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G. HOLST ET AL

2,058,878

DISCHARGE TUBE FOR AMPLIFYING ELECTRIC OSCILLATIONS

Original Filed Nov. 25, 1927

Fig. 1

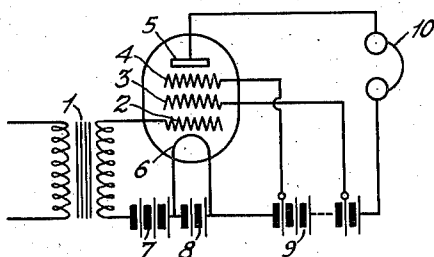


Fig. 2

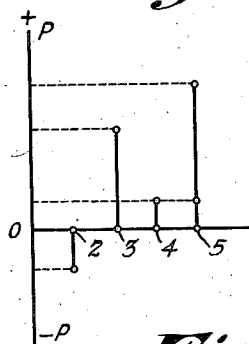


Fig. 3

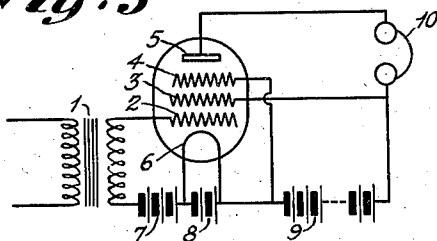


Fig. 4

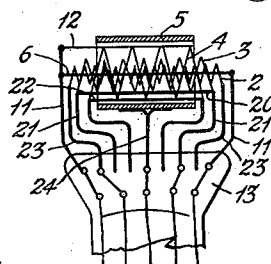
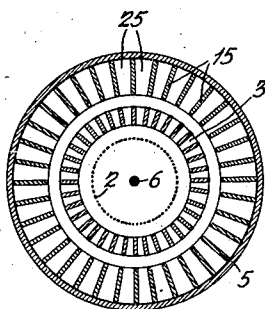


Fig. 5

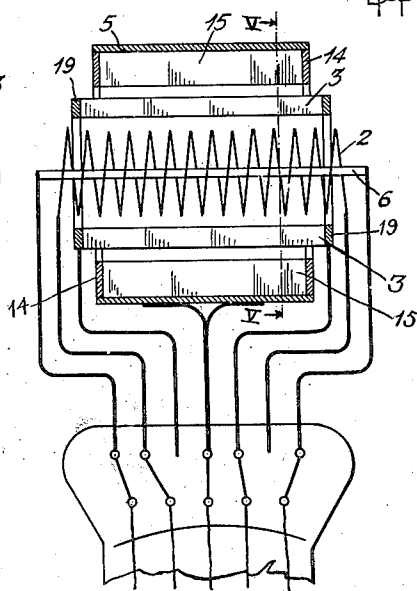


Fig. 6

Fig. 7

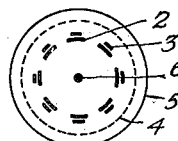
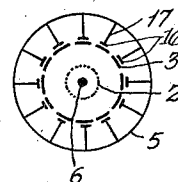


Fig. 8



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DISCHARGE TUBE FOR AMPLIFYING
ELECTRIC OSCILLATIONSGilles Holst and Bernardus D. H. Tellegen,
Eindhoven, NetherlandsOriginal application November 25, 1927, Serial
No. 235,504. Divided and this application Feb-
ruary 4, 1933, Serial No. 655,150. In the Nether-
lands December 14, 1926

12 Claims. (Cl. 250—27.5)

This application is a division of our copending application, Serial No. 235,504, filed November 25, 1927, issued as Patent No. 1,945,040, January 30, 1934, which has reference to the amplification of electric oscillations by means of thermionic devices. It is known that when these devices are to be used for amplifying purposes it is desirable that the slope of the grid voltage-anode current characteristic should be steep. With the customary triodes the steepness of the static characteristic decreases to an appreciable extent when oscillations are impressed on the control grid because these oscillations are transferred to the anode amplified, but in opposite phase, so that when the grid potential increases the anode current will on the one hand increase under the influence of the said increasing potential but the current will on the other hand decrease under the influence of the falling anode potential caused by the increased current flow so that the resulting increase of the anode current is diminished. In order to obviate this disadvantage with the final amplifier a so-called screening grid may be used between the control grid and the anode, said screening grid being maintained at a constant and fairly high positive potential, whereby the possibility remains of applying an appreciable negative grid bias to the control grid, which is very desirable in connection with the comparatively large output energy of the final amplifier.

