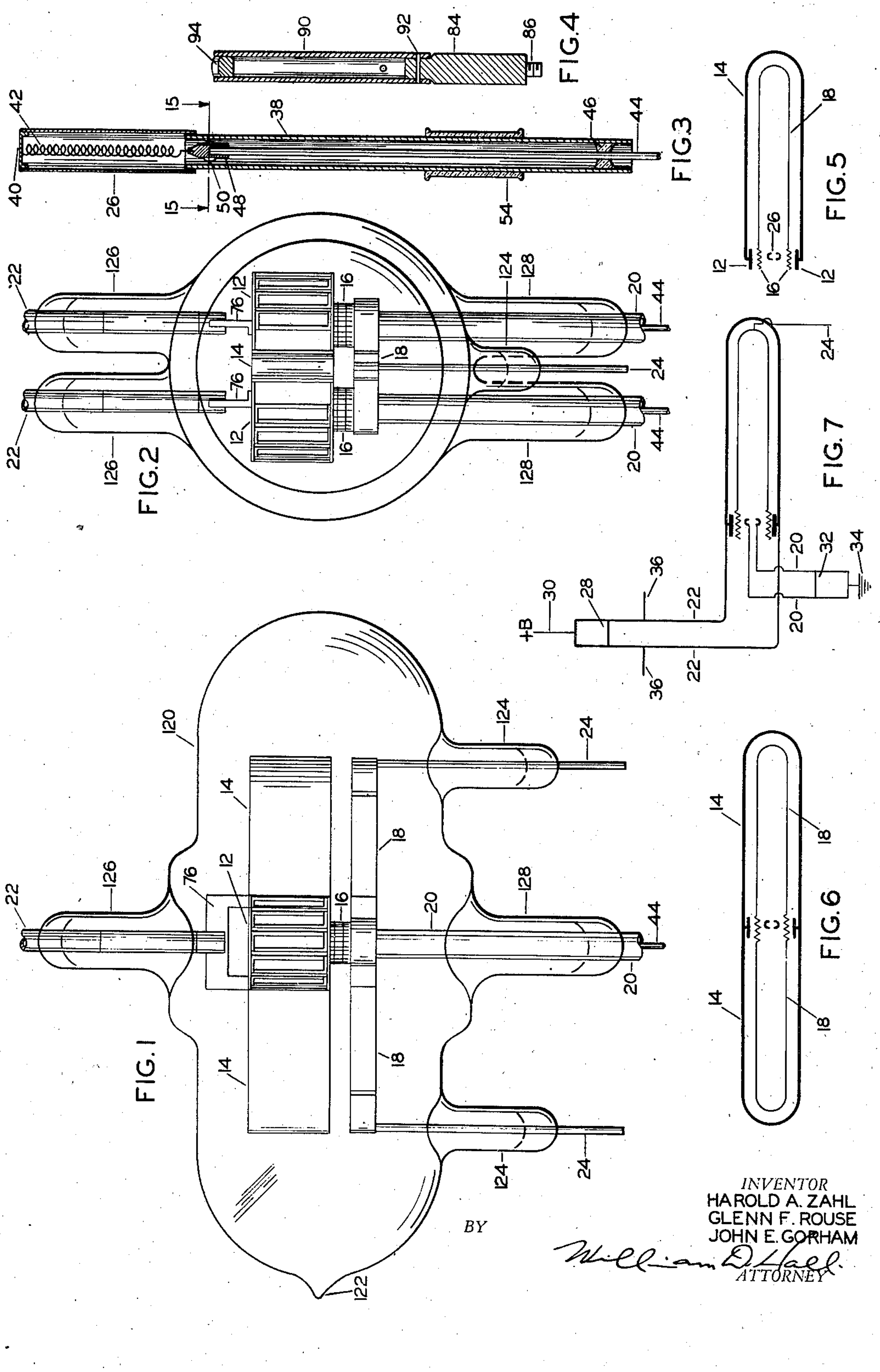
Nov. 23, 1948. H. A. ZAHL ET AL 2,454,298

