March 18, 1952 L. W. KOEHLER 2,589,397

ELECTRONIC DISCHARGE TUBE WITH A PLURALITY OF PLATE-GRID SYSTEMS

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Fig. 1.

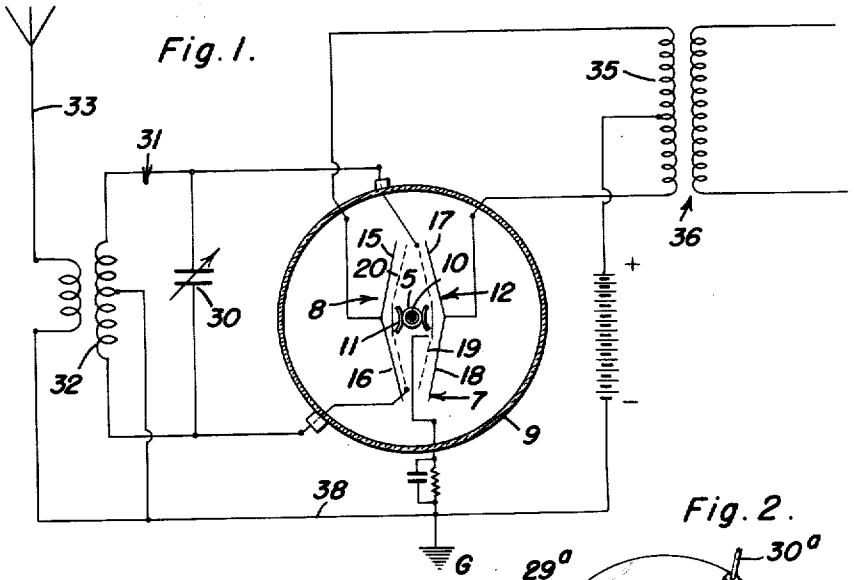


Fig. 2.

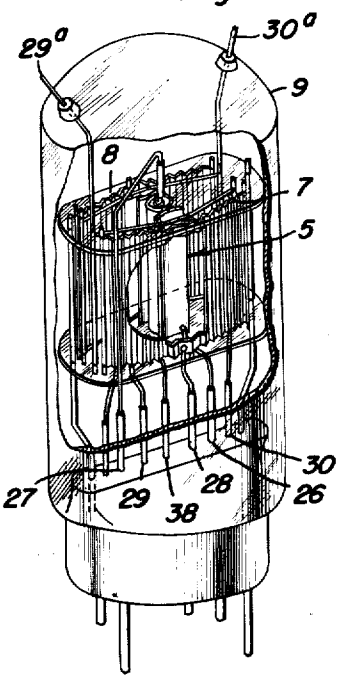


Fig. 3.

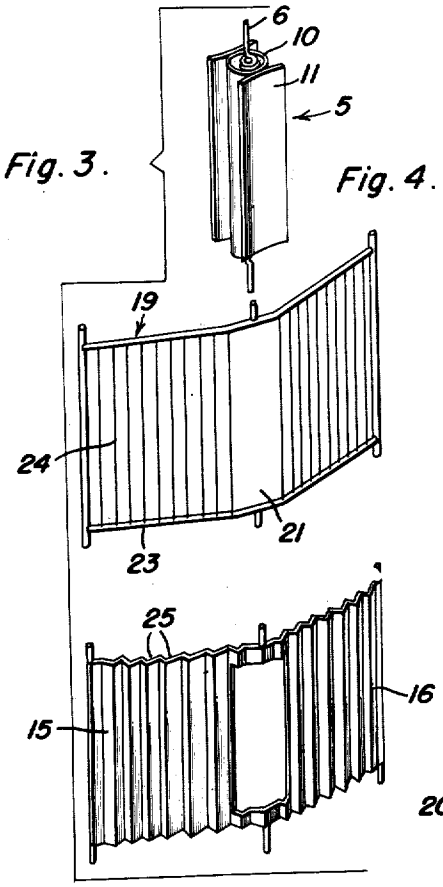
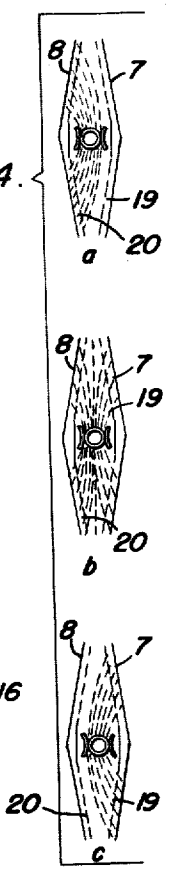


Fig. 4.



