April 25, 1939.

G. A. HOBART, 3D

2,156,017

HIGH FREQUENCY APPARATUS

Original Filed Jan. 29, 1936

2 Sheets-Sheet 1

Fig. 1.

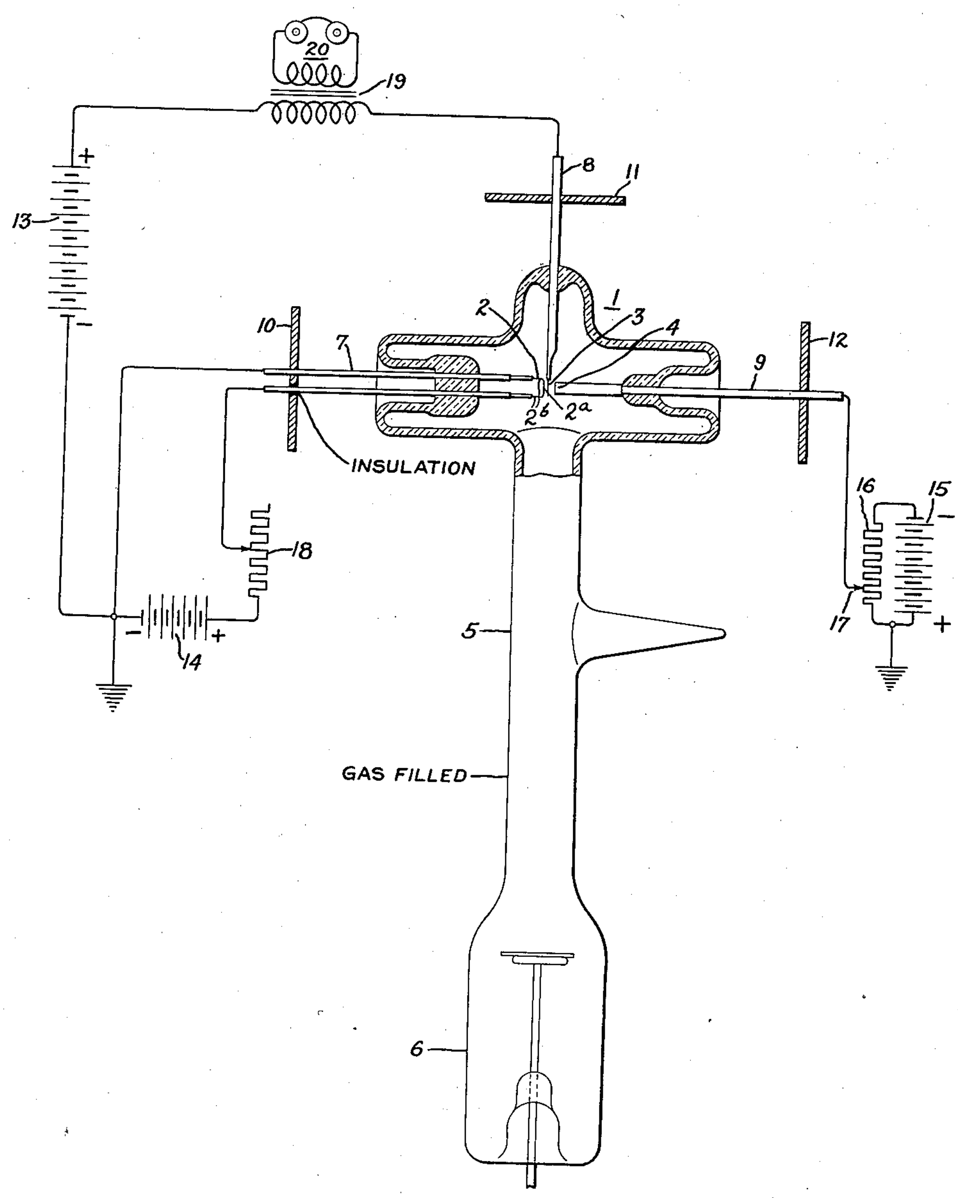

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Fig. 2.

