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ELECTRON DISCHARGE DEVICE

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Fig. 1

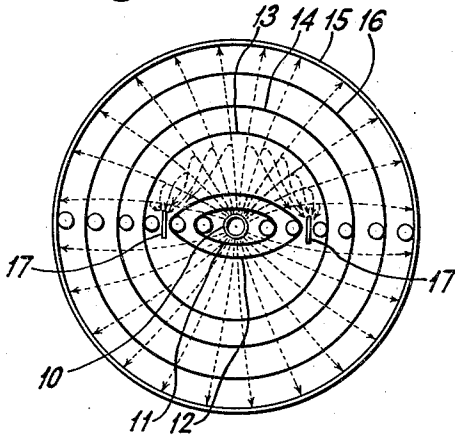


Fig. 2

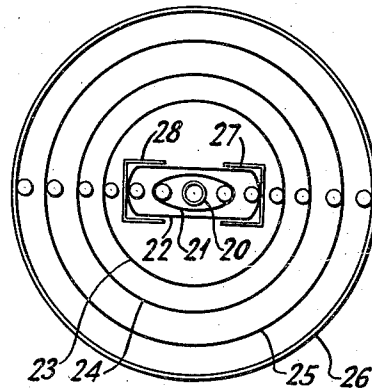


Fig. 4

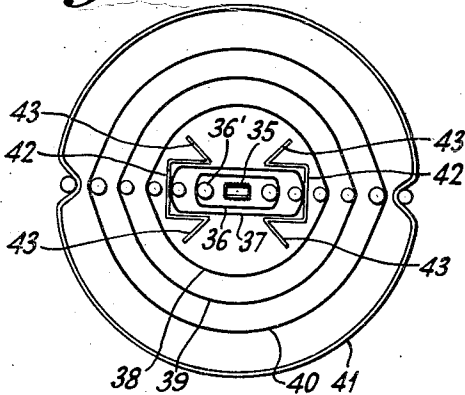


Fig. 3

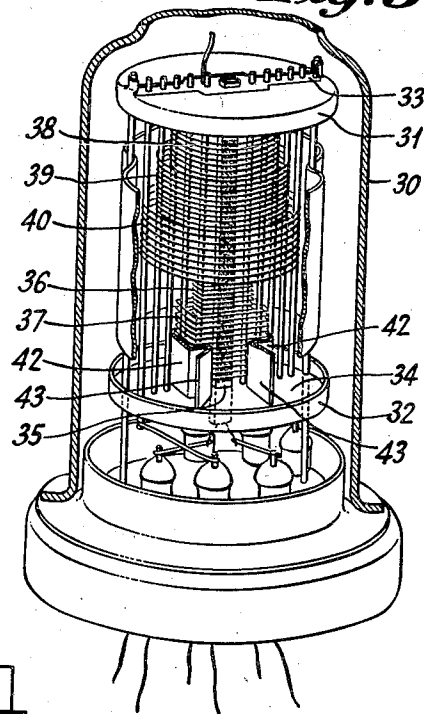
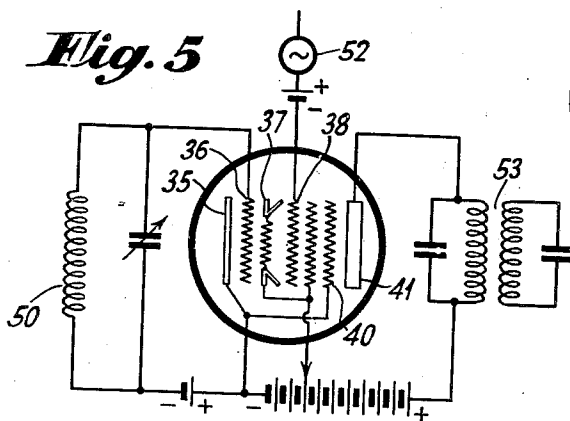


Fig. 5



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ELECTRON DISCHARGE DEVICE

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Application August 13, 1937, Serial No. 158,894

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 predetermined frequency and input oscillations of a different frequency, such as a radio signal, are mixed or combined within the device.

