated that the amount of energy transmitted from one region to the other is decreased. The path of the high frequency electromagnetic waves which effect the coupling between the respective cavities is principally through the annular path 21 between cylinders 2 and 20, thereby by virtue of the adjustability of cylinder 2 providing a ready means of controlling the amount of feedback.

Although the adjustment of the cylinder 2 in longitudinal position may be considered as predominantly controlling of the magnitude of the feedback voltage, it will be appreciated that changes in position of cylinder 2 of necessity in-

5

volve a secondary change in the phase of the voltage which is transmitted to the grid-cathode region 5. However, the phase of the resultant voltage impressed across grid 9 and cathode 8 may be controlled by the joint or separate adjustment of plungers 28 and 37.

While I have shown and described my invention as applied to a space resonant system of particular configuration and as employing a particular type electric discharge device as the control element therein, 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 space-resonant system comprising three telescoped conductors defining a first cavity resonator between the inner conductor and the intermediate conductor and a second cavity resonator between said intermediate conductor and the outer conductor, an electric discharge device having an envelope enclosing an anode, a cathode and a grid and provided with externally accessible high frequency terminals, the anode and grid of said discharge device being coupled with the inner and intermediate conductors forming said first-mentioned cavity resonator and the cathode and grid of said discharge device being coupled with the intermediate and outer conductors forming said second cavity resonator, adjustable tuning means located in said resonators for tuning said resonators to control the operating frequency of said system, a hollow conductor connected to the grid terminal and extending an appreciable distance around said intermediate conductor, and adjustable means connected to said intermediate conductor for controlling the axial position thereof in order to control the feedback of energy between said first and second cavity resonators.

2. A space-resonant system comprising three telescoped conductors defining a first cavity resonator between the inner conductor and the intermediate conductor and a second cavity resonator between the intermediate conductor and the outer conductor, an electric discharge device having an envelope enclosing an anode, a cathode and a grid and provided with externally accessible high frequency terminals, the anode and grid of said discharge device being coupled with the inner and intermediate conductors forming said first-mentioned cavity resonator and the cathode and grid of said discharge device being coupled with the intermediate and outer conductors forming said second cavity resonator, adjustable tuning means located in each of said resonators to control the operating frequency of said system, and adjustable means connected to said intermediate cylinder for controlling the axial position thereof to control the amplitude of the feedback oscillations transmitted from said first cavity resonator to said second cavity resonator.

3. An ultra high frequency oscillator comprising three telescoped conductive cylinders defining therebetween first and second cavity resonators, an electric discharge device having an envelope enclosing an anode, a cathode and a grid and being provided with externally accessible high frequency terminals in stepwise configuration, the anode and grid of said discharge device being

6

coupled to the inner and intermediate cylinders defining said first resonator and the grid and cathode of said discharge device being coupled to the intermediate and outer cylinders defining said second resonator, tuning means comprising axially adjustable plungers in each of said resonators for controlling the operating frequency of the oscillator, adjustable means connected to said intermediate cylinder for adjusting the axial position thereof to vary the magnitude of the electrical oscillations transmitted from said first cavity resonator to said second cavity resonator, and means for controlling the phase of the grid-cathode voltage comprising an adjustable plunger spaced at one end of said second resonator.

4. An ultra high frequency oscillator comprising three telescoped conductive cylinders defining therebetween first and second cavity resonators, an electric discharge device having an envelope enclosing an anode, a cathode and a grid and being provided with externally accessible high frequency terminals of stepwise configuration, the anode and grid of said discharge device being coupled with the cylinders defining said first cavity resonator and the grid and cathode of said discharge device being coupled with the cylinders defining said second cavity resonator, tuning means comprising axially adjustable plungers in each of said cavity resonators for controlling the operating frequency of the oscillator and adjustable means connected to the intermediate cylinder for adjusting the axial position thereof to control the magnitude of the electrical oscillations transmitted from the first cavity resonator to the second cavity resonator.

