

March 12, 1935.

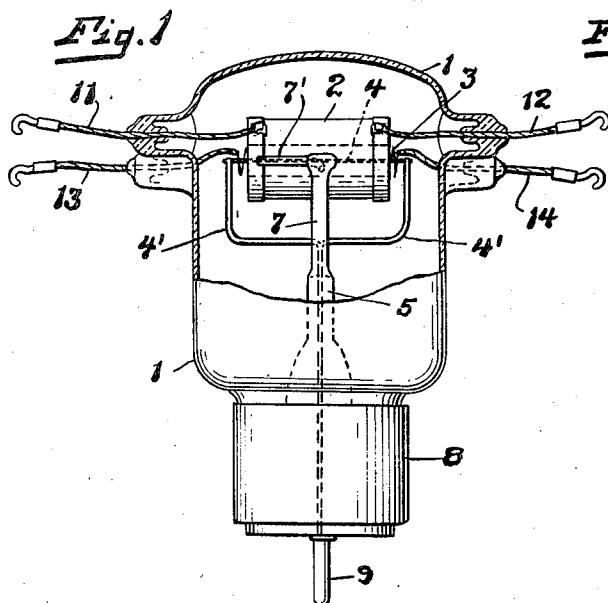
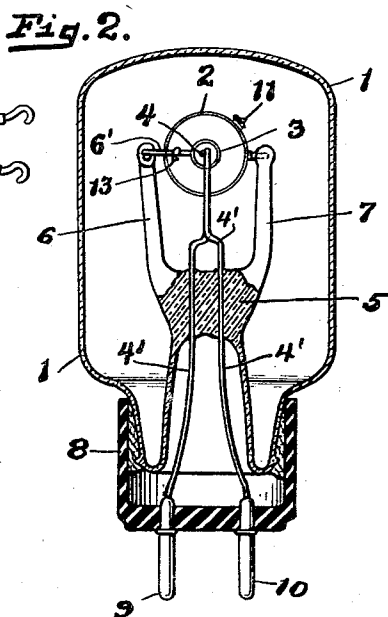
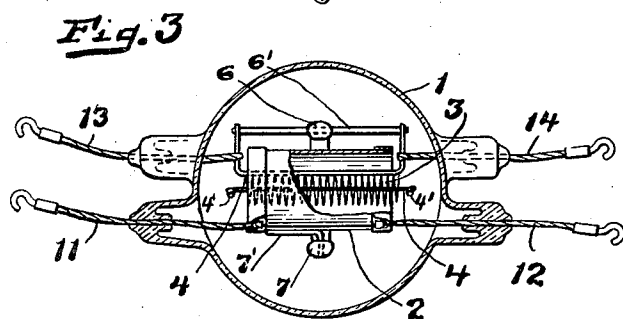
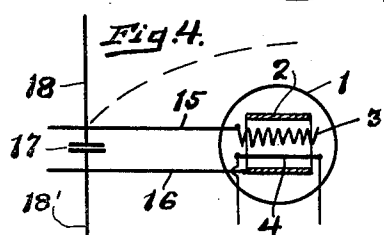
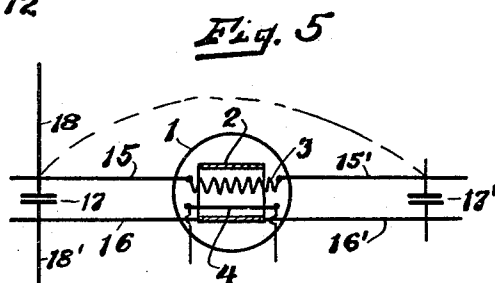
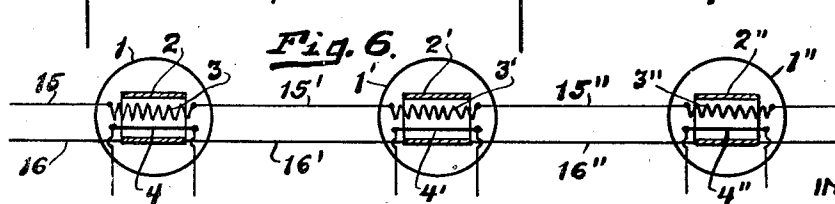
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1,994,219

