Feb. 1, 1949. F. H. BEST ET AL 2,460,484

ELECTRODE UNIT ASSEMBLY

Filed March 5, 1948

FIG. 1

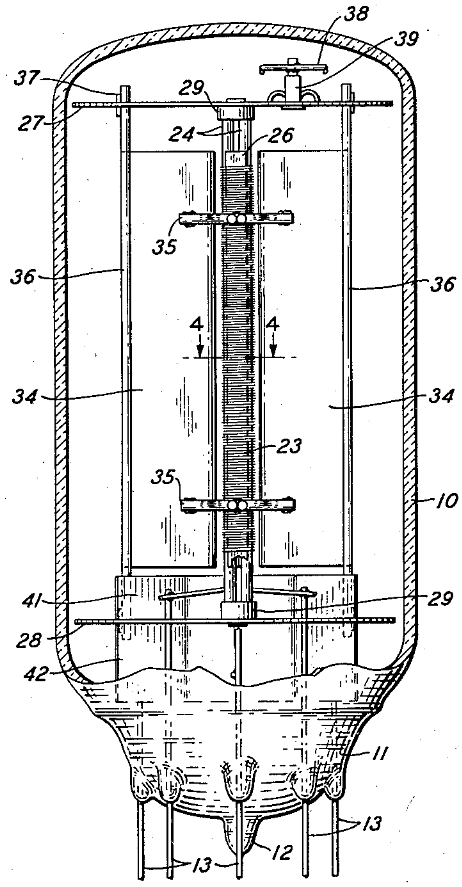


FIG. 2

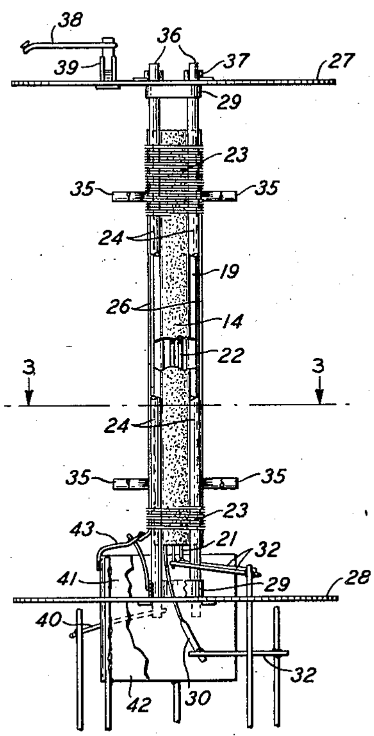


FIG. 3

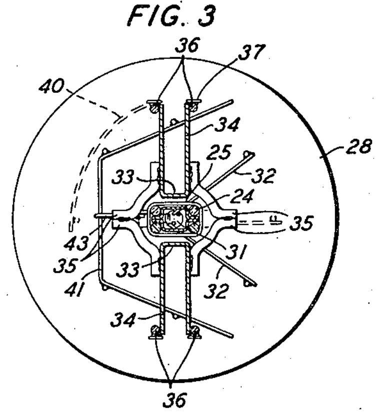


FIG. 4

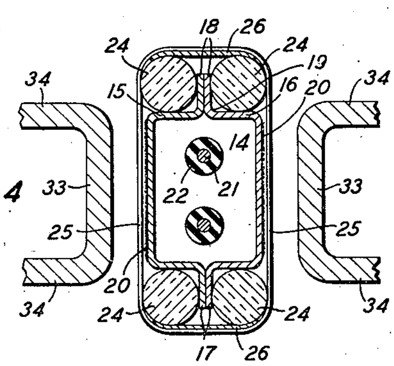


FIG. 5

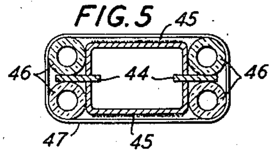
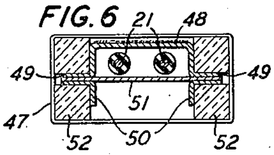


FIG. 6



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ELECTRODE UNIT ASSEMBLY

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10 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge devices and more particularly to such devices especially suitable for use in ultra-high frequency communication and television systems.

