

May 27, 1941.

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2,243,574

ELECTRICAL DISCHARGE APPARATUS

Filed Aug. 1, 1939

Fig. 1.

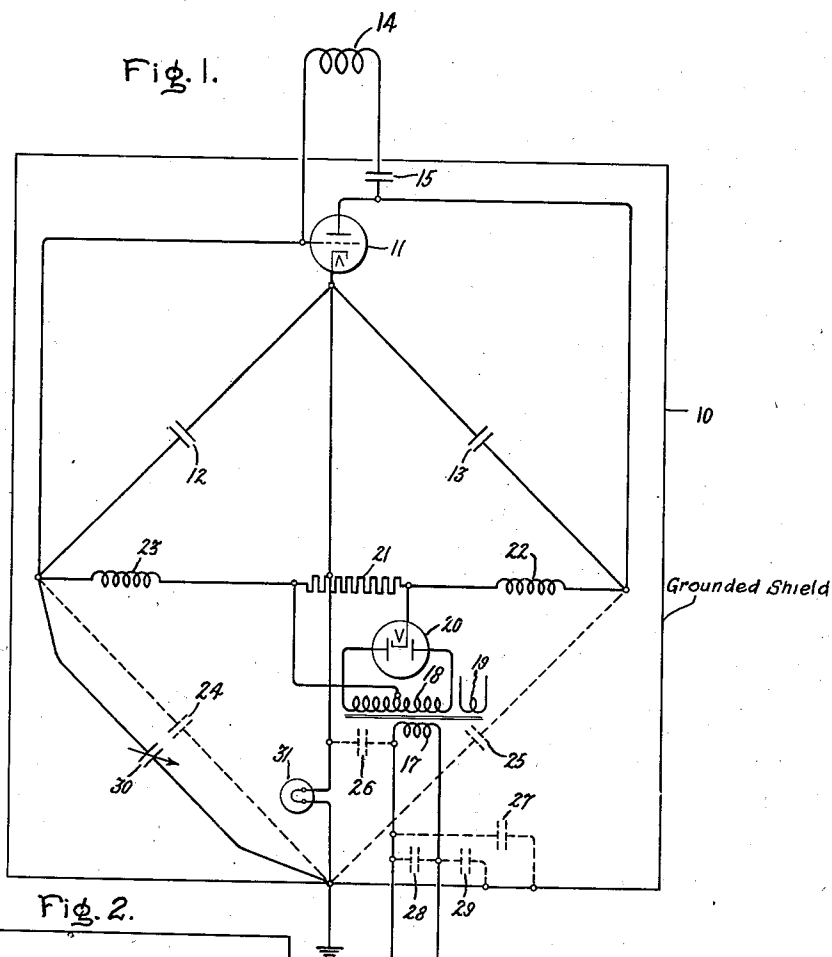
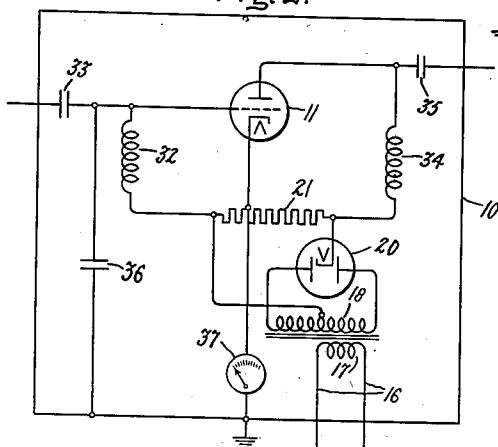


Fig. 2.



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## UNITED STATES PATENT OFFICE

2,243,574

## ELECTRICAL DISCHARGE APPARATUS

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Application August 1, 1939, Serial No. 287,782

7 Claims. (Cl. 250—36)

My invention relates to electron discharge apparatus and more particularly to high frequency electron discharge apparatus which is supplied with power from ordinary commercial lighting circuits.

It has been found that ultra high frequency oscillators of the type used in diathermy machines radiate large amounts of power into space with corresponding undesirable interference with radio communication. Such undesirable radiation, of course, represents a great loss of efficiency. A very large part of this power is radiated from the supply connections of the oscillator to the lighting circuit from which it is energized. It is accordingly an object of my invention to provide simplified and improved means to control the radiation from high frequency oscillators.

