Feb. 7, 1939. E. W. HEROLD 2,146,016

ELECTRON DISCHARGE DEVICE

Filed Nov. 18, 1937

Fig. 1

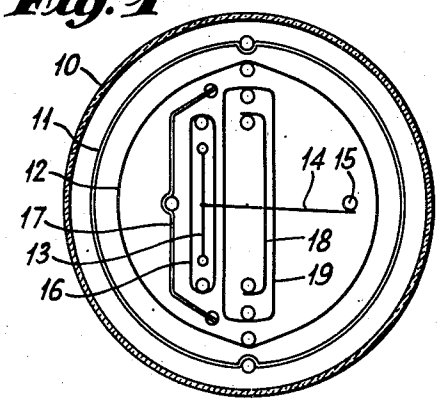


Fig. 2

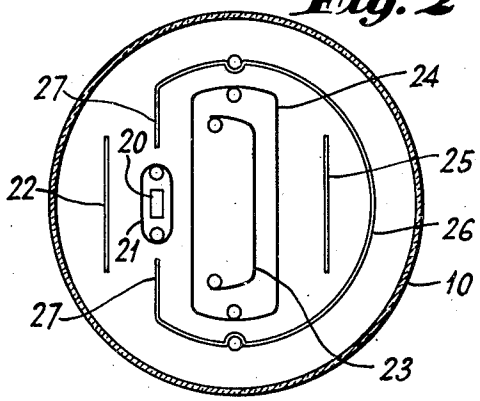


Fig. 3

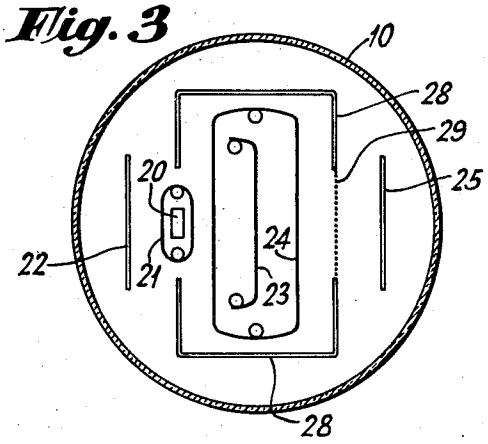
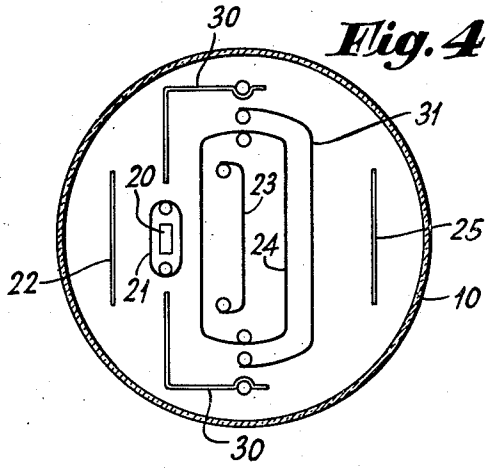


Fig. 4



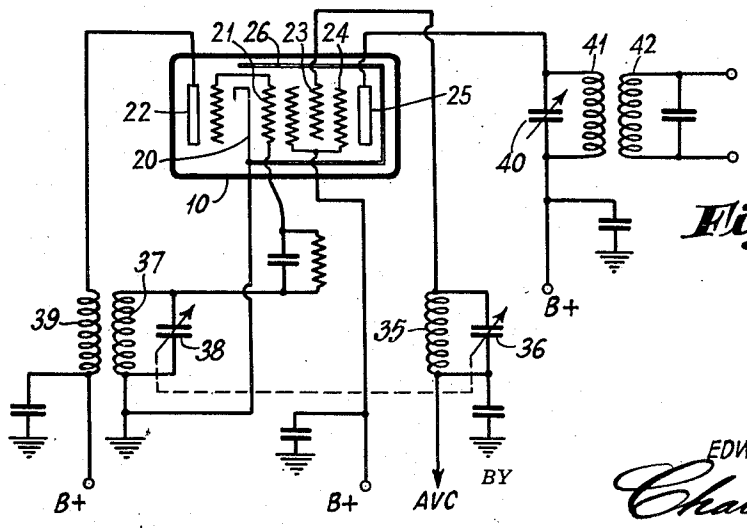


Fig. 5

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ELECTRON DISCHARGE DEVICE

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4 Claims. (Cl. 250—27.5)

