Oct. 15, 1946. C. S. BULL 2,409,417

ELECTRON DISCHARGE DEVICE

Filed May 29, 1944

Fig. 1.

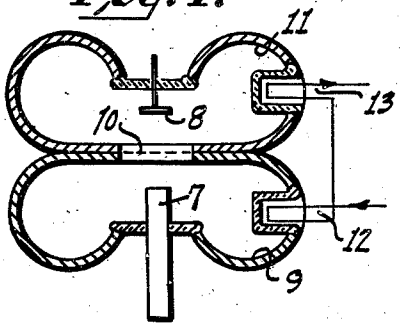


Fig. 2.

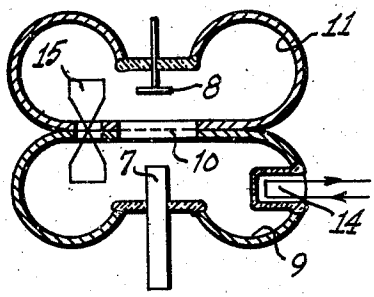


Fig. 3.

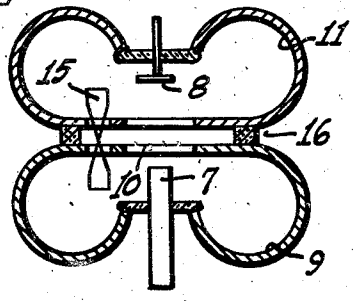


Fig. 4.

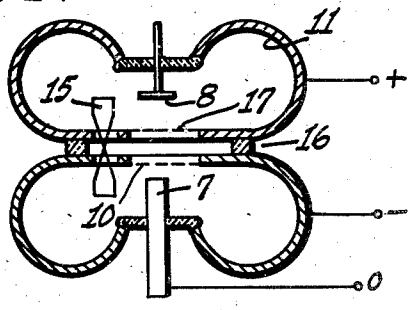


Fig. 5.

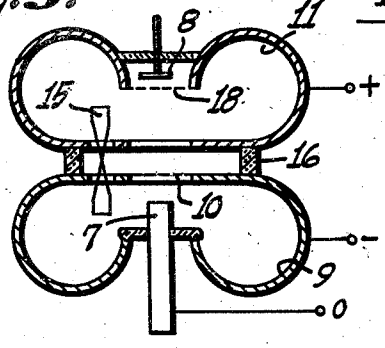
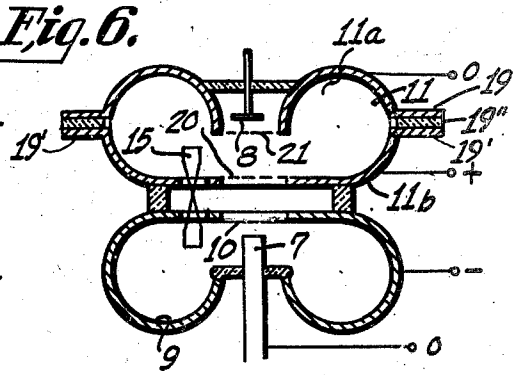


Fig. 6.



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ELECTRON DISCHARGE DEVICE

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Application May 29, 1944, Serial No. 537,854
In Great Britain June 21, 1941

5 Claims. (Cl. 315—6)

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My invention relates to high frequency electric circuits and to electron discharge devices employing hollow resonators for use in such circuits.

It has been proposed to use such a hollow resonator as a tuned circuit and control electrode in a conventional triode, a screened grid or similar valve. In such a case the input signals are fed to the hollow resonator and the aperture in the hollow resonator which may or may not be provided with a grid through which the beam passes, serves to control the flow of electrons in much the same way as the control grid in a conventional valve.

I have found, however, that the stream of electrons passing through the grid or aperture gives rise to a noise which is not encountered in the conventional type of valve. The electrons passing from the cathode towards the grid or aperture induce a charge on the interior surface of the hollow resonator and once the electrons pass through the grid or aperture they have little or no further influence on the resonator with the result that the induced charge discharges in an oscillatory manner. This discharge which is set up by each electron constitutes a noise power in the circuit and consequently the noise-to-signal ratio is not so good as with the conventional arrangement of electron discharge device.