It is a more general object of my invention to maintain the cathode, the heating circuits therefor, and the power supply of a vacuum tube in a circuit transmitting high frequency currents substantially at ground potential with respect to the high frequency currents transmitted there-through.

In accordance with my invention a high frequency oscillator, or amplifier, is arranged in such a way that the anode and control member of the electron discharge device employed in the oscillator, or amplifier, form opposite corners of a balanced bridge circuit between the remaining corners of which the cathode, the power supply and ground are connected. In such a bridge circuit high frequency currents transmitted through the apparatus and appearing across the first two corners of the bridge can produce no voltage between the remaining two corners of the bridge. It has been found necessary, in order to balance the bridge, to take account of the inherent capacity between the anode and ground, and between the control member of the discharge device and ground. To allow for convenient construction there is provided a shielded casing for the apparatus embodying my invention, which casing acts as a virtual ground and with which the means which I use for balancing the bridge may co-operate. It is therefore a particular object of my invention to balance the alternating voltage transmitted by an electron discharge device with respect to the source of cathode heating voltage and to ground so that no high frequency voltage appears between the source of voltage and ground.

The features of my invention which I believe to be novel 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 con-

nection with the accompanying drawing in which Fig. 1 is a schematic diagram representing apparatus embodying my invention; and Fig. 2 represents a different embodiment of my invention.

Referring to Fig. 1, which shows a circuit for a high frequency oscillator in which my invention is embodied, the oscillator is one adapted to produce heat in conductive objects by induction. The resonant circuit thereof is enclosed in a conductive shield casing represented by the rectangle 10 and the flow of energy in the circuit is regulated and maintained by an electron discharge device 11. The resonant circuit includes condensers 12 and 13 and a coil 14. The condenser 12 is connected between the control member and the cathode of the device 11 and the condenser 13 is connected between the anode and cathode thereof. The coil 14 is connected at one end to the grid and through a blocking condenser 15 at the other end to the anode of device 11.

Power is supplied to the oscillator from a pair of ordinary commercial lighting circuit lines 16 which are connected to a primary 17 of a transformer within the casing 10. This transformer has two secondaries 18 and 19. The ends of the secondary 18 are connected to the two anodes of a full wave rectifier tube 20. A center tap of the secondary 18 is connected to one end of a voltage divider resistance 21. The cathode of the tube 20 is connected to the other end of the voltage divider resistance 21. The secondary 19 of the power supply transformer has connections (not shown) to the heating circuits for the cathodes of the device 11 and the tube 20. A choke coil 22 is connected between the anode of device 11 and the cathode of tube 20 while a choke coil 23 is connected between the grid of device 11 and the center tap of the secondary 18. The cathode of device 11 is connected to a central point on the voltage divider resistance 21, such that the grid of device 11 is maintained at a negative bias potential suitable for proper operation of device 11.

The circuit, as thus far described, is a usual circuit for high frequency oscillators and has been found, particularly when operated at short wave lengths such as those of five meters, or less, used in diathermy, to radiate large amounts of energy in an undesired manner. It has been found that this troublesome radiation arises from the fact that the grid and the accompanying connections for device 11 as well as the anode and its connections have considerable capacity with respect to ground, and in this particular apparatus to the casing 10. These stray capacities are represented on the drawing by dotted lines in which capacitance 24 represents the capacity from the grid of device 11 to ground and capac-

itance 25 represents the capacity from the anode to ground. I have represented a capacitance 26 as existing between the primary 17 of the power supply transformer and the cathode of device 11. This capacity actually exists principally between the primary 17 and the secondaries 18 and 19 of the transformer. I have also represented the capacities between the lines 16 and between each of these lines and ground by capacitances 28, 27, and 29.

Since condenser 12 is usually of considerably greater size than condenser 13, and the capacitances represented at 24 and 25 are usually of about equal size, it is clear, particularly from the bridge arrangement illustrated, that the unbalance produces a voltage between the cathode of device 11 and ground. Since, at the frequencies involved, the cathode can be connected to ground only through a conductor having substantial impedance, the voltage produces a radio frequency current through capacitance 26, line conductors 16, and capacitance 27 and 29, and to a certain extent through capacitance 28. The potential thus produced on conductors 16, and on the metal cover about such conductors, as in the case of the so-called BX cable, produces a very large amount of radiation at considerable distances, even hundreds of miles, from the oscillator. In fact, it has been found in some cases that the current so produced in the line conductors and metal covering, such as BX cable, may be so great that the covering assumes such a potential that it is noticeable to touch, arcs to the fingers are produced, and lamps for ordinary lighting, which are connected between the conductors of the cable through open switches, become illuminated.

