April 25, 1939. G. A. HOBART, 3D 2,156,016

HIGH FREQUENCY APPARATUS

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Fig. 1.

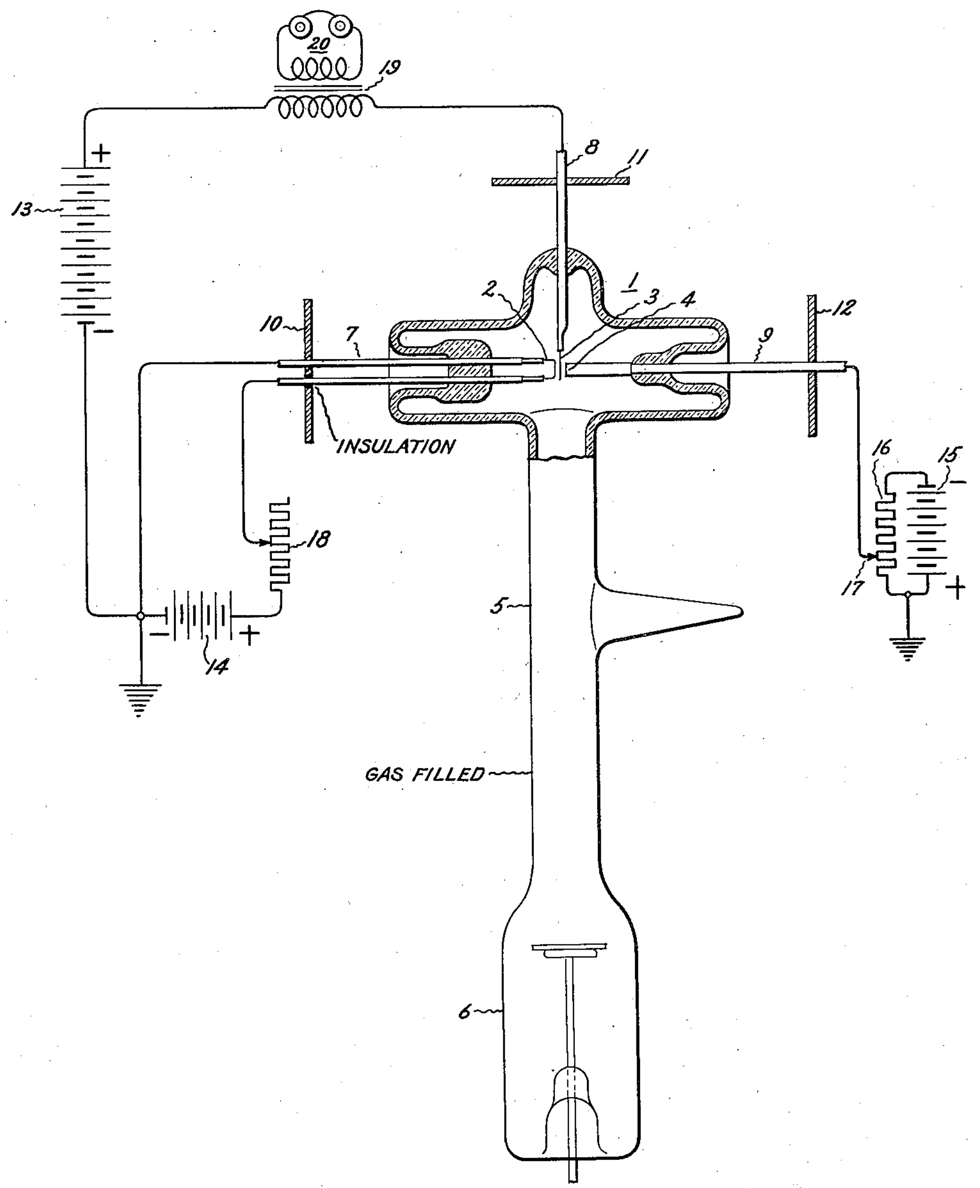

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Fig. 2.

