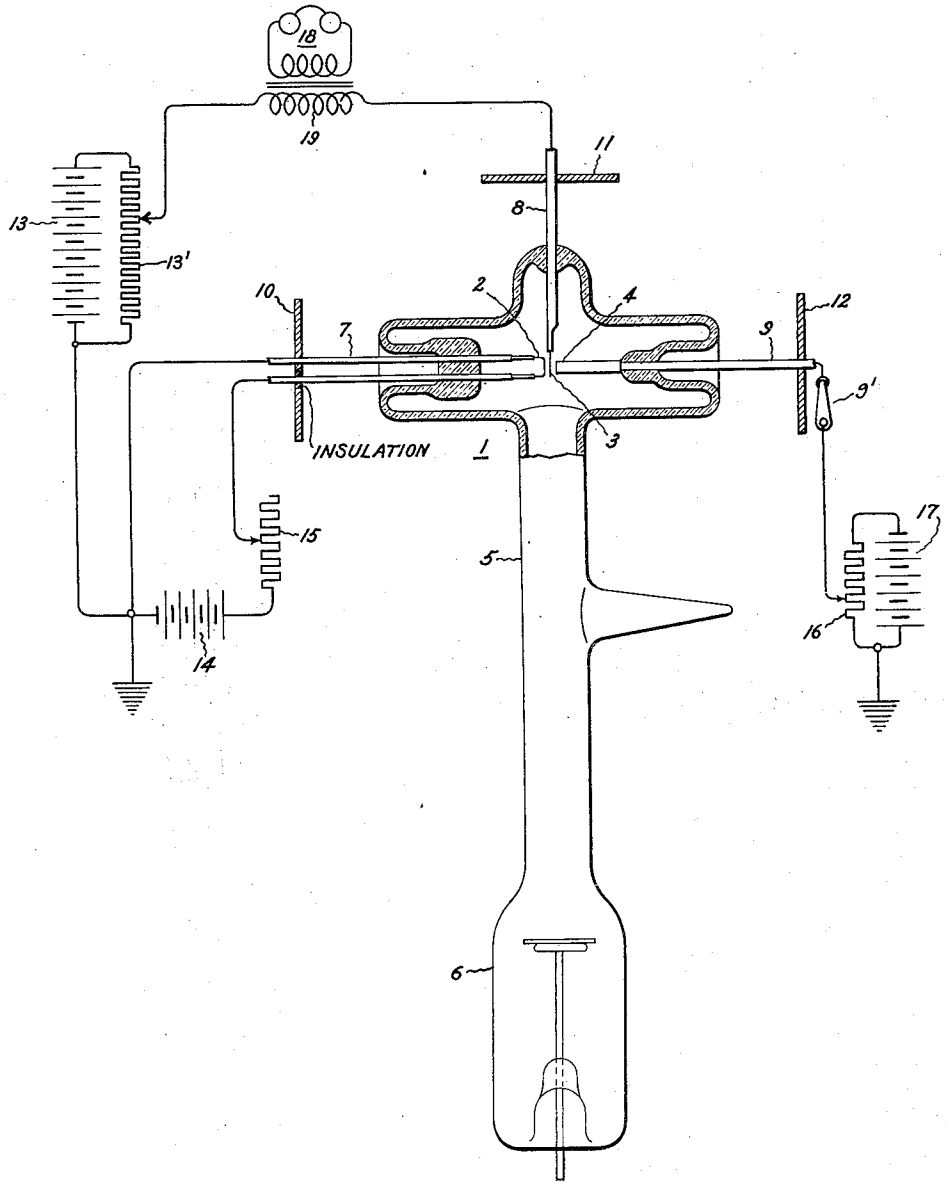
April 25, 1939. C. W. RICE 2,156,029

HIGH FREQUENCY OSCILLATOR

Filed Jan. 29, 1936



Inventor:
Chester W. Rice,
by Harry E. Dunham
His Attorney.

Patented Apr. 25, 1939 2,156,029

UNITED STATES PATENT OFFICE

2,156,029

HIGH FREQUENCY OSCILLATOR

Chester W. Rice, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application January 29, 1936, Serial No. 61,378

2 Claims. (Cl. 250—36)

My invention relates to a high frequency oscillator and more particularly to one which generates oscillations in the Barkhausen-Kurz manner.

