

June 20, 1939.

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2,163,247

ELECTRON DISCHARGE APPARATUS

Filed Feb. 26, 1937

2 Sheets-Sheet 1

FIG. 1

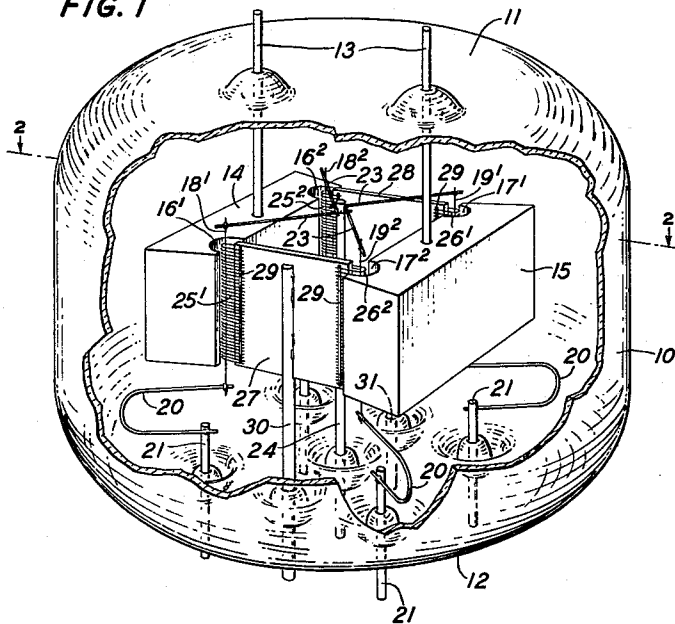
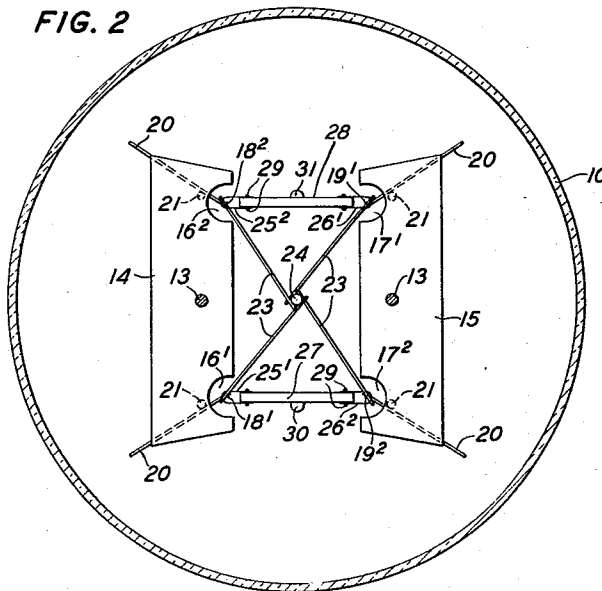