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ELECTRONIC DISCHARGE TUBE WITH A PLURALITY OF PLATE-GRID SYSTEMS

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6 Claims. (Cl. 313—5)

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This invention relates to electronic discharge tubes of the type controlling the flow of electrons by means of a plurality of plate-grid systems and it has for its main object to provide an electronic discharge tube of great sensitivity, capable of producing high amplification gains in which the control energy used at the control grids for controlling the current flow to the plate or plates is smaller than that required in customary tubes with grid control of a comparable construction.

A further object of the invention consists in providing an electronic tube with a plurality of plate and grid systems which may be connected with points of an oscillation carrying system showing opposite phase relation which is capable of utilizing the joint and added action of opposite voltage fluctuations.

A further object of the invention consists in providing an electron discharge tube with a plurality of plate-grid systems which are essentially independent of each other but which may be connected with points of an oscillation carrying system showing opposite phase relation and in which the control of the current flow is exercised continuously by the joint action of the said opposite phases acting on the grids of the plate-grid systems, the grids of the independent systems cooperating to control the current flow from the cathode to the plates of all systems.

A further object of the invention consists in providing an electronic discharge tube with a plurality of plate-grid systems in which the control of the current flow is produced by a combined electron accelerating and retarding action of the grid and by a deflection of the electron flow, thus combining the advantages of these two methods of electron control.

A further object of the invention consists in providing an electronic discharge tube with a cathode and a plurality of plate-grid systems in which the electron stream produced by the cathode sweeps from one plate-grid system to another system under the joint influence of the grids of all systems while the said electron stream is controlled in every moment by the change of voltage of the grids which it passes.

To attain these objects an electronic discharge tube provided with a plurality of symmetrically arranged plate-grid systems is used according to the invention in which a cathode or cathodes emit an electron stream along the plane of symmetry of said systems when not deflected by the same, while each plate-grid system consists of or comprises sections inclined towards the direction in which the electron stream is emitted, which sections therefore are reached by the flow of electrons as soon as said flow is deflected by the grid charges. The electron flow thus deflected which passes through one of the grids of one system is then also acted upon by the charge of the grids which it passes so that a double action results, one of the actions being the customary grid action accelerating and decelerating the flow of electrons, while the second action is a result of the deflection of the electron flow from its original direction which normally does not intersect one of the grids of the systems. The influence of the grid charge is thus increased so that less energy is necessary to produce the same change of plate current.

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Preferably according to the invention, the arrangement is symmetrical in two directions and consists of plate-grid systems arranged on both sides of a cathode which are either composed of two sections which are inclined towards each other and towards the plane of symmetry of the systems or which are curved or bent towards said plane or symmetry. The electron flow emitted by the cathode on both sides of the same is influenced in the same way and deflected towards the same side, thus producing a continuous deflection of the entire emission of the cathode with the result that the electron flow of the cathode passes through the grid which has a voltage deflecting it in its direction. The entire electron stream emitted by the cathode will then be controlled by the voltage applied to the grid, once the stream has been deflected in its direction.

According to the invention moreover this action may be improved by connecting the grids of the plate-grid systems with points of an oscillation carrying system which are permanently in opposite phase so that both grids act in opposite manner and may simultaneously contribute to the deflection of the electron stream in the same direction. In this way a well integrated multiple action may be exercised on the electron stream, driving said electron stream towards the grid of one or the other system by the joint action of the grids while the stream thus passing the grid is controlled by the voltage applied to the grids.

This action may be assisted, according to the invention, by providing the cathode with flow directing wings or shields preventing emission in certain directions and directing the electron flow in such a manner that it will have the tendency to stream substantially in the plane of symmetry

passing between the plate-grid systems grouped on both sides of a cathode.

Further, according to the invention, the electronic discharge tube may be connected with the oscillation carrying system in the manner of two tubes connected in push-pull connection whereby a great simplification is frequently obtainable.