OPERATING ELECTRIC DISCHARGE DEVICE

Filed Nov. 11, 1930

2 Sheets-Sheet 1



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OPERATING ELECTRIC DISCHARGE DEVICE

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2 Sheets-Sheet 2

Fig. 9

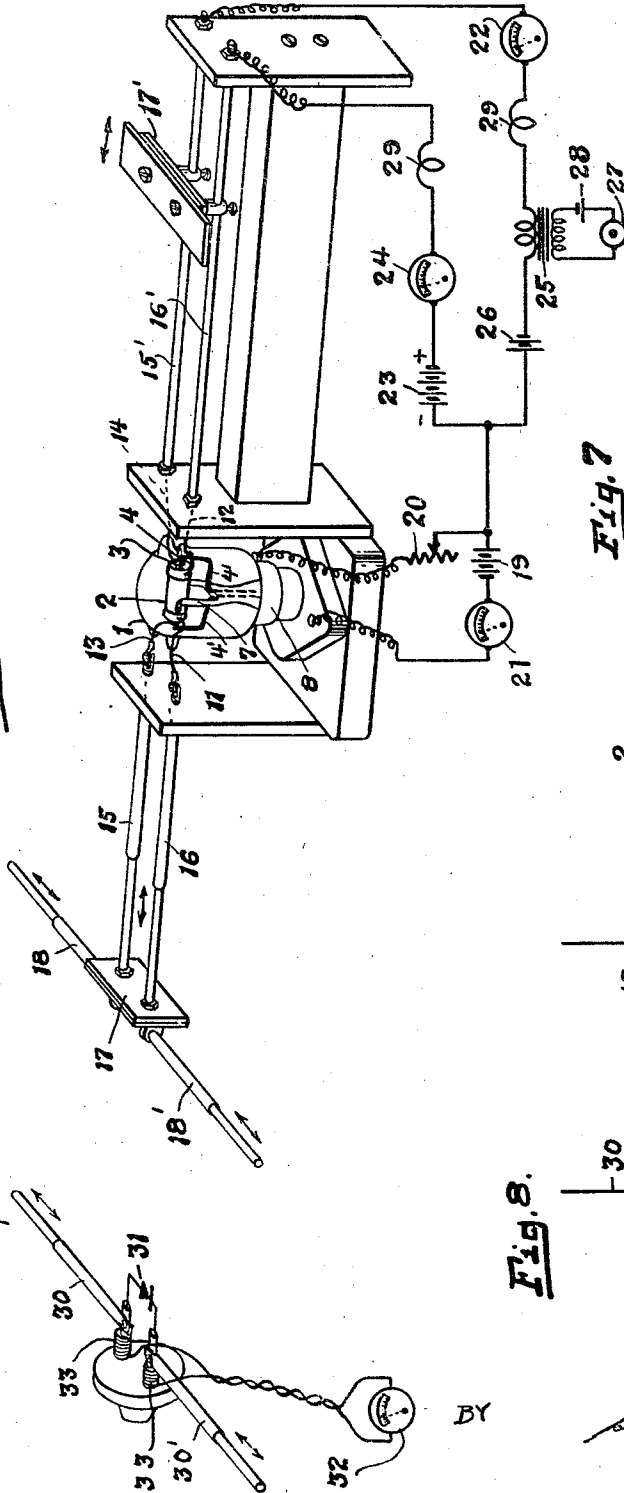


Fig. 7

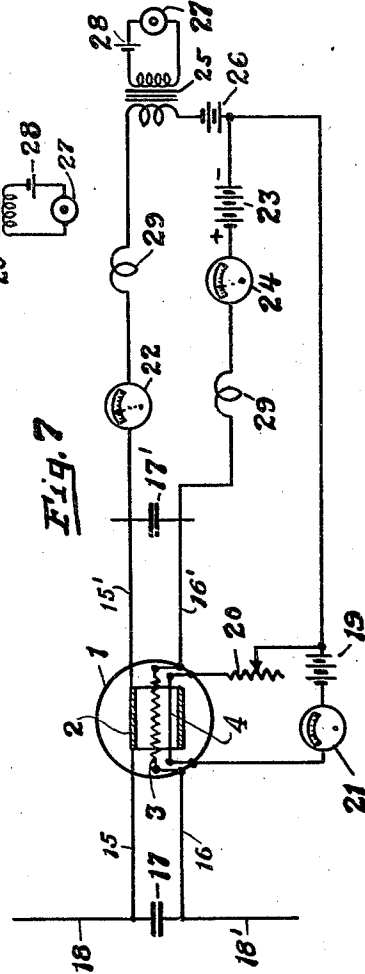
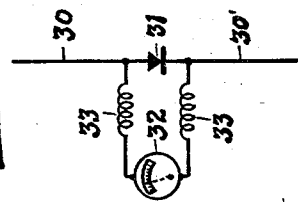


Fig. 8



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UNITED STATES PATENT OFFICE

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OPERATING ELECTRIC DISCHARGE
DEVICE

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by mesne assignments, to American Telephone
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Application November 11, 1930, Serial No. 494,832
In Germany November 16, 1929

7 Claims. (Cl. 250—36)

My invention relates to a novel electronic discharge tube and means for operating same for ultrashort wave work.

One object of my invention is to provide a vacuum discharge tube, in which at least two leads at opposite ends are provided for the electrodes, in such a manner that a minimum of interference with associated short wave circuits is insured.

A further object of my invention is to design a vacuum discharge tube, primarily adapted for short wave work, which is especially adapted for use in resonance circuits of the two parallel wire standing wave type and which insures increased efficiency and dependability of such systems.

A more specific object of my invention is the provision of a three-electrode vacuum tube, of special design and intended for operation in an electron oscillating system, by what is known in the art as the braking field or Barkhausen-Kurz method.

A still further object of my invention is a circuit for producing electron oscillations utilizing my novel vacuum tube, by which the energy and stability of the oscillations are increased, in such a manner as to enable the use for commercial purposes of this type of ultrashort wave transmission and reception.