FIG. 2



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2 Sheets-Sheet 2

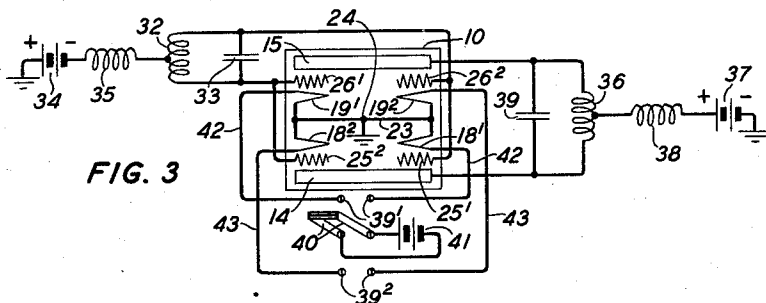


FIG. 3

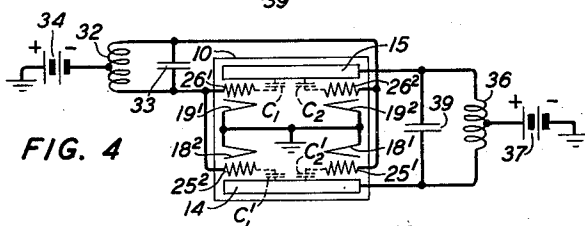


FIG. 4

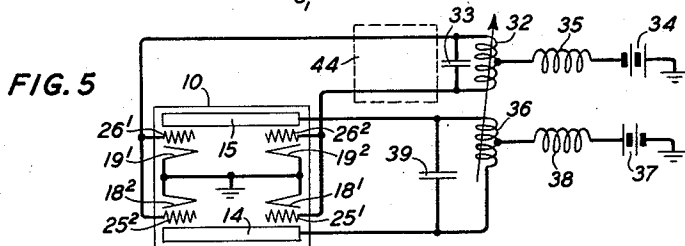


FIG. 5

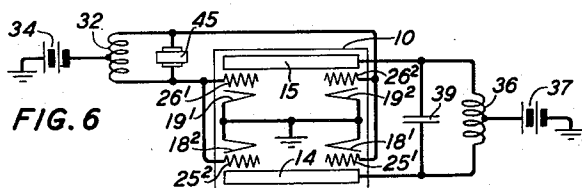


FIG. 6

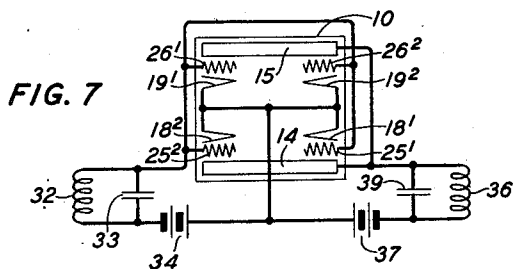


FIG. 7

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ELECTRON DISCHARGE APPARATUS

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Application February 26, 1937, Serial No. 127,899

11 Claims. (Cl. 250—27.5)

This invention relates to electron discharge apparatus and more particularly to such apparatus especially suitable for the generation, detection and amplification of ultra-high frequency impulses, for example of frequencies of 300 megacycles or more.

One object of this invention is to facilitate the substantially complete neutralization of inter-electrode capacitances in electron discharge devices, and more particularly of the grid-anode capacitances in a pair of triodes connected in push-pull relation.

Another object of this invention is to simplify the structure of electron discharge devices having a plurality of electrode units therein.

A further object of this invention is to enable the quick and facile substitution for certain electrodes in an electron discharge device in the event of failure thereof during operation.

Still another object of this invention is to enable the performance of a variety of functions in different apparatus by a single electron discharge device.

In one illustrative embodiment of this invention, an electron discharge device comprises a pair of spaced anodes, a pair of control electrodes or grids each having portions in cooperative relation to both of the anodes, and a plurality, for example four, of cathodes each associated with only one of the anodes and a corresponding portion of one of the control electrodes or grids.

This construction provides in effect four triode units or two pairs of triode units having common anodes. The various electrodes of each of the triode units may be of substantially identical parameters so that the grid-plate capacitances of these units are substantially equal. The electrodes may be so associated with external circuits that two of the units are connected in push-pull and the grid-plate capacitances of the other two units substantially neutralize the same capacitances of the first units.

The electrodes may be connected in other ways, to be described hereinafter, so that they form parts, for example, of detectors or various types of oscillators.

The invention and the various features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawings, in which:

Fig. 1 is a view in perspective of an electron discharge device constructed in accordance with this invention, a portion of the enclosing vessel being broken away to show the electrodes more clearly;

Fig. 2 is a view in cross-section along line 2—2 of Fig. 1, illustrating clearly the configuration and arrangement of the electrodes;

Fig. 3 is a circuit diagram illustrating the utilization of the device shown in Figs. 1 and 2 as a detector or amplifier;

Fig. 4 is schematic similar to Fig. 3, showing the relative distribution and association of the various grid-anode capacitances in the device shown in Figs. 1 and 2;

Fig. 5 is a circuit diagram of an oscillator including an electron discharge device constructed in accordance with this invention;

Fig. 6 is another circuit diagram illustrating the utilization of an electron discharge device such as shown in Figs. 1 and 2 in a crystal controlled oscillator; and

Fig. 7 is still another circuit diagram showing another oscillator including an electron discharge device of the construction illustrated in Figs. 1 and 2 wherein the various electrode units are connected in parallel.

Referring now to the drawings, the electron discharge device shown in Figs. 1 and 2 comprises a highly evacuated enclosing vessel 10 having substantially plane end walls 11 and 12. Mounted from the end wall 11, as by rigid metallic supports 13 sealed in this wall, are a pair of anodes 14 and 15, which may be of metal or graphite. The anodes 14 and 15 preferably are mounted substantially parallel to each other and are provided with parallel channels or recesses 16¹ and 16² and 17¹ and 17², respectively. These channels or recesses, as shown in Fig. 2, may be approximately semi-circular in lateral section.

