

Dec. 6, 1938.

R. A. HEISING

2,139,230

HIGH EFFICIENCY OSCILLATOR OF THE BARKHAUSEN TYPE

Filed April 13, 1935

FIG. 1

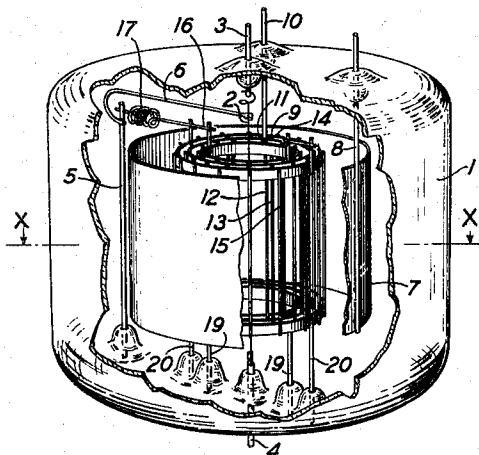


FIG. 2

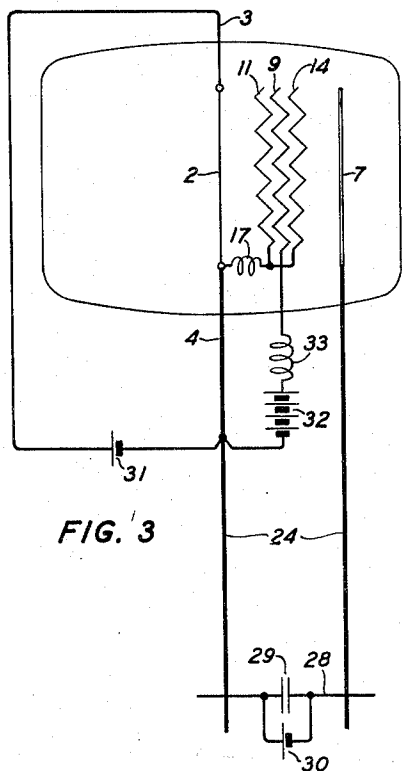
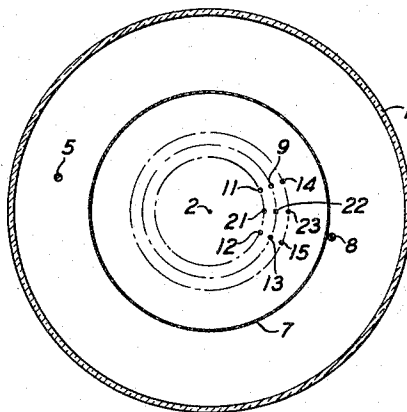


FIG. 3

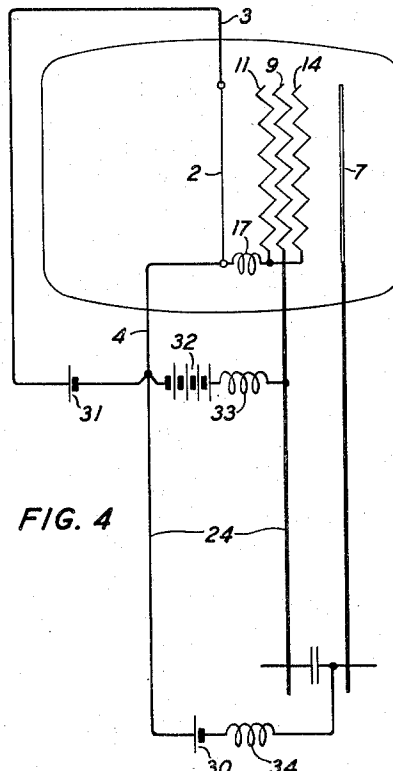


FIG. 4

INVENTOR
R. A. HEISING
BY
E. V. Briggs
ATTORNEY

UNITED STATES PATENT OFFICE

2,139,230

HIGH EFFICIENCY OSCILLATOR OF THE
BARKHAUSEN TYPERaymond A. Heising, Summit, N. J., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