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

Usual methods of a heterodyne reception employ a first detector or mixer tube in which the radio signal (input frequency) and the local oscillations of a different frequency generated in an oscillator circuit usually by a separate tube are both applied to the same tube but on different grids. This mixing action in modern receivers may be accomplished by means of two different types of tubes, one the so-called pentagrid converter, which has several grids, the oscillator grid being the inner grid near the cathode and the signal grid being an outer grid. This tube performs both the functions of the oscillator and mixer. The converter type of tube in which both functions are performed meets with several difficulties, the two major ones being space charge coupling between the oscillator and signal sections, and the change of oscillator frequency when automatic volume control voltage is applied to the tube. These difficulties were overcome to a certain extent by placing the signal voltage on an inner grid and the oscillator voltage on an outer grid. This method of operation, however, prevented a tube design which could combine the functions of an oscillator and mixer in the same section of the tube due principally to the fact that the oscillator would cease functioning when the signal or control grid became sufficiently negative to cut off the electron stream to the oscillator portion of the tube. For high frequencies, therefore, it was found more desirable to use the so-called straight mixer tube having a signal grid and an oscillator grid to which the oscillator voltage is applied by a separate tube or a separate group of electrodes in the same en-

velope effective as a separate tube to provide the oscillator voltage.

When the higher frequencies were encountered, however, it was found that even the mixer tube was subject to certain objections because of the transit time effect in the tube which caused grid current to flow in the first or signal grid when the second or oscillator grid voltage was high in frequency. This effect is explained as due to the electrons which are periodically repelled by the oscillator grid when it goes negative; that is, electrons which are in the space between the signal grid and the oscillator grid when the oscillator grid swings negative are returned to the signal grid. It was also discovered that the signal grid input resistance was quite low at the high frequencies and most of this so-called "transit time loading" was also due to the electrons repelled by the oscillator grid to the vicinity of the first grid.

A tube which eliminates the undesirable characteristics due to transit time loading is described and claimed in a co-pending application, Serial No. 139,375 filed in the name of Edward W. Herold, April 28, 1937 and assigned to the same assignee as the present application. Briefly this tube comprises a cathode surrounded by a control grid, a first screen grid, a second control grid, a second screen grid, a suppressor and an anode. The first screen grid is provided with a pair of oppositely disposed U-shaped channel members extending along and secured to the screen grid side rods to provide oppositely disposed apertures through which beams of electrons pass from the cathode to the anode. In operation electrons which are caught between the first screen grid and the second control grid, when the second control grid goes negative, are caused to be swept out of the space between the first screen grid and the second control grid and toward the channel members which intercept these electrons and prevent them from returning to the first control grid.

It is the principal object of my invention to provide an improved type of mixer tube for use in superheterodyne receivers, more particularly to provide a still further improved tube of the type described in the Herold application in which the transit time effects described above are substantially eliminated.

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 transverse cross section of the mount of an electron discharge device illustrating and embodying the principles of my invention; Figure 2 is a practical form of a mount of an electron discharge device described in the Herold application; Figure 3 is a perspective view partially in section to show details of construction of an electron discharge device made according to my invention and which has been found most satisfactory; Figure 4 is an end view of the electrode mount assembly of Figure 3, and Figure 5 is a conventional circuit in which an electron discharge device made according to my invention is incorporated.

In the conventional mixer tube such as shown in the Llewellyn Patent 1,876,780, issued February 7, 1933, and assigned to the Bell Telephone Laboratories the cathode is surrounded in turn by a signal grid, a screen grid, an oscillator grid to which the local oscillation is applied, and a second screen grid, and an anode. At very high frequencies the time required for the electrons to travel from the cathode to the anode is long enough so that electrons may be caught in flight between the signal grid and the oscillator grid when the oscillator grid goes negative. These electrons are sometimes repelled by the negative oscillator grid and return to the signal grid with an appreciably increased velocity. By means of my invention the electrons which are repelled by the oscillator grid are swept out of the space between the signal grid and oscillator grid and prevented from returning to the signal grid.