My invention relates to electron discharge devices for superheterodyne reception and more particularly to a multi-electrode electron discharge device in which local oscillations of a predetermined frequency and input oscillations of a different frequency, such as a radio signal, are mixed or combined directly in the tube.

In radio receivers employing the superheterodyne method of reception two different frequencies must be combined; that is, the frequency of the signal received by the antenna and usually amplified in the preceding stage must be combined with the local frequency produced by a local oscillator in the receiver proper so that the heterodyne action will produce an intermediate frequency modulated in the same manner as the sgnal frequency.

Usual methods of heterodyne reception employ a first detector or mixer tube, in which the radio signal (input) frequency and the local frequency, generated in an oscillator circuit usually by a separate tube are both applied to the same grid of the mixer tube. These methods generally depend on coupling the oscillator and input circuits by either capacitive or inductive coupling which requires rather critical adjustment, and due to this coupling, changes in the signal input circuit affect the operation of the oscillator and hence the local frequency.

Electron discharge tubes with high gain and in which heterodyne action may be obtained without undesirable intercoupling between the input (signal) and oscillator circuits have been proposed in which the oscillator grid and plate electrodes are positioned in the stream of electrons which flows from the thermionic cathode to the signal or modulator grid and output plate. In this type of tube where the oscillator anode is in the same electron stream as the modulator electrodes, undesired intercoupling between the oscillator and modulator sections is apt to be present. Furthermore any constructional changes in the oscillator section of the tube will have a direct effect upon the operation of the signal responsive or modulator section of the tube, for example a change in the turns per inch of the oscillator control grid wire will cause a substantial change in the current of the output plate, and for these reasons it is difficult to design the modulator (signal) and oscillator sections of the tube independent of each other and to screen them from each other in a manner to give the optimum operation for each. It has also been found that with this type of electrode construction, particularly with a V-shaped filament as the cathode, a reduction in the conventional size of the electrode mount, which for certain types of small tubes is desirable, introduced design difficulties which were not easily overcome by well-known mechanical expedients.

An improved electron discharge device with high gain and in which heterodyne action may be obtained without undesired intercoupling between the input and oscillator circuits, and in which the operation of the oscillator section of the device is independent of the modulator section of the device, is described in U. S. Patent 2,036,696 issued to me April 7, 1936.

The tube described in the above mentioned patent comprises a cathode surrounded by a grid, on one side of which is the oscillator anode and on the other side of which is a signal grid or modulator grid surrounded by a screen grid, all of the electrodes being surrounded by an output anode and, if desired, a suppressor grid. Electrons from the cathode are divided into two streams between the oscillator anode and the output anode. The grid surrounding the cathode serves both as the oscillator grid and as the grid for modulating the electron stream to the output anode at the oscillator frequency. The stream of electrons passing to the output anode is, therefore, modulated first at oscillator frequency and as they pass through the modulator grid by the signal frequency or modulator frequency, the result being an intermediate frequency at the output anode.

The object of the present invention is to further improve the electron discharge device described in the above mentioned patent.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a top end view with the top mica spacer removed of the electrode mount assembly of an electron discharge device described in the above mentioned patent, Figure 2 is a top end view of an electrode mount assembly of an electron discharge device made according to my invention, Figures 3 and 4 are top end views of modifications of the electron discharge device shown in Figure 2, and Figure 5 is a circuit diagram of a representative type of circuit used with the device shown in Figures 2 to 4 inclusive.