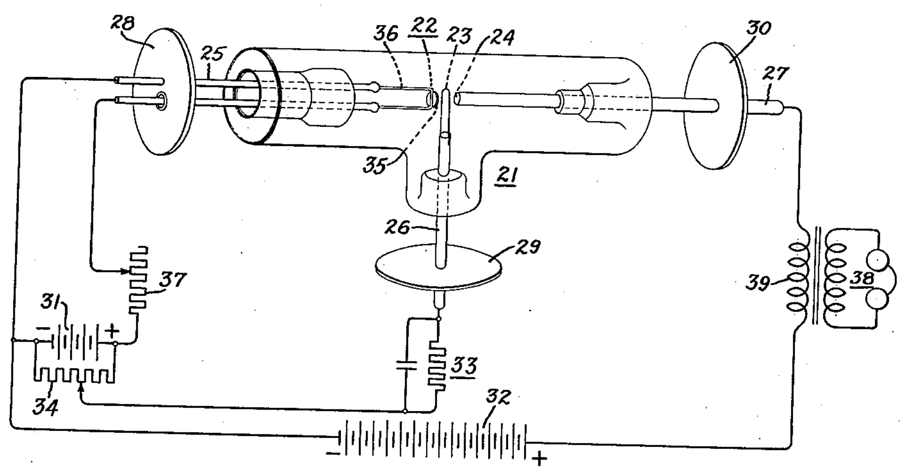
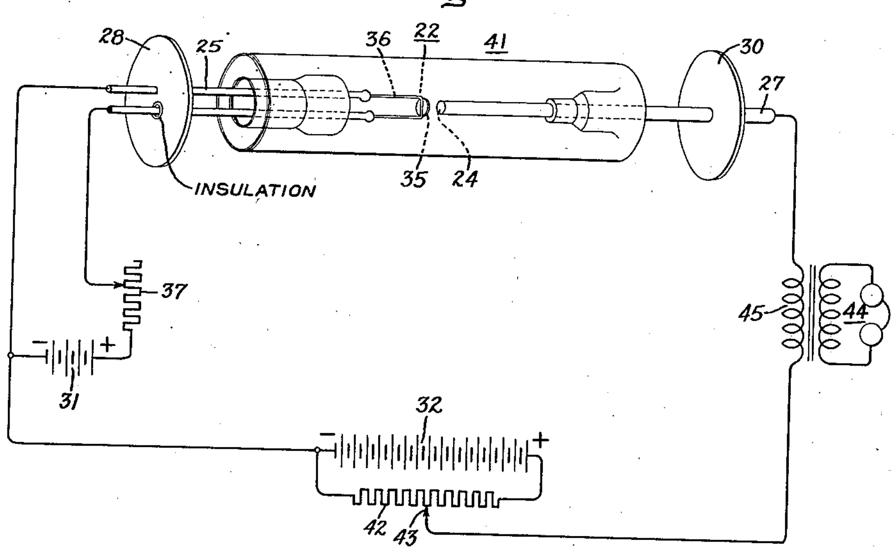


Fig. 3.



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UNITED STATES PATENT OFFICE

2,156,017

HIGH FREQUENCY APPARATUS

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Original application January 29, 1936, Serial No. 61,375. Divided and this application August 3, 1938, Serial No. 222,854

9 Claims. (Cl. 250—27)

This application is a division of my United States patent application, Serial No. 61,375, filed January 29, 1936, entitled High frequency apparatus, which is assigned to the same assignee as the present application.

The present invention relates to radio receiving systems and more particularly to receivers of extremely short wave lengths as, for example, wave lengths which may best be expressed in terms of centimeters and which I shall hereinafter refer to as centimeter waves.

An object of my invention is to provide improved means for receiving signal oscillations of extremely short wave length.

Another object of my invention is to provide such a receiver which is simple in its structure and in its adjustment and which is capable of orientation with facility with respect to the plane of polarization of received waves.

A further object of my invention is to provide a radio receiver of ultra-high frequencies in which the lead-in conductors to the tube elements are tuned as resonant transmission lines and, upon being suitably oriented with respect to the plane of polarization of a desired signal carrier wave, act as efficient collectors of signal energy.