A better understanding of the action may be obtained by referring to Figure 1 showing a cross section of a mount of a tube embodying the principles upon which my invention is based. A cathode 10 is surrounded in turn by a signal grid 11, screen grid 12, oscillator grid 13, screen grid 14 and anode 15. A suppressor grid 16 can be added if desired. Each of the grids is provided with oppositely disposed side rods, the side rods lying in a common plane. With the construction so far described, which is the conventional mixer tube, the electrons are projected in two more or less well defined streams or beams from opposite sides of the cathode due to the action of the signal grid side rods. In normal operation when the oscillator grid 13 is swung negative by the applied oscillator voltage, the electrons are prevented from reaching the anode 15 and are returned to the region of the signal grid through the screen grid 12 which is at a high positive potential. The effect of the returned electrons is to cause the signal grid to exhibit a very low input resistance at high frequencies. In addition, some of the electrons have appreciably increased velocities because of the change in oscillator grid potential during the time the electrons are in the region between grids 12 and 13. The increased velocity is sometimes sufficient to permit electrons to strike the negatively biased signal grid 11.

To render the returned electrons ineffective there is placed between the signal grid and oscillator grid, and in line with the side rods, a pair of auxiliary electrodes 17, which are maintained at a high positive potential with respect to the signal grid and the oscillator grid and being preferably at a higher potential than the screen grid 12. The result of this applied voltage is to cause the stream of electrons on either side to travel in more or less curved paths as indicated by the dotted lines from the cathode to

the anode. It will thus be seen that most of the electrons are made to pass considerably closer to the side rods than when the electrodes 17, 17 are not present. Electrons caught between the signal grid and the oscillator grid under these conditions will not return to the region of the signal grid but will be returned as indicated by the dotted lines to the auxiliary electrode 17, 17, which are at the higher positive potential. These returning electrons are indicated for only one-half of the tube, it being understood that this action takes place on both sides. In this way the electrons which would normally be returned by the oscillator grid going negative are swept from the field between the signal and oscillator grids and are rendered ineffective to cause grid current and low signal resistance.

In Figure 2 a modified form of tube is shown which is an improvement over that shown in Figure 1. The form shown in Figure 2 eliminates the necessity for separate auxiliary electrodes and the necessary leads and results in a simpler construction in which the high potential small auxiliary anodes are replaced by lower potential but much larger auxiliary anodes. In this arrangement the cathode 20 is surrounded by a control grid 21 and screen grid 22, followed in turn by the oscillator grid 23, screen grid 24, suppressor 25 and anode 26. In this form the auxiliary electrodes 27 and 28 have the form of channel members attached on the outside of the screen grid to the screen grid side rods so that oppositely disposed slots are provided for the electrons issuing from the cathode. This construction also has the advantages characteristic of the form shown in Figure 1, but is in addition simpler in construction.

The preferred embodiment of my invention disclosed in Figure 3 and embodied in a tube of the metal envelope type includes a metal envelope 30 in which the mount assembly is contained. The mount is positioned between a pair of shielding members 31 and 32 supporting the mica insulating spacers 33 and 34 which insulatingly support and space the electrodes from each other. As best shown in Figure 4, the cathode comprises a tubular member 35 of rectangular cross section. The flat opposite sides only preferably are coated, which assists in the beam formation of the electrons from the cathode to the anode. The cathode in turn is surrounded by a control grid 36, the wires of which are parallel to the flat coated surfaces of the cathode, the side rods 35' being opposite the non-coated surfaces of the cathode, a screen grid 37, oscillator grid 38, screen 39, suppressor 40 and anode 41. The collecting electrodes or auxiliary electrodes 42 are in the form of channel members electrically connected to the screen grid side rods and oppositely disposed to provide a pair of oppositely disposed slots or apertures through which the beams of electrons from the cathode are directed toward the anode.