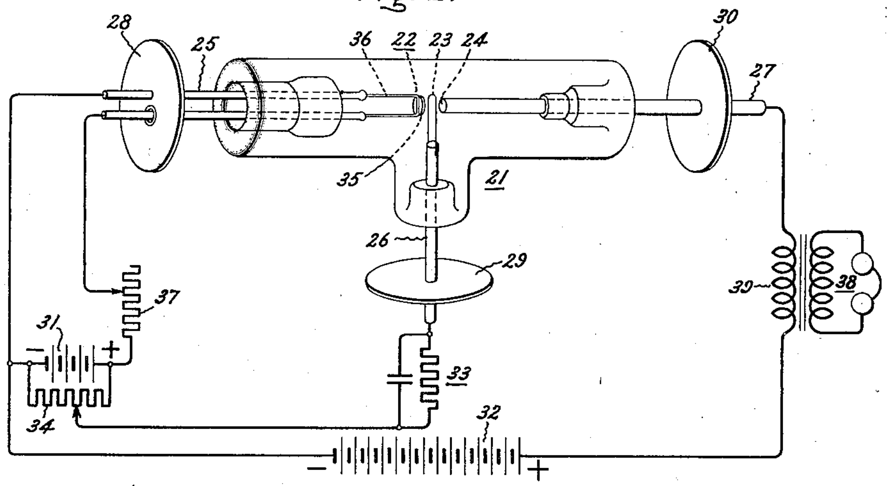
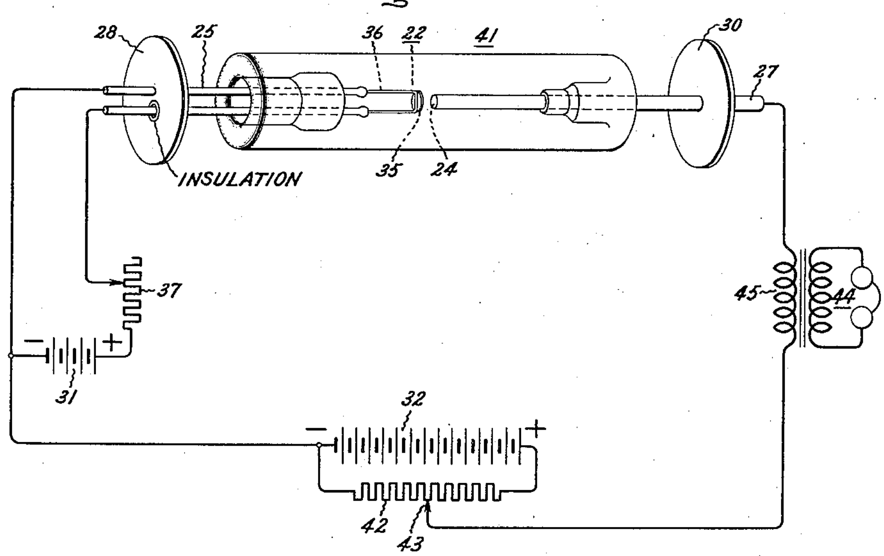


Fig. 3.



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UNITED STATES PATENT OFFICE

2,156,016

HIGH FREQUENCY APPARATUS

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Application January 29, 1936, Serial No. 61,375

12 Claims. (Cl. 250—36)

My invention relates to high frequency apparatus, and more particularly to apparatus adapted for operation at 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.

It has for one of its objects to provide certain improvements in such apparatus whereby waves of very short wave length may be generated with increased intensity.

A further object of the invention is to provide novel and improved means for controlling the frequency of such oscillations.

A further object of my invention is to provide means for varying the spacing between electrodes employed in discharge devices operating at such wave lengths.

A still further object of my invention is to provide an improved type of filament in electron discharge devices.