Further characteristic features and objects of the invention will be apparent from the following detailed specification.

The invention is illustrated in the accompanying drawings showing one embodiment of the invention and one modification thereof. It is however to be understood that the drawings illustrates an embodiment of the invention merely by way of example, selected in order to be able to explain the principle of invention and the best mode of applying said principle. Modifications of the invention not illustrated in the drawing are therefore not necessarily departures from the essence of the invention.

In the drawing:

Figure 1 is a diagram illustrating an electronic discharge tube and the connections of the same by way of example.

Figure 2 is a perspective view of the electronic tube with the glass envelope broken away.

Figure 3 is an exploded perspective view of the cathode plate and grid, a modification of the plate illustrated in Figure 1 being shown.

Figure 4 is a series of three diagrams showing the flow of electrons in three different stages of the operation.

As has been explained above the principle of the invention consists in providing an arrangement in which the electron stream emanating from the cathode will be subjected simultaneously to deflection and to the accelerating and decelerating action of one of the grids of one of the systems. The deflection towards different plate-grid systems is produced by the grid voltage prevailing at the moment and the invention is therefore most useful in circuits in which the grid voltages applied to all the plate-grid systems may cooperate to produce a deflection towards one and the same plate-grid system. Such an arrangement is shown in Figure 1 of the drawings as will be explained below.

The construction of the electronic discharge tube is illustrated by way of example in Figures 2 and 3. The discharge tube comprises a cathode **5** which may be either a directly or indirectly heated cathode, the latter type being shown in Figures 2 and 3. The heater **6** is arranged in the interior of a cathode tube **10** which is preferably provided with electron flow directing side wings **11** having the shape of straight or slightly curved strips welded to the cathode tube **10**. The flow directing wings or strips are provided on those sides of the cathode tube **10** which are turned towards the plate-grid systems and their purpose is to concentrate the electron stream between them so that the electrons will be mainly emitted from those portions of the cathode tube which is contained between the wings, the general direction of the emitted electron stream, when not deflected, being the plane of symmetry passing between the systems.

The discharge tube **9** comprises at least two symmetrically arranged plate-grid systems **7**, **8** each system consisting of two plates or two plate sections **15**, **16**, and **17**, **18** respectively inclined towards each other and towards the plane of symmetry between the systems. The two plate sections **15**, **16** and **17**, **18** thus form a roof shaped plate, the roof shaped plates of the two systems facing each other across the cathode with their concave sides turned towards each other. The cathode **10** is thus enclosed within a rhomboidal space formed by the two plates.

Instead of roof shaped plates as shown polygonal or curved plates may be used turning their hollow or concave sides towards the cathode and enclosing the same. The exact shape of the plates is not material provided the distance between the plates in the median plane passing through the plate centers is always larger than the distance between the outer edges of the plates.

The grids **19**, **20** have substantially the same shape although the inclination of the lateral sections towards each other may slightly differ from that of the plates. In the central portion facing the flow directing wings **11** of the cathode **10** the grid may be replaced by shields **21** or imperforate frame portions as there is no electron flow through this section. As shown in Figure 3 the grid may therefore consist of a frame **23** the side portions of which are joined by transverse members at the end and by shields **21** in the middle. The customary fine wires **24** are stretched between the lateral portions of the frame in the customary manner.

In Figures 2 and 3 a modification of the shape of the plate is shown. As will be seen especially in Figure 3 the plate may be provided with serrations **25**, the cross section of the serrated portions being approximately of saw tooth form. The front or stepped portion of each saw tooth separating two consecutive serrations may be arranged approximately in the direction in which the electron stream flows so that mainly the inclined parts of the serrated plate collect electrons. The surface of the plate is thus enlarged without producing pockets or other flow impeding disturbances.

As will be seen from Figure 3 each plate and each grid is connected to a separate lead in wire which may or may not be connected with the plugs of the socket and the same holds good of each grid **19**, **20**. The grids are connected with separate lead in wires **29***a* and **30***a* at the top while the plates are joined to the wires **28**, **38**. In addition lead in wires **26**, **27** for the cathode and further lead in wires **29**, **30** for the heater are shown in the figure. The tube socket according to the invention is therefore provided with five plugs in addition to the connections which are provided for the grid systems.