In accordance with my invention the collecting electrodes 42 are provided with fins 43 which are coextensive with and lie along the edges of the channel members adjacent the beams of electrons, being preferably bent back at an angle outwardly from the beam as shown in Figure 4. These fins give the returning electrons a much increased sideward component in their passage between the first screen grid 37 and the second control grid 38. In this manner the electrons which would normally cause grid current in the first control grid 36 are intercepted by the fins. In actual practice this arrangement gives an

increased reduction in the first grid current over the type of tube described in the Herold application without affecting the other desirable characteristics of a mixed type tube.

5 The application of a tube made according to my invention to a conventional circuit is shown in Figure 5 in which the tuned circuit comprising the inductance 50 and variable capacity 51 is connected between cathode 35 and control grid 10 36. The screen grids 37 and 39 are connected to the usual source of voltage 40, the oscillator grid 38 being connected to a separate local oscillator 52. The output from the anode is fed through the primary of the coupling transformer 53.

15 While I have indicated the preferred embodiment 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 20 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 25 in the appended claims.

What I claim as new is:

1. An electron discharge device having a cathode for supplying electrons surrounded by a first control grid, a screen grid, a second control grid 30 and an anode for receiving said electrons, said cathode and grids cooperating to cause electrons from said cathode to move in a beam to said anode, said second control electrode being adapted to have varying negative and positive potentials of high frequency applied thereto, and a 35 pair of oppositely disposed channel members connected to said screen grid on opposite sides of said beam, said channel members having fins extending along the edges adjacent the beam for receiving electrons returned by said second control grid when negative potentials are applied 40 to said second control grid during operation of the electron discharge device.

2. An electron discharge device containing a 45 cathode having a flat surface coated with emitting material for supplying electrons, a control electrode adjacent said cathode and lying parallel to said flat surface and provided with a pair of oppositely disposed members at opposite 50 edges of the flat cathode for providing a beam of electrons, an anode for receiving said beam of electrons, a second control electrode in the path of said beam of electrons adapted to have varying positive and negative potentials of high frequency 55 applied thereto, and means on opposite sides of said beam including a pair of oppositely disposed

channel members on opposite sides of said beam of electrons, said channel members having fins coextensive with and lying along the edges adjacent the beam for receiving electrons returned 5 by said second control electrode when said control electrode becomes negative during operation of said electron discharge device.

3. An electron discharge device containing a cathode having a flat surface coated with emitting material for supplying electrons, a control 10 electrode adjacent said cathode and having grid wires parallel to said flat surface and provided with a pair of oppositely disposed members at opposite edges of the flat cathode for providing 15 a beam of electrons, an anode for receiving said beam of electrons, a second control electrode in the path of said beam of electrons adapted to have varying positive and negative potentials at high frequency applied thereto, and means on 20 opposite sides of said beam including a pair of oppositely disposed channel members on opposite sides of said beam of electrons, said channel members having fins coextensive with and lying along the edges adjacent the beam for receiving electrons 25 returned by said second control electrode when said control electrode becomes negative during operation of said electron discharge device, and a screen grid positioned between said control electrodes.

4. An electron discharge device containing a 30 thermionic cathode having two opposite flat surfaces coated with electron emitting material, the surfaces between being uncoated, a control grid surrounding said cathode and having grid wires parallel to the flat emitting surfaces of said cathode and a pair of oppositely disposed side rods 35 positioned adjacent the non-emitting surfaces of said cathode whereby a pair of oppositely directed beams of electrons is formed, and an anode for receiving said beams of electrons, a screen grid 40 surrounding said control grid, a second control grid surrounding said screen grid and adapted to have varying negative and positive potentials of high frequency applied thereto, and a pair of oppositely disposed channel shaped members supported by and electrically connected to said screen 45 grid and providing a pair of apertures in said screen grid through which the beams of electrons pass, said channel shaped members having fins bent outwardly at an angle from the beams of 50 electrons and coextensive with and along the edges adjacent the beams of electrons for receiving electrons returned by said second control grid when a negative potential is applied thereto during the operation of said electron discharge device. 55

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