In speaking of a Barkhausen-Kurz oscillator, I refer to a three-element electron discharge device in which the conventional grid electrode is given a positive potential with respect to the negative end of the cathode. The plate electrode may be given a bias, zero or negative with respect to the cathode potential, or it may be permitted to float on the system. By floating I mean that the plate electrode is not electrically connected to any other part of the circuit but acquires a charge due to its proximity to the other electrodes in the electron discharge device. A Barkhausen-Kurz oscillator may be further defined as one whose oscillation frequency is dependent upon the average transit time of the electrons in their orbital motions within the electron discharge device.

It is an object of my invention to provide an electron discharge device which is capable of oscillating at very short wave lengths.

It is a further object of my invention to provide an electron discharge device capable of oscillating at very short wave lengths in which the electrodes therein are linearly disposed with respect to each other.

It is a still further object of my invention to provide an improved electrical tuning means for a high frequency oscillating system.

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 drawing, the single figure of which illustrates diagrammatically a high frequency oscillator embodying my invention.

Referring to the single figure of the drawing, I have illustrated at 1 a high vacuum 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 each provided with an electrical tuning means such as metal disks 10, 11 and 12 respectively, the function of which will hereinafter be more fully explained. Grid 3 is given a positive bias with respect to filament 2 by a suitable source of potential 13, the value of which may be adjusted through a potentiometer 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, or given a negative bias depending upon the position of the movable contact on potentiometer 16; or it may be permitted to float on the system by opening switch 9' in plate lead 9.

While the method of biasing the electron discharge device is similar to the conventional manner of biasing a discharge device for the production of Barkhausen-Kurz oscillations it will be seen that my invention departs widely from the conventional Barkhausen-Kurz oscillator both with respect to the discharge device and the circuits in which it is employed. The electron discharge device departs from the conventional Barkhausen-Kurz type which ordinarily has circular symmetry. By that, I mean that a cylindrical grid is disposed concentrically about a filament and a cylindrical plate is disposed concentrically about the grid.

Where the discharge device is to be used for the generation of very high frequency oscillations, I prefer to use a discharge device having the grid and plate electrodes located on one side only of the filament. In the embodiment of my invention illustrated in the drawing, filament 2 is a single loop of tungsten wire, and grid 3 is a straight piece of minute tungsten wire welded to grid lead 8. The grid and active portion of the filament, i. e. the bottom of the U, are parallel. The plate electrode 4 is simply the butt end of the plate lead 9. The size and spacing of the electrodes in discharge device 1 depend 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. When operating at this wave length, I use a spacing of 6 thousandths of an inch between filament 2 and plate 4, the grid being located midway between filament and plate when cold.

This linear arrangement of filament, grid, and plate electrodes permits the construction of an electron discharge device capable of operating at a much higher frequency than that possible with the conventional Barkhausen-Kurz oscillator previously referred to. Where an electron discharge device has circular symmetry it is im-

practicable to construct it to operate at wave lengths of less than about 15 centimeters at the fundamental wave length.

The use of a single straight grid wire disposed directly between the filament 2 and plate 4 appears greatly to improve the operation and practicability of manufacture of the electron discharge device over the use of the conventional multi-wire grid. This is probably due to the fact that the orbital path of electrons in the discharge device is largely dependent upon the location and size of positively biased elements in the device and since the oscillating frequency is primarily a function of the electron transit time, the precise position of such element or elements is important.

By employing at the intermediate electrode a single straight wire of a diameter which is a small fraction of the diameter of the plate the number of electrons emitted from the cathode which are intercepted by the intermediate electrode in one transit across the interelectrode space is reduced to a small number, the electrons thus being permitted to continue in their orbital course past the intermediate electrode and back and forth between the cathode and plate and about the intermediate electrode which is, of course, at positive potential relation to the other electrodes. This orbital motion of the electrons induces into the electrodes electromotive forces which excite the desired oscillations in conductors connected thereto. The frequency of these oscillations is dependent upon the time required for transit of the electrons about their orbits. This time I refer to as the orbital transit time of the electrons.