An object of the invention is to attain high transconductance and high ratio of transconductance to capacitance together with high power output in electron discharge devices for use in broad-band television systems, pulse modulation and other ultra-high frequency applications.

Another object of the invention is to insure relatively close spacing between input and control electrode areas to produce high figure of merit ratings for power output devices.

A further object of the invention is to increase the effective areas of the cooperating electrodes in the device without sacrificing relatively close space relation over extensive areas of the electrodes.

Another object of the invention is to utilize the unitary mounting of a continuous helical wire element on the cathode assembly, which is completely insulated therefrom, as the carrier of high frequency wave energy traveling along the wire to increase the amplified output of the device, in accordance with the traveling wave principle as set forth in a copending application Serial No. 640,597 filed January 11, 1946, of J. R. Pierce.

These and other objects of this invention are realized by constructions of the electrode assembly in the device in which a control electrode or element of a relatively fine wire helix is mounted in close parallel relation to the effective emission surfaces of a large area cathode element by an insulating assembly supported in juxtaposition to the cathode surface and in contact therewith, to positively insure that the relation between the electrodes be uniform and stable during operation. This is accomplished, in a particular embodiment of the invention, by constructing the cathode of a hollow metallic body, of generally rectangular cross-section and having longitudinal flange portions at opposite and medial points along the short dimensions of the cathode. The configuration of the cathode surface together with the flanges form corner pockets or ridges which provide parallel seats for a plurality of insulating rods of suitable dimensions to fit into the seats. The diameter of the rods is slightly larger than the height dimension measured from the flange portion of the cathode so that the rods project beyond the main parallel surfaces of the cathode. A wire helix wound over the rods will be uniformly spaced from the cathode surfaces and completely insulated therefrom to serve as the control electrode or grid. The pitch, number of turns and lateral relation of the grid determines the high transconductance characteristics of the device. The associate anode or output electrode may be mounted in close parallel relation to the main cathode and grid surfaces by joining two sections in opposed relation on opposite sides of the unit assembly of the grid and cathode and mounting the combined structure between spacing insulating discs to form an integrated unitary ensemble.

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A feature of this construction is that the power output of the device may be increased to any desired value merely by increasing the dimensional areas of the electrodes with the assurance of obtaining accurate space relation of the cooperating electrodes and maintaining stable relation between the electrodes.

Another feature of the invention relates to the collateral space relation of the adjacent turns of the control electrode with respect to an elongated area cathode surface, since the cathode construction together with the insulating spacer rods determine the close spacing of the grid to insure a relatively high transconductance component and low interelectrode capacitance characteristics in the operation of the device.

A further feature of the invention relates to the support of the grid turns in the unit assembly when the grid is employed as an element of a triode or multiple electrode power discharge device. In addition to the winding of the wire as a helix around the cathode and insulating rod assembly, metallic strips may be interposed between the winding and the rods along the short dimensions wherein a fusible metal coating on the wire or the strips provides a means of anchoring the turns of the grid to the strips during the high temperature processing of the device to insure positive relation of the respective turns of the grid to increase the stability of the grid helix.

These and other features and advantages of the invention will be more clearly understood from the following description when considered in connection with the accompanying drawing in which:

Fig. 1 is an elevation view of a complete device illustrative of this invention with a portion of the enclosing vessel broken away to illustrate the construction of the internal unitary assembly of the electrodes;

Fig. 2 shows the unitary electrode assembly removed from the enclosing vessel and illustrated from a different angle than shown in Fig. 1, with one of the anode sections removed and portions of the rods and cathode broken away to clearly set forth the components of the assembly;

Fig. 3 is a view of Fig. 2 taken on the line 3—3 and showing all the electrodes in cross-section with their cooperating supporting structure and the terminal conductors associated with the electrodes;

Fig. 4 is an enlarged cross-section view of the various electrodes embodied in the device of Fig. 1, taken on the line 4—4 of Fig. 1, to clearly show the unitary built-up construction of the cathode and grid, in accordance with this invention;

Fig. 5 is a cross-section view of a modified arrangement of the cathode-grid assembly in which separate medial flange extensions of the cathode are joined to opposed channel sections and tubular insulating rods support a helical coil electrode in relation to the active cathode surfaces; and

Fig. 6 shows another form of the construction in cross-section with rectangular insulating rods mounted at the corners of a modified arrangement of the cathode to attain the close space relation in accordance with this invention.