Disposed within the channels or recesses 16 and 17 and preferably coaxial therewith are a plurality of cathodes 18¹, 18², 19¹ and 19² which may be linear filaments or of the equi-potential or heater type. Each of the cathodes is supported at one end by a corresponding J-shaped resilient metallic member 20 carried by a rigid metallic stub 21 sealed in the end wall 12. The cathodes are supported at the other end by a plurality of resilient metallic members 23 carried in common by a rigid metallic standard or upright 24 sealed in the end wall 12 of the enclosing vessel.

Control electrode elements or grids 25¹, 25², 26¹ and 26² are associated with the cathodes 18¹, 18², 19¹ and 19², respectively, each of these control electrode elements comprising, for example, a plurality of parallel U-shaped wires, the base portions of which preferably are semi-circular and coaxial with the corresponding cathode.

The parallel wires may be affixed at their ends to relatively large area metallic plates or fins 27 and 28, as by welding, together with retaining wires or strips 29, the plates or fins being supported individually by rigid metallic uprights 30 and 31, respectively, sealed in the end wall 12 of the enclosing vessel.

The construction above described, it will be seen, provides in effect four triode units each including a cathode 18 or 19, a corresponding grid or control electrode element 25 or 26 and an anode 14 or 15. In the fabrication of the device the various electrodes are so constructed and mounted that the four triode units are as nearly identical mechanically and electrically as is possible. Hence, the impedances of each triode and particularly the capacitances between each of the grids 25 or 26 and the corresponding anode will be equal.

The electron discharge device shown in Figs. 1 and 2 may be utilized in a push-pull amplifier such as shown, for example, in Figs. 3 and 4. As illustrated in these figures, the grids 25¹ and 26² may be connected together and to one end of a coil 32, which may be the secondary winding of an input transformer, and the grids 25² and 26¹ similarly may be connected together and to the other end of the input coil 32. The coil 32 may be shunted by a suitable fixed or variable condenser 33. A suitable biasing potential may be applied to the grids 25 and 26 by a source, such as a battery 34, having one terminal grounded and the other connected to the mid-point of the coil 32 through an inductance or choke coil 35.

The anodes may be connected, as shown, to opposite ends of a coil 36, which may be, for example, the primary winding of an output transformer, a suitable potential being impressed upon the anodes by a source, such as a battery 37, having one terminal grounded and the other connected to the mid-point of the output coil 36 through an inductance or choke coil 38. The coil 36 may be shunted by a fixed or variable condenser 39.

In amplifiers wherein the production of harmonics is not desired, the choke coils 35 and 38 may be omitted as illustrated in Fig. 4.

Each of the filamentary cathodes 18 and 19 may be connected to ground at one end through the metallic members 23 and the standard or upright 24 to complete the grid-cathode and plate-cathode circuits. The diagonally opposite cathodes 18¹ and 19¹ are connected at the other end by conductors 42 to the poles 39¹ of a four-pole double-throw switch, the blades 40 of which are connected to opposite terminals of a source such as a battery 41. Similarly, the diametrically opposite cathodes 18² and 19² are connected at the other, ungrounded, end to the poles 39² of the double-throw switch through conductor 43. When the switch is closed in one position, for example to engage the blades 40 with the poles 39¹, cathodes 18¹ and 19¹ are supplied with heating current from the source 41 through a series circuit including the blades 40, conductors 42, cathodes 18¹ and 19¹ and the metallic members 23 connected to these cathodes. When the switch is closed in the opposite position, the cathodes 18² and 19² will be supplied with heating current through a series circuit including the blades 40, conductors 43, cathodes 18² and 19² and the metallic members 23 connected directly to these cathodes. In operation of the amplifier only one pair of diametrically opposite cathodes is energized at any one time.

It may be pointed out that the phase of the output is dependent upon which of the pairs of cathodes is energized and that a phase reversal may be obtained by shifting energization from one pair of diagonally opposite cathodes to the other pair.

As is known in the art, in electron discharge apparatus, such, for example, as push-pull amplifiers, because of the inherent capacitance between the grid and anode of the electron discharge device, some energy feedback occurs from the anode to the grid, and as a result undesired variable potentials appear upon the grid so that distortion obtains and, if the feedback is sufficiently augmented, undesired oscillations are produced. These undesirable effects are eliminated in accordance with this invention by neutralizing, in effect, the inherent grid-plate capacitances.