One of the important features of my invention is the method used for electrical tuning. While variations in the external circuit characteristics do not greatly alter the frequency with which the electron discharge device oscillates, proper tuning of the external circuit is necessary in order to obtain maximum oscillation amplitude. In order to obtain maximum reflection and thereby maximum oscillation amplitude, it is necessary to present an abrupt change of impedance at some point along each electrode lead wire. This may be accomplished by the use of a metal disk placed at such a point along an electrode lead conductor that an approximate node of potential is produced at the point where the disk is located. Accordingly, a metal disk 10 is placed on and electrically connected to filament lead 7, a second disk 11 on and connected to grid lead 8, and a third disk 12 on plate lead 9. One of the two holes in disk 10 is provided with insulation to prevent shorting the filament circuit. Disks 10, 11 and 12 are so designed that they may be moved back and forth along their respective conductors until maximum oscillation amplitude in the electron discharge device is obtained. These disks serve to confine the oscillations produced to the desired portions of the conductors and to exclude them from portions of the conductors beyond the disks from the discharge device.

A variable resistor 15 is placed in the filament circuit in order to obtain the desired filament temperature. By varying the current flowing through filament 2, the operating temperature of the filament varies and hence, the filament expands and contracts in response to variations in filament current. Consequently, because of its U-shape filament 2 is moved nearer to or farther away from the other electrodes in response to variations in filament current. The best filament operating temperature is a compromise between emission and spacing.

The plate conductor 9 is connected to the potentiometer 16 which is connected across a source of potential 17 having its positive side grounded. Potentiometer 16 provides the desired adjustable negative bias.

It is to be understood that the above described oscillating circuit may be used either in a receiving system or a transmitting system. In the single figure of the drawing, I have illustrated an audio output or work circuit 18 coupled to the oscillator circuit through an impedance 19 connected in the grid-cathode circuit of the oscillator. When operating as a receiver it is not necessary to use a separate element as an antenna for the high frequency waves are efficiently picked up by grid conductor 8 when the discharge device is properly oriented with respect to the transmitter antenna, i. e. when conductor 8 is properly oriented with respect to the plane of polarization of the transmitted waves.

The operation of the high frequency oscillator described as a detector for ultra short waves is as follows: With some suitable negative plate bias such as —20 volts on plate 4 and grid 3 positively biased by potential source 13 to some suitable value such as 125 volts and a filament current of approximately 1 ampere, oscillations of the Barkhausen-Kurz type will be set up in discharge device 1. Tuning disks 10, 11 and 12 are then moved along their respective conductors until the conditions for maximum oscillation amplitude are found. The values given above are typical of those used when receiving 4.8 centimeter radio waves.

The operation of my high frequency oscillator for purposes other than detecting is similar to that described above.

While I have described with particularity an electron discharge device employed in accordance with my invention in which the cathode comprises a single conductor disposed in parallel relation with a single wire grid and in alignment with said grid and a plate, it will be understood that this is by way of illustrating the preferred form of my invention and one by which I have been able to produce oscillations of the highest frequency with comparative facility in the construction and adjustment of the apparatus. I do not wish, however, to be limited to such a construction since I have found that good results may be obtained if the grid comprises a plurality of conductors disposed side by side in a plane between the plate and cathode. Further, the cathode may likewise be so formed, the plane thereof being parallel to the plane of the grid conductors. Other modifications both in the structure and circuit arrangement of the apparatus employed may be made without departing from the spirit and scope of my invention and I contemplate by the appended claims to cover any 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 combination, an electron discharge device, an electrode comprising a wire having a free end within said discharge device, a cathode electrode abutting, but spaced from the end of said wire, and a third electrode comprising a single straight wire interposed in the space between said cathode and first wire, means to produce a potential on said third electrode positive with respect to said cathode and first wire where-

by electrons emitted from said cathode travel in an orbital path about said third electrode and excite oscillations in said electrodes having a wavelength dependent upon the orbital transit time of said electrons and not greater than fifteen centimeters.

2. In combination, an electron discharge device, an electrode comprising a wire having a free end within said discharge device, a cathode electrode abutting, but spaced from the end of said wire and a third electrode comprising a single straight wire interposed in the space between said cathode and first wire, means to produce a potential on said third electrode positive with respect to said cathode and first wire whereby electrons emitted from said cathode travel in an orbital path about said third electrode and excite oscillations in said electrodes having a wavelength dependent upon the orbital transit time of said electrons, the diameter of said third electrode being a small fraction of the diameter of said free end of said first wire whereby said third electrode intercepts but a small fraction of the electrons emitted by said cathode during a single transit across the space within the discharge device, and the spacing and potentials between said electrodes being such that said wavelength of the oscillations produced is not greater than fifteen centimeters.

CHESTER W. RICE.