5. An ultra high frequency space resonant oscillator comprising three telescoped conductive cylinders defining therebetween two cavity resonators, an electric discharge device having an envelope enclosing an anode, a cathode and a grid each provided with a metallic supporting disk providing individual externally accessible high frequency terminals, the inner cylinder being coupled to the disk connected to said anode, the intermediate cylinder being coupled to the disk connected to said grid and the outer cylinder being coupled to said cathode, adjustable tuning means in said resonators for tuning said resonators to control the operating frequency of said oscillator, a cylinder conductively connected to said grid and extending an appreciable distance around said intermediate cylinder, and adjustable means connected to said intermediate cylinder for controlling the coupling between said resonators comprising adjusting means for adjusting the axial position of said intermediate cylinder.

6. An ultra high frequency space-resonant oscillator comprising three telescoped cylinders defining first and second cavity resonators therebetween, an electric discharge device having an envelope enclosing an anode, a cathode and a grid each provided with an externally accessible disk constituting a high frequency terminal, the inner cylinder being coupled to the disk connected to said anode, the intermediate cylinder being coupled to the disk connected to said grid and the outer cylinder being coupled to said cathode, a conductive grid cylinder coupled to the disk connected to said grid and extending an appreciable distance therefrom and surrounding at least a part of the intermediate cylinder, adjustable plunger means in said resonators for adjusting the effective length thereof to control the operating frequency of said oscillator, and adjustable means connected to the intermediate

cylinder for adjusting the axial position thereof within said grid cylinder for controlling the amplitude of the feedback voltage transmitted from said first resonator to said second resonator.

7. An ultra high frequency space-resonant oscillator comprising three telescoped conductive cylinders defining therebetween two cavity resonators, an electric discharge device having an envelope enclosing an anode, a cathode and a grid, each provided with a metallic supporting disk providing individual externally accessible high frequency terminals, the inner cylinder being coupled to the disk connected to said anode, the intermediate cylinder being coupled to the disk connected to said grid and the outer cylinder being coupled to said cathode, plunger means in each resonator for controlling the operating frequency of said oscillator, a grid cylinder conductively connected to said grid and extending an appreciable distance around said intermediate cylinder, means for controlling the coupling between said resonators comprising adjusting means connected to said intermediate cylinder for adjusting the axial position thereof, and a conductive connection between said grid cylinder and said intermediate cylinder.

8. An ultra high frequency space-resonant oscillator comprising three telescoped conductive cylinders defining therebetween two cavity resonators, an electric discharge device having an envelope enclosing an anode, a cathode and a grid, each provided with a metallic supporting disk providing individual externally accessible high frequency terminals, the inner cylinder being coupled to the disk connected to said anode, the intermediate cylinder being coupled to the disk connected to said grid and the outer cylinder being coupled to said cathode, adjustable tuning means in said resonators for tuning said resonators to control the operating frequency of said oscillator, a grid cylinder conductively connected to said grid and extending an appreciable distance around said intermediate cylinder, means for controlling the coupling between said resonators comprising adjusting means connected to said intermediate cylinder for adjusting the axial position thereof, and a conductive connection between said grid cylinder and said intermediate cylinder for impressing a biasing potential on said grid and for coupling the space between said grid cylinder and said intermediate cylinder to the resonator defined by the outer cylinder and the intermediate cylinder.

9. An ultra high frequency space-resonant oscillator comprising three telescoped conductive cylinders defining therebetween two cavity resonators, an electric discharge device having an envelope enclosing an anode, a cathode and a grid, each provided with a metallic supporting disk providing individual, externally-accessible, high frequency terminals, the inner cylinder being coupled to the disk connected to said anode, the intermediate cylinder being coupled to the disk connected to said grid and the outer cylinder being coupled to said cathode, adjustable tuning means in said resonators for tuning said resonators to control the operating frequency of said oscillator, a grid cylinder conductively connected to said grid and extending an appreciable distance around said intermediate cylinder, means for controlling the coupling between said resonators comprising adjusting means connected to said intermediate cylinder for adjusting the axial position thereof, and a conductive connection between said outer cylinder

and said grid cylinder for impressing a biasing potential on the grid of said discharge device.