The capacitances extant between the several grids 25 and 26 and the anodes 14 and 15 are indicated in dotted outline by the condensers C₁, C'₁, C₂ and C'₂ in Fig. 4. These capacitances, as pointed out hereinabove in the description of the device shown in Figs. 1 and 2, are substantially equal.

When the amplifier shown in Figs. 3 and 4 is operated, only one diametrically opposite pair of cathodes, for example, the cathodes 18¹ and 19¹, being energized, alternating potentials will be impressed upon the grid 26¹ by virtue of the capacitance C₁. Other potentials will be impressed upon the grid 26¹ by virtue of the capacitance C'₁ inasmuch as the grid 25² is electrically integral with the grid 26¹. The potentials impressed upon the grid 26¹ by virtue of the capacitances C₁ and C'₁ will be equal but opposite in phase. Consequently, the resultant thereof is zero or substantially so and the undesirable effects attributable to the capacitance C₁ are minimized or substantially eliminated. Similarly, the capacitance C₂ substantially neutralizes the effect of the capacitance C'₂.

If only the cathodes 18² and 19² are energized, the capacitances C₁ and C'₁ and C₂ and C'₂ will effectively neutralize each other in the same manner as described for the condition when only the cathodes 18¹ and 19¹ are energized.

The desired capacitance neutralization, it will be apparent, is achieved in the electrode structure itself and without the introduction of additional conductors which might introduce unduly high impedances in the systems in which the electron discharge device is to be utilized. Such obviation of high impedances, particularly relatively large inductances, is especially advantageous in ultra-short wave electron discharge apparatus in that it raises the maximum frequency limit at which the apparatus may be operated satisfactorily and efficiently.

As pointed out hereinbefore, only one pair of diagonally opposite cathodes need be energized when the electron discharge device is utilized in an amplifier circuit as illustrated on Figs. 3 and 4. Of course, either pair of diametrically opposite cathodes may be used. Hence, it will be seen that devices constructed in accordance with applicant's invention not only have a relatively long operating life but also enable a reduction in the interruption period of the circuit in which the devices are included, in the event of failure of one of the cathodes. For example, if the cathodes 18¹ and 19¹ are the ones energized in the amplifier illustrated in Figs. 3 and 4 and either of these cathodes should fail, the device

and circuit may be rendered fully operative again by merely throwing the switch into the position necessary to energize the cathodes 18² and 19². No changes in the other connections to the device are necessary, if the attendant phase reversal in the output is not of consequence, so that obviously the period during which operation of the amplifier is interrupted may be very short.

Furthermore, in devices constructed in accordance with this invention, the anodes have relatively large radiating surfaces so that heat is dissipated therefrom at a high rate. Likewise, because of the large surfaces of the plates 28 and 29, heat is dissipated rapidly from the several grids. Consequently, such devices are capable of safely handling high power.

The electron discharge device illustrated in Figs. 1 and 2 may be used to advantage also in oscillators as shown, for example, in Figs. 5, 6 and 7. Fig. 5 shows an oscillator having controlled regeneration, wherein the coils 32 and 36 constitute the oscillating inductances and the coupling therebetween may be varied. Only one pair of diagonally opposite cathodes need be energized at a time, for example by a battery 41 associated with the cathodes as shown in Fig. 3.

The circuit shown in Fig. 5 may be converted into a negative feedback amplifier by reversing the coupling between the coils 32 and 36 and introducing a phase shifting network, indicated by the box 44, in the grid circuit to provide the requisite phase relationships between the alternating potentials upon the grids and the anodes.

Fig. 6 illustrates the utilization of devices of the general construction shown in Figs. 1 and 2 in a crystal controlled oscillator, the control crystal 45 being shunted across the grid coil 32. The cathodes may be energized in the same manner as shown in Fig. 3.

In the oscillator shown in Fig. 7, all of the cathodes may be energized simultaneously in any suitable manner, the anodes connected directly together, and the four grids connected in parallel so that the four triode units of the electron discharge device are connected in parallel and a large output may be obtained.

Although a single electron discharge device and various applications thereof have been shown and described, it will be understood that these are but illustrative and that various modifications may be made therein without departing from the scope and spirit of the invention as defined in the appended claims.

