

May 17, 1960

L. F. MOOSE
HIGH FREQUENCY APPARATUS

2,937,316

Filed March 12, 1958

2 Sheets-Sheet 1

FIG. 1

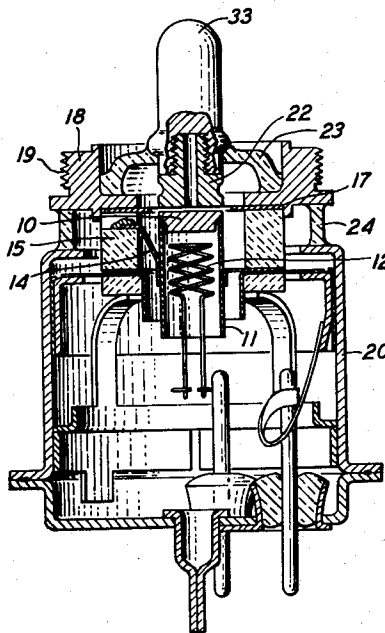


FIG. 2

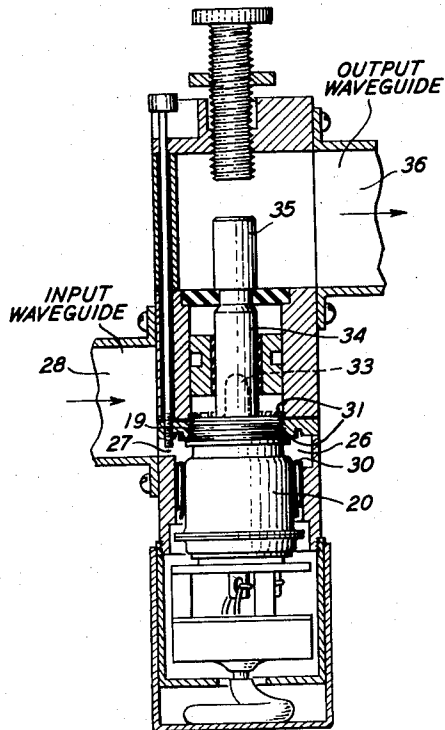
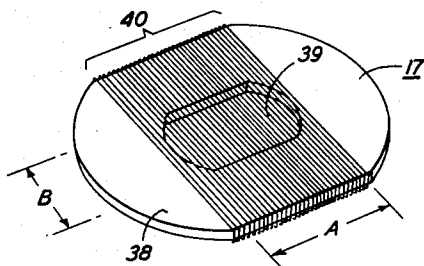


FIG. 3



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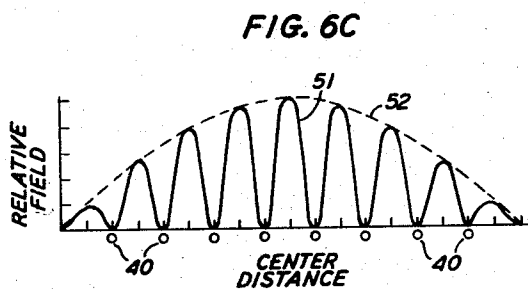
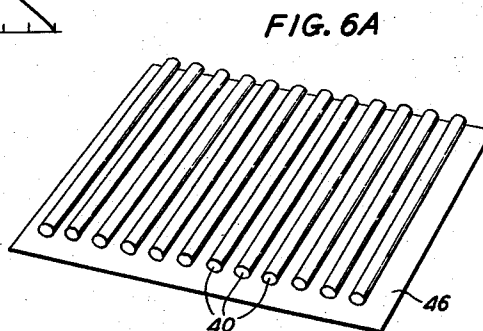
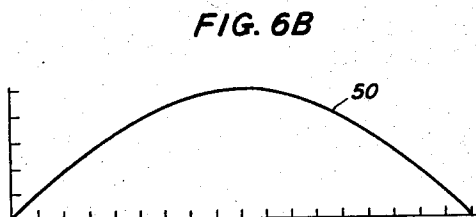
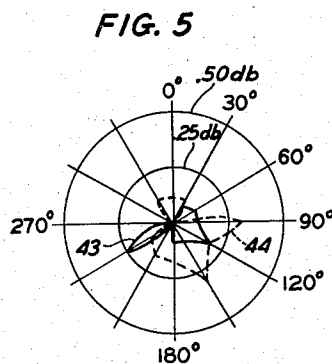
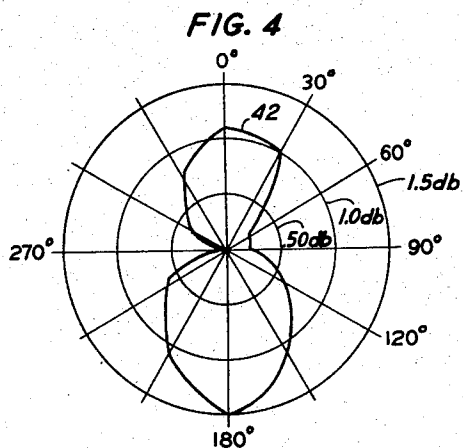
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2 Sheets-Sheet 2