The tube may be connected in various ways one of the methods of connecting the tubes being shown in Figure 1.

In the diagram the two grids **19**, **20** are connected with a condenser **30** of an oscillation circuit **31** which includes coil **32** which may be inductively or otherwise connected to any oscillation carrying system such as an antenna **33**. Moreover the two plate systems **7**, **8** are connected with the output coil **35** shown as one of the coils of a high frequency transformer **36** leading to a system capable of utilizing the amplified oscillations such as a receiver. The cathode **10** may be connected with ground G over a suitable resistance or filter and with conductor **39** leading to the centers of the center tapped coils **32**, **35**.

The operation will be readily understood when referring to the diagrams shown in Figure 4. During the amplification of a full wave let it be assumed that grid **19** is negative and grid **20** is positive during the first half wave. It will then

be clear that the electron stream coming out of the central portion of the cathode between the flow directing wings 11 is deflected towards the positive grid 20 and will be taken up by the positive plate 8, the negative grid 19 actually assisting in this deflection. When the positive wave will have reached its peak the electron flow will be that shown in Figure 4a.

As the positive voltage decreases the electron stream turns towards the middle and when the oscillating voltage passes the zero point it will be approximately parallel to the median plane passing between the two plate-grid systems. This phase is shown in Figure 4b. During the following negative phase the grid 20 will become negative while grid 19 receives the positive voltage with the result that the electron stream will now be deflected towards the plate 7 as indicated in Figure 4c.

The discharge tube according to the invention therefore operates in the manner of a push-pull arrangement, but with the difference that the two plate and grid systems always cooperate in shifting the electron system from one plate system to another.

An increase in sensitivity and an increase in the amplification factor therefore results from the fact that the electron stream is not only subjected to the retarding and accelerating influence of the grid but also sweeps along the grid from one system to the other system. The electron stream is thus subjected to a double control action one of these control actions being performed by the cooperation of the two systems. This materially improves the characteristics of the tube and moreover less energy on the grid is required to effect the control of the electron flow in the tube.

The tube thus allows to combine the advantages of direct grid control with the many advantages of the control by deflection.

The tube may be used in all arrangements in which a high degree of amplification or sensitivity is required but also in many other arrangements especially in those which require the use of a push-pull connection. Moreover the tube may replace the customary tubes in many arrangements in which a dual or push-pull connection may be of advantage, radio frequency amplifiers, detectors, audio frequency amplifiers, oscillators, modulators, etc., being mentioned as examples.

It will be clear that the construction of the details of the electronic discharge tube and also the shape of the parts described is in many respects not essential for the realization of the principle of the invention and therefore changes of an unessential nature will not affect the essence of the invention as defined by the annexed claims.

Having described the invention, what is claimed as new is:

1. An electronic discharge tube comprising an evacuated container, an electron emitting cathode, two anode-grid systems located symmetrically on both sides of a plane of symmetry passing through the cathode, each system including an anode and a grid, the latter covering and intersecting completely the space between the anodes, and each anode and grid consisting of two sections, inclined towards each other and towards the said plane of symmetry, electron flow preventing shields on the cathode arranged substantially on both sides of a plane at right angles to the said plane of symmetry, said shields dividing the electron flow emitted by the cathode and confining it to a zone located in the vicinity of the aforesaid plane of symmetry, and means for impressing fluctuating voltages of different phase on the grids of said system.

2. An electronic discharge tube comprising an evacuated container, an elongated electron emitting cathode, two anode-grid systems, located symmetrically on both sides of a plane of symmetry passing through the cathode, each system including an anode and a grid, the latter covering and intersecting completely the space between the two anodes of the two systems, and each anode and grid of each system consisting of sections inclined towards each other and inclined towards the plane of symmetry, the two anodes and grids of the two systems facing each other across a gap, bisected by the plane of symmetry, shields on the cathode on both sides of a plane at right angles to the aforesaid plane of symmetry, said shields being adapted to prevent a flow of electrons in the direction of the said last named plane, thus dividing the flow of electrons from the cathode to the two anode sections into two separate bundles, and means for impressing fluctuating voltages of opposite phase on the grids of the anode-grid systems, the fluctuating grid voltages producing a shifting of the electron flow of the cathode towards one of the systems in accordance with the fluctuations, the grids of the systems towards which the electron flow has been deflected controlling the electron flow towards the anode of the system.