It is an object of the present invention to provide a high frequency electric circuit including an electron discharge device having a control electrode in which undesired effects arising from the high frequency operation are reduced.

A further object of the invention is to provide an improved electron discharge device in which a hollow resonator is employed as the input circuit with an electron discharge device with a view to reducing or eliminating the noise that is generated due to the passage of electrons through the resonator.

According to one feature of the invention, an electric circuit arrangement is provided comprising an electron discharge device having at least a cathode and an anode and a control electrode for electrons passing between said cathode and said anode, and including means so connected and disposed as to be capable of deriving high frequency energy from electrons in the space between said control electrode and said anode, the arrangement being such that said energy will set up effects at said control electrode which wholly or partly neutralize undersired high frequency effects occurring at said control electrode due to the passage of said electrons.

According to a further feature of the invention,

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there is provided an electron discharge device comprising means for providing an electron beam and a pair of hollow resonators through which said beam can be caused to pass, in succession, said resonators being so coupled together that noise currents set up by the passage of an electron through the first resonator are reduced or substantially neutralized by the noise currents set up by the passage of that electron through the second resonator.

In order that the said invention may be clearly understood and readily carried into effect, the same will now be more fully described with reference to the drawing accompanying the specification, in which:

Figure 1 is a schematic longitudinal section of a triode electron discharge device for operation in accordance with the present invention;

Figure 2 illustrates a modification of Figure 1, and

Figures 3, 4, 5 and 6 illustrate the application of the invention to tetrode and pentode type electron discharge devices.

The device according to the invention shown in Figure 1 comprises a cathode 7, an anode 8 and a hollow resonator 9 which constitutes the input circuit and will normally be tuned to resonate at a suitable frequency depending upon the frequency of the signals to be applied to the device. The hollow resonator 9 has the cross-section shown, and is of toroidal form and the aperture through which the electrons pass from the cathode 7 to the anode 8 is covered by a grid 10 although in some cases this grid may be omitted. For the purpose of reducing noise current induced in the resonator 9 by the passage of the beam, a further hollow resonator 11 is provided, one wall of which is common with the wall of the resonator 9 containing the grid 10. With such an arrangement an electron leaving the cathode 7 and passing through the grid 10 leaves a negative charge on the side of the grid closing resonator 9 and gives rise to an oscillatory discharge or noise current. On passing through grid 10 and resonator 11, this electron will give rise to a further oscillatory discharge in a similar manner, the two resonators being coupled together so that the energy derived from the electron in the space within the second resonator is applied to the first resonator 9 in such manner that the resultant noise current therein is reduced or completely neutralized so that no noise voltages are set up on said control electrode due to the passage of electrons between the anode and the cathode. The coupling between the reso-

nators 9 and 11 in the example shown in Figure 1 is effected by the provision of a pair of coupling loops 12 and 13 connected in series with the source of input signals, the loops being reversed with respect to each other. In the arrangement shown in Figure 2 of the drawing, however, the input signals are applied to the resonator 9 via a separate coupling loop 14 and the two resonators 9 and 11 are coupled together by the reverse coupling loop 15, as shown. It will be understood that although the second resonator serves to neutralize the noise currents in the input resonator, it does not itself control the beam current directly because, due to the attraction of the anode 8, any electron which passes through the grid 10 will proceed to said anode. The second resonator would, however, tend to neutralize any velocity modulation in the beam so that this arrangement would be unsatisfactory in a circuit operating with velocity modulation of the electron beam.