ELECTRONIC TUBE

Filed July 29, 1943 2 Sheets-Sheet 1



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ELECTRONIC TUBE

Filed July 29, 1943 2 Sheets-Sheet 2

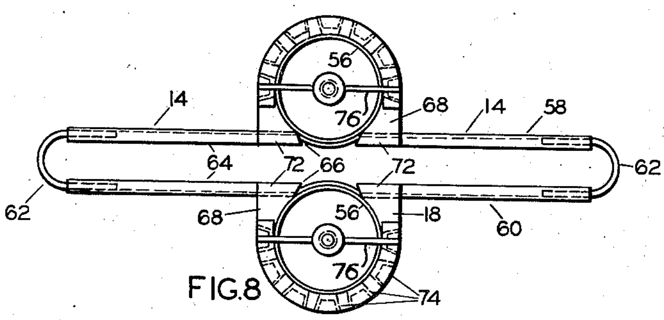

FIG. 8

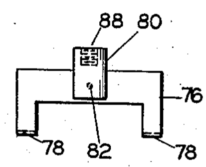

FIG. 11

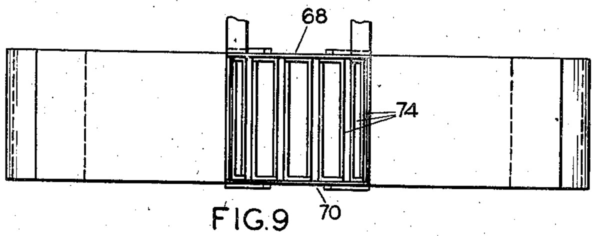

FIG. 9

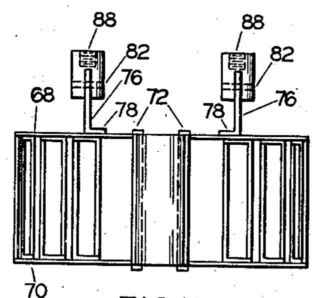

FIG. 10

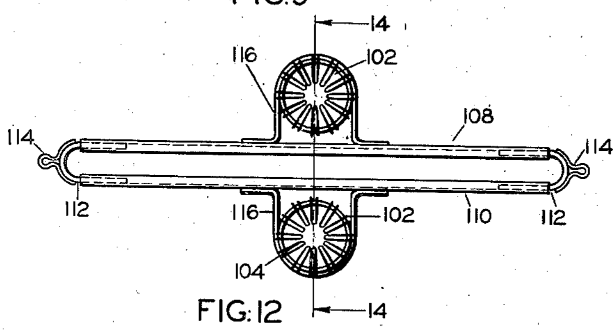

FIG. 12

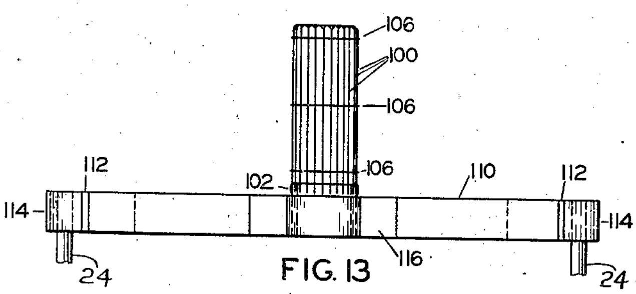

FIG. 13

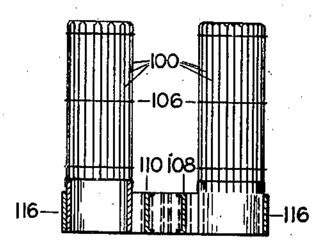

FIG. 14

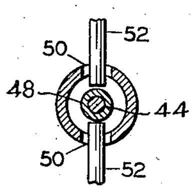

FIG. 15

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ELECTRONIC TUBE

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4 Claims. (Cl. 250—27.5)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to us of any royalty thereon.

This invention relates to improvements in electronic tubes, and more particularly to improvements in oscillator tubes for the generation of ultrahigh frequency energy.

A number of difficulties arise with high-power oscillator tubes working at ultrahigh frequency. It is difficult to obtain enough cathode area for adequate electron emission. There is a sharp break in the tuned filament circuit (with respect to radio frequency energy) between the relatively thin wire leads of the cathode and the more massive external part of the filament-tuning circuit.