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1

2,937,316

HIGH FREQUENCY APPARATUS

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Application March 12, 1958, Serial No. 720,865

3 Claims. (Cl. 315—43)

This invention relates to electron discharge devices and more particularly to such devices having a close spaced cathode and control electrode forming part of an input cavity.

A close spaced triode of the type described in Morton-Speck Patent 2,455,381, December 7, 1948; Morton-Vance Patent 2,502,530, April 4, 1950; and specifically in Gormley-Maggs-Moose Patent 2,527,127, October 24, 1950, has found extensive use as an amplifier in microwave radio systems. Such a tube, as best seen in the Gormley et al. patent, has a flat planar cathode and closely spaced therefrom a flat control grid comprising an apertured plate across which extends a plurality of parallel wires. When employed in the system, an input cavity is formed which includes the cathode and control grid and is partially defined thereby; the anode is advantageously a part both of an output cavity including the control grid and of a coaxial line output which is coupled, by a suitable coaxial-to-waveguide transducer, to an output wave guide. Such an arrangement of input and output connections is shown in W. W. Mumford Patent 2,530,836, wherein the tube is employed in a modulator.

As seen in the Gormley et al. patent, the control grid has priorly comprised a circular aperture across which the wires extend. While this would appear to be a physically symmetrical arrangement, in actuality it has been found that such a grid structure is, in fact, electrically asymmetrical. The asymmetry of the grid structure is caused by the parallel wire structure which introduces leakage gaps of varying length in the axis parallel to and perpendicular to the direction of the grid wires.

Additionally, the input cavity gives rise to an asymmetrical field. The asymmetry of the input cavity is the result of the single coupling iris in the side wall of the cavity and the relatively low Q of the circuit. As a result of these two asymmetries, the performances of apparently identical devices in the same circuit were found to vary. Specifically, I have found that the performance of the tube in typical microwave radio installations is dependent upon the orientation of the grid wires in the circuit input cavity. Particularly, variations of gain with tube orientation occur and become more pronounced at high signal levels.

It is possible, though for various reasons mentioned below it is not practicable, to provide a physically predetermined orientation, or rather, orientations. First, the control grid or electrode itself would have to be accurately positioned within the tube. Second, and of greater significance, the tube itself would then have to be aligned within the input cavity. In order to prevent leakage of wave energy around the grid terminal it is desirable that the grid terminal connection be made by screwing the tube, and specifically the grid terminal, into the mounting socket or cavity. Further, to prevent this leakage the tube must be fully tightened against these threads. Thus, to provide an accurate predetermined radial alignment of the tube in the cavity would require very expensive indexing threads, both on the grid terminal of the

2

tube and in the cavity. This in itself would prove to be an economic deterrent.

However, there is a further deterring factor to the reliance only on the accurate alignment of the present orientation sensitive tubes in the input cavity sockets. This is the fact that a very large number of such sockets are presently in use, which present sockets provide no means for indexing the position of the control electrode within the input cavity. It would be obviously unwise to attempt to replace all these sockets by a more expensive indexed socket. Further, it is almost impossible, from a maintenance standpoint and from the problem of providing a tight leakage-free connection, to attempt individually to orient each tube in its own socket as it is placed or replaced in the field.

It is an object of this invention to improve the performance of close spaced microwave discharge devices and more specifically to eliminate variations of performance among various types of such devices in the same circuitry.

It is a further object of this invention to remove the sensitivity of the discharge device to the orientation of the control electrode with respect to the input cavity.

These and other objects of this invention are attained in one specific illustrative embodiment thereof wherein the grid structure of the tube is made to appear to be electrically symmetrical. In control grids of this type, whether utilizing round grid frames as in the above-mentioned patents or other form frames, as further described herein, considerable leakage passes through the grid aperture, which leakage takes the form of degenerative feedback. With large size grid apertures, reductions of gain of 1 to 3 db may occur while the bandwidth increases proportionately so that the gain band product remains fixed. This leakage phenomenon is the grid structure is responsible for the sensitivity of the prior tubes to the orientation of the control grid in the input cavity.