These and further objects of my invention will become more apparent from the ensuing detailed description, taken in reference to the figures of the accompanying drawings, which are intended to be illustrative only of the broader principles underlying the invention.

Figure 1 shows a front view of the novel vacuum tube structure, in accordance with my invention.

Figure 2 is a side elevation of Figure 1.

Figure 3 is a top view of the tube structure according to Figures 1 and 2.

Figure 4 is a circuit arrangement, showing the manner in which the tube is ordinarily utilized for ultrashort wave work.

Figure 5 shows an improved arrangement, in accordance with the invention.

Figure 6 illustrates, in a schematic manner, the way in which the novel tube, according to my invention, may be used for a chain connection of a number of single tubes, for the purpose of obtaining increased energy output.

Figures 7 and 9 show a complete working circuit of the Barkhausen-Kurz type, utilizing the novel tube, for producing or receiving ultra-short wave oscillations.

Figure 8 illustrates a simple receiver to co-

operate with the transmitter system, according to Figures 7 and 9.

Similar reference numerals designate similar elements throughout the different views of the drawings.

In discharge tubes as hitherto used in the art, the current is supplied to the electrodes exclusively from one side, in general, by means of a vacuum tight lead or bushing passing through the glass walls, or a press at the bottom of the tube. Only for special purposes is it customary to dispense with the common press for the leads and to arrange certain electrode leads separately and at great distance from each other. This is, for instance, used for the purpose of minimizing the effect of mutual capacity between the leads, in screen grid tubes and others. However, all these cases have in common that there is provided only a single lead for each electrode.