One particular oscillator tube which is efficient and desirable in many respects is the tube disclosed and claimed in a copending application of Harold A. Zahl, Serial No. 473,556, filed January 25, 1943. This tube raises a difficulty because, in order to obtain adequate cathode emission, four electrode assemblies or so-called "barrels" have been employed, instead of two. The four filaments require four pairs of leads, and four glass stems to seal the leads, all of these stems being located relatively close together, thus making the tube a difficult glass-blowing job and assembly job.

One object of the present invention is to generally improve electron emission tubes. Another object of the present invention is to overcome the difficulties and disadvantages pointed out above. Another object of our invention is to obtain maximum cathode emission with minimum power consumption for cathode heating. Another object of our invention is to provide a cathode-tuning circuit which is very efficient for radio frequency oscillation. Still another object of our invention is to provide an efficient tube of simplified construction.

To accomplish the foregoing objects and other objects, some of which hereinafter appear, our invention resides in the electron tube elements and their relation one to the other as are hereinafter more particularly described in the following specification. The specification is accompanied by drawings in which:

Figure 1 is a front elevation of an electronic tube embodying features of our invention;

Figure 2 is an end elevation of the same;

Figure 3 is a longitudinal section through a cathode unit made in accordance with our invention;

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Figure 4 is a longitudinal section through the anode lead of the tube;

Figure 5 is a schematic diagram explanatory of a feature of the tube;

Figure 6 is a modification thereof;

Figure 7 is a diagram schematically showing the external tuned circuits of the tube;

Figure 8 is a plan view of the anode structure of the tube;

Figure 9 is a front elevation of the same;

Figure 10 is an end elevation of the same;

Figure 11 shows a detail of the anode structure;

Figure 12 is a plan view of the grid structure;

Figure 13 is a front elevation of the same;

Figure 14 is a transverse section taken approximately in the plane of the line **14**—**14** of Figure 12; and

Figure 15 is a section taken approximately in the plane of the line **15**—**15** of Figure 3, and is explanatory of a step in the fabrication of the cathode unit.

Referring to the drawing, and more particularly to Figures 1 and 2, the particular tube there shown comprises spaced anodes **12**, connected by anode-to-anode circuits or loops **14**. Grids **16** are disposed within the anodes **12** and are connected by tuned grid circuits or loops **18**. Cathodes (not visible in Figures 1 and 2) are disposed within the grids **16** and are carried at the upper ends of tubular cathode leads **20**. The anodes are supported by anode leads **22**, and the grid circuits are supported by leads **24**.

The operation of this particular tube may be explained with reference to schematic Figures 5, 6 and 7. Figure 5 shows how the anodes **12** are connected by a preferably U-shaped resonant anode circuit **14**, while the grids **16** are connected by a second preferably U-shaped resonant circuit **18**. The cathodes are indicated at **26**. Referring now to Figure 6, it will be seen that the circuit is substantially the same, except that two tuned grid and anode loops have been provided on opposite sides of the grids and anodes. It will be understood that the oppositely-directed anode circuits **14** correspond to the structural parts **14** shown in Figures 1 and 2, and that the oppositely-directed grid circuits **18** correspond to the structural parts **18** shown in Figures 1 and 2.

The external wiring is schematically shown in Figure 7. For the sake of clarity this is based on the simplified showing of Figure 5. In Figure 7, it will be seen that external anode leads **22** are shorted by an adjustable shorting bar **28**. The anodes may be operated at either ground potential or at a high positive potential (with respect to direct current) and this is applied by means of a lead 30. The cathode leads 20 are tuned by means of an adjustable shorting bar 32, and the cathodes may be connected either to ground or to a source of high negative potential (with respect to direct current). In the present case they are grounded at 34. An appropriate grid biasing potential may be applied to the grids through another connection 24.

The power output from the tube may be taken from either the anode circuit or the cathode circuit. This may be done by means of an appropriate transmission line, but in the present case the output is schematically shown as being delivered directly to the poles of an antenna 36.