In Figure 1 the electron discharge device is provided with an evacuated envelope 10, having the usual stem and press, not shown, upon which

the electrode assembly is mounted and electrically connected to a plurality of the usual lead-in wires and supports.

The electrode assembly is mounted in a conventional manner between a pair of insulating discs, not shown, preferably of mica. The outer cylindrical electrode 11 is the main or output anode. A cylindrical suppressor grid 12 may, if desired, be mounted within and concentric with the output anode. A cathode 13, which is shown of the filamentary type, but may be of the indirectly heated type is positioned within the anode 11. The filamentary cathode may conveniently be supported at its upper end by a spring 14 secured to support rod 15. Positioned around the cathode 13 is a grid 16, preferably in the form of a flattened helix suitably supported on side rods. Adjacent the oscillator grid 16 and on one side of the cathode is an oscillator anode 17, preferably a sheet of metal parallel to the plane of the cathode. The cathode 13, grid 16 and anode 17 comprise the oscillator portion of the tube for generating local oscillations within the tube.

Mounted on the opposite side of the cathode from the oscillator anode is a signal or modulator grid 18 preferably connected to a terminal cap, not shown, at the top of the tube envelope 10, and surrounded by a flattened helical grid 19 which acts both as an accelerating grid for the electron stream and also as an electrostatic screen for reducing the direct capacity between the signal grid 18 and the other tube elements. These two grids 18 and 19 are interposed between the cathode and the output anode 11 of the signal responsive or modulator section of the tube.

The electron discharge from the cathode 13 is divided into two electron streams leaving the cathode, and preferably flowing in opposite directions. One of the streams flows through the oscillator grid 16 to the oscillator anode 17 and the other through the grids 18 and 19 to the output anode 11. The oscillator frequency on the grid 16 modulates the electron stream leaving the cathode to the output anode so that the frequency of the local oscillator is imposed upon the electron stream passing through the modulator or signal grid 18, which further modulates the electron stream in accordance with the received radio signal frequency applied to the signal grid.

The present invention is directed to a tube of the type shown in Figure 1 but in which undesired interaction between the oscillator and modulator portions of the tube is still further reduced, special electrodes being used to insure the minimum of interaction. The cut-off characteristics of the tube are also improved by a tube made according to my invention and described below. Referring to Figure 2 the electron discharge device comprises the flat cathode 20 from which oppositely disposed electron streams are directed. This is surrounded by the oscillator grid 21. The oscillator anode 22 is disposed on one side of the cathode and on the other side of the cathode are disposed the modulator grid 23, screen grid 24 surrounding the modulator grid, and the output 25. To insure against any electrons being returned by the signal grid, for example, around the cathode and oscillator grid to the oscillator anode, I provide a shield 26 surrounding the modulator electrodes and provided with the flat oppositely disposed members or portions 27 lying in the plane of the cathode and the oscillator grid and closely adjacent the oscillator grid side rods. With this arrangement the electrons which might be directed to the oscillator anode by means of the signal grid 23 would be blocked by the shield portions 27. This shield may be operated at cathode potential or some positive potential substantially lower than that of the screen and anodes.

With the signal grid side rods disposed in the plane of the screen grid side rods as shown in the arrangement in Figure 1, some tendency existed for some of the electrons to follow a curved path around the inside of the shield shown in Figure 2, these electrons eventually striking the output anode without having passed through the signal grid. This represented a residual current which, although not in itself harmful, was found to cause at very negative signal-grid bias voltages some modulation of the current in opposite phase to the normal modulation. This caused a bucking out giving a critical point of zero gain at a definite bias. According to my invention I move the grid side rods forward toward the cathode to the off-center position shown in Figure 2. By doing so these stray electrons are prevented from reaching the output anode around the inside of the shield and the cut-off of the tube is considerably improved.