3. An electronic discharge tube comprising an evacuated container, an elongated electron emitting cathode, two anode-grid systems located symmetrically on both sides of a plane of symmetry passing through the cathode, each anode and grid of each anode-grid system consisting of two sections inclined towards each other and inclined towards the aforesaid plane of symmetry, and arranged symmetrically with respect to a second plane of symmetry at right angles to the aforesaid plane of symmetry, each grid covering and intersecting completely the space between the anode and cathode, the outer end of said grid and anode sections being separated by a gap bisected by the first named plane of symmetry, shields on said cathode intersecting the second plane of symmetry, said shields being adapted to prevent an electron flow in the direction of the said second plane of symmetry, thus dividing the electron flow from the cathode to the anode of each system, means for impressing fluctuating voltages of different phase on the grids of the grid systems, the fluctuating grid voltages of different phase deflecting the electron flow towards one of the systems, the grid of which controls the deflected electron flow towards the anode of the system.

4. An electronic discharge tube comprising an evacuated container, an electron emitting cathode, two anode-grid systems, substantially encompassing said cathode and located symmetrically on both sides of a plane of symmetry passing through said cathode, each plate and each grid of the anode-grid systems consisting of two sections inclined towards each other and inclined towards the above mentioned plane of symmetry, the outer ends of said sections facing each other across a gap bisected by the aforesaid plane of symmetry, the two sections of each anode and each grid of the anode-grid systems being symmetrically arranged with respect to a second plane of symmetry arranged at right angles with respect to the first mentioned plane of symmetry, shields on the said cathode on the sides of the cathode

facing the anode-grid systems, said shields being adapted to prevent a flow of electrons between the cathode and the anode-grid system in a zone near the said second plane of symmetry, thus producing a divided flow of electrons between the cathode and the anode sections in zones located in and on both sides of the first mentioned plane of symmetry, means for impressing fluctuating voltages of opposite phase on the two grids of the two anode-grid systems, the combined influence of the two grids, when equal, producing an electron flow substantially parallel to the first named plane of symmetry and when unequal producing an electron flow directed towards the anode sections of one of the anode-grid systems, said flow passing through one of the grid sections of said system.

5. An electronic discharge tube comprising an evacuated container, an elongated electron emitting cathode, two anode-grid systems, arranged in substantial parallelism to the said cathode and substantially encompassing the same, each anode-grid system being located symmetrically on both sides of a plane of symmetry passing through said cathode, each anode and grid of the anode-grid system consisting of two sections, inclined towards each other and inclined towards the above mentioned line of symmetry, the outer ends of said sections facing each other across a gap bisected by the aforesaid plane of symmetry, the two sections of each anode-grid system being symmetrically arranged with respect to a second plane of symmetry at right angles to the first mentioned plane of symmetry, and each anode section being fully covered by a substantially parallel section of the grid on the side facing the cathode, shields on both sides of the cathode facing the point of junction of the sections of the plates and grids of the anode-grid systems, said shields being arranged on both sides of the first named

plane of symmetry and intersecting the second plane of symmetry, said shields being adapted to prevent a flow of electrons between the cathode and the anodes of the anode-grid systems substantially in the direction of the second plane of symmetry, thus producing a divided flow of electrons, substantially in and on both sides of the first mentioned plane of symmetry, means for impressing a fluctuating voltage of opposite phase on each of the grids of the anode-grid systems, the voltage impressed on the two grids alternatively suppressing and producing a current flow between the cathode and the anode of one of the systems, the electron flow from the cathode thus being divided into two distinct bundles, oscillating around the first named plane of symmetry, the extent of said oscillations being limited by the inclination of the anode-grid system toward the first named plane of symmetry.

6. An electronic device as claimed in claim 5, in which the grids are provided with imperforate strips facing the shields of the cathode.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,437,607	Mueller	Dec. 5, 1922
1,632,104	Whiting	June 14, 1927
1,672,977	Field	June 12, 1928
2,061,594	Samuel	Nov. 24, 1936
2,295,816	Wilson	Sept. 15, 1942

FOREIGN PATENTS

Number	Country	Date
565,889	France	Nov. 13, 1923