In accordance with one aspect of my invention I have modified the control grid of such tubes so that the length of the leakage path in a direction parallel to the grid wires is reduced while the length of the leakage path in the other direction has been increased. In this manner I have balanced the leakage with respect to orientation of the grid wires, as the leakage will be greater in a direction parallel to the direction of the grid winding than it is in a perpendicular direction.

Accordingly, it is a feature of this invention that, in an electron discharge device having a flat cathode and an adjacent control electrode defining a portion of an input cavity which gives rise to an asymmetrical field configuration in the input cavity, the control electrode comprises a flat supporting disc having an aperture therein narrower in one direction than in the other and a plurality of fine parallel wires extending across the aperture in this one direction whereby the electromagnetic transmission characteristic of the control grid is independent of its orientation in the input cavity.

A complete understanding of the above and other objects and features of this invention may be gained from consideration of the following detailed description, together with the accompanying drawing, in which:

Fig. 1 is a sectional view of a close spaced triode in which a control electrode in accordance with my invention may be incorporated;

Fig. 2 is a sectional view of an amplifier cavity in which the device of Fig. 1 may be mounted;

Fig. 3 is a plan view of a control electrode in accordance with my invention;

Fig. 4 is a plot of the variation of gain with angular orientation of the control grid for a device as described in Gormley et al. Patent 2,527,127, October 24, 1950;

Fig. 5 is a plot of the variation of gain with angular

orientation of a control grid in accordance with my invention; and

Figs. 6A, 6B, and 6C are figures illustrating the leakage phenomena involved in these grid structures.

Referring now to the drawing, Fig. 1 depicts a close spaced triode of the type in which the control grid in accordance with my invention may be incorporated. Such a device is fully described in Gormley-Maggs-Moose Patent 2,527,127, October 24, 1950, and need only be briefly discussed herein. The tube includes a flat disc cathode 10 supported by a sleeve 11 in which is positioned the heater 12. The cathode is supported by arms 14 extending in slots of a ceramic ring 15 on the upper surface of which is mounted the flat grid or control electrode 17. Connection is made to the control electrode 17 through the grid terminal ring 18 having an external threaded portion 19. Connection may be made to the cathode 10 through the metallic shell 20 itself.

The anode 22 is positioned directly opposite the cathode and is supported and insulated from the grid terminal ring 18 by a glass or ceramic portion 23. Similarly, the grid ring 18 is insulated from the cathode housing 20 by a glass or ceramic portion 24.

The device depicted in Fig. 1 is advantageously mounted in an amplifier cavity or support as shown in Fig. 2; as this mounting arrangement is basically similar to that shown for the modulator of W. W. Mumford Patent 2,530,836, November 21, 1950, it also need only be described briefly. For our purposes the important aspects of this structure include the input cavity 26 which is coupled through an iris 27 to the input wave guide 28. The cathode 10 and control grid 17 define the upper and lower elements of the input cavity, connection being made from one side of the wave guide 28 to the cathode through fingers 30 bearing against the shell 20 of the lower portion of the tube and being made to the control grid 17 through the threaded portion 19 joined electrically to the other side of the wave guide 28 and also through fingers 31.

The anode is connected through its terminal 33 to a coaxial line section 34 and thence to a coaxial-to-waveguide transducer 35 for launching the output wave into output wave guide 36.

As discussed briefly above and further explained below, the asymmetry of the input field, together with an electrically asymmetrical control electrode, gives rise to a distinct orientation sensitivity of the output and specifically the gain of the tube. I have found that this sensitivity may be obviated by utilizing a control electrode 17 as shown in Fig. 3. As seen therein, the control electrode comprises a flat disc or support member 38 having an aperture 39 therein, which aperture is elongated in one direction. In one specific illustrative embodiment the length A was .225 inch, while the length B was .165 inch. Across the aperture 39 extend the control grid wires 40, the wires extending across the width or short length of the aperture 39. In the above-mentioned specific embodiment the wires 40 were of .0003 inch diameter wire and were initially wound a thousand turns to the inch.

The advantage of the structures in accordance with my invention can readily be seen from Figs. 4 and 5 which are plots of the gain of three specific tubes as a function of the orientation of the tube, and thus of the control grid, in the input cavity 26; these are experimental plots, and it should be noted that they would be smooth curves if experimental errors were eliminated. In Fig. 4 the single plot 42 therein depicted is for a tube utilizing a control grid as disclosed in the above-mentioned Gormley et al. patent; as can readily be seen, there is a marked gain variation with orientation up to a 1.5 db reduction in gain. In Fig. 5 two plots 43 and 44 are depicted for two different tubes both including a control grid as depicted in Fig. 3 and in accordance with my invention. As can be seen, there is only a negligible variation of gain with orientation, the maximum reduction in gain being only

of the order of .25 db and being random with respect to orientation.