It will be appreciated from a consideration of the construction shown in Figures 1 and 2 that the two resonators 9 and 11, since they have a common wall, will be maintained at the same direct current potential. This, however, is not necessary and is undesirable in some cases, since it does not permit the two resonators to be maintained at different direct current potentials. Thus, the construction shown in Figure 3 may be employed, from which it will be seen that the resonator 11 is formed separately from the resonator 9. The space between the resonators may be filled with dielectric material, if required, for constructional reasons, leaving, of course, a suitable gap in the dielectric near the grids for the passage of electrons. With such an arrangement it will be appreciated that the resonators may be maintained at different direct current potentials and that, if desired, the resonator 11 may be maintained at a high positive potential so that the field produced due to the high potential applied to the resonator 11 will serve to draw electrons from the cathode, even though the grid 10 is at a negative potential. Thus, the resonator 11 can effectively perform the function of the screen-grid of a conventional valve. If desired, as shown in Figure 4, the aperture in the resonator 11 may be provided with a grid 17 or, alternatively, as shown in Figure 5, the aperture in the resonator remote from the aperture adjacent the grid 10 may be provided with a grid 18. In a further form of the invention as shown in Figure 6, the resonator 11 is formed in two parts 11*a* and 11*b*, which are capacitatively coupled together through the medium of the peripheral flanges 19—19', which may be separated by air or vacuum or by a dielectric substance 19'' if a higher capacity is required. In this case the aperture in the portion 11*b* may be provided with a grid 20 and the portion 11*a* provided with a grid 21 and if the portion 11*a* is maintained at a low potential, such as cathode potential, the grid 21 can serve to prevent secondary electrons leaving the anode 8 so that the device can be made to function similarly to a conventional pentode valve.

In all the arrangements shown in Figures 2 to 6, inclusive, of the drawing, coupling means such as loop 15 is required and in Figure 1 loops 12 and 13 are required between the two resonators 9 and 11.

The devices described may be employed for any suitable purposes, such as for amplification, detection or mixing of high frequency oscillations

and although the output from the devices described is taken from the anode 8, it will be appreciated that, if desired, the beam of electrons passing through the hollow resonator 11 may be caused to pass through a further hollow resonator from which an output can be obtained. Where the device is employed for mixing oscillations the electron beam, after leaving the resonator 11, may pass to a further system of any suitable form by which oscillations of a different frequency can be applied to the beam so as to produce resultant oscillations of the different frequency.

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 cathode for supplying a beam of electrons and a collector for receiving said electrons, and a pair of cavity resonators surrounding the electron path between the cathode and the collector and through which the beam of electrons successively passes, and a reversed coupling loop extending between said resonators whereby noise currents set up by passage of the electron beam through the first resonator are reduced or substantially neutralized by the noise current set up by the passage of the electron beam through the second resonator.

2. An electron discharge device having a cathode for supplying a beam of electrons and a collector for receiving said electrons, a first resonator positioned adjacent said cathode and provided with a grid through which the electrons pass, and a second resonator surrounding the electron path between said first resonator and said collector, and a reversed coupling loop extending between said resonators whereby the noise currents set up by the passage of the electrons through the first resonator is reduced or substantially neutralized by noise current set up by the passage of said electrons through the second resonator.

3. An electron discharge device including a cathode for supplying a beam of electrons, and a collector for receiving said electrons, and a first resonator surrounding said cathode and through which said electron beam is directed, and a second resonator surrounding the electron path between said first resonator and the collector and having a common wall with said first resonator, said common wall being provided with an aperture and grid extending across said aperture, and a reverse coupling loop extending between said resonators whereby noise currents induced in the first resonator are substantially neutralized by the same noise currents induced in said second resonator.

4. An electron discharge device having a cathode for supplying a beam of electrons and a collector for receiving said electrons, a first resonator adjacent said cathode and through which the electron beam passes, and a second resonator surrounding the electron path between said first resonator and said collector, said resonators having aligned apertures through which the beam of

electrons successively passes, a reverse coupling loop extending between said resonators whereby noise currents set up by the passage of electrons through the first resonator are reduced by noise currents set up by the passage of electrons through the second resonator.

5. An electron discharge device having a cathode for supplying a beam of electrons and a collector for receiving said electrons, a first resonator adjacent said cathode and through which the electron beam passes, and a second resonator surrounding the electron path between said first resonator and said collector, said resonators having aligned apertures through which the beam of

electrons successively passes, a reverse coupling loop extending between said resonators whereby noise currents set up by the passage of electrons through the first resonator are reduced by noise currents set up by the passage of electrons through the second resonator, said second resonator comprising two parts, one of which is adapted to have a positive voltage applied thereto and the second of which is adapted to have a lower voltage applied thereto to function as a suppressor, the two halves of said second resonator being capacitively coupled together.

CABOT SEATON BULL.