The features of the present invention relating to the cathode unit may be described with reference to Figure 3 of the drawing, in which the cathode 26 is a cylinder made of a suitable cathode metal (for example, sheet nickel) and is secured in coaxial relation to a tube 38 made of a suitable lead-in metal (for example, Kovar). The cathode cylinder is closed at the top by means of a flanged disk or cap 40. Tube 38 preferably has a diameter approaching that of the cathode, and in the specific unit illustrated the structure appears to be one continuous element, the difference in thickness for the cathode being very slight, although exaggerated in the drawing for the sake of clarity. The coaxial relation of the cathode and cathode lead is very desirable for efficient conduction of high radio frequency energy, and constitutes one of the main advantages of the present improved cathode unit.

The heating filament 42 may be made of tungsten or other suitable metal. To energize the filament, a pair of leads may be used within the tube 38, but we prefer to connect the upper end of the filament to the disk 40 as shown, so that the circuit may be completed by the addition of a single wire 44 running through tube 38. This wire is supported near its lower end by means of an insulation or glass bead 46. The wire 44 and glass bead 46 are preferably substantial in dimension so that the wire will require no further support to keep it in the desired preferably coaxial position. The lower end of filament 42 is connected to the upper end of wire 44 by means of a small metallic connector 48. This is generally cylindrical and provided with a small hole at the top to receive the lower end of the filament, and a large hole at the bottom to receive the top end of wire 44.

To assemble the parts of the tube, the upper end of the filament is welded to disk 40 before disk 40 is welded to cylinder 26. The lower end of filament 42 is welded to connector 48 before cylinder 26 is secured to tube 38. The wire 44 is secured within tube 38 by means of glass bead 46 before the cathode assembly is secured to the lead 38. The two assemblies are then put together, the lower end of the cathode cylinder 26 being welded to the upper end of tube 38. Diametrically opposed holes 50 are provided near the upper end of tube 38, and by working through these holes, the operator makes sure that connector 48 is in proper position on wire 44, following which the connector and wire are welded together by means of electrodes passing from opposite sides through the holes, as is indicated by the electrodes 52 in Figure 15.

To complete the cathode unit, a glass sleeve 54 is fused around tube 38, this being preparatory to subsequent sealing of the tube to the glass stem of the main envelope.

An important benefit of the cylindrical cathode is its large area, thus making possible substantial electron emission. However, to heat a large cylindrical cathode instead of a thin filament raises considerable difficulty. We have found that it is feasible to use an oxide coating for the cathode even though the cathode is used in a relatively powerful oscillator for transmission purposes. When using an oxide coating, the cathode will operate at relatively low temperature and the cathode may therefore be sufficiently heated without difficulty by means of a simple internal heater filament, as above described. An appropriate coating of barium or strontium carbonate or a combination of these compounds is applied to the cathode surface, from which the desired oxide coating is later formed while the tube is on the pump. The carbonate coating may conveniently be applied after completion of the structure of the cathode unit.

The anode structure is illustrated in Figures 8, 9 and 10 of the drawing. The anodes are sheet metal cylinders 56. These are made of a suitable heat-resistant metal such as tantalum. The anodes are secured on opposite sides of the anode circuits or loops. More specifically, the loops are made of channels 58 and 60, closed at the ends by U-shaped pieces 62. The inwardly-turned flanges 64 of the channels are cut away at the center as indicated at 66, thus facilitating bending of the metal to conform to the cylindrical anodes 56. Top and bottom plates 68 and 70 may be secured to the anodes, and have their inwardly-directed ends overlaying the channels at 72. The anodes may be completed by cooling fins 74, which in the present case are trough-shaped pieces of metal having bent-over ends. The backs of the troughs are secured to the outside of the cylinders 56, while the ends are secured to the top and bottom plates 68 and 70. It will be understood that all of the parts of the structure are secured together by welding or other appropriate method.

Reverting to Figures 1 and 2, the anode structure is supported by the anode leads 22, which extend upwardly through the glass envelope of the tube. The leads 22 are connected to the anode structure by means of yoke-shaped pieces of metal 76. The construction of these will be clear from inspection of Figures 10 and 11. Each consists of a piece of sheet metal of inverted U-shape, the lower ends of the legs being bent sidewardly at 78 and welded to the top plates 68 of the anodes. The yokes are so dimensioned as to be located diametrically of the anodes, as is best shown in Figure 8. In order to facilitate detachable attachment of the anode lead, each yoke is provided with an internal threaded boss 80, the lower end of which is slit to straddle the yoke 76, and is secured thereto, as by means of a pin 82 which is preferably welded in position.