Referring to the drawings and particularly to Figs. 1 and 2, the high frequency discharge device of this invention is embodied in a specific structure of a triode amplifier tube in which a unitary mount or electrode assembly is enclosed in a highly evacuated glass vessel 10 having a cup stem 11 with a central exhaust tip 12 and a plurality of conductors 13 sealed in a circular boundary in the stem. The unitary electrode mount extends within the vessel from the conductors which support it and provides a relatively elongated structure having large electrode areas to attain high power output in the operation of the device.

In order to secure optimum efficiency in ultra-high frequency operation at high power rating, it is essential that the transconductance be relatively high and the ratio of transconductance to interelectrode capacitance be of a high order. These characteristics are readily obtained in low power devices of short length since the space relation and other attributes of the assembled electrodes can be accurately controlled to produce the results desired. However, when higher power output is required, it is necessary to increase the length of the electrodes. As the length of the electrodes is increased, difficulties arise particularly in relation to the fine wire grid and cathode spacing for the grid is easily deformed by heat and mechanical stresses or strains. While it is possible to obtain initial spacial relation of the grid laterals to the emissive surface of the cathode to realize high transconductance values, such minute space relation, of the order of .001 to .003 inch, is generally destroyed when the device is placed in operation due to the temperature and mechanical conditions imposed on the fragile wire of the grid or control electrode.

In accordance with features of this invention, these disadvantages are overcome by a construction in which the cathode of the device forms the base or foundation for mounting the helical wire grid in such relation to the active cathode surfaces that uniform and stable collaterality of the grid turns with respect to the cathode surfaces is easily assured regardless of the extent of increase of dimensions of the electrodes to attain higher power outputs. This is effectively accomplished by winding the helical grid wire tightly on insulating spacer members which are seated on a base cathode element in which the diameter of the spacer members may be so chosen to absolutely determine the space relation of the close grid lateral wires with respect to the emissive surface of the cathode. The grid-cathode structure, therefore, forms a combined unit in which the space relation determining transconductance is uniform and stable throughout the range of design frequencies and the operating life of the device.

A typical construction of the cathode-grid unit of this invention is shown clearly in Fig. 4 that illustrates a particular embodiment which, however, may be modified in various ways to attain the results of this invention. In the particular example shown in Fig. 4, the large area cathode is a hollow sleeve 14, preferably of a highly refractory metal such as molybdenum, which is formed of two channel-shaped portions 15 and 16 having angular flange projections 17 and 18 along their longitudinal edges. The projections are welded in abutting relation to form a box-like or rectangular cathode body or base for serving as the electron emission source in the operation of the device. The coplanar medial flanges 17 and 18 form angle sockets or seats 19 at the four corners of the cathode body along the minor dimensions thereof. The structure also provides relatively large parallel areas along the major dimensions which may be coated with emissive material 20, such as barium and strontium oxides, to supply copious electron emission when heated to emission temperature, for example, by conduction from an internal tungsten heater element 21 of hairpin configuration having an insulating coating 22, preferably of a high dielectric composition such as aluminum oxide, thereon.

The cathode body or base is relatively strong since it is made of molybdenum so that high temperature operation may be realized without danger of warping or distortion. The box-like construction also increases the stability of the structure even though high temperature changes occur in the operation of the device. The medial flange construction of the channel sections of the cathode provides equal angle seats or pockets at the four corners of the rectangular body which are collaterally uniform in dimensions along the length of the cathode and are contiguously formed in angular relation to the main parallel surfaces of the cathode.

