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ELECTRON DISCHARGE DEVICES
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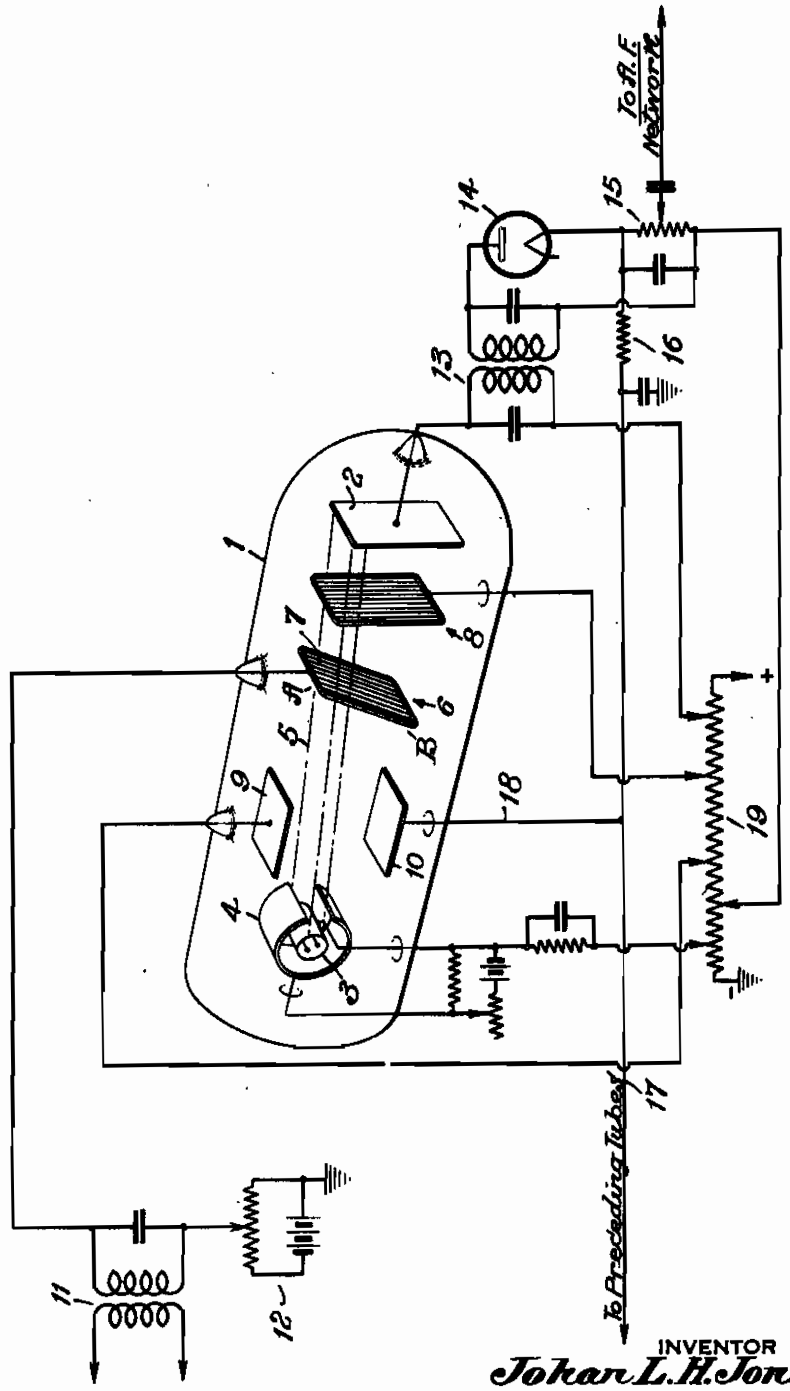

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ELECTRON DISCHARGE DEVICES

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This invention relates to an electron discharge device of the variable mu type in which the mutual conductance may be varied or controlled in response to control voltages, such as those used in automatic volume control.