An additional object of my invention is to provide an arrangement for receiving centimeter wave signal oscillations in which the cathode element of an electron discharge device employed in the arrangement is variably spaced at will from the grid and anode elements of the device whereby the sensitivity of the device is a maximum when the device operates to detect or amplify selected signal oscillations.

In certain types of short wave oscillation generators, for example, generators of the Barkhausen-Kurz types, the frequency of oscillations produced is dependent upon the time required for electrons to travel from the cathode to a second electrode of said discharge device. Hereinafter the term "electronic oscillations" will be used to designate oscillations whose frequency depends upon the electron transit time of the discharge device. In accordance with my invention means are provided whereby the spacing between such electrodes may be varied, even during operation of the device, thereby to vary the frequency of oscillations produced.

It has been found in accordance with my invention that the intensity of oscillations produced in such a system may be increased by the use of suitable gas within the discharge device.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings in which Figs. 1, 2, and 3 represent different embodiments of my invention.

Referring to Fig. 1 of the drawings I have illustrated at 1 a gas-filled electron discharge device having a U-shaped filament 2, a grid electrode 3, and a plate or anode electrode 4. A long side tube 5 with a getter bulb 6 at the bottom is provided to take care of the occluded gases of the device in the conventional manner. The filament, grid, and plate leads 7, 8, and 9 are provided with electrical tuning means such as metal disks 10, 11 and 12, respectively. The grid 3 is given a positive bias with respect to filament 2 by a suitable source of potential 13. A second source of potential 14 supplies the filament current necessary to heat filament 2 to its desired electron emission point. Plate 4 may either be maintained at filament potential, given a negative bias, or permitted to float on the system, as desired. A source of potential 15 having its positive side grounded and having a potentiometer 16 connected across it, may be connected to lead wire 9 through movable contact 17 for this purpose. When it is desired to have plate 4 float on the system contact 17 is removed entirely from potentiometer 16. When plate 4 is permitted to float, it acquires a charge due to the proximity of the other electrodes in the discharge device 1.

The high frequency oscillating circuit described above is similar to the conventional Barkhausen-Kurz oscillating circuit but the electron discharge device itself departs materially from the conventional Barkhausen-Kurz type which ordinarily has circular symmetry. By that I mean that a cylindrical grid is placed concentrically about the filament and a cylindrical plate is placed concentrically around the grid. In accordance with my invention a discharge device having the grid and plate electrodes located on one side only of the filament is provided. In Fig. 1 I have illustrated filament 2 as being constructed of a single loop of tungsten wire. Grid 3 is a straight piece of minute tungsten wire welded to grid lead 8. The plate electrode 4 of discharge device 1 is the butt end of the plate lead 9.

The size and spacings of the electrodes depends of course upon the frequency at which the oscillator is designed to operate. For example, when operating at a wave length of 4.8 centimeters I prefer to use a grid having a diameter of 1 thousandth of an inch, a filament having a diameter of 2 thousandths of an inch, and a plate having a diameter of 40 thousandths of an inch. For operating at this frequency, I use a spacing of 6 thousandths of an inch between filament **2** and plate **4** and place the grid approximately half way between filament **2** and plate **4** when cold.

If the above-described electron discharge device had a good vacuum maintained within it, oscillations would be generated of the Barkhausen-Kurz type. It has been found, however, that when the discharge device is filled with mercury vapor, the oscillation characteristics of the discharge device are greatly improved. Of course, as in all mercury-filled discharge devices, the pressure of the gas is determined by the ambient temperature of the discharge device, or at least by the temperature of the coolest portion of the discharge device. By a variation of the temperature the best operating temperature may be ascertained for any particular discharge device, but it has been found that very satisfactory operation may be obtained at ordinary room temperatures. It is my belief that this improved performance is due to a condition of plasma resonance within the discharge device. The term "plasma" refers to a condition of equilibrium in an electron discharge device where the number of free electrons equals the number of free positive ions. Very little is known at the present time about plasma electron oscillations, but it is thought that the period of these oscillations is a function of the number of free electrons and of the boundary conditions of the plasma. It is further thought that plasma electron oscillations are not self-sustaining. It is therefore my belief that Barkhausen-Kurz oscillations occur in the above-described mercury vapor discharge device which when of the same frequency as the plasma electron oscillation frequency, have a greatly increased oscillation amplitude.