If, however, a so-called final valve is used in an amplifier the phenomenon occurs that when the anode potential decreases, the screening grid current increases at the expense of the anode current and that when this potential fall becomes so large that the anode potential is less than the potential of the screening grid, secondary electrons will pass from the anode to the screening grid while part of the primary electrons which reach a position between the screening grid and the anode will reverse their direction, and return to the screening grid. These phenomena result, some to a greater extent and others to a smaller extent, in the screening grid current increasing at the expense of the anode current so that the advantage incidental to the use of the screening grid is again largely lost.

The invention is based on the recognition of the just mentioned phenomena and consists therefore in providing means which ensure that when the anode potential falls the increase of the screening grid current at the expense of the anode current will be substantially avoided. At the present state of knowledge it is possible to suggest various means by which this object can be at-

tained, said means being therefore also included in the invention. Some of these means, which on account of their simplicity and efficacious effect are particularly advisable, are the following:

1. The screening grid and the anode of the final amplifier have arranged between them an auxiliary grid kept at a constant potential which is not materially higher, preferably even lower, than the lowest instantaneous value of the anode potential.

2. A discharge tube, having at least two auxiliary electrodes between the cathode and the anode, is used as the final amplifier, the distance between the anode and the outermost auxiliary electrode being such that any electrons coming from the anode are prevented from passing to the said auxiliary electrode because of the space charge of the auxiliary electrode.

3. A discharge tube is used having at least three auxiliary electrodes between the cathode and the anode, the auxiliary electrode on the anode's side being electrically connected to the cathode. This electrical connection can be provided within the tube.

4. A discharge tube having at least two auxiliary electrodes between the cathode and the anode is used as the final amplifier, the anode comprising a number of partitions directed radially with respect to the cathode. The advantage of this construction will be more fully set out later.

In this construction of the discharge tube the auxiliary electrode nearest the anode is preferably made of a number of conductors positioned parallel to the cathode and so that each conductor is located in a plane with one of the anode partitions and the cathode.

5. A discharge tube, having at least two auxiliary electrodes between the cathode and the anode, is used as the final amplifier, and in which the auxiliary electrode nearest the cathode screens the next following auxiliary electrode against the electrons coming from the cathode. For this purpose the first mentioned auxiliary electrode may be formed of a number of small flat ribbons. This construction will also be explained hereinafter.

6. A discharge tube having a screening grid, is used as the final amplifier, the said screening grid being in turn screened by an auxiliary grid in its proximity and nearer the anode, said auxiliary grid being electrically connected to the anode.

The invention will be more clearly understood by reference to the accompanying drawing in which some circuit arrangements and tube constructions according to the invention are dia-

grammatically illustrated by way of example. In the said drawing:

Figure 1 shows a circuit arrangement according to the invention in which the final amplifier is provided with an auxiliary grid between the screening grid and the plate, the said auxiliary grid being maintained at a constant positive potential.

Figure 2 is a diagram showing the potentials of the various electrodes of the final amplifier shown in Figure 1.

Figure 3 shows a circuit arrangement corresponding to that shown in Figure 1, the difference being inter alia that the auxiliary grid is electrically connected to the cathode.

Figures 4, 5, 6, 7 and 8 show diagrammatically various constructions of those discharge tubes which in accordance with the invention should be preferably used as the final amplifier.

Referring to Figure 1 the secondary of a transformer 1, has one end connected to the control grid 2 of the final valve and its other end is connected through a grid bias battery 7 to the negative end of the cathode 6. In addition the discharge tube comprises a screening grid 3 which is connected to such a point of the high tension battery 9 that it is kept at a high positive potential which, however, is slightly lower than the average potential of the anode 5. In the circuit of the anode 5 is included a reproducer 10 (telephone, loudspeaker, recording set or the like). The cathode 6 is supplied from a battery 8 which may be connected across a variable resistor. Between the screening grid 3 and the anode 5 is arranged an auxiliary grid 4 which is connected to such a point of the battery 9 that the potential of 4 is materially lower than that of the screening grid 3.

In the diagram shown in Figures 2, 3, 4 and 5 are graphically plotted so as to give a better idea of the distribution of the electric field within the discharge tube. The potential of the auxiliary grid 4 should be so little positive that it can be assumed with all reliability that the instantaneous anode tension never falls materially below the potential of 4, even not with maximum potential amplitudes on the control grid 2. Therefore any secondary electrons emitted by the anode are absolutely prevented from passing to the auxiliary grid 4 because the potential of 5 is so much greater than that of 4 that the strength of the field, due to the potentials, increases continuously and rapidly from grid 4 to 5.