In Figure 3 I show a modification in which the shield comprises a pair of channel members 28 providing between their longitudinal edges a passageway for the electron stream going to the output anode 25. The low potential at which the channel members are operated cause this passageway to operate in a similar manner to a suppressor grid, reducing the secondary emission interchange between the output anode 25 and screen grid and also increasing the output resistance. In some cases it may be desirable to augment this action by joining the channel members by transverse grid wires 29. The grid wires shown by 29 may advantageously be replaced in some cases by one or more longitudinal strips or wires, symmetrically located in the opening between the channel members and connected electrically to the channel members.

A still further modification is shown in Figure 4 where the shield comprises a pair of L-shaped members 30 and in which a separate suppressor 31 is provided.

A circuit which may be used with the tube described is shown in Figure 5. The input or signal circuit comprising the inductance 35 and variable capacity 36 is connected to the signal grid 23. The screen grid 24 may have a positive voltage applied to it with respect to the cathode 20. The anode 22 of the oscillator is coupled to the oscillator circuit comprising the inductance 37 and variable capacity 38 by means of the oscillator anode output coil 39, energy from the oscillator anode circuit being fed to the oscillator circuit to generate oscillations of local frequency which are applied to the oscillator control grid 21, which modulates the electron stream leaving the cathode, and going to the output anode 25. The signal grid 23 modulates this electron stream in accordance with the received signal. The intermediate frequency output is fed to the circuit comprising the condenser 40 and inductance 41 coupled to the next succeeding stage by means of inductance 42. The shield 26 may be connected to cathode 20 or to a source of voltage less than that of the screen and anode by a separate lead.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it

will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

What I claim as new is—

1. An electron discharge device having a thermionic cathode, an oscillator anode and an output anode positioned on different sides of said cathode to produce two separate and distinct electron streams from the cathode, a grid surrounding said cathode, a control grid positioned between said output anode and said cathode, and a screen interposed between said control grid and said cathode, a shield surrounding said control grid and screen grid and having flat portions extending toward each other and lying in a plane passing through the cathode, said portions providing an opening in which the cathode and grid electrode surrounding the cathode lie.

2. An electron discharge device having a thermionic cathode and a grid electrode surrounding said cathode, a plurality of grids and an output anode positioned on one side of said cathode for providing a main discharge path between said cathode and said anode, and an auxiliary anode placed on the opposite side of said cathode from said plurality of grids and said main anode to provide a second discharge path between said cathode and said auxiliary anode, and a pair of oppositely disposed U-shaped channel members having the legs extending toward each other, one leg of each channel member lying in a plane passing through said cathode and transverse to the discharge paths between the cathodes and anodes and the other of each pair of legs forming between them an opening through which the electron discharge takes place between the cathode and output anode.

3. An electron discharge device having a thermionic cathode and a grid electrode surrounding said cathode, a plurality of grids and an output anode positioned on one side of said cathode for providing a main discharge path between said cathode and said anode, and an auxiliary anode placed on the opposite side of said cathode from said plurality of grids and said main anode to provide a second discharge path between said cathode and said auxiliary anode, and a pair of oppositely disposed U-shaped channel members having the legs extending toward each other, one leg of each channel member lying in a plane passing through said cathode and transverse to the discharge paths between the cathodes and anodes and the other of each pair of legs forming between them an opening through which the electron discharge takes place between the cathode and output anode, a control electrode between said main anode and said cathode and a grid electrode surrounding said control electrode and permitting the passage of current between the cathode and said main anode, and an auxiliary anode placed on the opposite side of said cathode from said main anode to provide a discharge path between said cathode and said auxiliary anode, said control grid and said grid surrounding said control grid each being provided with oppositely disposed parallel side rods, the side rods of said control grid lying between a plane passing through the cathode, and a plane passing through the side rods of the grid surrounding said control electrode, and a shield comprising sheet metal members on opposite sides of and adjacent the cathode and lying in a plane passing through the cathode and transverse to the discharge paths between the cathode and said anodes.

4. An electron discharge device having a thermionic cathode and a grid electrode surrounding said cathode, a main anode positioned on one side of said cathode, a control electrode between

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