Oscillations of the Barkhausen-Kurz type are sometimes called electronic oscillations for the reason that the oscillation frequency is dependent upon the time that it takes an electron to describe an orbit within the electron discharge device. Since the oscillation frequency is dependent primarily upon the electron transit time, it is apparent that control of the frequency of oscillation may be obtained by regulating the inter-electrode spacings. By placing a variable resistor **18** in the filament heating circuit, I obtain a simple means for adjusting the spacing between the filament and grid after the discharge device has been built. Filament **2** is so constructed as to have a cathode portion **2**a which is spaced in parallel relation to the grid **3** and to have leg portions **2**b which are perpendicular to the grid. The entire filament including the cathode and leg portions expands and contracts in response to variations in filament current. Consequently, because of its U-shape, contraction and expansion of the legs of the U causes the spacing between the cathode portion **2**a and grid **3** to vary as a function of filament current. The electron emission characteristics of the filament do not appear to be very critical and for this reason a small change in the filament current does not seriously affect the electron emission of the discharge device.

Tuning disks **10**, **11**, and **12** are moved back and forth along their respective conductors until the desired oscillation amplitude occurs in the oscillating circuit. Presumably, when these tuning disks are adjusted for maximum amplitude, they are located on their respective conductors at potential nodes. At points of potential nodes they present a low impedance to ground and hence cause a maximum reflection of energy at such points. The tuning disks as thus located on their respective conductors operate as transmission lines tuned, in the case of at least the cathode and the grid conductors, to what is believed an odd number of one-quarter wave lengths of received signal oscillations. The glass seal through which each of the conductors **7**, **8** and **9** extends produces an abrupt change in the value of the standing potential along these conductors and, in view of the very high frequency at which the system operates, renders it difficult precisely to determine that the conductors have a length equal to a definite number of one-quarter wave lengths of the wave at which the system operates. The system appears to operate best when the plate conductor **9** is tuned by the disk **12** to what is believed to be substantially an even number of one-quarter wave lengths of the wave at which the system operates. The tuning of the plate conductor has been found not critical for those values of plate potential which it has been necessary to employ to obtain proper operation of the system with the tubes thus far available.

While it is to be understood that my invention may be applied either to a receiving or a transmitting system, I have illustrated diagrammatically an impedance **19** in the grid cathode circuit of the oscillator through which the oscillator is coupled to an audio output device **20**. It is not necessary to have a separate antenna to pick up ultra high frequency radio waves for conductor **8** when properly oriented with respect to the transmitter antenna acts as an efficient antenna for the receiving system.

It will be noticed in Fig. 1 that the grid structure is perpendicular to the axis containing the filament and plate elements. This construction makes it possible to impress a plane polarized electric wave on the grid electrode alone without setting up current in the filament-plate circuit. It has been found, however, that when the discharge device is mounted so that a line bisecting the angle between the grid and plate conductors is in the plane of polarization of the received signal, good results are obtained. While the reason for this is not entirely clear, it is evident that the potential between the grid **3** and cathode **2**a is equal at any instant to the sum of the instantaneous signal potentials induced in the grid and filament conductors. Further, the induced potentials are proportional to that component of the polarized signal field gradient which lies along the direction of a respective conductor. This in turn is proportional to the cosine of the angle which the conductor makes with the plane of polarization of the received signals. It is therefore believed that the mounting of the tube with the grid and filament conductors at an angle of 45° to the plane of polarization results in good reception of the signal by virtue of the fact that the induced potentials on the grid and filament conductors is 1.414 larger than is the case where the grid conductor is parallel to the plane of polarization of the signal. However, rotation of the tube to position the grid, filament and plate conductors at an angle to the plane of polarization causes a signal potential to be induced in the plate conductor, the effect of which on the operation of the sytsem is not known, but may add materially to the sensitivity of the system. It has been found that this relation of grid structure to filament and plate elements is highly desirable in the reception of centimeter radio waves for such waves maintain their original state of plane polarization, and do not become elliptically polarized as do long waves.