What is claimed is:

1. Electron discharge apparatus comprising a pair of spaced anodes, a pair of control electrodes each having similar portions adjacent each of said anodes, a cathode adjacent only one of said anodes and one of said control electrodes, and another cathode adjacent only the other of said anodes and the other of said control electrodes.

2. Electron discharge apparatus comprising a pair of spaced parallel anodes, a pair of control electrodes disposed parallel to each other and at substantially right angles to said anodes, each of said control electrodes having opposite sides adjacent said anodes, a cathode disposed adjacent one side of one of said control electrodes, and another cathode disposed adjacent the opposite side of the other of said control electrodes.

3. Electron discharge apparatus comprising a pair of anodes, a cathode adjacent one of said

anodes, a second cathode adjacent the other of said anodes, a control electrode having a grid portion adjacent said first cathode and said one anode and a grid portion adjacent said other anode forming a capacitance therewith substantially equal to the capacitance between said first grid portion and said one anode, and a second control electrode remote from said first-mentioned control electrode having a grid portion adjacent said second cathode and said second anode and a grid portion adjacent said first anode forming therewith a capacitance substantially equal to the capacitance between said second anode and said grid portion thereadjacent.

4. Electron discharge apparatus comprising a pair of anodes each having a pair of spaced recesses therein, the recesses in one anode being in alignment with those in the other anode, a control electrode having portions adjacent one set of aligned recesses, a cathode adjacent one of said portions and one of said anodes, a second control electrode having portions adjacent the other aligned recesses in said anodes, and a second cathode adjacent the other of said anodes and the portion of said second control electrode thereadjacent.

5. Electron discharge apparatus comprising a pair of anodes, two pairs of grids, one grid of each pair being adjacent one of said anodes and forming a capacitance therewith and the other grid of each pair being adjacent the other anode and forming a substantially equal capacitance therewith, means electrically connecting the grids in each pair, a cathode adjacent one of said anodes and one of said grids thereadjacent, and a second cathode adjacent said other anode and one of said other grids thereadjacent.

6. Electron discharge apparatus comprising a pair of parallel anodes, a pair of parallel metallic plate members mounted between said anodes and at substantially right angles thereto, a pair of grids mounted on each of said plate members at opposite sides thereof, said grids being of the same construction and equally spaced from said anodes, a cathode adjacent one of said anodes and the grid at one side of one of said plate members, and a second cathode adjacent the other of said anodes and the grid at the opposite side of the other of said plate members.

7. Electron discharge apparatus comprising a plurality of pairs of cathodes, a plurality of control electrodes each adjacent a corresponding pair of said cathodes, and a pair of anodes each having portions adjacent all of said control electrodes.

8. Electron discharge apparatus comprising a pair of anodes, a pair of control electrodes each having spaced portions adjacent said anodes, a plurality of cathodes each of which is disposed adjacent a corresponding one of said spaced portions, means electrically connecting said cathodes at one end, and individual leading-in conductors connected to the other end of said cathodes.

9. Electron discharge apparatus comprising a pair of anodes, a pair of cathodes adjacent one of said anodes, a second pair of cathodes adjacent the other of said anodes, corresponding cathodes in said pairs being in alignment, a control electrode having portions adjacent one set of corresponding cathodes, a second control electrode having portions adjacent the other corresponding cathodes, and means connecting each pair of diagonally opposite cathodes in series.

10. Electron discharge apparatus comprising a pair of parallel anodes, a pair of control electrodes extending between said anodes and having

their sides equally spaced from said anodes, said sides being of similar construction whereby the capacitances between said anodes and said control electrodes are substantially equal, a cathode adjacent each of said anodes and the juxtaposed side of each control electrode, means for energizing only the cathode adjacent one anode and one side of one control electrode and the cathode adjacent the other anode and the opposite side of the other control electrode, an input circuit connected between said control electrodes, and an output circuit connected between said anodes.

11. Electron discharge apparatus comprising a pair of parallel anodes each having a pair of

recesses therein, a pair of control electrodes each having a grid portion in one recess in one of said anodes and a second grid portion in one recess in the other of said anodes, said grid portions and the portions of the anode thereadjacent being so spaced and of such construction that the capacitances therebetween are substantially equal, a plurality of cathodes each opposite a corresponding one of said grid portions, individual leading-in conductors connected to one end of said cathodes, and means electrically connecting at least two of said cathodes at the other end.

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