The so-called "variable mu tubes" usually comprise one or more grids having a variable pitch or two or more grids between which the distance is unequal at various points along the grids so as to ensure a gradual decrease in mutual conductance with increasing negative bias or grid voltage with reference to the cathode. The anode-current grid-voltage characteristic of a variable mu tube may be imagined to be made up of the individual characteristics of small parts or portions of the grid. For instance, in a variable mu tube having a grid with apertures of various sizes the smallest apertures through which consequently a comparatively small electronic stream passes will impart to the tube a characteristic having a steep slope, and to this small stream is then added the much larger electronic stream passing through the large apertures, which impart to the tube a characteristic having much less slope. This tube characteristic may be imagined to be the resultant or sum of these characteristics for each individual aperture, and is of gradually decreasing slope. At minimum grid bias the discharge passes through all of the apertures, the mutual conductance characteristic is predominantly that due to the smaller apertures, and therefore its slope is steep and the anode current is a maximum. As the grid bias increases and the grid becomes more negative, the discharge through the smaller apertures stops, the mutual conductance is determined principally by the larger apertures and therefore its slope is less, and the anode current decreases. It has been found difficult to construct such tubes which have a very steep slope of the anode current grid voltage characteristic without at the same time having an undesirably large anode current at minimum grid bias where the slope is very steep. If the distance between two grids through which the discharge passes in succession is not equal throughout the length of the grids, the characteristics for different points along a grid will have different slopes, so that electric discharge tubes having grids between which the distance varies along the grids will also have a grid voltage-anode current characteristic whose slope will gradually decrease. It has been customary to operate a variable mu tube at different points along this characteristic by varying the grid bias, in spite of the drawback that upon adjusting the grid bias to operate the tube where the characteristic has very steep slope the anode-current is much higher than necessary for attaining this slope.

The principal object of the invention is to provide a device having a mutual conductance which can be readily controlled or regulated so as to vary between high mutual conductance and low mutual conductance without changes in the bias of the control grid, and preferably with a very continuous and uniform variation in mutual conductance.

According to the invention the different characteristics imparted to the tube by the different portions of the grid are in effect used individually and practically unaffected by other portions of the grid. Preferably the device is so made that there can be obtained a very continuous transition from one of these characteristics to another, such as from high mu to low mu. To this end the electron discharge is concentrated into one or more electron beams shifted along a signal grid of the variable mu type by beam control or deflecting members. Preferably two or more grid-shaped electrodes are placed in the path of the beam so as to be passed successively by the beam, one of the grids being sufficiently irregular with reference to the other tube elements, as, for example, by being inclined to the other grid to cause the mutual conductance of the tube to vary along the grids in a direction in which the electron beam can be deflected. This construction in which the distance between the signal grid-plane and another grid-plane varies along the grids is a simple way of obtaining an uneven potential in a grid-plane through which the beam passes.

By varying the difference of potential between deflecting members on opposite sides of the electron beam path the beam can be directed and the discharge practically confined to different sections of the gird which impart different grid voltage-anode current characteristics to the tube. If the spaced grid conductors extend parallel with the direction in which the electron beam can be deflected, the transition between the different characteristics will be very gradual and will not change abruptly, as might occur at each aperture if the grid conductors were spaced non-uniformly and extended transversely of the direction of deflection of the electron beam. Thus, according to the invention, a great variation in the slope of the grid voltage-anode current characteristic is obtainable without the attainment of steep slopes being accompanied by undue increase of the anode current.

An electron discharge device according to the invention is very useful in various circuit arrangements, such as those for automatic volume control, as the voltage of the automatic volume control can vary the difference in potential between the deflecting members and the device will automatically adjust itself in accordance with the signal strength to a definite grid voltage-anode current characteristic of a definite slope.

The invention will be more clearly understood by reference to the accompanying drawing, which represents schematically one embodiment of the invention.

The particular embodiment of the device shown in the accompanying drawing comprises an electron discharge tube having an evacuated envelope 1 enclosing electrode elements arranged to constitute a variable mu or variable amplification factor tube having an anode or output electrode 2 and a source of electrons for directing an electron beam to the anode, such as an indirectly heated cathode 3 and a beam forming electrode, such as a cylinder 4 coaxial with the cathode and having a slot or opening in one side. The electrons emitted by the cathode are formed into an electron beam 5 which, in the particular construction shown in the drawing, is a flat-sided or ribbon-like beam substantially rectilinear in cross-section and directed to the anode 2. Interposed between the anode and the source of electrons is a grid electrode 6 which comprises a rectangular frame and a plurality of spaced parallel conductors 7 extending lengthwise of the frame and may be used as a control grid.