Referring to Fig. 2, wherein I have illustrated a second embodiment of my invention, I have illustrated at **21** an electron discharge device of either the high vacuum type or of the gas-filled type having a cathode **22**, a grid **23**, and a plate **24**. The cathode, grid, and plate leads **25**, **26**, and **27** are provided with electrical tuning means such as metal disks **28**, **29**, and **30** respectively. A source of potential **31** supplies the filament current necessary to heat cathode **22** to its desired electron emission point and simultaneously obtain the most favorable spacing characteristic. Plate **24** is given a positive bias by a second source of potential **32**. The grid **23** is either left floating (not shown) or is biased in the conventional manner through a grid leak **33** from potentiometer **34** when the discharge device is operating as a short wave grid leak detector.

It has been found that under certain circumstances, better operation may be obtained by increasing the electron emission area of the filament. In this modification of my invention, I have achieved this result by welding metal disk **35**, preferably of nickel, directly to the end of the single loop tungsten filament **36**. This type of cathode should be distinguished from the conventional indirectly heated cathode type in which no electrical contact exists between the electron emitting element and the filament. The nickel disk **35** of my invention, on the contrary, is electrically part of the filament and filament current flows through the disk.

A variable resistor **37** is provided in the filament heating circuit for the purpose of varying the magnitude of the current flowing through filament **36**. By regulating the amount of current flowing through filament **36**, the spacing between cathode **22** and the other electrodes of discharge device **21** may be controlled, as described in connection with Fig. 1.

An audio output or work circuit **38** is coupled to the oscillator circuit through impedance **39** as is indicated in Fig. 2.

A different embodiment of my invention is illustrated in Fig. 3 wherein I have shown a diode **41** constructed in accordance with my invention. Diode **41** is similar to discharge device **21** of Fig. 2 with the exception that the grid electrode is left out. A slight change is also indicated in the plate biasing circuit whereby the magnitude of the bias may be adjusted. A potentiometer **42** is provided across potential source **32** for this purpose. Movable contact **43** of potentiometer **42** is connected to the plate lead **27**. Diode **41** has been found to constitute an effective centimeter wave detector when cathode temperature and plate bias are properly adjusted. An audio output or work circuit **44** is coupled to the oscillator circuit through impedance **45** as is indicated in Fig. 3.

While I have shown particular embodiments of my invention, it will, of course, be understood that I do not wish to be limited thereto since many modifications may be made both in the circuit arrangement and in the instrumentality employed, and that I therefore contemplate by the appended claims to cover all 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. In a high frequency radio receiving system, the combination comprising an electron discharge device having cathode, grid, and plate electrodes, a conductor connected to each of said electrodes and tuned substantially to a number of one-quarter wave lengths of the wave at which said system operates, said conductors being arranged in a manner such that when said grid conductor is in the polarization plane of a received signal the cathode and plate conductors are perpendicular to the polarization plane, and means for detecting the received signal.

2. In a high frequency radio receiving system, the combination comprising an electron discharge device having cathode, grid, and plate electrodes, a conductor connected to each of said electrodes, means for tuning the portions of said conductors immediately adjacent said electrodes as transmission lines of a length equal substantially to a number of one-quarter wave lengths of the wave at which said system operates, said grid conductor being perpendicular throughout its tuned portion to a line extending between said cathode and plate conductors, and means for detecting the received signal.

3. In a high frequency radio receiving system, the combination comprising an electron discharge device having cathode, grid, and plate electrodes, a conductor connected to each of said electrodes, means for tuning the portions of said conductors immediately adjacent said electrodes as transmission lines of a length equal substantially to a number of one-quarter wave lengths of the wave at which said system operates, said conductors being arranged in a manner such that when a line bisecting the angle between said plate conductor and said grid conductor is in the plane of polarization of a received signal a line bisecting the angle between said cathode and said grid conductors is perpendicular to the plane of polarization of the received signal, and means for detecting the received signal.