The circuit arrangement may be slightly simplified by connecting the auxiliary grid 4 directly to one of the ends of the filament 6, as shown in Figure 3. The auxiliary grid 4 consequently has a zero potential so that the same remarks made above in connection with the secondary electrons from the anode apply in this case. In addition it is possible to connect the grid 4 to the cathode within the valve as shown in Fig. 4, or, if desired, within the cap. Thus the number of the contact screws or pins to be fitted on the valve is decreased by one. A second difference between the structure of Figure 3 and that of Figure 1 is that the screening grid 3 is connected to the positive end of the battery 9 and thus receives the same direct current potential as the anode 5. The output of the final valve is thereby increased.

Figure 4 shows the principal elements of a tube constructed according to the invention in which the cathode and the anode have arranged

between them three auxiliary electrodes, the outermost of which is electrically connected to the cathode. In this construction the various electrodes are sealed in a well known manner, with some of the carriers serving also as leading-in wires, in the glass squeeze 13 of a stem only the uppermost part of which is shown. The glass bulb to which the stem is sealed is also omitted in the drawing.

The cathode 6 is formed by a taut wire which is stretched between two carriers 11, the left hand one of which is lengthened upwardly and connected electrically at the top to a small metal beam 12 which in addition to the lower metal beam 22 serves to stiffen and support the outermost grid 4. This grid serves as an auxiliary grid in the sense of the invention and is arranged between the anode 5 and the screening grid 3. The latter or screening grid is supported in a well known manner by a small carrying beam 20 and by two carriers 21 sealed in the squeeze 13. The right hand carrier is led out through the squeeze. Finally the screening grid 3 and the cathode 6 have between them a control grid 2 which, similarly to the two grids 3 and 4, is shown as a helically wound wire attached on the lower side to a small carrying beam which is supported by means of two carriers 23 sealed in the squeeze 13. The control grid carrying beam which may be similar to those for the screen grid 3 and auxiliary grid 4 is not illustrated for the sake of simplicity. The left hand carrier of the two last mentioned carriers is led out through the squeeze. The anode 5 is supported in a well known manner by a stiff central carrier 24 which is sealed in the squeeze 13 and led out through this squeeze. There are therefore in the aggregate five leading-out wires, four of which may, for example, be connected to contact pins at the bottom of the cap, whereas the fifth one, for example the leading-out wires of the screening grid, may be led to a contact screw (not shown) on the cylindrical side wall of the same cap.

Figure 5 is a diagrammatical cross sectional view of the electrodes of a discharge tube of different construction. Again the cathode 6 is a stretched wire which is surrounded by a control grid 2 which may be of any construction. The control grid is surrounded by a screening grid 3 formed by a number of small metal ribbons parallel to the cathode 6 and arranged according to radial planes, said ribbons being united at their ends by metal rings. These rings are shown as members 19 in Figure 6, which shows a longitudinal section of such a tube construction. The anode 5 contains a number of radial partitions 15 which are in alignment with the ribbons 3 but which are much wider than the latter. These partitions are united at their ends by flat rings 14 to form a stiff aggregate. The intermediate space between the grid 3 and the anode 5 should preferably be small and also the intermediate spaces 25 between the partitions 15 are preferably kept small by choosing a large number of partitions. This arrangement has for its object to cause the electrons which have passed through the grid 3 and which show a tendency to return to the grid 3 instead of passing on to the anode, and which because of this tendency to return to grid 3, deviate laterally from their straight paths, to be intercepted by the partitions 15 and thereby reach the anode.

If in this construction the control grid 2 is formed by a helical coil or by a number of par-

allel rings, the elements of the grid 2 and 3 cross each other at substantially right angles. This will have a favorable effect since the electrons will consequently be less deviated from their straight paths than they would be in case the said elements were substantially parallel to each other.

Another construction which has also for its object to prevent the primary electrons which have traversed the screening grid from returning to the latter is shown in Figure 7. This Figure is a diagrammatic cross-sectional view of the electrodes of a discharge tube according to the invention, the grid 2 of which is formed by a number of small flat ribbons parallel to the filament 6 and normal to the plane passing through their longitudinal axis and the cathode. On that side of the ribbons which is turned away from the cathode are the elements, for example wires, of the screening grid 3 which thus are almost completely screened by the ribbons 2. This has the effect that the electrons will deviate but little under the combined influence of the grids 2 and 3, and therefore the tendency to return to the grid 3 will be lessened. In addition, owing to the screening effect of the control grid 2 on the screening grid 3 there will be hardly any primary electrons that reach the screening grid directly. If in addition the screening grid 3 is surrounded by an auxiliary grid 4 which in the manner before described prevents the emission of secondary electrons from the plate 5 to the grid 3, all three prejudicial phenomena mentioned in the opening part of the present specification are consequently neutralized.

With the invention it is possible to use a final amplifier having a large power output and an internal resistance which is so large as compared with the impedance of the reproducer (loudspeaker or the like) that the current variations through the reproducer follow exactly the potential variations of the control grid of the final valve so that the reproduction is undistorted.