Preferably a second similar grid electrode 8 is interposed between the control grid 6 and the anode 2, and is connected to act as a screen grid. The control grid 6 is so related to the other elements of the tube, preferably by being inclined to the anode, so that one end is nearer the anode than the other, as indicated in the drawing, that the grid electrodes 6 and 8 constitute a grid structure which is sufficiently irregular with reference to the other elements of the tube to give the tube a different mutual conductance or amplification factor at different positions of the beam 5 along the conductors of the grid 6. In the particular construction shown the upper end of inclined grid 6 is nearer the anode, and grid 8 is parallel to the anode. When the beam is at the position A near the upper end of the grid 6, the mutual conductance or amplification factor is high and the tube acts as a high mu tube, and when the beam is near the other end of the grid at position B, the amplification factor is low and the tube acts as a low mu tube. By shifting the beam 5 along the grid 6 lengthwise of the grid conductors 7, a very regular and continuous change in mutual conductance from high mu to low mu can be obtained.

The tube may be regulated to operate at will with any selected amplification factor within the range of the tube by control means for deflecting the beam lengthwise of the conductors 7 of the grid 6, such as deflection plates 9 and 10 positioned between the electron source and the grid 6 on opposite sides of the path of the beam to provide a passage for the beam. The position of the beam on the grid 6 will depend upon the difference of potential between the deflection plates 9 and 10, and by varying the potential of the plate 10, for example, the beam can be deflected and field at any selected point on the grid 6.

For clearness of illustration, the tube is shown as of the elongated type, but obviously the tube can be made of cylindrical construction and the beam 5 instead of being a flat ribbon-like beam can be a circular disc beam such as may be obtained by known constructions as, for example, U. S. patent to Hamacher, 2,090,001. In this case the two grids and the anode are obviously in the form of rings or cylinders to correspond to the shape of the circular disc beam.

The variation in potential on the deflection plate 10 to determine the position of the beam on the grid 6 may be obtained in various ways, but for purposes of illustration, the device is shown for use in automatic volume control with the tube connected to a conventional automatic volume control circuit of a construction and operation well known in the art. As shown, an input circuit 11 is connected to the control grid 6 which can be biased as desired by a grid bias connection 12. The output circuit 13, connected to the anode 2, includes the usual diode rectifier 14 connected to the conventional diode resistor 15 from which the audio frequency network is supplied. One end of the diode resistor 15 is connected through the usual filter network 16 to the automatic volume control connection 17 leading to the preceding tubes of the set. This automatic volume control connection 17 is connected by a lead 18 to the deflection plate 10 so that the voltages developed upon the connection 17 will be impressed upon the deflection plate. The circuit is supplied from the usual voltage divider 19 which is connected to the various elements of the circuit and tube in the conventional way.

In operation, the electron beam 5 shaped as a broad thin band or ribbon is deflected along the grid 6 by the deflection plates 9 and 10 so that this beam impinges on the grid 6 at different points in accordance with the differences in potential between the deflection plates. Owing to the difference in spacing between the grids 6 and 8 at different points along the grids, a different anode current-grid voltage characteristic is obtained at different points along the grid 6 so that in accordance with the potential on the deflection plate 10, the tube will operate with different mutual conductance characteristics. When the signal strength is high, the voltage impressed on the deflection plate 10 will be sufficiently high to pull the beam 5 to the position B, where the mutual conductance of the tube is low. When the signal is weak, the voltage on the deflection plate 10 is lower, the beam assumes the position A, as shown in the drawing, and will be directed through the control grid 6 at a point where the mutual conductance or mu of the tube is high. Since the grid conductors 7 extend in a direction parallel with the direction of deflection of the electron beam, the transition between the different characteristics at different points of the grid 6 will be very regular and continuous, with the mu factor decreasing regularly and continuously as the control voltage on the deflection plate 10 increases with increasing output.

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