While the length of the cathode 14 provides a relatively large surface area for the production of a copious supply of electrons from the emissive material 20 on the parallel outer surfaces and the structural configuration increases the stability of the emission surfaces to maintain constant linearity with respect to other cooperating electrodes, a principal function of the cathode, in accordance with this invention, is to form a mounting base or foundation for the support of a small diameter wire helix serving as the control element or grid. Consequently relatively close lateral spacing, of the order of a few mils, is insured over the effective emission surfaces to attain high transconductance values and high efficiency in ultra-high frequency operation. The fine wire grid 23 is insulatingly mounted on the cathode by the continuous winding of .001 inch gold-plated tungsten wire around four insulating rods or pillars 24 situated in the corner seats of the cathode formed by the angles 19 created by the flange portions and the short wall sections of the cathode body. The rods are preferably made of high dielectric material, such as a ceramic composition of zirconium oxide, obtainable commercially as "Zircon" rods. These rods, as shown in Fig. 4, are of solid cylindrical construction. In a typical example, the height of the channel angles may be .040 inch and the rods have a diameter of .045 inch so that the close spacing attained between the laterals 25 of the grid helix and the active coating 20 on the cathode, assuming that this coating is .002 inch in thickness, is .003 inch. This construction, therefore, attains uniform space relation between the collateral surfaces of the grid-cathode assembly along the whole length of the cathode.

In the triode shown in Fig. 1, the lateral turns of the grid may be short-circuited to provide a uniform potential electrode by winding the wire over metallic bridging strips 26 of gold-plated nickel, extending between the pairs of parallel rods 24. The laterals 25 of the grid 23 may be wound at the rate of 200 turns per inch and these closely spaced laterals may be held in uniform relation by fusing the turns to the bridging strips, for example in the high temperature treatment of the electrodes, so that the gold platings of the wire and strips are consolidated to rigidly anchor the laterals in position.

The combined assembly of the cathode and grid provides a unitary construction wherein the stability of the lateral turns of the grid is constant and uniform regardless of the area of the cathode. This is accomplished by determining the dimension of the minor axis of the cathode and the pillar supports for the grid. This produces accurate and relatively close space relation of the wire helix and cathode since the insulating mounting is controlled by the collateral relation of the rods with respect to the cathode foundation.

In the construction shown in Fig. 1, the rods 24 are longer than the cathode 14 and while the cathode forms the foundation support for the grid helix, the grid assembly including the rods also forms the mounting support for the cathode. As shown in Figs. 1 and 2, the combined cathode-grid assembly is mounted between end insulating spacer discs 27 and 28, each of which is provided with a central rectangular metallic socket 29 on the inner surface thereof. These sockets are anchored to the discs by bent tabs extending through the discs. The rods 24 are inserted in the sockets 29 with the ends of the rods in abutting relation to the surface of the discs to centrally mount the rectangular cathode-grid assembly within the electrode structure. A flexible connector strip 30 is attached to the lower end of the cathode sleeve as shown in Fig. 2, and extends through a circular opening 31, shown in Fig. 3, for connection to a stub wire 32 which is attached to one of the conductors 13 in the stem. The internal heater element 21 extending into the cathode has terminations passing through the bottom of the cathode and coupled to a pair of stub wires 32 which are connected to separate conductors 13 in the stem on opposite sides of the cathode conductor.

The output electrode necessary to complete the assembly of the triode tube, as shown in Fig. 1, is formed of a pair of channel or U-shaped sections, for example of molybdenum, spaced in parallel relation to the emissive surfaces of the cathode 14 in which the short side 33 is coextensive with the cathode sleeve both along the length and width thereof. These surfaces are spaced at a distance of the order of .020 inch from the lateral wires 25 of the grid to form the receptive surfaces of the output electrode of the device. The anode sections are also provided with relatively long heat radiation surfaces 34 to increase the heat dissipation of the device. The anode sections are held in spaced parallel relation by joined angular stub wires 35 adjacent opposite ends and on opposite sides of the large heat radiation portions. A plurality of upright support rods 36 are welded to the outer ends of the anode sections and extend to the insulating discs 27 and 28 where they are anchored by short metallic straps 37 on opposite sides of the discs to combine all the electrodes in a unitary structure and rigidly hold the cathode-grid assembly within the sockets 29 in the unit. A getter mounting 38 is attached to the upper insulating disc 27 by an eyelet connection 39 and the anode assembly is connected to another conductor in the stem by a tie wire 40.