According to my invention, I propose a vacuum tube in which there are at least two leads for each electrode, arranged at opposite ends thereof; that is, in the case of a three-electrode vacuum tube for the grid, as well as for the anode. This enables the direct connection of the electrode in the path of the current, whereby the electrodes themselves constitute part of the circuit. This is of primary importance in connection with short wave work, as will be explained later.

Referring to Figure 1 of the drawings, I have shown, for illustration, a vacuum tube, comprising a glass vessel 1, carried by a socket 8 and including a press or stem 5 at its bottom, serving as a support for the electrodes. These are an anode 2 of cylindrical shape, grid 3, consisting of a spirally wound wire arranged concentrically to the anode and a straight wire cathode 4 disposed in the axis of the anode or grid cylinders. The anode is supported by a supporting glass rod 7, which is an extension of the press 5 and the grid is supported by a similar rod 6 at the opposite side, also being integral with the press 5. For this purpose, supporting wires 6' and 7' are melted in the ends of rods 6 and 7, respectively and soldered on, or connected in any other way to the grid and anode electrodes. The filament 4 is supported by supporting wires 4', which pass directly through the press 5 and are connected to prongs 9 and 10, serving for connecting tube in a proper socket for its filament supply. In accordance with the invention, two leads 11 and 12, soldered on, or otherwise connected to opposite ends of the anode cylinder 2, are provided and led through a vacuum tight seal through the tube to the outside, as shown. Similar leads 13 and 14

are provided for the grid, which are preferably directly connected to the supporting wires 6' for the grid electrode, such as shown.

It is obvious that the principle of the invention may be applied to any kind of tube structure and is not restricted to the special exemplification of the drawings, showing cylindrical anode and grid electrodes. A very simple structure is obtained when using flat anode and grid electrodes, as is readily understood.

As already pointed out, my novel vacuum tube, as described, is primarily adapted for use in short wave systems and, although the following embodiments are especially directed to the so-called Barkhausen type of short wave circuit, it is readily understood that the application and advantages of the tube apply to any kind of short wave generator or receiver.

The Barkhausen-Kurz ultrashort wave circuit differs from the customary oscillating circuits, in that the grid carries a substantially high positive potential in respect to the cathode, whereas the anode is either at zero potential, or has a slight negative potential in respect to the cathode. Thus, electrons emitted from the cathode and shooting through the meshes of the grid will reach a point where the retarding action of the negative anode is sufficient to force the electrons to turn back and, in this way, a to and fro movement of the electron particles within the vacuous space of the tube about the grid electrode is maintained. The frequency of these movements is mainly dependent on the voltage applied to the grid, which, as is apparent, determines the speed at which the electrons are traveling and, thus, indirectly the frequency; that is, the number of back and forth movements during one second.

In order to practically utilize these intertube oscillations, customarily a two-wire tuning system of the standing wave type is connected to the electrodes, such as the grid and anode electrodes. Such a system, as is well known, consists of two parallel wires, whose effective length may be changed, such as by displacing a condenser of high capacity bridging the two wires, or by changing the length through a telescopic arrangement of the wires. The effective length of the wires is then a direct measure of the wave length.

Referring to Figure 4, I have shown this schematically. Two parallel wires 15 and 16 are connected to the grid and anode and bridged by the displaceable condenser 17. If it is desired to radiate the energy in the form of high frequency waves into space, wire antennae 18, 18' of proper length corresponding to the wave length of the oscillations produced within the tube, may be arranged, as is well known in the art. In such a system, which may generate wave lengths below one meter, the electrodes themselves constitute an essential part of the standing wave oscillating system and, therefore, have to be tuned together with same, whereby it was found that, with a given tube of given dimensions and electrode structure, the shortest wave which could be utilized was obtained when the electrode system was excited in $\frac{1}{4}$ wave length, such as is indicated in dotted lines in Figure 4. When it is desired to decrease the wave length still further, in accordance with the general trend in short wave work, due to the increasing advantageous effects of shorter waves, it is necessary to decrease the dimensions of the electrodes, which decrease, however, on the other hand, will entail the disadvantage of a decrease of the oscillating power output.