4. The method of reception of oscillations upon an electron discharge device having a cathode, a control electrode, an anode, and lead conductors therefor, the portions of said conductors immediately adjacent said electrodes being tuned substantially to a number of one-quarter wave lengths of the wave at which said system operates, the tuned portion of the lead conductor for said control electrode extending at right angles to the tuned portion of other of said lead conductors, which comprises so orienting said discharge device that the tuned portion of said control electrode lead conductor is parallel with a plane of polarization of the wave to be received and intercepts said wave whereby said wave is not materially intercepted by the tuned portion of other of said lead conductors.

5. The method of reception of oscillations upon an electron discharge device having a cathode, a control electrode, and an anode and lead conductors therefor, the portions of said conductors immediately adjacent said electrodes being tuned substantially to a number of one-quarter wave lengths of the wave at which said system operates, the tuned portion of the lead conductor for said control electrode extending at an angle to the tuned portion of other of said lead conductors, which comprises so orienting said discharge device with respect to the plane of polarization of

the wave to be received that the line bisecting the angle between the tuned portion of said anode and grid conductors is parallel with the plane of polarization of said wave.

6. The combination, in a radio receiver of ultra-high frequencies, of an electron discharge device having electrodes including a cathode whose effective electron emitting portion is substantially linear, an anode, and a linear grid aligned with and disposed between said cathode and said anode, conductors connected to said electrodes, means for tuning the portions of said conductors immediately adjacent said electrodes as transmission lines each substantially to an odd number of one quarter wave lengths of desired signal oscillations, means including grid-cathode and anode-cathode circuits for impressing unidirectional potentials on said grid and said anode with respect to said cathode, means for supplying signal oscillations to the tuned portion of at least one of said conductors, a translating device, and means for supplying signal oscillations appearing in said grid-cathode circuit to said translating device.

7. The combination, in a radio receiver of ultra-high frequencies, of an electron discharge device having elements including a cathode, an anode, and a grid, conductors connected to each of said elements, means for tuning to resonance with desired signal oscillations a portion of each of said conductors immediately adjacent the element to which it is connected, said anode and said cathode conductor tuned portions being substantially linearly aligned each with the other in substantially perpendicular relation to said grid conductor tuned portion, means including grid-cathode and anode-cathode circuits for impressing on said grid a positive unidirectional potential and on said anode a negative unidirectional potential each considered with respect to said cathode, means for impressing signal potentials between said grid and said cathode, and means for translating modified signal energy appearing in said grid-cathode circuit.

8. In a radio receiver of high frequencies, the combination of an electron discharge device having a linear cathode, an anode, and a linear grid arranged parallel to said cathode, means including a linear conductor connected to said grid and having a tuned portion immediately adjacent said grid for receiving desired signal oscillations, means for supplying a positive unidirectional potential to said grid and a negative unidirectional potential to said anode each considered with respect to said cathode whereby orbital transit time movements of cathode-emitted electrons are effected, and means for varying the spacing between said cathode and said grid to establish the most sensitive operating condition of said electron discharge device for the reception of said desired signal oscillations.

9. In a radio receiver of high frequencies, the combination of an electron discharge device having a cathode, an anode, and a grid, means including linear conductors connected to said cathode, said anode, and said grid each having a tuned portion immediately adjacent the element to which the conductor is connected for receiving desired signal oscillations, means for energizing said cathode, means for supplying unidirectional potentials to said grid and to said anode each with respect to said cathode to establish orbital transit time movements of cathode emitted electrons, means responsive to increasing values of cathode energization for effecting increasing changes of spacing of said cathode with said grid and anode, and means for controlling the value of energization of said cathode whereby said last-named means effects said changes of spacing thereby to change said electron orbital transit time to control the sensitiveness of said electron discharge device in receiving said desired signal oscillations.

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