Application April 13, 1935, Serial No. 16,179

6 Claims. (Cl. 250—36)

This invention relates to high efficiency ultra short wave oscillator circuits of the Barkhausen type. As is well known, the Barkhausen oscillator circuit involves an electron discharge device having a cathode which serves to emit electrons, a grid element to which a high potential positive with respect to that of the cathode is applied and an anode which is maintained at or near the potential of the cathode. Electrons from the cathode are impelled toward the grid and the anode under the influence of the strong electric field between the positive grid and the cathode. Some of the electrons thus attain high velocities and in their outward course from the cathode happen not to collide with an element of the grid but to pass through one of its interstices. Their subsequent course from the region of the grid toward the anode is attended with a braking or retarding effect on account of the fact that the anode is at a potential approximately that of the cathode and, accordingly, the direction of the electric field with respect to the motion of the electron is opposite to that in the space between the cathode and grid. Consequently, the electron is repelled by the anode and decelerated. The electron finally comes to rest and reverses its direction, returning with an accelerating velocity toward the positive grid. The duration of these excursions of the electrons through the grid is determined chiefly by the inter-electrode distances and the electrode potentials. During each transit past the grid a cloud of electrons loses some of its number which are attracted to and absorbed by the highly positive grid elements. These absorbed electrons are accordingly removed from the oscillating operation and give rise to a large grid current which is responsible for a large portion of the energy loss in a Barkhausen oscillator.

An object of the invention is to increase the efficiency of Barkhausen oscillators by reducing the energy loss occasioned by current in the circuit connecting the cathode and the highly positive grid.

In accordance with the invention, a Barkhausen oscillator comprises an electron discharge device having a cathode, a highly positive grid and an anode, the device being so constructed that electrons emitted from the cathode find no linear or direct free path to the positive grid and electrons returning from the region of the anode likewise find no linear free path to the positive grid. This is accomplished by deflecting grids, having a potential which may be low with respect to that of the positively polarized grid or which

may approximate the cathode potential, one of which is placed between the cathode and the highly positive grid so that all direct linear paths from the cathode to the positive grid are intercepted by elements of the deflecting grid. A second deflecting grid is placed between the highly positive grid and the anode and polarized like the first so that substantially all paths which an electron may take in returning from the anode zone toward the positive grid are intercepted by elements of the second or outer deflecting grid. In order that the two deflecting grids may effectively intercept the direct linear paths to the positive grid, it is desirable that each have a configuration similar to that of the grid or, in other words, be provided with a similar number of grid elements so placed that a direct line from the cathode to an element of the positive grid will pass through corresponding elements of the two deflecting grids. The effect of the deflecting grids is to deflect electrons from a course directly toward an element of the positive grid so that the deflected electrons pass through interstices of the positive grid instead of colliding with the elements of the grid and being absorbed. Accordingly, the magnitude of the electron stream passing directly to the positive grid is greatly reduced with respect to that of the oscillating electron stream. This increases the effective number of electron transits of the oscillating electrons and likewise increases the efficiency of the circuit as a whole.

Referring to the drawing, Fig. 1 illustrates the structure of an electric discharge device according to one embodiment of the invention. Fig. 2 is a sectional view of the electrodes and container of Fig. 1 in a horizontal plane of the line X—X, Fig. 3 is a schematic diagram of a Barkhausen oscillator circuit embodying the invention and Fig. 4 illustrates a modification of the circuit of Fig. 3.

In Fig. 1 an electron discharge device 1 comprises a central linear cathode 2 having leads 3 and 4. The cathode is supported by a standard 5, the base of which is anchored in the lower wall of the device 1. The standard 5 has a horizontal arm 6 to which the upper portion of the cathode 2 is anchored. The arm 6 serves as a spring support to hold the cathode taut and in its proper central position. The upper lead 3 is also electrically connected to the arm 6 of the electrically conducting standard 5. A cylindrical anode 7 is mounted centrally about cathode 2 and is supported from the upper wall of the discharge device by a heavy lead-in wire 8 which is rigidly

anchored in the upper wall. A concentric cylindrical grid 9 between the cathode 2 and the anode 7 is supported by a heavy lead-in wire 10 which, like lead-in wire 8, is anchored in the upper wall of the device. The lead-in wire 10 is welded or otherwise mechanically connected to the upper ring-shaped member of grid 9 which carries the grid structure. The cathode 2, anode 7 and grid 9 form the principal interior elements of an oscillator of the Barkhausen type.