In certain types of short wave oscillation generators, for example, generators of the Barkhausen-Kurz type, 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 also 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 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 ordinariy has circular symmetry. By that I means 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, causes 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 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 filament 2 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.

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 that when the discharge device is mounted so that a line bisecting the angle between the grid and anode conductors is in the plane of polarization of the received signal, good results are obtained. 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.

The several modifications of the receiving system shown in this application are the subject of and are claimed in my divisional application Serial No. 222,854, filed Aug. 3, 1938, entitled high frequency apparatus.

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. An electron discharge device comprising a U-shaped filament and at least one additional electrode arranged at a distance from said filament dependent upon the length of the legs of the U, means for causing the legs of said U-shaped element to expand or contract thereby to vary the electrode spacing of said electron discharge device, and means to operate said discharge device within a range of frequency at which the transit time of the electrons between said filament and electrode is material in the operation of said device.

2. The combination comprising an electron discharge device having a cathode, a plate and a grid electrode, means for establishing oscillations in said discharge device having a frequency dependent upon the transit time of electrons emitted by said cathode, and means for varying the spacing between said cathode and said grid electrode, thereby to vary the electron transit time.

3. In an electron discharge device comprising a U-shaped filament and at least one additional electrode, an electron emitting disk mounted on the end of said U-shaped filament and in good electrical contact therewith, means for establishing a current through said filament, means for varying the electrode spacing in said discharge device to an extent usefully to affect the operation of said discharge device by varying the magnitude of said current, and means to operate said device within a range of frequency at which the transit time of electrons between said disk and electrode is material in the operation of said device.

4. A high frequency oscillator comprising a gas-filled electron discharge device having a cathode, a grid electrode and a plate electrode, means for heating said cathode, means for biasing said grid positive with respect to said cathode, and means for maintaining said plate at a potential negative with respect to said cathode.

5. A high frequency oscillator comprising an electron discharge device filled with a gas, and means for generating oscillations in said device having frequency dependent upon the time required for an electron to traverse its path in space within said discharge device.

6. A high frequency oscillator comprising an electron discharge device, means for creating a plasma in said device, and means for producing oscillations in said device having frequency dependent upon the time required for an electron to traverse its path in space within said discharge device.

7. A high frequency oscillator comprising an electron discharge device, means for creating a plasma in said device, and means for producing electronic oscillations in said device having frequency dependent upon the time required for an electron to traverse its path in space within said discharge device.

8. An electron discharge device having a cathode and at least one additional electrode spaced therefrom, means connected to operate said discharge device at a frequency at which the transit time of electrons between said cathode and electrode is material in the operation of said device, and means to vary the spacing between said cathode and electrode to vary said transit time.

9. An electron discharge device having a cathode and at least one additional electrode spaced therefrom, means connected to operate said discharge device at a frequency at which the transit time of electrons between said cathode and electrode is material in the operation of said device, said cathode being mounted on a thermally expansible conducting support, and means to heat said support to cause variation in spacing between said cathode and electrode to vary said transit time.

10. An electron discharge device having a cathode and at least one additional electrode spaced therefrom, means connected to operate said discharge device at a frequency at which the transit time of electrons between said cathode and electrode is material in the operation of said device, an expansible conducting member supporting one of said electrodes, and means to pass current through said conducting member to cause expansion thereof, thereby to vary the spacing between said cathode and electrode.

11. An electron discharge device having a cathode and at least one additional electrode spaced therefrom, means connected to operate said discharge device at a frequency at which the transit time of electrons between said cathode and electrode is material, and means to vary said frequency by varying the spacing between said cathode and electrode.

12. In an electron discharge device having at least two electrodes and an output circuit coupled thereto operating at a frequency at which the spacing between said electrodes is material, the method of operation which includes varying said spacing during the operation of said device sufficiently materially to affect the transit time of electrons between said electrodes.

GARRET A. HOBART, 3D.