Referring to Figure 8 a third construction is shown in which the electrons are prevented from returning to the screening grid. For this purpose a grid 16 is provided immediately outside the screening grid and insulated therefrom and electrically connected to the anode 5 (this electrical connection is diagrammatically shown at 17) the elements of the said grid being in alignment with the elements of the screening grid. If now electrons change their direction of movement in the space between 16 and 5 the greater majority of these electrons will impinge on the outer surfaces of the element 16 and not on the grid 3.

In summary, the invention therefore comprises means used either separately or in combination, with a final amplifier having a screening grid between the control grid and the anode by which the screening grid current is prevented entirely or partially from increasing at the expense of the anode current when the anode potential falls.

What is claimed is:

1. An electron discharge tube comprising an electron emitting electrode, control grid electrode and screen grid electrode, an anode having a substantially smooth surface, and means for minimizing the effect of secondary electron emission resulting from impact of the primary electrons against the anode, said means comprising a conductive member mechanically and electrically connected to the substantially smooth-

surfaced anode and interposed in the path of the electron stream from cathode to anode.

2. An electron discharge tube, comprising an electron emitting electrode, control and screen grid electrodes, an anode having a substantially smooth surface, and means for minimizing the effect of secondary electron emission resulting from impact of the primary electrons against the anode, said means comprising a series of fin-like members attached to and extending from the inner face of the anode into the path of the electron stream from cathode to anode.

3. An electron discharge tube, comprising an electron emitting electrode, control and screen grid electrodes, an anode having a substantially smooth surface, and means for minimizing the effect of secondary electron emission resulting from impact of the primary electrons against the anode, said means comprising a plurality of parallelly-arranged ribbon-like metal strips which are attached to and extend from the inner face of the anode into the path of the electron stream from cathode to anode.

4. An electron discharge tube, comprising a cathode, control grid and screen grid electrodes, an anode having a substantially smooth cylindrical surface surrounding the aforesaid electrodes, and means for minimizing the effects of secondary electron emission resulting from primary electron impact against the anode comprising a series of closely spaced metal strips mechanically and electrically connected to the inner surface of the anode and arranged in parallel relation with respect to the cathode.

5. In an electron discharge tube, the combination with an electron emitting electrode, control grid electrode and screen grid electrode, of an anode structure comprising a substantially smooth surface and cavity-forming means on its face exposed to the electron stream for entrapping secondary electrons emitted from the anode resulting from impact of primary electrons thereagainst.

6. In an electron discharge tube, the combination with an electron emitting electrode, control grid electrode and screen grid electrode, of an anode comprising a substantially smooth surface and a plurality of channel-shaped cavities of substantially rectangular cross-section formed on that side of its face exposed to the electron stream for entrapping secondary electrons emitted from the anode resulting from impact of primary electrons thereagainst.

7. An anode structure for an electron discharge tube comprising a sheet metal member having a smooth surface and a plurality of closely spaced thin metal strips fastened to said surface and extending at substantially right angles thereto and forming therewith a plurality of long and narrow channel-shaped cavities of substantially rectangular cross-section.

8. An electron discharge tube comprising a cathode, a control grid surrounding the cathode, a screen grid formed of radially-extending ribbon-like strips surrounding the control grid, and a plate electrode formed with substantially similar radially-extending ribbon-like strips on its inner surface surrounding the screen grid.

9. An electron discharge tube comprising a cathode, a control grid surrounding the cathode, a screen grid formed of radially-extending ribbon-like strips surrounding the control grid, and a plate electrode formed with substantially similar but wider radially-extending ribbon-like

strips on its inner surface surrounding the screen grid.

10. In an electron discharge tube, the combination with a cathode, control grid and screen grid, 5 of an anode electrode surrounding the aforesaid electrodes, said anode electrode being provided with members, one at each end thereof and a series of ribbon-like strips extending between said members along the inner surface of said anode 10 electrode.

11. In an electron discharge tube, the combination with a cathode and a control grid, of a screen grid having terminal ring members and a series of closely-spaced ribbon-like strips extending 15 between said ring members, and a plate electrode provided with terminal ring members and a series of closed-spaced ribbon-like strips ex-

tending between the latter ring members and along the inner surface of said anode electrode.

12. In an electron discharge tube, the combination with a cathode and a control grid, of a screen grid having terminal ring members and 5 a series of closely-spaced ribbon-like strips extending between said ring members, and a plate electrode provided with terminal ring members and a series of closely-spaced ribbon-like strips 10 extending between the latter ring members and along the inner surface of said anode electrode, the said ribbon-like strips of said screen grid and plate electrodes being equal in number and radially disposed in the same planes. 15

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