The anode lead itself is shown in Figure 4, in which it will be seen that the lower part 84 is solid and is threaded at 86 to mate with the threaded hole 88 of the yoke (Figures 10 and 11). The upper part 90 (Figure 4) of the anode lead is tubular and is preferably made of Kovar to facilitate sealing to the glass envelope. The solid part 84 and the tube 90 are secured together, as by means of welding or the use of a pin 92, or both. The upper end of tube 90 is sealed by a plug 94, which may be welded in position.

The grid structure is shown in Figures 12, 13 and 14 of the drawing. The grids are made of vertical wires 100, the lower ends of which are welded on the outside of a short tube or mandrel **102**. The wires are preferably in pairs, that is, relatively long wires are reversely bent at the top, and the open lower ends are secured to the mandrel. The upper ends may be bent inwardly to partially close the upper end of the grid, as is best shown at **104** in Figure 12. The resulting wire cage may be reenforced by circular wires **106**.

The grid circuit structure is made of metal channels **108** and **110**, closed at the ends by U-shaped pieces **112**. Sheet metal ears **114** are added at the ends to receive the support wires **24** (Figures 1 and 2), which pass through the glass envelope of the tube.

The grids are secured to the grid circuits by pieces of sheet metal **116** (Figure 12), which are bent around the mandrels **102**. The ends of the pieces **116** are turned outwardly and are secured directly to the outside of the channels **108**, **110**. It will be understood that the supports **116** are so dimensioned as to locate the grids coaxially within the anodes.

Reverting to Figures 1 and 2, it will be seen that the glass envelope **120** is generally cylindrical, with the tuned circuits **14** and **18** disposed longitudinally thereof. The envelope is exhausted through a tubulation **122**. The grid leads **24** pass through downwardly-projecting glass stems **124**. These are spaced widely apart and are far from the other stems of the tube. The anode leads **22** pass through upwardly-directed glass stems **126**. These are remote from the other stems, thus facilitating the glass-blowing operation, and insuring against breakdown under high voltage. The cathode leads **20** pass downwardly through glass stems **128**. These are remote from the other stems, and are far more convenient to make than is the case with the four-barrel tube of the patent application, Serial Number 473,556, aforesaid, in which four independent glass stems are located in closely adjacent relation.

It may be helpful to set forth the specific dimensions of a few tubes made in accordance with the present invention. These tubes were designed to oscillate at about 600 mc. In the case of the particular tube illustrated, the cathode was made of 0.005″ thickness nickel and had a diameter of 0.395″. The overall length of the cathode was 1⅜″. The effective or oxide-coated length of the cathode was 1″. The cathode can was mounted on a seamless nickel-plated Kovar tube, having a diameter of 0.375″.

The sides of the grid loop were made of 0.010″ channeled tantalum, the vertical inside width of the channel being ¼″. The ends were closed by U-shaped pieces of tantalum having a thickness of 40 mil. The length of the grid loop was 4″ inside, and the width of the grid loop or spacing between its sides was 5⁄16″ inside. The inside diameter of the grid cage was 0.528″. The length of the grid cage was 1⅝″. The cage was made of 20 equally-spaced wires, the wires being 12 mil platinum-clad molybdenum. The band at the base was 10 mil tantalum having an axial length of 11⁄32″.

The anode loop was made of 0.020″ thickness tantalum, the width or vertical dimension of the channel being 1″. The U-shaped pieces closing the ends of the channels were made of tantalum, having a thickness of 40 mil. The length of the anode loop was 4½″ inside and the width or spacing between sides was ⅜″ inside. The anode tubes were made of 0.020″ tantalum having an inside diameter of 0.794″. The length of the anode was 1″, and the spacing between centers of the two anodes was 1⅛″.

In another example having a larger barrel, the cathode was made of 0.005″ thickness nickel formed on a mandrel having a diameter of 0.515″. The overall length of the cathode was 1⅝″. The effective or oxide-coated length of the cathode was 1″. The cathode can was mounted on a seamless Kovar tube, having a diameter of ⅜″.