The afore-mentioned disadvantage is readily overcome by using a tube of the type according to my invention, in such a manner that the electrodes are excited in half waves, by means of the leads arranged at the opposite ends, such as is schematically illustrated in Figure 5, according to which each side of the tube is connected to a tunable standing wave system, the system connected to the right end leads being designated by 15', 16', 17'.

In this manner, despite equal oscillating output, the wave length may be decreased to about $\frac{1}{2}$, as compared to the simple arrangement as used in such systems, according to the older art. A further important advantage of a double tuning system, in accordance with Figure 5, is increased stability of the oscillations and ease of adjustment to a definite desired wave length and increased dependability and safety of operation, which render such systems suited for commercial work. A complete practical operating circuit will be described in connection with Figure 7.

A further novel advantage of my discharge tube, especially in short wave operation, consists in that the double leads to the electrodes enable a very simple chain connection of a number of tubes, for the purpose of increasing the oscillating output energy, without impairing the fundamental wave and interfering with the operating stability of the system. This is shown by Figure 6.

Referring to Figure 7, I have shown a complete working circuit, including a tube of the type described, having its grid connected to a source of positive potential, by means of a grid battery 23 and having its anode carrying a slightly negative potential, by means of an anode battery 26. I have also shown a filament battery 19 connected in series with a heating resistance 20, filament 4 of the tube and a meter 21. A double two-wire tuning system is connected to the tube, in a manner illustrated by Figure 5. The grid circuit includes a meter 24 for reading the grid current and the anode circuit includes a meter 22 for indicating the oscillating current. 29 are choke coils inserted in the anode and grid leads for blocking the current supply source against the high frequency portion of the circuits. The anode lead circuit further includes an audio frequency transformer 25, in whose primary a battery 23 and a modulating device, such as a microphone 27, are inserted, for the purpose of modulating the high frequency currents generated by the tube and radiated by the antennae 18, 18'. The operation and adjustment of this circuit are as follows: After the filament of the tube has been brought to proper incandescence, condensers 17 and 17' are displaced along the parallel wires 15 and 16, to such relative positions at which the anode current observed by the meter 22 is at a maximum. Then the antenna wires 18, which are preferably of the telescopic type, are adjusted to proper length, until a maximum volume of the receiving current in a proper receiver, such as, for instance, shown in Figure 8, is obtained. Then the tuning of the system is readjusted to half the previous anode current, by increasing the effective length of the tuning system and antenna wires and then the transmitter may be modulated and signals transmitted. For transmission over short distances, a crystal detector 31, of known type, may be used connected between two receiving wires 30 and 30' (see Figure 8). For recording or indicating the received energy, a microammeter 32 is connected preferably to the crystal, in series with choke coils 33. As the wires 18 and

18' of the transmitter radiate a polarized wave, it is necessary to place the receiving wires 30 and 30' in a parallel position to the transmitting wires, in order to insure maximum reception.

5 In Figure 9 I have illustrated a structural arrangement of a short wave circuit, according to Figure 7 and similar reference numerals indicate the same parts.

10 When it is desired to transmit over longer distances, a receiver is used, whose construction is substantially identical to the transmitter structure, according to Figure 7, in which case, however, the heating current is adjusted to a slight value only, so as to maintain the oscillator close to the threshold of oscillations, or to allow the production of weak oscillations and in such a manner that the oscillations are instantly started or increased whenever energy is received from the transmitter.

20 Although I have described my invention with specific reference to the showing of the drawings, it is understood that the same is subject to many modifications coming within its most comprehensive and broad scope, as comprised by the ensuing claims.