An electrostatic shield formed of two angular sections of sheet nickel is mounted about the lower end of the cathode-grid assembly with one section 41 extending above the lower insulator 28 and the other section 42 extending below the insulator, both sections being welded to a plurality of conductors 13 extending from the stem, as shown in Fig. 3, and the helical grid being attached to the upper section 41 by a strap 43, as shown in Fig. 2. The multiple connection to the grid as provided by the four connections extending from the stem, improves the efficiency of the triode tube when employed in grounded grid amplifier circuits in high frequency operation.

While the specific construction of the device in this invention is shown in a triode to attain higher power output, it is, of course, understood that the detailed construction of the cathode-grid assembly may be incorporated in multielectrode devices to attain still higher output in the operation of the device so that the invention need not necessarily be limited to a triode but may find application in various constructions to increase the power output.

Fig. 4 shows a particular embodiment of the cathode-grid assembly to attain relatively close spacial relation between the laterals of the grid and the adjacent active surfaces of the cathode, wherein high transconductance values are attained. In this construction, the flanged portions are formed integral with the channel sections of the cathode sleeve to secure the results of this invention in an expeditious manner.

Fig. 5 shows a different construction in which the flange portions are separate from the main channel sections of the cathode sleeve and the insulating supports of the grid helix are shown as a variation in the combined assembly of this invention. In this arrangement, the flange extensions may be coplanar lateral strips 44 disposed between opposed channel sections 45 of the cathode or the flanges may be formed of a single sheet of metal with a central slot extending along the length of the cathode, in which the channels 45 are welded to the strips intermediate the edges to provide the angle seats for a plurality of insulating sleeves 46 which may be of a highly vitreous material, such as borosilicate glass. The diameter of the sleeves 46 in relation to the angle seats of the cathode assembly will determine the spacial relation of the laterals of a continuous helical wire 47 which is wound tightly around the rods 46, to form a continuous coil element surrounding the cathode. The laterals are closely spaced with respect to the cathode surface and uniformly spaced in insulating relation along the whole length of the cathode by the corner rods mounted on the cathode.

Fig. 6 shows a further modification of the cathode-grid assembly in which a channel-shaped section 48 is provided with flange extension 49 and is joined to a pair of angle strips 50 by an intermediate plate 51. The plate and channel section form an enclosure for a heater element 21 in which the flat surface of the channel section is the only emitting surface. The angle corners of the cathode construction form seats for rectangular ceramic rods 52 and the continuous helical winding 47 completely surrounds the cathode and insulator structure to provide relatively close spacing between the laterals of the helical electrode 47 and the emissive surface of the cathode.

In both the modifications, the control element is a continuous helical coil in which the progressive turns or laterals cooperate with the emissive cathode surface to provide high transconductance values in the operation of the device wherein the continuous helix may have a variable potential applied thereto for securing a high amplification output according to the traveling wave principle. Of course the structure shown in Fig. 4 may be modified to serve in the same capacity by eliminating the bridging strips 26.

While several structural assemblies have been disclosed, in accordance with this invention, it is, of course, understood that various modifications may be made in the specific structures disclosed without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. A unitary electrode assembly for electron discharge devices, comprising a metallic body of box-like configuration, flange extensions projecting from oppositely disposed surfaces of said body, a plurality of insulating rods in contact with said extensions and the adjacent surfaces of said body forming spacers in relation to the main surfaces of said body, and a winding having spaced turns encompassing said body and rods and supported by said rods.

2. A unitary electrode assembly for electron discharge devices, comprising a hollow metallic body of box-like configuration, flange extensions projecting from oppositely disposed surfaces of said body at medial points thereof, a plurality of insulating rods in contact with said extensions and the adjacent surfaces of said body forming oversize spacers in relation to the main parallel surfaces of said body, longitudinal metallic strips bridging the gap between adjacent rods on opposite sides of said body, and a winding having spaced turns encompassing said body and rods and in contact with said strips.

3. A unitary electrode assembly for electron discharge devices, comprising a hollow metallic body of box-like configuration, flange extensions projecting from oppositely disposed surfaces of said body at medial points thereof, a plurality of insulating rods in contact with said extensions and the adjacent surfaces of said body forming oversize spacers in relation to the main parallel surfaces of said body, longitudinal metallic strips bridging the gap between adjacent rods on opposite sides of said body, a helical wire winding having spaced turns encompassing said body and rods and in contact with said strips, and means fixedly attaching the turns of said winding to said strips.