10. An ultra high frequency space-resonant oscillator comprising three telescoped conductive cylinders defining therebetween two cavity resonators, an electric discharge device having an envelope enclosing an anode, a cathode and a grid, each provided with a metallic supporting disk providing individual externally accessible high frequency terminals, the inner cylinder being coupled to the disk connected to said anode, the intermediate cylinder being coupled to the disk connected to said grid and the outer cylinder being coupled to said cathode, adjustable tuning means in said resonators for tuning said resonators to control the operating frequency of said oscillator, a grid cylinder conductively connected to said grid and extending an appreciable distance around said intermediate cylinder, means for controlling the coupling between said resonators comprising means for adjusting the axial position of said intermediate cylinder, and a conductive connection between said outer cylinder and said grid cylinder for controlling the impedance encountered by electromagnetic waves emanating from the space defined by said intermediate cylinder and said grid cylinder.

11. A space-resonant system comprising three telescoped conductors defining a first cavity resonator between the inner conductor and the intermediate conductor and a second cavity resonator between the intermediate conductor and the outer conductor, an electric discharge device having an envelope enclosing an anode, a cathode and a grid and provided with externally accessible high frequency terminals, the anode and grid of said discharge device being coupled with the two conductors defining said first cavity resonator and the cathode and grid of said discharge device being coupled with the two conductors defining said second-mentioned cavity resonator, adjustable tuning means in at least one of said resonators to adjust the operating frequency of the system, a hollow conductor connected to the grid terminal and extending an appreciable distance along and spaced from said intermediate conductor, and conductive means connected between said intermediate conductor and said hollow conductor.

12. A space-resonant system comprising three telescoped conductors defining a first cavity resonator between the inner conductor and the intermediate conductor and a second cavity resonator between the intermediate conductor and the outer conductor, an electric discharge device having an envelope enclosing an anode, a cathode and a grid and provided with externally accessible high frequency terminals, the anode and grid of said discharge device being coupled with the two conductors defining said first cavity resonator and the cathode and grid of said discharge device being coupled with the two conductors defining said second cavity resonator, adjustable tuning means in at least one of said resonators to adjust the operating frequency of the system, a hollow conductor connected to the grid terminal and extending an appreciable longitudinal distance along and spaced from said intermediate conductor, and a metallic finger supported by said hollow conductor and in slidable engagement with said intermediate conductor for impressing on the grid of said discharge device a biasing potential and for coupling said second cavity resonator to the resonator defined by said hollow conductor and said intermediate conductor.

13. A space-resonant system comprising three telescoped conductors defining a first cavity resonator between the inner conductor and the intermediate conductor and a second cavity resonator between the intermediate conductor and the outer conductor, an electric discharge device having an envelope enclosing an anode, a cathode and a grid and provided with externally accessible high frequency terminals, the anode and grid of said discharge device being coupled with the two conductors defining said first cavity resonator and the cathode and grid of said discharge device being coupled with the two conductors defining said second cavity resonator, adjustable tuning means in at least one of said resonators to adjust the operating frequency of the system, a hollow conductor connected to the grid terminal and extending an appreciable distance along and spaced from said intermediate conductor, and a

metallic connection between said hollow conductor and said outer conductor to control the impedance of said second cavity resonator.

ANATOLE M. GUREWITSCH.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,169,396	Samuel -----	Aug. 15, 1939
2,251,569	Hansen -----	Aug. 5, 1941
2,259,292	Conklin -----	Oct. 14, 1941
2,270,949	Hulster -----	Jan. 27, 1942
2,272,374	Kallmann et al. ----	Feb. 10, 1942
2,284,405	McArthur -----	May 26, 1942
2,351,895	Allerding -----	June 20, 1944
2,400,753	Haefl -----	May 21, 1946