What I claim to be secured by Letters Patent in the United States is:—

1. An ultrashort wave circuit comprising an electron discharge device having a pair of electrodes, a plurality of tuned circuits each comprising a pair of conductors, each of said electrodes being connected to one conductor of each of said pairs of conductors whereby the reactances of said electrodes are effectively divided between the plurality of tuned circuits and are proportionately decreased, and means for effectively isolating said tuned circuits from all other high frequency reactances external to said conductors.

40 2. An ultrashort wave system comprising an electron discharge device having a plurality of electrodes, a pair of said electrodes having two terminals each, a tuned circuit comprising a pair of conductors, each conductor of which is connected to one terminal of one of said pair of electrodes, and a second tuned circuit comprising a pair of conductors each of which is connected to one of the remaining terminals of said pair of electrodes whereby the reactances of said electrodes are effectively divided between the two circuits and means for effectively excluding from both of said circuits all other external high frequency reactances so as to permit tuning said circuits to frequencies higher than the frequency determined by either of said circuits when alone connected to the electron discharge device.

60 3. An ultrashort wave system comprising an electron discharge device having cathode, grid and anode electrodes and terminals therefor, means for applying polarizing potentials to said electrodes, a Lecher system connected to terminals of said grid and of said anode, a second Lecher system connected to terminals of said grid and anode, a short-circuiting condenser terminating each of said Lecher circuits at the terminals thereof remote from said electron discharge device, and means for tuning each of said Lecher circuits together with the effective reactance of said grid and anode to constitute a quarter wave length section of a standing wave circuit at the frequency of the oscillations produced by said ultrashort wave system.

70 4. An ultrashort wave oscillator comprising

an electron discharge device having an anode, a cathode and a grid, terminals therefor, means for energizing said cathode and said anode, means for polarizing said grid highly positive with respect to said cathode, a Lecher circuit having one pair of terminals connected to said anode and grid and its other pair of terminals short-circuited for ultra high frequency currents by a condenser of relatively large capacity, means whereby said Lecher circuit together with said grid and said anode may be tuned to constitute a one quarter wave length section of a standing wave system, a second Lecher circuit also connected to said grid and said anode and similarly tuned to a quarter wave length of the oscillations to be produced and a radiating antenna system connected to said last-mentioned Lecher circuit at approximately a nodal point and positioned non-inductively with respect thereto.

5. A physically linear ultrashort wave system comprising an electron discharge device having a cathode, an anode and a grid, said anode and said grid each having two external terminal connections extending in diametrically opposite directions and two aligned Lecher circuits connected to the corresponding terminals of said anode and grid and similarly tuned together with said anode and grid whereby said Lecher circuits together with said electron discharge device constitute a unitary wave transmission system of a half wave length.

6. In a short wave system, an electron discharge device having cathode, grid and anode electrodes, means for applying a highly positive potential to said grid electrode, two leads from said grid electrode and two leads from said anode connected respectively to opposite ends of said electrodes and leading directly to the outside of said tube at opposite sides, a two-wire system connected to the leads from corresponding sides on said grid and said anode, a bridging condenser, and sliding connector means between said condenser and said wires for changing the effective wave length thereof, a second two-wire system connected to the leads from the opposite ends of said grid and said anode and in physical alignment with said first mentioned system, a second bridging condenser for said second wire system and means to adjust the effective wave length thereof to the same wave length as said first system, a radiating two-wire antenna connected to the terminals of one of said condensers, and means for changing the effective length of said antenna.

7. An ultrashort wave system comprising an electron discharge device having a plurality of electrodes, a pair of the electrodes each having a plurality of terminals located at points on the respective electrode separated from each other by portions of the electrode constituting a substantial reactance at the operating frequency of the system, a plurality of resonating circuits, each circuit being connected to an individual terminal of each of the pair of electrodes, and means for effectively excluding from said circuits all other external reactances whereby the resonating frequency of said circuits is determined by a portion only of the interelectrode reactance of the pair of electrodes and is higher than that corresponding to any of said circuits when alone connected to said pair of electrodes.

HANS ERICH HOLLMANN.