4. A unitary electrode assembly for electron discharge devices, comprising a hollow rectangular metallic body having longitudinal medial flange portions extending outwardly from the short dimensional sides thereof, insulating rods fitting into sockets formed by said flange portions and the adjacent walls of said body, said rods having surfaces extending beyond the plane surfaces of said body, and a wire helix continuously wound around said rods spacing the turns in close parallel relation to the main surfaces of said body.

5. A unitary electrode assembly for electron discharge devices, comprising a hollow rectangular metallic member having a pair of similar channel portions with oppositely disposed flange extensions at opposite edges, said portions being fitted together with said flange extensions in abutting relation, ceramic rods mounted in the angles formed by said flange extensions at the four corners of said member, and a helical wire element embracing said rods and insulatingly spaced thereby from said hollow member.

6. A unitary electrode assembly for electron discharge devices, comprising a hollow rectangular metallic member having a pair of similar channel portions with oppositely disposed flange extensions at opposite edges, said portions being fitted together with said flange extensions in abutting relation, ceramic rods mounted in the angles formed by said flange extensions at the four corners of said member, said rods having a diameter slightly greater than the smallest dimension of said channel portions, and a helical wire continuously wound about said rods insulatingly spacing the turns thereof from said hollow member.

7. A unitary cathode-grid assembly for electron discharge devices, comprising a large hollow metallic cathode element of rectangular cross-section with flange portions on opposite surfaces, ceramic rods seated in the corners of said element against said flange portions, said rods having a diameter slightly greater than half the dimension of said surfaces, and a wire helix applied to said rods providing spaced turns in close spaced relation to the parallel surfaces of said cathode element.

8. An electronic discharge device comprising an enclosing vessel, an electrode assembly therein including a rectangular hollow cathode having intermediate flange portions parallel to the main surfaces thereof, insulating spacer members mounted in parallel relation on said flange portions, a helical wire element supported on and surrounding said spacer members spacing the turns of said wire element in parallel relation to the main surfaces of said cathode, and an anode portion opposite each main surface of said cathode with the laterals of said wire element therebetween.

9. An electron discharge device comprising an enclosing vessel, an electrode mount therein including a central rectangular cathode of relatively long length having portions projecting outwardly therefrom along the axis thereof, a heater element enclosed within said cathode, a plurality of cylindrical insulating rods coextensive with said cathode and fitted in the corner angles formed by said portions, a helical wire grid surrounding said rods and insulated from said cathode by said rods, said grid being unitarily supported by said cathode, and a pair of anode surfaces in parallel and spaced relation to said grid and cathode surfaces

and transverse to the angle portions of said cathode.

10. An electron discharge device comprising an enclosing vessel, a unitary multiple electrode mounting therein including a cathode, grid and anode, end spacer discs and conductors for the electrodes sealed in said vessel, said cathode being a hollow elongated metallic sleeve of two flanged channel portions in juxtaposed relation forming a cross-sectional configuration having angle seats at the corners thereof, insulating rods mounted in said angle seats and extending longitudinally beyond the ends of said sleeve, said rods in assembled relation increasing the width dimensions with respect to said sleeve, longitudinal metallic strips along the outer boundaries of said rods, a helical wire grid embracing said rods and strips and spaced in parallel relation to the exposed surfaces of said sleeve, centrally mounted metallic sockets on said spacer discs receiving the ends of said rods for supporting said cathode sleeve and grid, a heater element extending within said sleeve, a pair of U-shaped anode sections disposed opposite the parallel grid and cathode surfaces, metallic spacer brackets joining said anode sections together, support rods for said anode sections extending to said spacer discs and locking said cathode-grid assembly therebetween, leads from said anode, cathode and heater elements connected to individual conductors, an angular shield adjacent one of said spacer discs segregating the anode lead from the cathode lead, and a conductive connection between said grid and said shield, the remaining conductors being attached to said shield.

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No references cited.