The grid loop was dimensioned as before. The diameter of the grid cage was 0.635″ o. d. and 0.611″ i. d. The overall length of the grid cage was 1⅝″. The cage was made of 32 equally-spaced wires, the wires being 12 mil platinum-clad molybdenum. The grid was made on a copper mandrel having a diameter of 0.629″.

The anode loop was dimensioned as before. The anode tubes were made of 0.020″ tantalum having an inside diameter of 0.794″. The length of the anode was 1″ and the spacing between centers of the two anodes was 1⅛″.

In still another tube, the cathode diameter was increased still further from 0.515″ to 0.652″. In both of these cathode units, the Kovar cathode lead was kept at a diameter of only ⅜″, thus necessitating an inward step (preferably sloping or frustro conical) between the cathode can and the Kovar lead. This was done mainly because seamless Kovar tubing is not at present available in sizes larger than ⅜″, and we encountered difficulty in maintaining proper vacuum when using seamed instead of seamless Kovar tubing. Moreover, there is greater difficulty in sealing a glass stem to a lead when the diameter is too great. It should be noted, however, that even with a reduction in diameter between the cathode and the tubular lead, there still remain the important advantages that the lead is symmetrically and coaxially related to the cathode, and that the lead is a large-diameter, efficient conductor for ultrahigh frequency energy.

It will be understood that the foregoing specific dimensions are given solely by way of exemplification, and not in limitation of the invention.

It is believed that the construction and assembly of our new electronic tube, as well as the advantages thereof, will be apparent from the foregoing detailed description. It will also be understood that our new cathode unit is of value for use in tubes different from that here disclosed, although it is of particular value for the present tube.

It will be apparent that while we have shown and described our invention in a preferred form, changes and modifications may be made in the structure disclosed without departing from the spirit of the invention as sought to be defined in the following claims.

We claim:

1. An oscillator tube for generating ultrahigh frequencies, said tube comprising an elongated envelope, an approximately elliptical circuit disposed inside the envelope in the direction of the axis of the envelope, a second approximately elliptical circuit disposed generaly parallel to the first, anodes secured directly on the outside of each side of said first circuit, a grid disposed within each anode, the ends of said grids projecting beyond the ends of said anodes and being secured directly to the sides of said second circuit, cathodes inside said grids, each cathode including a cylindrical can having a heating filament therein, tubular cathode leads extending from the cathodes transversely of the enveloped axis through the side wall of the envelope, additional

filament-heating leads running through said tubular cathode leads, grid leads extending through the envelope, and anode leads extending from the anodes through the envelope in a direction transverse to the envelope axis.

2. An oscillator tube for generating ultrahigh frequencies, said tube comprising a generally cylindrical elongated evacuated glass envelope, an approximately elliptical circuit disposed inside the envelope in the direction of the axis of the envelope, a second approximately elliptical circuit disposed generally parallel to the first in regeneratively-coupled relation thereto, anodes secured directly on the outside of each side of said first circuit, a grid disposed within each anode, the ends of said grids projecting beyond the ends of said anodes and being secured directly to the sides of said second circuit, cathodes inside said grids, each cathode including an oxide-coated cylindrical can having a heating filament therein, tubular cathode leads extending from the cathodes transversely of the envelope axis through the side wall of the envelope, said tubular cathode leads having a diameter substantially equal to that of the cathode cans, additional filament-heating leads running through said tubular cathode leads, grid leads extending from the remote ends of the grid circuit through the envelope, and tubular anode leads extending from the anodes through the envelope in a direction transverse to the envelope axis.

3. A cathode structure comprising a tubular member, a heating filament at one end of said member, a filament lead extending from the other end of said member to a point therein in the vicinity of said filament, said member having an aperture at said point to permit entry of a tool for fastening said filament to said lead.

4. A cathode structure comprising a tubular member, a heating filament at one end of said member, one end of said filament being connected to said member, the other end of said filament having a connector welded thereto, a filament lead extending from the other end of said member to a point therein in the vicinity of said connector, said member having an aperture at said point to permit entry of a tool for fastening said connector to said lead.

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Certificate of Correction

Patent No. 2,454,298. November 23, 1948.

HAROLD A. ZAHL ET AL.

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 5, line 50, for "1⅜′′" read *1⅝′′*; column 6, line 74, claim 1, for "enveloped" read *envelope*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 19th day of April, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.