In the circuit shown, a variable condenser 30 is connected between the grid of device 11 and ground, which in this apparatus may be considered for practical purposes the casing 10, to balance the bridge comprising condensers 12, 13, 24, and 25. If the circuit is that of a high frequency oscillator used for some purpose in which the circuit elements are substantially invariable, the condenser 30 may be prefixed at some value which balances the bridge. If, however, the circuit is used as a generator of oscillations for diathermy, in which the coil 14 is adjustable about the body of a patient and the capacity of different portions thereof with respect to ground are thereby changed, it is of great advantage that the condenser 30 be adjustable by the operator whenever the coil 14 is adjusted. It has been found convenient to connect a small lamp 31 between the cathode of device 11 and ground to indicate the presence or absence of radio frequency voltage therebetween. Condenser 30 may then be adjusted until this lamp is de-energized or unilluminated. Of course, a case may arise when condenser 13 is larger than condenser 12, so that condenser 30 should be connected between the anode of device 11 and ground, rather than as shown.

The changes in capacities from various portions of coil 14 to ground produced by adjustment of coil 14 about the patient occur in the capacities which are represented at 24 and 25. If the invention is used in a diathermy machine, these frequency changes require that some means for convenient adjustment be provided. However, it has been found that if the device 11 be a tube with a low amplification factor the condensers 12 and 13 are of nearly equal size. This is of great advantage since a greater percentage

change of capacitances 24 and 25 can then be tolerated without necessitating adjustment of condenser 30.

It has been found that by the use of my invention the radio interference produced at a distance of a few miles may be reduced by as much as 95 per cent. In fact currents of arcing proportions in the BX cable comprising conductors 16 may be reduced to such an extent that they may not be detected even by sensitive galvanometers. The increased efficiency due to the use of my invention, as well as the reduction of unwanted radiation is of advantage in any type of high frequency oscillator. By the use of this balancing scheme, it is possible to reduce the load on the anode circuit of an oscillator to allow it to oscillate at a higher frequency than it otherwise could operate with power enough to supply not only the stray load but also the grid circuit.

With reference to Fig. 2, I have illustrated a circuit for an amplifier embodying my invention. Several parts of this circuit are similar to those of Fig. 1 and are designated by like characters. The capacitances which were represented by the dotted lines in Fig. 1 are present in the circuit of Fig. 2 also, although they are not shown, and react in the same way. In Fig. 2 a resistance or inductance 32 is connected between the grid of device 11 and the center tap of transformer secondary 18. High frequency voltages may be impressed across this inductance through condenser 33 which is connected between one end of the inductance and one side of a source of high frequency current, the other side of which is grounded. A resistance or inductance 34 is connected between the anode of device 11 and the cathode of tube 20 to supply operating current to device 11. The anode of device 11 varies in voltage as the grid voltage is changed, the variations in anode voltage being due to variations in voltage drop through inductance 34. The anode of device 11 is connected through a condenser 35 to any device to which it is desired to transmit the voltage variations of the anode. It is usually preferred to use resistances at 32 and 34 if the apparatus must amplify a broad range of frequencies.

In operation the stray capacitances in conjunction with the resistances or inductances 32 and 34 form a bridge whose configuration is identical with that shown in Fig. 1. A condenser 36 is connected from the grid of device 11 to the casing 10 and to ground to balance the bridge and assure maintenance of the cathode of device 11 at ground potential. Since it is usual that the circuit constants of an amplifier remain relatively invariable, it may be possible to place a fixed condenser at 36. The value of this condenser may be determined by connecting a meter 37, responsive to high frequency currents, between the cathode of device 11 and ground. When the meter indicates the flow of no high frequency current, as the value of condenser 36 is changed, the bridge is balanced and the value for condenser 36 which was used at that time should be used permanently. Meter 37, of course, may be removed after the balancing is once completed.