The leakage phenomena which cause this marked variation in tube performance of prior devices and which I have utilized to advantage to eliminate this problem can best be understood by considering the grid wires 40 alone and by determining the field conditions existing some distance away from the plane of the grid wires and studying the field between this parallel plane and the plane of the grid. Due to the curvature of lines of electric potential in such a field, a real and finite field condition will exist at mid-points between grid laterals or wires 40 at distances beyond the grid plane. Fig. 6A illustrates the general form of the field problem discussed and shows the hypothetical plane 46 positioned a distance away from the grid wires 40.

Fig. 6B shows the field parallel to the axis of the grid wires at the plane 46 and displaced by half the distance between wires, i.e., the curve 50 illustrates the field midway between two adjacent grid wires 40. As the strength of the main field in the input cavity 26 or in the output cavity between the control electrode 17 and the anode 22 varies approximately sinusoidally with the distance from the center, a similar condition exists for the leakage field which we are considering now and which is depicted by the curve 50. Fig. 6C shows the leakage field along the plane 46, the curve 51 being along a line perpendicular to the direction of the wires 40. It is noted that at the plane 46 a near sinusoidal variation in field exists between the individual grid wires 40 and that this is modulated, as indicated by curve 52, by the overall main field condition of the input cavity. This results in approximately only 70 percent as much leakage field existing in this direction as in the direction parallel to the grid wires 40, as depicted in Fig. 6B.

Accordingly, I have found that the leakage field through the grid wires 40 may be equalized and the sensitivity of the tube to orientation of the control grid in the input cavity removed by the control grid as depicted in Fig. 3 wherein the dimension B of the aperture 39 in the direction of the grid wires 40 is only approximately 70 percent as long as the dimension A of the aperture 39 in the direction perpendicular to the direction of the grid wires. The relationship between leakage or orientation sensitivity and the ratio of the dimension B to dimension A appears to be approximately linear so that as the aperture 39 more closely approximates a circular hole, the sensitivity, which is not present in the plot of Fig. 5, becomes again apparent, more closely resembling the plot of Fig. 4. If the dimension B is made even smaller relative to dimension A, then the sensitivity will be overcompensated and a plot similar to Fig. 4, but shifted by 90 degrees, will depict the orientation sensitivity. Further, if the dimension B is made too small, there may be excessive grid shielding of the cathode, reducing the emission from the cathode unduly.

While in the specific embodiment depicted and described the aperture 39 is depicted with curved ends and straight sides, this is not essential; instead, the aperture could be entirely rectangular or entirely oval. The size of the cathode, the desired cathode emission, and the configuration of the main field in the input cavity are the controlling factors as to the optimum shape of the aperture 39 itself.

The leakage field effects, which give rise to the orientation sensitivity problem, are not appreciably affected by the aperture shape. Instead, as the leakage field existing in the grid structure is itself in an area of relatively high main field in the cavity, by varying the length of the grid wires I have found that I can affect the amount of leakage field coupling through the grid, as to the hypothetical plane 46.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be

5

devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. High frequency apparatus comprising a hollow electromagnetic wave supporting member, threads within said wave supporting member for mounting an electron discharge device having a certain gain, means for stabilizing said gain comprising a control electrode within said device having an aperture therein the width of which is approximately .7 the length, and a plurality of parallel wires extending across the width of said aperture, said gain being substantially independent of the length of said threads.

2. High frequency apparatus comprising a hollow conductive support member, an electron discharge device randomly radially oriented in said support member and having a planar cathode and a planar control electrode closely spaced therefrom, said cathode, control electrode, and said support member defining an input cavity resonator having therein an asymmetrical electric field, said control electrode comprising a disc having an aperture therein

6

which is narrower in one dimension than in the other, said narrow dimension being approximately .7 the length of said other dimension, and a plurality of fine parallel wires extending across said aperture in said narrow dimension, whereby the operation of said device is independent of its orientation in said support member.

3. A high frequency electron discharge device comprising a flat cathode, a control electrode closely spaced therefrom and forming therewith a portion of an electromagnetic wave supporting member, and an anode, said control electrode comprising a flat disc having an elongated aperture therein, one dimension of said aperture being .7 the length of the other dimension.

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