In order to prevent the direct absorption by grid 9 of electrons emitted from the cathode 2, a cylindrical grid member 11 having a configuration similar to that of grid 9 is placed between the cathode 2 and the grid 9. The longitudinal conductors 12 of grid 11 are so aligned that there is one in each plane which includes cathode 2 and a longitudinal conductor 13 of grid 9. A third cylindrical grid 14 also having a configuration similar to that of grid 9 is placed between the grid 9 and the anode 7 and its longitudinal conductors 15 likewise lie in the planes that include the corresponding elements 12 and 13 of the two inner grids. The two grids 11 and 14 which are thus located at opposite sides of the positive grid 9 are anchored together by a tie member 16 within the discharge device and the tie member is electrically and mechanically connected through a heavy inductance coil 17 to standard 5. The grids 11 and 14 are also supported at their lower ends by stiff rods 18 and 20 respectively which are rigidly attached to the grids and are anchored in the lower wall of the discharge device.

As will be apparent from Fig. 2, an electron emitted from cathode 2 in the direction of an element 22 of the positive grid 9 will find in its path an element 21 of the grid 11. Since the element 21 is at a potential substantially that of the cathode 2, the electron will be deflected by the electric field of the element 21. Accordingly, electrons emitted from the cathode will, for the most part, be prevented from proceeding directly to the elements of the positive grid 9 and will be constrained to follow paths passing through the interstices of the grid 9. In like manner, electrons which are in the region of the anode 7 are each impelled to proceed inwardly in a radial direction under the influence of the radial electric field between the positively polarized grid 9 and the low potential anode 7. Such inwardly proceeding electrons will be largely prevented from collision with and absorption by the elements of the positive grid or electron accelerator 9 as, for example, element 22, because of the fact that the direct radial path passing through each such element 22 also passes through an element 23 of the outer grid. Therefore, the electron on its inward transit is deflected from the direct path toward element 22 by the electric field of the element 23. In this manner, the electrons are caused to pass alternately, outwardly and inwardly through the interstices of the intermediate grid 9 without absorption by that grid.

As indicated in Fig. 3, a Lecher wave conductor system comprising conductors 24 has one conductor connected to the cathode 2 and the other to the anode 7. Such Lecher systems are well known in the art of wave transmission for waves of less than 10 meters wave length which are known as ultra short waves. The Lecher circuit is terminated by the usual short-circuiting tuning element 28 including a large series connected capacity element 29 which effectively ties the outer terminals of the conductors 24 directly together

so far as oscillations of the frequency being generated are concerned. In order to polarize the anode 7 at a suitable potential a source 30 connected to the terminals of capacity element 29 may be employed. As shown, this source is so poled as to render the anode 7 somewhat negative, e. g., four or five volts, with respect to cathode 2. It will be understood, however, that the polarity of the source 30 may be reversed so as to render the anode 7 slightly positive with respect to cathode 2, or the capacity 29 and the source 30 may both be eliminated so that the slider 28 will provide a path of substantially zero impedance for both oscillations and uni-directional currents.

The cathode 2 is provided with heating current by a source 31 of uni-directional current connected to its terminals 3 and 4. The grid 9 is maintained highly positive with respect to cathode 2 by a source 32 having an electromotive force of perhaps 300 to 400 volts. To prevent the external circuit connections of grid 9 from entering into the oscillating system a choke coil 33 presenting high impedance to ultra high frequency oscillations is connected in series with source 32. Grids 11 and 14 are likewise connected to the cathode 2 through a similar high frequency choke coil 17 and, accordingly, assume the normal polarizing potential of the negative terminal of the cathode 2. In the particular embodiment disclosed, the electric coil 17 is placed within the tube. It will be appreciated, however, that instead of a single coil separate choke coils may be used to connect grids 11 and 14 to the cathode 2. It will also be understood that, if desired, these separate choke coils may be placed outside the electric discharge device so as to permit introduction of a suitable polarizing electromotive force in the circuit of each.

In the circuit, as shown, only the cathode and the anode are provided with high frequency connections to the external oscillating system. By virtue of the small spacing between the grids 11, 9 and 14, the inherent inter-grid capacitances between the grids are sufficiently large so that at the ultra high frequency oscillations involved they present low reactance. Accordingly, when the highly positive grid 9 has its instantaneous potential varied by virtue of the oscillating operation, the entire grid group, i. e., the three grids 9, 11 and 14, acts like a single unit and participates in the potential variations.

Fig. 4 illustrates a modification of the circuit of Fig. 3 in which the two Lecher conductors are connected respectively to the anode and to the positive grid. The circuit is otherwise similar to that of Fig. 3 except that the path including the source 30 is provided with a series choke coil to exclude the high frequency oscillations from the external path connecting the anode and cathode. In this circuit, as in that of Fig. 3, the three concentric grids will operate as a unit at the high frequency of the ultra short waves which are generated.