While I have shown a particular embodiment of my invention, it will, of course, be understood that I do not wish to be limited thereto, since different modifications may be made both in the circuit arrangement and instrumentalities employed, and I aim 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, in a circuit including an electron discharge device having an anode, a cathode, and a control member, a circuit impedance between said control member and said cathode, a circuit impedance and a source of operating potential between said anode and said cathode, each of said circuit impedances having alternating voltage therealong and having substantial capacity with respect to ground, an impedance of substantial magnitude at the operating frequency of said device separating said cathode from ground and means connected between ground and a point on one of said circuit impedances of different potential from said cathode for maintaining said cathode at ground potential.

2. In combination, in a circuit including an electron discharge device having an anode, a cathode, and a control member, circuit connections including impedance between said control member and cathode, circuit connections including impedance between said anode and cathode, there being capacitances between said control member and ground and between said anode and ground, said two impedances and two capacitances forming four arms of a bridge across which potentials are developed, an impedance of substantial magnitude at the operating frequency of said device separating said cathode from ground and forming a diagonal of said bridge across which an objectionable potential appears upon unbalance thereof, and means including impedance connected between ground and a point of said bridge of different potential than said cathode to balance the bridge to remove the objectionable potential from said diagonal.

3. An oscillator including an electron discharge device having an anode, a cathode, and a control member, a resonant circuit having points of different potential connected respectively to said anode and control member and having a point of intermediate potential connected to said cathode so that continuous voltage variations are produced in said resonant circuit, said anode and said control electrode with the adjacent portions of said resonant circuit having substantial capacity with respect to ground, an impedance of substantial magnitude at the frequency of said voltage variations separating said cathode from ground, whereby said voltage variations appear on said cathode, and means connected between ground and a point of said tuned circuit other than said point of intermediate potential to prevent appearance of said continuous voltage variations on said cathode.

4. An oscillator including an electron discharge device having an anode, a cathode, and a control member, a resonant circuit having points of different potential connected respectively to said anode and control member and having a point of intermediate potential connected to said cathode so that continuous voltage variations are produced in said resonant circuit, a source of operating voltage connected to said cathode and having lines connected to a remote source of power, said lines, said anode and said control electrode with the adjacent portions of said resonant circuit having substantial capacitance with respect to ground, the impedance of said source and said lines separating said cathode from

ground and being of substantial magnitude at the operating frequency of said oscillator whereby said voltage variations appear on said cathode and produce objectionable radiation from said lines, and a variable condenser connected between said control member and ground for maintaining said cathode at ground potential.

5. In combination with an electron discharge amplifier device having a low amplification factor, said device having an anode, a cathode, and a control member, a circuit impedance between said anode and cathode and circuit impedance between said control member and cathode, said circuit impedances being nearly equal and having alternating voltages therealong, said control member and said anode with the adjacent circuit impedances each having substantial capacitance with respect to ground, an impedance of substantial magnitude at the operating frequency of said device separating said cathode from ground, and means connected between ground and a point on one of said circuit impedances of different alternating potential than said cathode for maintaining said cathode at ground potential.

6. In combination with an electron discharge device having an anode, a cathode, and a control member, a circuit arranged in the form of a bridge connected to said anode, cathode, and control member at three separated points, the arms of said bridge comprising respectively the portion of said circuit connected between said cathode and control member, the portion of said circuit connected between said cathode and anode, the inherent capacity to ground of said first portion and the inherent capacity to ground of said second portion, means for producing alternating voltages along the arms of said bridge, an impedance of substantial magnitude at the operating frequency of said device separating said cathode from ground and forming a diagonal of said bridge, said bridge being unbalanced so that a portion of the voltage between said anode and control member appears between said cathode and ground across said impedance, and means comprising an impedance connected between ground and a point on said bridge of alternating potential difference from said cathode for balancing said bridge and maintaining said cathode at ground potential.

7. In combination with an electron discharge device having an anode, a cathode, and a control member, a circuit arranged in the form of a bridge connected to said anode, cathode, and control member at three separated points, the arms of said bridge comprising respectively the portion of said circuit connected between said cathode and control member, the portion of said circuit connected between said cathode and anode, the inherent capacity to ground of said first portion and the inherent capacity to ground of said second portion, means for producing alternating voltages along the arms of said bridge, an impedance of substantial magnitude at the operating frequency of said device separating said cathode from ground and forming a diagonal of said bridge, said bridge being unbalanced so that a portion of the voltage between said anode and control member appears between said cathode and ground across said impedance, and a condenser connected between said control member and ground to balance the bridge and maintain said cathode at ground potential.

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