What is claimed is:

1. An ultra short wave apparatus comprising an electric discharge device having a cathode, an anode and an impedance control grid, a path connecting the anode to the cathode and including a source of polarizing potential for the anode, a circuit including a polarizing source connecting the cathode and grid and including a source of high potential for positively polarizing the grid, an element within the discharge device similar in configuration to the grid and interposed between

the grid and cathode to intercept substantially all linear paths from the cathode to the grid, the spacing of the grid and the element being sufficiently small so that the resulting capacity between the grid and the element presents low reactance to ultra short waves whereby the element and the grid participate in ultra short wave variations as a single unit, and means for maintaining the element polarized at approximately the potential of the cathode while electrically isolated from the cathode at ultra short wave frequencies.

2. An oscillator comprising an electric discharge device including a cathode, an anode and impedance control grid therebetween, a path connecting the anode to the cathode and including a source of polarizing potential for the anode, means for polarizing the grid to a high positive potential with respect to the cathode, an auxiliary grid located between the impedance control grid and the cathode and having members which are similar in configuration to those of the impedance control grid and which are correspondingly positioned in radial alignment therewith with respect to the cathode so that the members of the auxiliary grid intercept substantially all direct paths from the cathode to the impedance control grid, the impedance control grid and the auxiliary grid being sufficiently close to each other so that the resulting inter-grid capacity presents low reactance to ultra short waves whereby the grid group participates in ultra short wave potential variations as a single unit, and means for maintaining the members of the auxiliary grid polarized at substantially the potential of the grid to deflect electrons proceeding along the intercepted paths.

3. An ultra short wave oscillator comprising in combination, a linear cathode, three concentric grids of cylindrical form surrounding said cathode and sufficiently close to each other so that the resulting inter-grid capacity presents low reactance to ultra short waves, a cylindrical anode concentric with and surrounding said grids, means for maintaining the intermediate grid polarized at a high positive potential with respect to the cathode, means for polarizing the other two grids and the anode at potentials which are in the region of that of the cathode, all of said polarizing means including high impedance at the ultra short wave frequency, and a Lecher system having one conductor connected directly to the positively polarized intermediate grid and a second conductor connected directly to the anode.

4. An ultra short wave oscillator comprising an electric discharge device having electrodes including a cathode, three grids and an anode relatively positioned in the order recited, means for maintaining the intermediate one of the three grids at a high positive potential with respect to the cathode and for maintaining the anode at a potential approximating that of the cathode, a

Lecher circuit having terminals connected to the anode and one of the other electrodes whereby the apparatus functions as a Barkhausen oscillator, means for maintaining the other two grids at approximately the direct current potential of the cathode, means for substantially isolating all of said grids from said cathode at the high frequencies of the oscillations generated, the spacing of the intermediate grid from the other two grids being such that the resulting inter-grid capacity offers low impedance to the high frequency oscillations whereby the entire grid group participates in the high frequency potential variations as a single unit.

5. An oscillator comprising an electric discharge device including a cathode, means for heating the cathode to constitute it a source of electrons, a grid, means to polarize the grid highly positive with respect to the cathode to impel electrons to travel from said cathode toward the grid, an anode located in the direction toward which said electrons are impelled and more remote from the cathode than the grid, means for maintaining the anode at a potential not differing greatly from that of the cathode and much lower than that of the grid so that electrons passing through interstices of the grid and proceeding toward the anode are repelled by the anode, means tending to intercept electrons moving in radial lines toward an element of the grid so that it will not absorb electrons initially passing toward it from the cathode and will not absorb electrons repelled in radial lines from the anode comprising a pair of auxiliary grids located one on each side of the highly positive grid, and means to maintain the auxiliary grids at substantially the direct current potential of the cathode but substantially isolated from the cathode at the high frequencies of the oscillations generated.

6. An oscillator of the Barkhausen type comprising an electric discharge device having a cathode, an anode, an interposed grid and means for polarizing the grid to a potential that is highly positive with respect to both that of the cathode and the anode, characterized in this, that additional means are provided for materially reducing the electron stream entering the positively polarized grid from the direction of the cathode and from the direction of the anode comprising a pair of auxiliary grids located one on each side of the interposed grid, each of the auxiliary grids comprising elements corresponding in number and in general configuration with those of the interposed grid and positioned to intercept all radial paths passing through the cathode and the interposed grid at both sides of the interposed grid together with means to maintain the auxiliary grids at substantially the direct current potential of the cathode to effectively electrically isolate it at high frequencies from the cathode.

RAYMOND A. HEISING.